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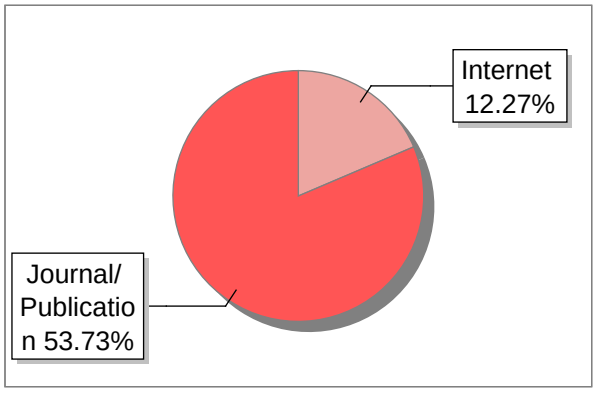

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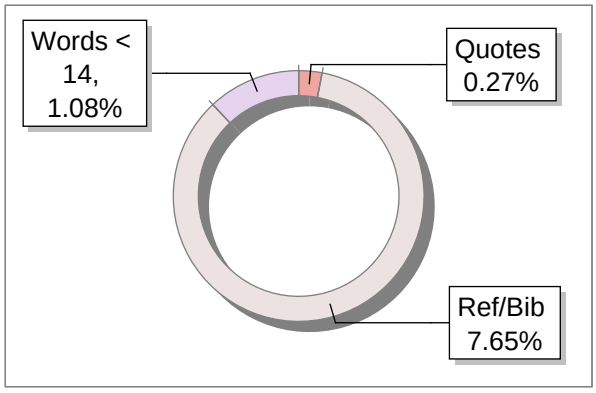

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INTRODUCTION

–The science fiction of today can be a reality tomorrow!

Research in medical and dental science have helped millions of people lead longer and healthier lives. We owe these improvements to decades of medical research as newer things are found, the older concepts may become obsolete and sometimes older concepts maybe rejuvenated by some researchers. This process creates myths and realities among the clinicians. Even in dentistry, there are myths and realities with regard to various aspects such as myths in diagnostic, disease process and even in treatment process.

Lesions of the pulp are often infectious and treatments involve several critical steps that are aimed to restrain infections of the root canal system in teeth. Originally, treatment methodologies in endodontics, like those in many other dental disciplines, evolved based on trial-and-error observations and only in recent decades have scientific methods been adopted to support clinical strategies. Yet, research reports focusing on issues relevant to the disease processes of the pulp and how they can be diagnosed and managed effectively are rare in the endodontic literature. An assessment of articles appearing in leading endodontic journals reveals that technical aspects of the testing of instruments and restorative materials, often by in vitro evaluations in extracted teeth, tend to be the dominating topics[1].

As a consequence, the advancement of biologically based knowledge significant to clinical endodontics has been slow.

In a critical review on contemporary issues in endodontics, observed: "The preoccupation of dentists with techniques has channelled dentistry (including endodontics) into a state of technical excellence that often is not accompanied by a biological awareness of the basic pathologic problems with which we are dealing or the biologic consequences of our therapy. The schism between clinicians and basic scientists is propagated by a tendency of each group to confer with themselves rather than with each other." The past 30 years have brought little change, and only modest amounts of the accumulated biological knowledge have found clinical application in the endodontic arena[2]. It is, therefore, not surprising that, in this field of dentistry, there are many contradictory views and opinions as to the proper management of

endodontic disorders. This library dissertation reviews and examines the background of some of the more significant issues that have been debated in the endodontic field in recent years and discusses controversies regarding the clinical management of the disease processes associated with the vital and the non-vital dental pulp.

REVIEW OF LITERATURE

1. The state of our scientific knowledge concerning inflammation and infection of pulp and periapical tissues is reviewed with respect to the correlation and lack of correlation of this body of scientific fact with present-day clinical practice. Caps in our knowledge are emphasized, and suggestions made as to possible paths of future research.[2]

2. Comparing some data on linear measurement of dye penetration following the cold lateral condensation of gutta-percha that were published between 1980 and 1990, a high level of variation has been found, although the experimental methods used in these studies were quite similar. In almost all studies evaluating various techniques, the cold lateral condensation technique has been used as a standard control for comparison. The reliability of these results is questionable. The problems with such studies were discussed. It seems that more research should be done on leakage study methodology, instead of continuing to evaluate the sealing ability of different materials and techniques by methods that may give little relevant information.[1]

3. The healing capacity of mechanically exposed and bacterially contaminated dental pulps was assessed in monkeys after capping with 2 commercial Ca(OH)2 containing compounds. Class V buccal cavity preparations resulting in pulpal exposure were prepared, left open to the oral cavity for 0, 1, 24 h or 7 days and employed as controls, or debrided, capped, restored with amalgam and left undisturbed for 5 weeks as treated exposures. Zero and 1 h untreated exposures presented damage from the mechanical trauma only, whereas 24 h and 7 day pulp wounds exhibited pronounced infiltrations of polymorphonuclear and mononuclear leukocytes. In addition, the 7 day exposures demonstrated several teeth with partial and total necrosis. Treated 0, 1 and 24 h exposures demonstrated wound healing, minimal pulp tissue inflammation, reorganization of soft tissue and formation of new hard tissue at the exposure site in 86 of 99 teeth. Treated 7 day exposures healed less frequently, showing signs of dentin bridging in 15 of 27 teeth. This study indicated that mechanically exposed and orally contaminated dental pulps in monkeys have a high capacity to resolve inflammation and initiate healing with new dentin formation at the exposure site when treated as described.[12]

4. The healthy pulp has good healing potential when it is exposed, although the exact repair mechanism is still undetermined, and it is not material-specific. Calcium hydroxide appears to promote the healing process and is the most widely accepted capping material. Paste-type calcium hydroxide formulations are more consistent in promoting healing of pulp exposures than cement forms where bacterial microleakage is eliminated. The prognosis for pulp capping with calcium hydroxide is good if the pulp has no pre-existing symptoms of pain, and the environment provided for it is suitable. This requires the absence of blood clots and bacterial contarnination. Where there are some symptoms of pain in a vital tooth, pretreatments with suitable materials improve the prognosis.[9]

5. There are many skeptics who condemn pulp capping but like to keep an eye on the research progress being made. Considerable literature emphasizes the negative aspects of vital pulp therapy and discourages its practice. Some clinicians and investigators continue to condemn pulp capping therapy for the same reasons reported in the literature 80 years ago despite the advances made in pulp biology. Clinicians are well aware of the immediate and long-term success rates after root canal therapy, but are less certain of the success of pulp capping. A number of nagging questions plague clinicians, when confronted with the choice of treatment. The research data on pulp capping is at times inadequate, confusing, misleading or even incorrect and diminishes the confidence of the practitioner in performing pulp capping.[11]

6. One hundred twenty-three pulp cappings had been performed by students in 1984 to 1987 (= 10-yr group) or in 1990 to 1992 (= 5-yr group) and were followed up in 1997. Teeth were checked for sensitivity (CO2/electrical pulp testing), percussion, and palpation; radiographs were taken to assess periapical status. In addition several other factors were determined that might have an influence on the success or failure rates, such as base material, type of restoration, site of exposure, etc. Results showed 44.5% failures (18.5% questionable and 37% successful cases) in the 5-yr group and 79.7% failing, 7.3% questionable, and 13% successful cases in the 10-yr group. As a factor of influence, the placement of a definitive restoration within the first 2 days after pulp exposure was found to contribute significantly to the survival rate of these teeth.[13]

7. Trans-dentinal stimulation of tertiary dentinogenesis has long been recognized, and has traditionally been ascribed to diffusion of irritant substances arising during injury and restorative treatment. Identification of bio-active components, especially growth factors including TGF-beta s, sequestered within dentin matrix provides a new explanation for cellular signaling during tertiary dentinogenesis. Both isolated dentin matrix components and pure growth factors (TGF-beta s) have been shown to signal cellular events leading to reactionary and reparative tertiary dentinogenesis. Careful consideration of the interplay between tissue injury and surgical and restorative material factors is required for optimum exploitation of the exquisite regenerative capacity of dentin-pulp for more biological approaches to clinical treatment of dental disease.[14]

8. An in vitro study investigated the resistance to static loading of endodontically treated teeth with uniform and nonuniform ferrule configurations. The results demonstrated that central incisors restored with cast dowel/core and crowns with a 2-mm uniform ferrule were more fracture resistant compared to central incisors with nonuniform (0.5 to 2 mm) ferrule heights. Both the 2-mm ferrule and nonuniform ferrule groups were more fracture resistant than the group that lacked a ferrule.[19]

9. A study was done to compare the dissolving potential of Dakin's solution with that of equivalent buffered and unbuffered sodium hypochlorite solutions on fresh and decayed tissues. In addition, the antimicrobial effect of Dakin's solution and equivalent unbuffered hypochlorite was tested. In contrast to earlier statements, the results of this study do not demonstrate any benefit from buffering sodium hypochlorite with sodium bicarbonate according to Dakin's method. An irrigation solution with less dissolving potential may be obtained by simply diluting stock solutions of NaOCl with water.[30]

10. A review of the relevant literature on chelating agents was done, presents an overview of the chemical and pharmacological properties of EDTA preparations and makes recommendations for their clinical use. Chelating agents were introduced into endodontics as an aid for the preparation of narrow and calcified root canals in 1957 by Nygaard-Østby. A liquid solution of

ethylenediaminetetraacetic acid (EDTA) was thought to chemically soften the root canal dentine and dissolve the smear layer, as well as to increase dentine permeability. Although the efficacy of EDTA preparations in softening root dentine has been debated, chelator preparations have regained popularity recently. Almost all manufacturers of nickel-titanium instruments recommend their use as a lubricant during rotary root canal preparation. Additionally, a final irrigation of the root canal with 15-17% EDTA solutions to dissolve the smear layer is recommended in many textbooks. [33]

11. Study was done to investigate in vitro the antimicrobial activity of 0.2%, 1%, and 2% chlorhexidine gluconate (CHX gel and CHX liquid), against endodontic pathogens and compare the results with the ones achieved by 0.5%, 1%, 2.5%, 4%, and 5.25% sodium hypochlorite (NaOCl). A broth dilution test was performed, and the timing for irrigants to kill microbial cells was recorded and statistically analyzed. Both 2.0% gel and liquid formulations eliminated Staphylococcus aureus and Candida albicans in 15 seconds, whereas the gel formulation killed Enterococcus faecalis in 1 minute. All tested irrigants eliminated Porphyromonas endodontalis, Porphyromonas gingivalis, and Prevotella intermedia in 15 seconds. The timing required for 1.0% and 2.0% CHX liquid to eliminate all microorganisms was the same required for 5.25% NaOCl. The antimicrobial action is related to type, concentration, and presentation form of the irrigants as well as the microbial susceptibility.[31]

12. The combination of sodium hypochlorite (NaOCl) and chlorhexidine (CHX) results in the formation of a precipitate. The aim of this study was to determine the minimum concentration of NaOCl required to form a precipitate with 2.0% CHX. This was accomplished with a serial dilution technique. X-ray photon spectroscopy (XPS) and time-of-flight secondary ion mass spectrometry (TOF-SIMS) were used to qualify and quantify the precipitate. A color change and precipitate were induced in 2.0% CHX by 0.023% and 0.19% NaOCl, respectively. Both XPS and TOF-SIMS showed the presence of para-chloroaniline in an amount directly related to the concentration of NaOCl used. Until this precipitate is studied further, its formation should be avoided by removing the NaOCl before placing CHX into the canal.[35]

13. Study was done to test the ability of a mixture of a tetracycline isomer, an acid, and a detergent (MTAD) to kill Enterococcus faecalis and compare its efficacy to that of sodium hypochlorite (NaOCl) and ethylene diamine tetraacetic acid (EDTA). The zones of inhibition and minimum inhibitory concentrations were measured for these solutions. Measurement of zones of inhibition and determination of the minimum inhibitory concentrations showed that MTAD is as effective as 5.25% NaOCl and significantly more effective than EDTA ($p < 0.0001$). Furthermore, MTAD is significantly more effective in killing E. faecalis than NaOCl when the solutions are diluted ($p < 0.0001$). Measurement of the minimum inhibitory concentrations demonstrated that although MTAD is still effective in killing E. faecalis at 200x dilution, NaOCl ceases to exert its antibacterial activity beyond 32x dilution. EDTA did not exhibit any antibacterial activity. Based on the results of this study, it seems that MTAD is an effective solution in eradicating E. faecalis.[37]

14. Antibiotics were first discovered in the late 1920s but were not routinely used clinically until the early 1940s during the Second World War. They can be used as an adjunct to endodontic treatment in a number of ways-systemically, prophylactically and locally. There are few real indications for the systemic use of antibiotics in conjunction with endodontic treatment. They are only needed when the body's efforts at fighting bacteria are failing. Use of antibiotics to prevent infection (antibiotic prophylaxis) may prevent some case of bacterial endocarditis. Therefore, prophylaxis is recommended for individuals in high-risk and moderate-risk categories. Another mode of application of antibiotics is local application as intracanal medicaments and root canal irrigants.[38]

15. The antibacterial effect of calcium hydroxide as a short-term intracanal dressing was clinically evaluated by applying the medicament for 10 minutes or 7 days in root canals of teeth with periapical lesions. The results showed that the 7-day dressing efficiently eliminated bacteria which survived biomechanical instrumentation of the canal, while the 10-minute application was ineffective.[43]

16. In the presence of endodontic gutta-percha cones, several species of bacteria were killed in vitro. Silver points, when compared with gutta-percha cones, were not or were considerably less effective against the target organism. Staphylococcus

aureus, in our assay system. Growth of bacteria in serum could be abolished by the mere presence of gutta-percha, especially when time was allowed for previous contact between the serum and the cones. It is concluded that gutta-percha cones possess a slowly acting, relatively weak, but, in our opinion, significant inherent antimicrobial property.[45]

17. A clinical study explored the influence of calcium hydroxide as an interappointment dressing on the healing of periapical lesions associated with pulpless teeth that had not been endodontically treated previously. This was achieved by comparing the prognosis after a two-visit root canal treatment with that following a one-visit treatment. From a microbiological perspective, one-visit root canal treatment created favourable environmental conditions for periapical repair similar to the two-visit therapy when calcium hydroxide was used as antimicrobial dressing. One-visit root canal treatment is an acceptable alternative to two-visit treatment for pulpless teeth associated with an endodontically induced lesion.[46]

18. Activated polymorphonuclear leukocytes (PMNs) release lysosomal enzymes and toxic oxygen-free radicals into their immediate environment. The persistent activation of PMNs by pulpotomy medicaments may contribute to the chronic inflammatory changes and root resorption seen in histologic sections. The authors examined the effects of pulpotomy medicaments commonly used in pediatric dentistry on PMN adherence, the earliest observable change in PMN behavior following activation, and perhaps 1 of the most crucial. The results showed that formocresol, eugenol, and calcium hydroxide caused lysis of PMNs at high concentrations, but activation of PMN adherence at low concentrations. By contrast, glutaraldehyde did not produce PMN lysis at high concentrations, nor did it cause activation of PMN adherence at low concentrations. These findings correspond to previous histologic studies which found that formocresol, eugenol, and calcium hydroxide, but not glutaraldehyde, can cause inflammatory destruction of pulpal tissues.[60]

19. Concern has been expressed about the safety of formocresol use in pediatric dentistry. Formaldehyde, a primary component in formocresol, is a hazardous substance and is considered a probable human carcinogen by the International

Agency for Research on Cancer, Health Canada, the Agency for Toxic Substances and Disease Registry in the U.S. Department of Health and Human Services, and the U.S. Environmental Protection Agency. Humans inhale and ingest formaldehyde daily, however, and produce formaldehyde during cellular metabolism. The human body is physiologically equipped to handle formaldehyde through multiple conversion pathways. The resultant single carbon atom released during metabolism is deposited in the "1-carbon pool," which, in turn, is used for the biosynthesis of macromolecules including DNA and RNA. Reevaluation of earlier research that examined potential health risks associated with formaldehyde exposure has shown that this research was based on flawed assumptions, which resulted in erroneous conclusions. The purpose of this review was to examine more recent research about formaldehyde metabolism, pharmacokinetics, and carcinogenicity. These results indicated that formaldehyde is probably not a potent human carcinogen under low exposure conditions. Extrapolation of these research results to pediatric dentistry suggests an inconsequential risk associated with formaldehyde use in pediatric pulp therapy.[64]

20. One of the major events involving inflammatory processes is the alteration of microcirculatory hemodynamics by inflammatory mediators released from tissue components. Using modern macrocirculatory techniques, 15 mu radioisotope labeled microspheres, 133Xe washout, laser Doppler flowmetry and double isotopes, 125 and 131I-albumin, and microcirculatory methods, intravital fluorescence microscopy with FITC labeled dextran, we have examined the effects of selected mediators, e.g. 5-hydroxytryptamine (5-HT), prostaglandin E2 (PG-E2), bradykinin (BK), substance P (SP), calcitonin gene related peptide (CGRP) and histamine on blood flow and vascular permeability in the pulp of experimental animals. Results of this study clearly show that there is a high structural/functional correlation in pulpal microcirculation in inflammation. As demonstrated in this presentation, the effects of inflammatory mediators on pulpal microcirculatory hemodynamics are complex.[66]

21. Male and female Fischer-344 rats were exposed to target concentrations of 0.5, 6, or 15 ppm formaldehyde by inhalation for 6 h/day for 5 days. Blood was removed by cardiac puncture within 1 h following termination of exposures and cultured in the presence of 5-bromodeoxyuridine (BrdU) (4 microM) for analyses of sister-chromatid exchange (SCE) and chromosome breakage. Formaldehyde did not

cause a statistically significant increase in either SCE frequency or in the number of metaphases displaying chromosome aberrations.[70]

22. There are three types of the root canal sealers commonly used in clinical applications. They are calcium hydroxide base (Sealapex), zinc oxide-eugenol base (Canals), and epoxy-resin base (AH Plus). Elutable substances and degradation products from root canal sealers may gain access to periodontal tissue in a number of ways. A study was done to evaluate the biologic effects of the root canal sealers on human oral cancer cell line (OC2). The tetrazolium bromide (MTT) assay was to evaluate the cell's survival rate. The DNA electrophoresis was used to evaluate the OC2 cell's DNA damage. The results demonstrated that the above root canal sealers' survival rates are in dose-dependent increase ($p < 0.05$). The toxicity of fresh mix group is higher than that of the mixed after 24h group. DNA fragmentation assay of sealer treated OC2 cells shows a smear layer pattern on the electrophoresis gel. There is no DNA damage found. The toxicity that regulated the cell death is not by the apoptic change of cells.[72]

23. A study was done to compare bacterial leakage using Streptococcus mutans and Enterococcus faecalis through gutta-percha and a thermoplastic synthetic polymer-based root filling (Resilon) using two filling techniques during a 30-day period. Teeth were decoronated, roots prepared to a length of 16 mm, and instrumented to ISO sizes 40 to 50. A total of 156 roots were randomly divided into 8 groups of 15 roots (groups 1-8) and 3 control groups (12 roots each). Roots were filled using lateral and vertical condensation techniques with gutta-percha and AH 26 sealer (groups 1 and 2) or with gutta-percha and Epiphany sealer (groups 3 and 4). Groups 5 and 6 were filled with Resilon and Epiphany sealer using the lateral or vertical condensation techniques. Resilon showed minimal leakage (group 8: one leakage; groups 5-7: each with two leakages), which was significantly less than gutta-percha, in which approximately 80% of specimens with either technique or sealer leaked. Kruskal-Wallis test showed statistical significance when all groups were compared ($p < 0.05$). Mann-Whitney U test compared the respective groups and found Resilon groups superior to gutta-percha groups ($p < 0.05$).[76]

24. A study compared the quality of obturation of high- and low-temperature thermoplasticized injectable gutta-percha techniques and standard lateral

condensation. A new model system was developed to more closely simulate the clinical environment. All obturations were performed in this same model which allowed direct comparisons between the different techniques. The resultant mass of gutta-percha was visually examined and graded for each obturation. Statistical analysis of the results indicated that both thermoplasticized injectable techniques were significantly better than lateral condensation. There was no significant difference between either of the thermoplastic obturation techniques.[81]

25. A study was done to evaluate the number of canals and isthmuses obturated after Cr, Er: YSGG laser treatment. Fifty-two canals were instrumented to a size 40 Profile 0.06 file combined with RC-Prep and sodium hypochlorite, or sterile water. The teeth were divided into 3 groups: (I) canals were flooded with 17% ethylenediaminetetraacetic acid for 3 minutes, (II) canals treated with the laser for 40 seconds, and (III) received no further treatment. Obturation was done with System B and Obtura III and AH Plus sealer. The specimens were rendered transparent and evaluated for the number of canals/isthmuses obturated. Under the conditions of this study, Cr, Er: YSGG treatment resulted in a statistically significant greater number of canals/isthmuses obturated ($P < .001$).[84]

26. A study was done to compare the microtensile bond strength (MTBS) between root canal and pulp chamber dentin with two bonding strategies (self-etching primer and total-etch technique). Bonding to pulp chamber dentin seems to be more predictable than to root canal dentin. In the former region, the total-etch technique may result in a higher bond strength.[90]

27. The ideal restoration of endodontically treated teeth (ETT) has been widely and controversially discussed in the literature. Prevention of healthy dental structure is essential to help mechanical stabilization of tooth-restoration integrity, increase the amount of suitable surfaces for adhesion and thus positively affect the long-term success. ETT are affected by a higher risk of biomechanical failure than vital teeth. With the development of adhesive systems, the need for post-core restorations is also reduced. Especially for restoration of excessively damaged ETT, endocrowns have been used as an alternative to the conventional post-core and fixed partial dentures. Compared to conventional methods, good aesthetics, better mechanical performance, and less cost and clinic time are the advantages of endocrowns.[96]

28. A study was done to compare healing after root-end resection with a root-end filling of mineral trioxide aggregate (MTA) or smoothing of the orthograde gutta-percha (GP) root filling. The results from this RCT emphasize the importance of placing a root-end filling after root-end resection. Teeth treated with MTA had significantly better healing (96%) than teeth treated by smoothing of the orthograde GP root filling only (52%).[102]

29. A study was done to determine the effect of 1- or 2-visit root canal treatment on the postoperative pain in the retreatment cases. Two-visit endodontic treatment with intracanal medication was found to be effective in reducing postoperative pain of previously symptomatic teeth and decreased the number of flare-ups in all retreatment cases.[115]

30. Evidence-based medicine (EBM) is defined as the conscientious, explicit and judicious use of current best evidence, combined with individual clinical expertise and patient preferences and values, in making decisions about the care of individual patients. In an effort to emphasize the importance of EBM in plastic surgery, ASPS and PRS have launched an initiative to improve the understanding of EBM concepts and provide tools for implementing EBM in practice. Through a series of special articles aimed at educating plastic surgeons, our hope is that readers will be compelled to learn more about EBM and incorporate its principles into their own practices. As the first of the series, this article provides a brief overview of the evolution, current application, and practice of EBM.[108]

CONTROVERSIES IN DIAGNOSIS

Establishing an accurate diagnosis is one of the most important and sometimes difficult situation for the clinician treating a patient with a traumatized tooth. This is in part a result of the limitations on the reliability and validity of the vitality measurements of the pulp. Controversy regarding the validity of these tests after trauma exists, and therefore the practitioner may become confused with respect to whether or not endodontic therapy is necessary.

According to Andreasen in 1981, a false-negative response may be obtained in the early stages of pulpal repair at the initial examination cannot be assumed to be healthy and continue to give a response over time.

According to Andreasen & Vestergaard Federsen, the development of pulpal necrosis may occur up to 3 months after concussion injuries, 1 year after subluxation and extrusion injuries, and as long as 2 years after lateral and intrusive luxation.

Oilman and Andreasen suggested that the ideal time period to wait in order to obtain a valid positive response from vitality testing is 1 to 6 weeks.

Recently, new studies have evaluated additional methods for vitality testing, such as laser Doppler flowmetry, which consists of the measurement of the pulpal blood flow and consequently the degree of pulp vitality.

However, the information concerning the unreliability of pulp vitality following trauma is still scarce[3]

Diagnosis of Pain

General Classification	Origin of Pain	Basic Quality of Pain
Local pathosis of extracranial structures	Craniofacial organs	Any
Referred pain from remote pathologic sites	Distant organs and structures	Aching, pressing
Intracranial pathosis	Brain and related structures	Any
Neurovascular	Blood vessels	Throbbing
Neuropathic	Sensory nervous system	Shooting, sharp, burning
Causalgic	Sympathetic nervous system	Burning
Muscular	Muscles	Deep aching, tight
Unclassifiable	Etiology as yet unknown	Any

Sinus pain

The sinuses themselves are relatively pain insensitive structures. Reynolds and Hutchins demonstrated that most so-called __sinus‘‘ pain actually arises from the nasal mucosa or from the stimulation of the nasal ostia. Conversely, various intranasal and sinus abnormalities, anatomic variations or subclinical inflammation, may present as primary headache disorders. Allergies may also cause boggy, edematous nasal mucosa. This may cause swelling of the turbinates, that may, in turn, block off the ostia of the maxillary sinuses. This has been implicated in causing referred symptoms to the teeth. Sicher pointed out that the superior alveolar nerves, supplying the maxillary molar and premolar teeth, pass along the thin wall of the sinuses. The canaliculi of the teeth often open toward the sinus, and pulpal nerves may be in direct contact with the inflamed mucoperiosteum of the sinus lining. Their direct irritation may cause dental symptoms. The reverse is also true. Inflammation or infection from the root of a tooth in contact with the sinus floor may cause sinusitis. This, in turn, will not resolve until the dental problem is corrected. Contrary to popular belief, infection and inflammation of the sinuses rarely cause facial pain or headache. Many headache patients with autonomic features will probably have tension-type headaches or migraines. Most authors feel that acute or chronic headache processes are not a result of overt paranasal sinus disease.

Angina Pectoris Vs Dental Pain

Severe pain of cardiac origin can be referred to the mandible and the maxillary region. The opposite pain reference has also been reported-pain from pulpalgia

referring down the homolateral neck, shoulder, and arms. That cardiac pain can be referred as far away as the jaws is fascinating. Yet remembering that dorsal root ganglion cells have been shown to branch in the periphery and that, in the rat at least, the dorsal root ganglion cell supplying the heart also supplies the arm helps to provide a probable explanation to this referred pain phenomenon. Angina pectoris is typically characterized by heaviness, tightness, or aching pain in the mid or the upper sternum. These symptoms may radiate upward from the epigastrium to the mandible—the left more frequently than the right.

Myocardial Pain

Myocardial infarct pain is similar to angina but is more pronounced, long-lasting, and does not resolve with rest. Severe pain in the left maxilla and mandible related to angina pectoris or myocardial infarction may occur without any other symptoms. Severe pain in the left maxilla and mandible related to angina pectoris or myocardial infarction may occur without any other symptoms. Bonica reported an incidence as high as 18% for the presentation of cardiac pain as jaw or tooth pain alone. The distribution of this cardiac pain may vary.

A careful history is important in diagnosing the referred oral pain of cardiac origin. Usually, the patient has a rather unusual story to tell, with a fairly severe pain that began rather suddenly in the left jaw and grew in intensity. The symptoms may sound very much like a pulpitis. The pain might even have moved from the mandible to the maxilla. The dentist must rule out dental pathosis quickly and efficiently. Radiographs and pulp testing of all of the teeth in the site of pain or rinsing with ice water will be equivocal. Analgesic block of the involved tooth or teeth will fail to relieve the pain. After localized dental or TMJ origins have been ruled out, referred pain from the chest must be considered.

Neurovascular Pains

This category of pain encompasses several of the primary headache disorders such as migraines, trigeminal autonomic cephalalgias, and simple intracranial vasodilation, as well as some headaches associated with pathological vascular disorders, such as temporal arteritis. The list includes only those headaches that have a higher likelihood of presenting in the dental office. In general, these headache types share the following

features. They all have primarily a deep, throbbing, pulsing, or pounding quality, occasionally sharp, and occasionally with an aching or burning background. The pain is exclusively or predominantly unilateral with pain-free or almost pain-free periods between attacks. The main difference between the different headache types lies in their temporal patterns and their associated symptoms.

The diagnosis of migraine can usually be made by history. Nonetheless, examination of the patient complaining of undiagnosed intermittent toothache or facial pain should include a thorough dental, TMJ, and muscle evaluation. Once obvious dental and joint pathology has been ruled out, and the qualitative and temporal pattern of the pain raises the possibility of dental or facial migraine, referral to an orofacial pain dentist should be made[4].

Reversible Vs Irreversible Pulpitis

Reversible pulpitis is a clinical diagnosis based on subjective and objective findings, indicating that the inflammation should resolve and the pulp return to normal. Signs of reversible pulpitis often include a normal periapical diagnosis but an increased response to cold that is non-lingering in nature (disappearing within seconds). The term lingering is often a confusing term to some, but it is used on an individual basis. If the patient response is equal in duration on all teeth, it would be non-lingering. If one tooth (or more) stands out above the rest of the teeth in terms of a variation or duration of symptoms, that is classified as lingering.

Reversible pulpitis is commonly related to recent restorations, root scaling, traumatic brushing techniques, incipient caries, and small infractions in the tooth crown. Patients who complain of symptoms related to sweets also are typically exhibiting a reversible pulpitis.

Irreversible pulpitis exhibits many forms and symptoms. Lingering painful thermal responses, particularly to cold, are the classic form of irreversible pulpitis. This pain is intensified by a stimulus but can be spontaneous. It is typically episodic in nature initially but may progress into a constant intense pain or toothache. The pulp is considered a deep tissue, it can be very difficult to isolate and pinpoint the exact tooth. Referred pain is common. Pulp testing needs to be thorough and methodical. Irreversible pulpitis, although commonly associated with its symptomatic form, also

presents in numerous other ways. Many times, an asymptomatic tooth may have an irreversible pulpitis. Lin and Langeland showed that when caries invaded the pulp space, bacteria were present, and a root canal filling is the appropriate treatment. The exception to this will be the young patient who still exhibits open apices or incomplete root development. Another form of irreversible pulpitis is hyperplastic pulpitis. Also referred to as a pulp polyp, this is a growth of pulp tissue from the pulp chamber that is usually covered with epithelium. This is typically seen again in a younger population and can be found in both primary and permanent dentition. Aerodontalgia or barodontalgia has often been referred to as an irreversible pulpitis.

Endo perio lesion

A controversy surrounding the treatment aspect of combined lesion is, which treatment should be done first. 3 schools of thought exist regarding this :

- Perform either the endo treatment first or the perio treatment depending up on the origin of the lesion.
- Start the endo treatment and continue till BMP. Place an intracanal medicament and perform the periodontal treatment. Wait till periodontal healing is observed and then complete the obturation.
- Perform the endo treatment prior to the periodontal treatment regardless of the disease.

The last philosophy is the most agreed upon treatment plan. However at times periodontal treatment is performed before an endo treatment.
For instance, an unexpected need may arise to perform a radicectomy during a periodontal surgery.
In such situations, the periodontal treatment is completed and the Endo treatment done at least within 2-3 weeks of the amputation[5].

CONTROVERSY- Endodontic therapy is contraindicated if the periapical area associated with a pulp less tooth involves one third of the root.

REALITY- the size of a periapical lesion has no relation to the size of the body to repair the lesion. Enormous lesion will heal completely following endodontic therapy by removing the source of irritant which lies within the canal, and thereafter completely filling the canal spaces.

CONTROVERSY-Endodontic therapy is contraindicated if the periapical lesion is an apical cyst.

REALITY- Bhaskar believes that over 42% of all periapical lesions are periapical cyst. It's quite obvious that when teeth involved with apical cyst are treated endodontically whether or not the cyst is enucleated, the periapical osseous defect will usually repair as readily as any other intrabony lesion.

CONTROVERSY- Endodontic therapy is contraindicated if the pulp involved tooth is badly broken down by caries.

REALITY- if the tooth is badly decayed, it must be evaluated on the basis of its usefulness. For example a severely involved molar tooth that has no opponent or maybe readily replaced by a bridge would not be a good candidate of endodontic therapy and restoration. A strategic tooth can be saved by a periodontic-endodontic therapy, restored with a post crown and serves as an excellent bridge abutment.

CONTROVERSY- Endodontic therapy is contraindicated because the involved tooth has torturous canal anatomy or very fine lumen.

REALITY- Although canal tortuosity contributes greatly to the problem of clinical endodontics, it does not render the treatment impossible. Most of these problems maybe solved with patience, perseverance, a lubricant such as EDTA and RC prep and fine sharp instruments. The extremely curved root maybe handled with ingenuity. This situation may call for decuspation or amputation of the root if the canal cannot be enlarged.

CONTROVERSY- Endodontic therapy is contraindicated because the involved tooth has advanced pulp recession.

REALITY-The surgical-length contra-angle bur allows the operator to reach into the tooth 13-14 mm, which is 4-5 mm further than one can advance with a standard-length contra-angle bur. By using the surgical length bur in the miniature contra-angle, one may extend the cut another 2-3 mm.

CONTROVERSY- Endodontic therapy is contraindicated because the involved tooth has an open flaring apex.

REALITY- The tooth with the open flaring apex maybe be endodontically treated, however and quite successfully. The first approach should be **apexification** procedure. Fortunately, this procedure leads to reawakening of root formation that ceases with premature pulpal death. Following the new growth, root canal therapy must be completed, however to obturate any tiny opening into the canal.

CONTROVERSY- Endodontic therapy is contraindicated because the involved tooth has a broken instrument in the canal.

REALITY- As the study of endodontic failures indicates, the number of failures from broken instrument is negligible. Indeed, the broken instrument itself may serves as an adequate root canal filling if it is locked into the dentin as it is twisted off. A broken instrument may also be bypassed and the canal obliterated beyond the instrument with softened gutta percha. If the instrument cannot be removed or bypassed, it maybe be necessary to fill the apex by retro filling.

CONTROVERSY- Endodontic therapy is contraindicated because the involved tooth has a procedural root perforation.

REALITY- It is a matter of degree or position of the perforation that determines whether the tooth can be saved. Perforation through the pulpal floor of premolar or a molar maybe frequently repaired. Perforation through the labial aspect of an anterior maybe repaired by using a surgical approach. Teeth with perforations on the lingual/palatal aspects preclude an attempt to salvage the damaged tooth.

CONTROVERSY-Endodontic therapy is contraindicated because the involved tooth has been perforated by internal resorption.

REALITY- The situation may be handled entirely as an internal problem, that is the metaplastic pulp causing the internal resorption maybe extirpated and the canal and the defect obliterated through the coronal approach. On the other hand, it maybe

necessary to approach the defect surgically and fill the defect with extra radicular filling technique rather than the usual intraradicaular approach. If the perforation from the internal resorption involves one root of a multirooted tooth, it is altogether possible to totally amputate the involved root and treat the other canals by endodontic means.

CONTROVERSY- Endodontic therapy is contraindicated because the involved tooth has external resorption present.

REALITY- External root resorption of the lateral walls of the root is not comparable in healing capacity to external root end resorption. Lateral root resorption is frequently related to traumatic injury of the suspensory apparatus of the tooth. Once this process has begun, and ankylosis between bone and tooth develops, it‘s difficult to interrupt. A successful result may be obtained when the perforating defect is in operable position. There appears to be no rule of thumb for prognosticating the outcome of this type of resorption.

CONTROVERSY- Endodontic therapy is contraindicated if the involved tooth is wholly of partially luxated.

REALITY- Traumatic luxation per se is certainly not a singular contraindication for root canal therapy. If the root of the wholly or partially luxated tooth hasn‘t ben fractured by trauma, replantation of tooth should be attempted.

CONTROVERSY-Endodontic therapy is contraindicated if the involved tooth has been treated previously and the endodontic treatment has failed.

RESULT- The previously treated pulpless tooth that ahs failed is far from a hopeless prognosis. Usually an error in treatment or diagnosis has been made which results in failure. By careful examination, the clinician must determine why the case has failed and if the cause is correctible, the clinician may correct the errors of omission or commission, which led to failure and therby turn a failure into success[4].

CONTROVERSIES IN VITAL PULP THERAPY

DISEASE OF THE PULP

Teeth may be exposed to a wide range of injuries that may put the vital functions of the pulp at risk. Some of the adverse influences are non-infectious injuries and disease processes produce defects in the tooth structure. Common examples include dental caries, attrition, erosion, abrasion, and various forms of fracture. Also, as a consequence of dental treatment procedures for managing caries and periodontal disease or to replace lost teeth, tooth substance is frequently lost. While injuries per se may interfere with the normal function of the pulp, they may also open up pathways to the pulp for a variety of noxious agents present in the oral cavity of which the resident microbiota are the most important and include trauma from accidents that interferes with the tissue's neuro-vascular supply. Normally, the hard-tissue barriers of the tooth, together with the capacity of the pulp to mount an appropriate inflammatory response, allow the tissue, similar to other connective tissues, to sustain injury and bacterial challenges. However, direct exposures to the oral environment are a threat to the pulp. Undeniably, the pulp has little self-healing capacity in such a situation because of lack of epithelia, which can bridge the defect and thereby offset deleterious effects of oral micro-organisms. Unless properly treated, even a minute pulpal exposure can provide oral microorganisms with the opportunity to cause a severe inflammatory lesion that eventually may result in complete breakdown of the tissue. Once the pulp has lost its vital functions, the potential for regeneration is slim in the adult tooth as microbes readily take over the pulpal space and multiply into large numbers. The ultimate consequence of this development is a chronic release of bacterial products that lead to peri-radicular inflammatory lesions and possibly also to undesirable systemic health effects. It is in this clinical context that endodontic therapies are carried out, sometimes to prevent but often in attempts to cure painful and non-painful clinical expressions of infections of the vital and the non-vital pulp[6].

DISEASE OF THE EXPOSED PULP

Nature Of The Controversy

The management of direct exposures of the pulp to the oral environment by caries or other forms of injury has intrigued the dental profession for hundreds of years. While

for a long time it was considered a hopeless task to save it from breakdown by a conservative pulp-capping or pulpotomy procedure, it became apparent, some 70-80 years ago, that pulpal healing is indeed possible. This occurred when it was discovered that wound treatment with calcium hydroxide in a water vehicle resulted in the repair of the exposure site The hard-tissue-repair response, although it does not occur consistently, has since been considered a desirable outcome, since it indicates healing of the pulp[7].

Despite the fact that pulpal healing and repair have been reported at a high rate in both experimental and clinical follow up studies, regardless of whether the tissue was injured by caries or accidental trauma, capping of the exposed pulp has remained a controversial treatment for the adult dentition. Disbelievers claim that the predictability of carrying out pulp-capping procedures successfully is inferior to the long-term success rate that endodontic therapy (pulpectomy and root filling) offers. Another compelling reason that has been put forth is that if treatment fails[8].

In the emergency situation, the dentist may also be challenged with the dilemma of having to identify the offending tooth among several candidate teeth. The subsequent endodontic treatment may furthermore become complex and more difficult to carry out than at the initial exposure, since the reparative phenomena, developing in the pulp during the healing phase, may result in a narrowing of the pulpal space. This is likely to have led many clinicians to uphold a skeptical attitude and to consider pulp capping a less-than-desirable therapeutic alternative[9]. Proponents of the treatment, on the other hand, allege that far too many pulps are extirpated that could have been saved by a conservative approach[10]. From a socio-economic point of view, procedures less invasive than pulpectomy are certainly desirable, since they are less tissue destructive and easier to carry out, thus saving effort, time, and money.

Between these two points of view are those who consider pulp capping appropriate only for exposures in healthy pulps occurring after accidental trauma. In particular, conservative treatment of exposures in young individuals is deemed suitable, since the pulp tissue volume in these individuals is large and rich in blood vessels and cells, making it apt to respond favorably to physical and microbiological challenges. Based on the analysis of a substantial number of clinical cases, Baume and Holz argued that direct capping with calcium hydroxide should not be used on pulps which have been

exposed by caries. Treatment should therefore be reserved only for teeth which display minimal signs of pulpitis. Such a clinical strategy is currently still advocated[8].

Potential Factors of Significance to Failure of Pulp Capping

Although often regarded as only one of many factors that can cause failure of pulp capping, there is ample evidence to suggest that the major threat to the pulp is of bacterial origin. A most convincing study in this context is that by, who compared the tissue response to direct exposures of the pulp, after leaving them unprotected to the oral cavity, in molars of germ-free and conventional rats. While the pulps in the conventional rats, as expected, became necrotic after a period of time and obviously infected, as indicated by the development of periapical abscesses, no such responses took place in the germ-free animals. On the contrary, pulp tissue in these animals remained healthy, and, at the exposure site, hard tissue repair developed despite the presence of debris of various origins in direct contact with the tissue. A most obvious inference of the latter study and similar observations is that pulpal wounds should heal if wound infection can be controlled. In other words, critical to the maintenance of pulpal health after capping should be the integrity of the wound site and whether it can be protected over the course of time from adverse influences of the oral microbiota. Calcium-hydroxide-mediated hard tissue repair is thought to provide such protective functions. Indeed, it has been reported that this hard tissue barrier can withstand microbial challenges if the surface restoration is lost[11].

In fact, it may become less than homogenous and may display porosities and defects, which can serve as pathways for microbial organisms to reach the pulp, should the integrity of the restoration margins or the entire restoration be lost[12].

This mechanism of lesion development and pulpal breakdown may be one important reason why pulps show a declining rate of survival over time following capping. a retrospective analysis was carried out of 510 pulps that were previously capped because of accidental exposure or exposure due to excavation of deep caries. While some pulps were lost soon after treatment, there was a successive decrease of pulpal survival over time. In a life table analysis, pulpal deaths amounted to 20% at 5 years, a rate that continued to increase until the end.

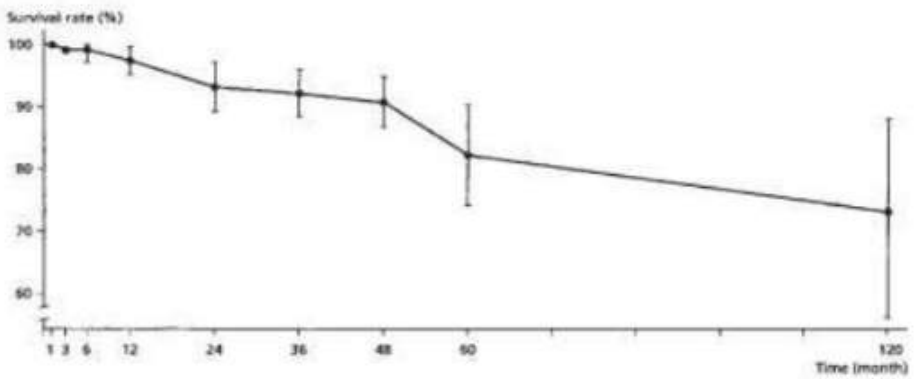


Figure 1. Graphic representation of the findings in the study by Hörsted *et al.* (1985). While the overall rate of pulpal survival was high, there was a decline over time. Bars indicate 95% confidence intervals.

In a similar retrospective analysis of pulp-capped carious exposures, the failure rate increased from 45% of treated cases at 5 years to 80% at 10 years—a daunting high rate of pulp-capping failure.

Some failures, especially those that occur soon after the completion of the treatment, may be due to reasons other than a leaky surface restoration. The previous injury and the associated bacterial exposure or both may have impaired the condition of the pulp to such an extent that it is unable to survive, regardless of treatment measure. It is most challenging for a clinician encountering a clinical exposure of the pulp to make such an assessment. This is particularly difficult when there has been caries penetration[13].

In the treatment of deep caries, clinicians run the risk of displacing infected dentin chips into the pulp tissue proper. This is a distinct possibility unless the last layer of carious dentin covering the pulp is very carefully removed. While non-infected dentin debris may become integrated into the hard tissue to generate molecules of significance for hard tissue induction, displaced infected debris may exacerbate the lesion or serve as a source of continual bacterial irritation of the tissue, or both. Consequently, the caries excavation procedure is potentially hazardous and could enhance the risk for an inflammatory breakdown of the pulp[14].

To circumvent this problem, Cvek has designed a procedure that has shown promise. The treatment, which he termed "partial pulpotomy", utilizes a pulp-cutting technique described by Granath and Hagman. The pulp tissue is atraumatically cut with an end cutting diamond at high speed and with copious irrigation. The wound surface is smoothed and completely debrided and cleaned prior to being capped. Limited case series of clinical follow-ups of treatments using such measures have shown that the five-year pulpal survival rate in young teeth with penetrating caries might be as high as 90%[15]. It should be noted, however, that no such data exist on more mature adult teeth. Claimed to be critically important for the outcome of a pulp-capping or partial pulpotomy procedure is the degree of pulpal bleeding upon mechanical exposure[11]. A profuse bleeding response that is difficult to stop is likely to indicate a more or less grave inflammatory involvement of the tissue. It may be equally important that unstoppable bleeding prevents proper management of the wound site and precludes its adequate closure by the capping agent. A blood coagulum may also be susceptible to wound infection. On the other hand, if the infection is controlled, the coagulum may serve as a matrix or mold for tissue re-organization[15].

DISEASE OF THE UNEXPOSED PULP

The inflamed pulp unexposed by caries or trauma always has the potential to be repaired. Although our diagnostic ability to differentiate a vital from a necrotic pulp is good, differentiating between reversibly and irreversibly inflamed pulp remains an educated guess at best.

Indirect pulp capping is finished by a permanent restoration in a one-step treatment, in the step-wise mode, various amounts of carious dentin are sealed off by a temporary restoration for a period of time. In anticipation of the remineralization of softened non-infected dentin over the pulp and recovery of any prevailing pulpal lesion with hard.

This latter mode of treatment has been severely criticized. By leaving caries behind to avoid pulp exposure, the clinician is unable to assess the depth of the caries lesion and the status of the pulp. Nygaard-Östby has drawn attention to the different scenarios that might exist in a case when caries has progressed to near the pulp tissue. On the one hand, an unbroken layer of primary dentin may separate the pulp from the caries lesion. In such an instance, the inflammatory involvement of the pulp is normally

small if present at all and thus is inconsequential. On the other hand, caries may have invaded reparative dentin and even advanced to the pulp tissue proper. Pulpal inflammation is then evident due to bacterial invasion of the tissue, a response which can progress to an abscess and partial necrosis. In both of these scenarios, leaving infected dentin permanently is not likely to change the preconditions for a successful outcome of a pulp preservation effort. Similarly, in the case of a healthy layer of remaining dentin, carious dentin in situ is of no benefit, and only impairs the prospect of a good restoration and a healthy pulp being retained in the long term. In a situation where bacteria have invaded the tissue, it remains to be shown that partial excavation of caries can actually suppress the infection. No such documentation is yet available tissue repair, a re-entry operation is carried out to complete excavation of remaining caries[7].

In this context, Jordan et al reported results from a follow-up of 24 molars which had signs of periapical involvement (small periapical lesion or widened apical periodontal space). These teeth had responded as vital to testing and had no history of spontaneous or prolonged pain. Of interest is that 11 teeth showed resolution of the periapical lesion and were judged clinically healthy at the final examination, from 10 months to 7 years following treatment. But 13 of the 24 treatments failed. Spontaneous recurrent pain occurred in 12 instances, and one tooth developed an acute swelling after 3 days[16].

For the reasons stated above, and the fact that convincing clinical data in support of the procedure have not surfaced over the years, indirect pulp capping as an attempt to preserve a functional and asymptomatic pulp tissue should be discouraged. Step-wise excavation, on the other hand, has the advantage that the clinician can evaluate, on reentry, whether vital pulpal conditions prevail and at the same time can check the integrity of the hard tissue covering the pulp. The method has been spurred by promising results in randomized clinical trials. In these studies, complete caries removal in one step was compared with the step-wise procedure as to the number of pulpal perforations. Significantly fewer pulpal exposures were recorded in primary and young permanent teeth. Notably, regardless of direct or stepwise excavation, the teeth with no pulpal exposure presented with normal clinical and radiographic conditions at the final clinical check-up. Björndal and Thylstrup confirmed these findings in an uncontrolled follow-up of step-wise treatments carried out by general

practitioners. Only 5 of 94 teeth with deep caries lesions, which the clinicians believed would result in pulp exposure if excavated in a single session, resulted in exposure. On the basis of these findings, it is reasonable to conclude that the procedure of excavating caries in a stepwise fashion may avoid inadvertent (iatrogenic) exposure of pulps. It is believed that by closing off the caries lesion from the oral environment for a period of time, acid-producing bacteria will be deprived of their nutritional supply. As a result, less acid will be generated, which in turn may allow for remineralization of softened but not infected dentin. Support for this potential comes from numerous reports of reduced microbial counts in caries lesions sealed off from the oral environment. In assessing the evidence in support of the stepwise excavation procedure, one has to take into consideration that, in the clinical follow-ups so far published, the cases were carefully selected. It is not unreasonable to assume that, in many of these instances, there was a favorable pulpal condition because of the absence of or limited bacterial invasion of the tissue, owing to a more or less intact layer of primary dentin. So far, there are no data to show that more pulps are actually being saved by such a measure in comparison with a direct capping procedure. Consequently, there is an obvious need to validate whether step-wise excavation is a worthwhile clinical procedure. Controlled prospective clinical trials with due consideration of relevant clinical parameters are therefore called for[17].

CONTROVERSIES IN ACCESS CAVITY PREPARATION

Modern clinicians must factor the unique and dramatically higher biting force of the molar tooth when designing the endodontic portion of the endo-endorestorativeprosthodontic (EERP) continuum. The occlusal forces created by the attachment position of the elevator muscles to the mandible generate occlusal forces that vary dramatically throughout the dentition, with light biting force in the front of the mouth to increasingly heavier forces at the back of the mouth. In physics, the mandible with its hinged access (the temporomandibular joint) is classified as a moment arm. The closer to the hinge, the higher the moment, or force, applied. The ability of the incisor to splay forward when loaded occlusally also comes into play when evaluating tooth stresses during occlusal loading. However, the molar absorbs a more vertical force and, therefore, a significantly higher net compressive force. When these 2 factors are combined (moment arm and splay), the overall compressive forces on the molar create a situation that requires a different set of rules for the calculation of ferrule, post and core design, resistance to fracturing, and (of utmost importance) endodontic access and removal of radicular dentin during endodontic shaping[18].

There are also different forces. The incisor must withstand milder, but more oblique, shearing forces. Most of the in vitro and in vivo research of post and core design has been conducted on maxillary incisor teeth, and attempting to extrapolate these findings to the molar tooth is not feasible. Placing a post in a round, husky maxillary anterior root and subjecting it to mild shearing force has little relevance to placing a post in a delicate, ovoid root in a mandibular molar and subjecting it to heavy compressive force.

Endodontic accesses are traditionally conservative to the occlusal/incisal tooth structure. However, with the changes that occur in restorative dentistry, this technique is unnecessarily restrictive for the operator and potentially damaging to the more critical cervical area of the tooth[19].

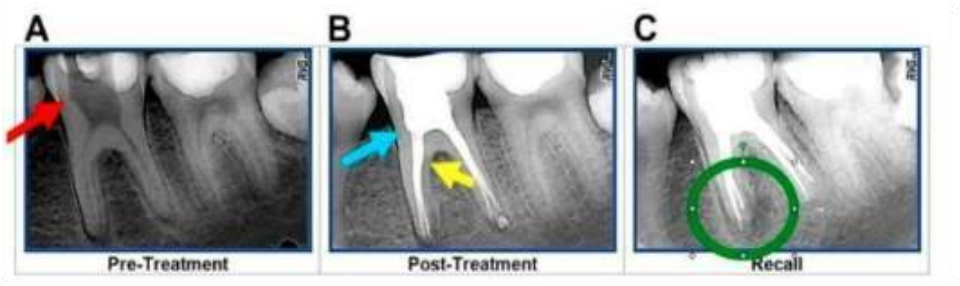


Figure A- First access using fissure burs and with the type of dentin removal that is the standard today.

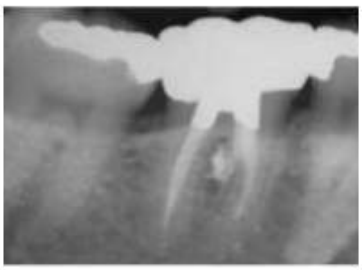
Figure B- The tooth was then re-accessed by an internationally recognized endodontist. This model for generous removal of peri-cervical dentin is common in many specialty practices.

Figure C- Eighteen months later, the lesion on the mesial root continues to enlarge. The wholesale loss of Peri Cervical Dentin has reduced the value of this tooth to the point that, when the tooth becomes symptomatic, extraction and replacement with an implant is a better option[18].

LOOK, GROOM, AND FOLLOW: SHAPING VERSUS MACHINING

Why are Gates Glidden (GG) burs so problematic?

Since the introduction of rotary files, GG burs have been used more aggressively and with more reliance on larger sizes (4, 5 and 6) to reduce binding and fracture of rotary files. Gates burs have always been considered safe because they do not end cut and are self-centering. There is a significant problem here, which is cervical self-centering. Because the shank of the GG is so thin, it is difficult to steer the GG away from high-risk anatomy. As the GG straightens the coronal or high curve, it can shortcut across a fluting or furcation and weaken or even create strip perforations



Why are round burs so destructive?

The traditional method of initiating endodontic access is predicated on mental models that do not represent the day-to-day clinical reality presented to the clinician. Round bur technique rely on tactile feedback as the round bur drops into the chamber. If the pulp chamber is sufficiently large, then a round bur can truly drop into the pulp chamber.

The case shown here is more representative of the cases typically presenting for endodontic treatment. Trying to drop a round bur into the scant or nonexistent chamber is not going to lead to the desired outcome.

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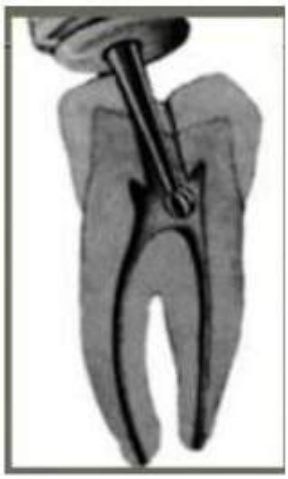


Instead, the size of the burs relative to the chambers, the omnidirectional cutting blades (which side cut aggressively), and chatter common with this bur design are much more likely to lead to the kinds of outcomes seen in

Eighteen months follow-up- Despite generous access opening and aggressive canal enlargement, the lesion on the mesial root continues to grow.

Why is complete deroofing so dangerous?

When the authors first began to maintain a soffit, which is a small piece of roof around the entire coronal portion of the pulp chamber, it seemed sloppy and contradicted the compulsive nature of traditional dentistry that has made complete deroofing a mark of a thorough clinician. The pulp seemed difficult to remove under the tiny eve and the removal of sealer and gutta percha was equally difficult. It just seemed wrong. Cleanup is easier and the authors take pride in this important advance in minimally invasive access. It is a perfect example of banked tooth structure. However, it is the attempts at removing the soffit that are far more damaging to the surrounding PCD.

The idea that a round bur can be dropped below this soffit and drawn coronally to unroof the chamber is predicated on large pulp chambers and exceptional hand skills. Clinically, it is impossible. Attempting to remove the pulp chamber roof does not accomplish any real endodontic objective, and invariably gouges the walls that are responsible for long-term survival of the tooth.

The primary reason to maintain the soffit is to avoid the collateral damage that usually occurs, namely the gouging of the lateral walls. Research will certainly need to be done to validate the strength attributes of the roof strut or soffit. However, in the absence of a compelling reason to remove dentin, our default position should always be conservative. This 360 soffit or roof-wall interface can also be compared with the metal ring that stabilizes a wooden barrel. Inference to the second moment of inertia in structural engineering deserves analysis.

In practice, it is impossible to cut flat walls in 3 dimensions with a round instrument. The chamber is not unroofed in some areas, leaving pulpal and necrotic debris with no specific subsequent step to address the debris, yet the walls are overextended and gouged in other areas. Further, the internal radius of curvature at many of the pulp chamber line angles is simply too small for all but the smallest of round burs.

In the final analysis, round burs point cut in an endodontic access application, whereas what is needed is planning. What is needed is a new set of mental models

based on vision, and a new set of instruments reflective of the task at hand and the desired shaping outcomes. The new vision-based mental model is Look, Groom, Follow.

The new burs are all round-ended tapered

It is appropriate to provide updated cavosurface outlines and cross-sectional illustrations for initial access for the maxillary and mandibular molars

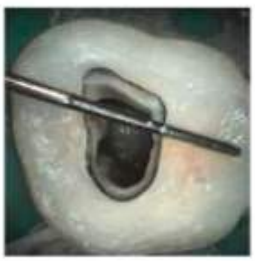
Cavosurface And Cross-Sectional Illustrations For Maxillary Molar Access

Traditional textbooks devote considerable length and effort on drawing access outline forms that are done on restoration-free, caries-free teeth. When in doubt, a larger outline form through the restorative should be cut, but only to the level at which dentin is encountered. Then, the access should be vision based, cuing from the colour map and the presence of any PTRs that can be identified. This method is a stepped access, in which an intentionally over-enlarged access is made through the cavosurface of a restored tooth (typically a crowned tooth) to the level at which dentin is encountered, then the access steps in to the size of the pulp chamber outline. The occlusal view drawing shows an inner outline of maxillary molars.

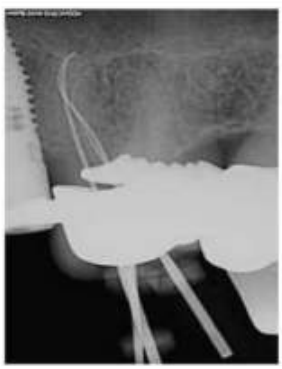
An access extension or modification that is frequently needed is the fluting or notching of the mesial wall in the area of the MB2. This requirement is due to the pattern of calcification that often places the angle of entry to the MB2 at an untenable

distal angle. This notching can be performed in dentin with a BUC-1 ultrasonic tip, and, if need be, extended into restorative using an LAAxxess nipple-tipped diamond. This case shows a preliminary access with a slight amount of fluting. A closeup shows the finished fluting in the prepared case, and the overall sizes of the access through the porcelain fused to metal (PFM) (crown) and the dentin

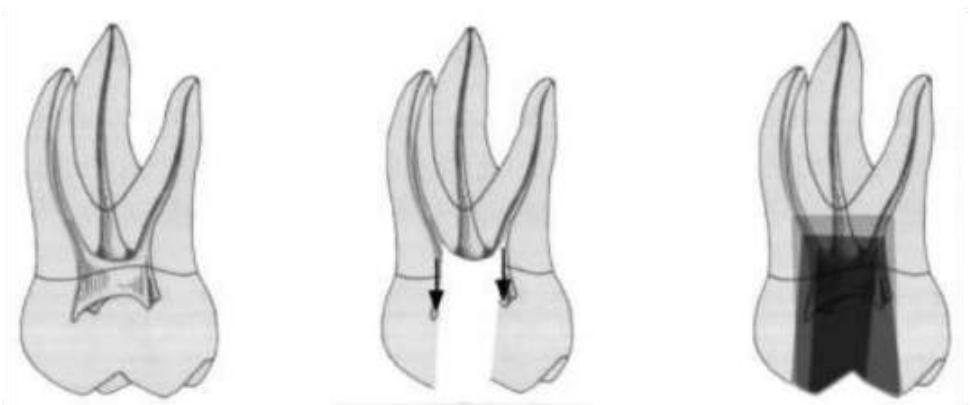


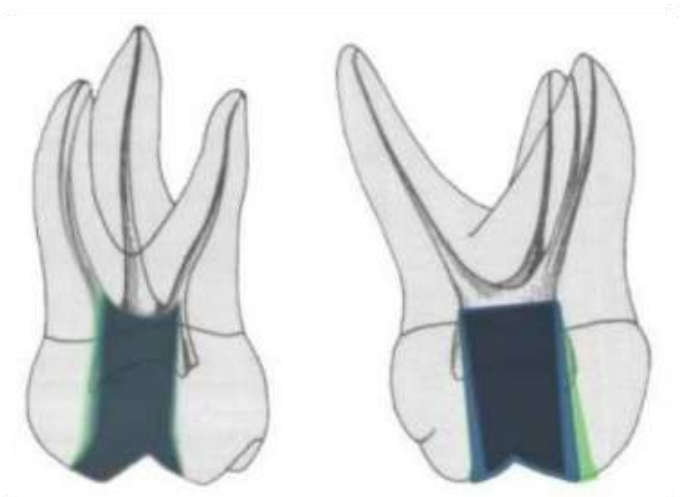
A frequent criticism of the techniques demonstrated here is that these more precise shapes preclude the discovery of coronal points of negotiation (PONs), and deep anatomy, and preclude the development of condensation hydraulics. The authors have not found this to be the case. In this case with an apparent confluent MB/MB2, precurved files were introduced with intent on the palatal aspect of the MB2, which often contains a deep split. The wire radiograph shows the 2 larger files, 1 in the MB orifice and 1 in the MB2 orifice joining, and a smaller file, also in the MB2. The completed case is shown as




The first 2 buccal views show a large pulp chamber, and a raw Clark/Khademi (CK)-style access with small soffits of chamber roof left to be debrided later. The next buccal view is an overlay of the CK-style access, a more traditional occlusally divergent access, and an access taken from a recent text showing fairly parallel walls, but grossly overextended cervically. The second set of overlays shows the CK-style access with blue and green extensions, with cavosurface finish lines appropriate for a bonded substrate with a bonded restorative, which are described later.



The mesial view shows the various extensions, again emphasizing the directions to extend as opposed to exact amounts and locations. The extension is not balanced equally between buccal and palatal, but favors the buccal.



Restorative materials should almost always be sacrificed before tooth structure. More occlusal tooth structure should be sacrificed for more cervical tooth structure. The key pericerivcal tooth structure should remain as untouched as possible. Final cavosurface outline extension at the finish appointment (which may be the start appointment on a 1-step case) hinges on the existing restorative, and the restorative plan. If abundant highly bondable substrate such as etchable porcelain or always be sacrificed before tooth structure. More occlusal tooth structure should be sacrificed for more cervical tooth structure. The key pericerivcal tooth structure should remain as untouched as possible. Final cavosurface outline extension at the finish appointment (which may be the start appointment on a 1-step case) hinges on the existing restorative, and the restorative plan. If abundant highly bondable substrate such as etchable porcelain or enamel is available, and a bondable restorative material such as a heavily filled composite resin is planned, the cavosurface should be Cala Lillied, or generously beveled on those areas. If the bondability of the substrate is of low, or a bond cannot be established between the substrate and restorative material, a butt joint or 70 to 90 interface at the cavosurface should be the objective. On multiple visit cases in which an unbonded temporary restoration is placed, the cavosurface should be maintained at 70 to 90 until the completion visit.

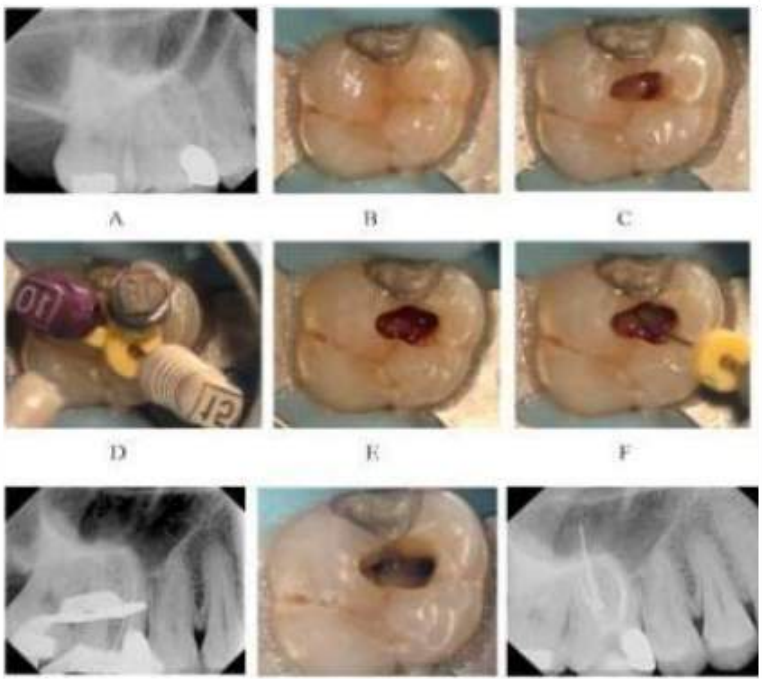
Cavosurface And Cross-Sectional Illustrations For Mandibular Molar Access

These illustrations are consistent with the style of access demonstrated in the maxillary molar section earlier (generously flared and flattened when appropriate in the coronal third of the tooth, then conservative in the middle and apical portion of the coronal portion of the tooth). The first step in contemporary molar access in the noncrowned tooth is flattening. It is a step that is ignored or overdone in most practices[18].

Controversies regarding conventional and conservative access cavity preparation

Recently, variously-sized access cavity designs have been described and compared, including the traditional endodontic cavity, the conservative endodontic cavity, and the so called –ninja‖ endodontic cavity. The controversy should not be whether to completely de-roof or partially de-roof a pulp chamber, or whether to cut a ninja-type access cavity to any given orifice; rather, the answer to this debate should

be based on the reality of –do what you can, with what you got, where you are.‖ Ultimately, the size of the access cavity is most influenced by anatomical knowledge, experience, and the technologies and methods utilized to shape, 3D clean, and fill root canal systems.



Traditionally-sized access cavities only reduce tooth stiffness by 5%, whereas cutting an MOD preparation decreases tooth stiffness by more than 60%. Yet, it is appreciated that it is the cumulative loss of tooth structure that increases the possibility of radicular fracture. Tooth survival following endodontic treatment is most dependent on full coverage, as teeth without full coronal coverage are extracted 6 times more frequently (Figure 6). In one large epidemiological study, initial endodontic treatment was performed by general dentists and endodontists in 1,462,936 teeth. Overall, 97% of these teeth were retained in the oral cavity for at least 8 years, while analysis of the 3% extracted teeth revealed that 85% had no full coronal coverage. Further, ongoing debate continues regarding whether to preserve, partially remove, or eliminate any given triangle of dentin. Yet, eliminating triangles of dentin allows the coronal aspect of any given canal to be intentionally relocated away from an external root concavity and toward the greatest bulk of dentin. Histological evidence demonstrates that removing triangles of dentin results in more

radicularly centered final preparations, which in turn, make teeth more fracture resistant.8 Experienced dentists appreciate that, in the instance of full coronal coverage, the buccal and lingual aspects of a circumferential ferrule are far superior at resisting vertical and lateral occlusal loading as compared to the mesial and distal aspect of the same ferrule[20]

CONTROVERSIES IN WORKING LENGTH DETERMINATION

One of the major controversies in root canal treatment is the apical end point of the working length. It is a paradigm in modern endodontics that instrumentation beyond the apical foramen should be avoided because it is so often associated with a reduced success. Most clinicians prefer to end the biomechanical instrumentation at the apical constriction (narrowest point in the canal at approximately the dentin–cemental junction), where the contact between root canal filling material and the apical tissues is minimal. In addition, many dentists practice apical patency with small files in order to maintain communication with the apical tissues and prevent canal blockage and ledging coronal to the determined end point.

Stein and Corcoran discussed the possibility of unintentional over-instrumentation when radiographs alone were used for working length determination. They reported that the position of a file placed for working length determination appeared radiographically 0.7 mm shorter than its actual position. The results of another investigation suggest that a working length that ends radiographically 0 to 2 mm short of the radiographic apex does not guarantee that instrumentation beyond the apical foramen will be avoided in premolars and molars. The authors conclude that radiographic measurements should be combined with electronic working length determination using modern apex locators to better help identify the apical end point of root canal preparation and avoid over-instrumentation[21].

Weine (1982) stated that, in general, a point located 1 mm coronal to the apex is close to the area of the cemento-dentine junction (CDJ). He said that in the evaluation of the exact point where the canal preparation should end, 1 mm short of the radiographic apex is probably acceptable. Another study which identified a smaller diameter or `apical constriction' as the point where the canal preparation should end and where the deposition of calcified tissue is most desirable. In the case of a periapical radiolucency with radiographic signs of apical resorption, the preparation should be shortened by an additional 0.5 mm from the radiographic apex[22].

Weine (1982) suggested instrumentation and obturation to the CDJ, which he believed was located at the same level as the apical constriction (Figs 1 and 2). Nguyen indicated the CDJ as the limit of the preparation.

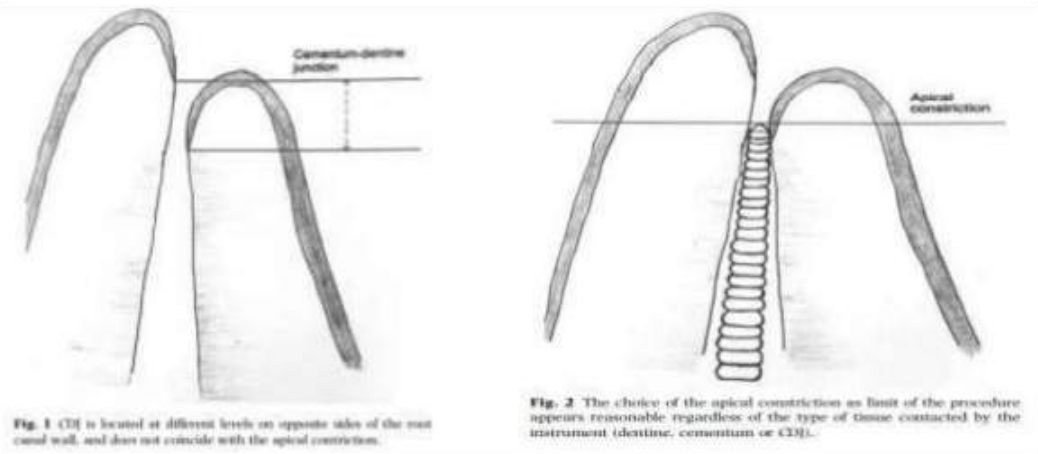


Fig. 1 CDJ is located at different levels on opposite sides of the root canal wall, and does not coincide with the apical constriction.

Fig. 2 The choice of the apical constriction as limit of the procedure appears reasonable regardless of the type of tissue contacted by the instrument (dentine, cementum or CDJ).

Ingle, based on Kuttler's study, stated that the narrowest diameter of the apical foramen was located at the CDJ (Figs 1 and 2), which was usually found about 0.5 mm from the external surface of the root. Limiting the instrumentation to 0.5 mm from the radiographic terminus of the root would certainly maintain the minimum and ideal apical opening. The overextension of instrumentation and the displacement of toxic products from the root canal into the periapical tissue would be avoided. This author also recommended obturation at 0.5 mm from the radiographic apex and stated that obturating up to the radiographic terminus of the root actually results in an overfilling[23,24].

Frank et al. (1988) suggested an apical stop located between 0.5 mm and 1 mm from the apex. The stop represents the apical limit of the instrumentation and keeps the obturation material inside the canal during condensation. With regard to the problem of accessory canals, these authors stated that too much importance has been given to these canals, as if they were crucial elements in obtaining success or failure. In fact their importance is relatively little if the main canal is properly prepared and filled. Their obturation happens by chance and does not have clinical significance.

Guldener (1985) suggested choosing a working length which corresponds to the tooth length less 0.5 mm for cases with a necrotic pulp. In cases of vital pulp extirpation, he recommended an additional reduction of 0.5 mm, 1 mm short of the tooth length. Taylor (1988) pointed out a narrower spot at the apical level called `Minor Diameter' which he believed to correspond histologically to the CDJ[25].

Langeland, however, advocated termination of instrumentation and obturation at the apical constriction. He demonstrated histologically that the pulp in the apical portion of the root canal, in the lateral canals and in the apical ramifications remains vital and often uninflamed, even in the presence of a radiolucency. Finally, despite necrosis and bacteria establishing themselves in the periapical lesion, the instrumentation and obturation should remain at the apical constriction. He also stated that the most frustrating clinical aspect is that no exact distance from the radiographic apex could be given, because the distance from the radiographic apex to the apical constriction varies widely from root to root. Histologically, he demonstrated that the CDJ ± being highly irregular (e.g. 3 mm higher on one wall than on the opposite wall) ± did not at all coincide with the apical constriction. Consequently, he refused to accept any distances from the radiographic apex as an accurate indicator for the termination of the endodontic debridement and obturation. Contrary statements in the literature, although calculated from large numbers of measurements, are based on averages and oversimplifications which cannot give accurate clinical direction. This is a situation where the use of averages adds to the confusion rather than giving a solution to the problem. Furthermore the CDJ is a histopathological structure which cannot be found clinically and thus cannot be instrumented or obturated. His firm clinical advice is: Carefully study a good quality radiograph in a viewing device blocking out all extraneous light, have the knowledge of the variations of root canal anatomy foremost in your mind, use your tactile sense to locate the apical constriction, observe if blood or other tissue fluids appear on the instrument tip, or anywhere on a paper cone, indicating that you are in the periapical tissue. This is an inaccurate art, based on precise science. Finally, put it all together using common sense: instrumentation beyond the foraminal constriction causes an unnecessary enlargement of the pulpal wound, contaminants from the canal will interfere with the wound healing and medicaments and/or materials will cause tissue destruction, inflammation, and a foreign body reaction in the periapical tissue'.Regardless of a vital or necrotic pulp, however, he suggests termination of the obturation at the apical constriction, that is short of the apex, radiographic or anatomic, which will result in the smallest possible wound and optimal healing. This decision is based on anatomical and histological material[26].

Pecchioni (1983) stated that during instrumentation it is better not to go nearer than 0.5±1 mm from the radiographic apex. Even regarding the distance where the obturation should end. He affirmed that it must, in any event, end at 0.5 mm from the radiographic apex. However he continued while it is very serious and damaging to go beyond this limit with instrumentation, it is less serious to slightly overfill the apex, since the common sealers are generally tolerated and easily resorbable'. Thus: we feel comfortable saying that in necrotic cases an overfill does not represent a contraindication. In fact, while treating vital teeth alteration of the apical pulp stump must be avoided, in necrotic cases leaving necrotic or infected debris, or an empty space in the last part of the root canal must be avoided'. Langeland, by contrast, stated that all endodontic sealers are irritant and resorbable[27]. The above authors seem to agree that instrumentation and subsequent canal obturation should be confined to the root canal space, coronal to and at some varying distance from the radiographic apex.

Table 1 *Recommended limit of instrumentation and obturation*

Authors	Ideal limit	Practical limit	Modifications in 'necrotic cases'	Materials beyond the foramen	Lateral canals and apical ramifications
Weine (1982)	CDJ (apical constriction)	1 mm from the apex	Additional 0.5 mm shorter (1.5 mm total from the apex	—	Rarely cause failure
Nguyen (1985)	CDJ	—	—	—	—
Ingle (1983)	CDJ (apical constriction)	0.5 mm from the apex	—	—	—
Frank et al. (1988)	—	0.5–1 mm (apical stop)	—	—	Their obturation casual and not clinically relevant
Guldener (1985)	—	1 mm from the apex	0.5 mm longer (0.5 mm from the apex)	—	—
Taylor (1988)	Apical constriction (minor diameter)	—	—	—	—
Pecchioni (1983)	—	0.5–1 mm from the apex	Overfilling accepted	Slight overfilling not relevant	—
Seltzer et al. (1968, 1969)	—	Instrumentation and obturation 'short'	—	Not accepted	—
Langeland (1967)	Apical constriction	Apical constriction	No difference in limit of procedure	Not intended	Not intended material in lateral canals
Schilder (1967, 1976, 1987)	—	Radiographic terminus of the canal	No difference in limit of procedure	Not relevant	Obturation desired

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This chapter aims to clarify the problems described on the basis of strict scientific criteria. These will include (i) statistical/longitudinal studies, (ii) anatomical evidence, and (iii) histopathological/microbiological evidence.

Statistical/longitudinal studies

Since 1956 many statistical studies on the results of endodontic treatment have been published. From these studies a correlation between clinical variables and success rate can be made. One of the most investigated aspects is success rate related to the radiographic level of the endodontic obturation.

In a study on 1007 endodontically treated teeth, 1770 canals, Swartz et al. (1983) evaluated several variables and came to the conclusion, among others, that overfilled canals were four times more likely to fail than canals filled short of the radiographical apex'. Marin (1989) conducted a retrospective analysis on the clinical radiological results of a sample of 1200 roots treated over a period of 5 years. The purpose was to determine whether a significant statistical relationship existed between the level of the root canal filling and the success rate. He concluded that cases with fillings at 0.5 and 1 mm from the radiological apex appear to have a significantly superior clinical prognosis. In cases where the filling reaches or goes beyond the radiological apex, there is a considerable decrease in the number of complete repairs and a consequent increase in incomplete repairs and failures. The importance of staying inside the root canal with the obturation and avoiding extruding material into the periapical tissues in order to obtain a higher success rate has also been stressed more recently found that in roots with necrotic pulps and periapical lesions the best prognosis was obtained when the filling reached within 2 mm of the apex (94%). By contrast, in cases with excess root filling the success rate decreased to 76%; in cases of excess root filling during retreatment of previously filled roots the success rate decreased to 50%.

Smith et al. had a 86.95% success rate when the position of the root filling was within 2 mm of the radiographic apex. In cases with `long' obturation the success rate was reduced to 75%. Friedman et al. (1995) found that in the presence of extruded sealer the success rate was 56.7% against 81.9% in the absence of extrusion. Contrary to the studies undertaken by endodontic specialists which reported success rates of 91±94%, epidemiological studies of large population groups showed uncertain and failure rates of about 50% of endodontic procedures performed by generalists. OÈ desjoÈ et al. found that 24.5% of the endodontically treated roots demonstrated periapical lesions. Buckley & SpaÊngberg found 31.3% of root-filled teeth with periapical lesions, and 42.9% of overfills had periapical disease. These studies agreed that inadequate canal

obturation and overfilling were strongly associated with the presence of periapical disease. It is clear that all studies confirm the practice of staying short of the apex with a proper obturation to obtain the highest success rate[25].

Anatomical evidence

The anatomical complexity of the root canal system has been well known since the beginning of this century. Preiswerk stated that he was the first to describe the presence of an anastomosing canal system. Subsequently Hess undertook a further study of the anatomical complexity of the root canal system. Kuttler made an impressive number of measurements on the apical part of the canal. Very seldom does a root canal end at the radiographic apex. Much more frequently the foramen ends at a location short of the apex. This was reconfirmed in a recent study by Gutierrez & Aguayo, who examined 140 extracted permanent teeth with a scanning electron microscope. All the root canals were found to deviate from the long axis of their roots. The number of foramina ranged from 1 to 6. The openings always ended short of the apices by 0.20±3.80 mm[24].

This represents a problem for the endodontist, because this phenomenon is recognizable on the radiograph only when the foramen ends on the mesial or distal aspect of the root. When the foramen ends on the buccal or lingual aspect it is not possible to recognize it radiographically. Thus, over-instrumentation of the root canal must be a common and unnoticed occurrence, unless the operator is diligently examining the tip of the instrument for blood. Cases of endodontic failure where the canal appeared to be filled short of the apex radiographically were in fact obturated beyond the foramen. Apicectomies and successive histological sections demonstrated that the obturation material protruded into the periodontal ligament from a foramen ending several millimetres short of the apex on the buccal aspect[25].

Frequently the main canal in the apical third divides into several branches, each ending on the external root surface with a distinct foramen. Lateral canals can also be present at any level along the root, and it is evident that the tip of a file cannot suddenly make a 908 turn to instrument these spaces. From all these considerations it may be concluded that the best place to end the preparation procedure is at the apical constriction which is usually located at a distance between 1 and 2 mm from the radiographic apex, keeping in mind that in particular cases the foramen could be

found several millimetres short of the apex (Ricucci et al. 1990, 1991, Gutierrez & Aguayo 1995). However, apart from those exceptions where the experience and expertise of the operator will allow recognition of anatomical variations, instrumenting at an average distance of between 1 and 2 mm from the apex will prevent over instrumentation, leaving the pulp tissue contained in the apical part of the canal and the ramifications undisturbed.

Langeland (1996), based on anatomical/histopathological studies, refused to settle for any particular length from the apex. The radiographic apex with all its radiographic inaccuracies is the `constant' against which the everchanging distance from the anatomical apical constriction must be measured. This has to be inaccurate, as confirmed by Gutierrez & Aguayo[26].

Histopathological/microbiological evidence

The first scientific basis for modern clinical endodontology was established by Davis. This author, on the basis of Hess's study, was the first to suggest that careful treatment of the apical tissue was a requirement for success in endodontics. His conclusion was not based on histological observation, but since then many histological studies based on biopsies of the apex with the surrounding periapical tissues or on extractions of teeth performed at varying periods of time following the endodontic treatment have confirmed his observation. All these studies agreed that, in vital pulp treatment, partial pulpectomy was preferred to total pulp removal. The first histological studies on pulp wound healing were made by Hatton et al. and by Blayney but the series were too small and data about diagnosis, procedures, observation periods and results were insufficient.

Subsequently Nygaard-Ostby performed clinical/histopathological studies on 20 human teeth. On some of them pulpectomy was performed; in the others a partial pulpectomy was performed using a blunted Hedstroem file. The distance from the apex was checked radiographically. Observation periods ranged from one month to several years. Despite limitations in the number of cases and a number of uncontrolled variables such as diagnosis, medicaments and filling materials, Nygaard Ostby stated: `To leave the apical and foraminal part of the pulp tissue and to retain its vitality will play a decisive role for the success in the treatment of the vital pulp'. Also: `In cases where the pulp is vital before treatment, no matter whether the

diagnosis be clinically intact pulp, acute or chronic pulpitis, partial extirpation seems to give the most favourable prognosis. By appropriate treatment, in the majority of cases, the vitality of the residual pulp may be conserved, the result being a normal apical periodontal ligament and fibrous connective tissue in the apical portion of the root canal[28].

Histological results after pulpectomy in 17 teeth with previous vital pulps. In 15 of these a pulpectomy was performed, with the wound surface between 1.5 and 6 mm from the radiological apex. Although a number of uncontrolled variables were present, they recorded histological success in 10 out of the 15 cases.

Partial pulpectomies in 12 contralateral tooth pairs were perfromed. Half the canals were obturated with calcium hydroxide mixed with saline, the other half with chloropercha and gutta-percha, according to the Nygaard-Ostby technique. The teeth were extracted after observation periods of 4 to 29 weeks. They classified 12 of the 23 partial pulpectomies as successful and 4 as more or less successful. They concluded that optimal results `would appear to be obtained' with a residual apical pulp 1±2 mm long.

They concluded that, in cases of vital pulp extirpation, optimum results, in terms of tissue repair, were obtained when root canals were instrumented and filled short of the apices of the teeth. They emphasized that when obturation materials are forced into the periapical tissues they cause the inflammatory response to persist. The foreign materials act as continuing irritants. Over-all the best results are obtained when the apical pulp stump retains its vitality and no foreign material is impinged on the pulp or periapical tissues. Substantial agreement exists among many researchers that partial pulpectomy is preferable to total pulpectomy in vital pulp treatment. The same agreement is not registered in the treatment of `necrotic cases'. A very strict distinction between the vital pulp condition and necrotic pulp condition has always been made by clinicians. It seems a very common cliche that, when a pulp appears clinically necrotic (i.e. it does not respond to sensitivity tests), it is generally considered to be necrotic in its entirety, including the apical pulp and the tissue contained in lateral canals and in apical ramifications. This is a basic conceptual error on which, subsequently, inappropriate therapeutic options have been based. In fact progression of the pulp necrosis as the result of caries is a slow process. The invasion

of bacteria into necrotic pulp tissue occurs in irregular `pockets', deeper in some areas, adjacent to vital pulp tissue on the same level as the orifice[25].

The involvement of lateral canals

It has already been stated that it is incorrectly presumed that when a pulp appears to be `clinically necrotic' it is considered entirely necrotic, including the pulp tissue in the lateral canals and apical ramifications. Langeland demonstrated that the histological condition of the tissue contained in lateral canals reflects the condition of the pulp in the main canal, from which they emerge: when a lateral canal is present in an area where healthy pulp tissue is present in the main canal, healthy pulp tissue will be found throughout the lateral canal; when a lateral canal is present in an area where there is an inflammation in the main canal, there will be an inflammation in the adjacent area of the lateral canal; and when a lateral canal is present in an area where there is necrosis in the main canal, there will be necrotic tissue in the adjacent part of the lateral canal[26]. This will be followed by a transition zone of necrosis/neutrophilic leucocytes, and then vital and inflamed tissue connected to a periodontal lesion. In other words, during disintegration of the main canal pulp the tissue in the lateral canals and in the apical ramifications remains vital as far as the tissue in the main canal, but is partially necrotic when necrosis reaches the level of the pulpal entrance of lateral canals and apical ramifications. The inflammatory reaction of the tissue contained in the lateral canal will become weaker closer to the periodontal ligament. Circulation from the periodontal ligament is mainly responsible for the maintenance of this tissue vitality. The explanation for lateral lesion formation in the presence of an inflamed but vital pulp tissue is the same as for periapical lesion formation. The accumulated disintegration products of the coronal pulp, bacterial disintegration products and their toxins are transferred through functioning veins and diffuse into the periodontal tissue. The subsequent evolution of this situation will depend on time; necrosis may finally reach the periodontal ligament. Practical consequences resulting from these observations are the following: it is impossible to instrument lateral canals and apical ramifications. Material which radiographically appears in the lateral canals are forced into the tissue. When lateral canals appear `filled', it is evidence that a sufficient amount of sealer has been pushed into them to make them appear radiodense[25].

In summary, the root canal should be prepared and obturated to a point as close to the apical foramen as possible yet still within sound tooth structure. The objective of determining the WL is to enable the root canal to be prepared as close to the apical constriction as possible.

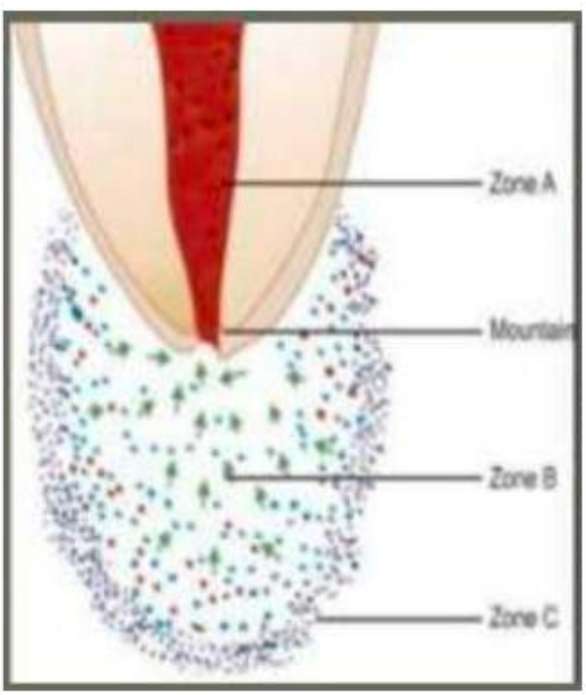
CONTROVERSIES IN CLEANING AND SHAPING

Location of micro-organisms

It is in the expanding phase that micro-organisms may invade the periapical tissue compartment. However, once the lesion has entered a more established form, it is believed that bacteria are eliminated from the soft tissue lesion.

Careful microscopic examinations have failed to identify micro-organisms in inflammatory periapical lesions associated with necrotic pulps in more than occasional instances (Nair, 1987).

Kronfield explained that the granuloma does not provide a favorable environment for the survival of the bacteria. He employed the FISH concept so as to explain the tissue reaction in and around the granulomatous area.



Numerous publications have reported the presence of micro-organisms in seemingly quiescent periapical inflammatory tissue lesions (Sundqvist and Reuterwing, 1980), and these findings question the validity of the concept of the sterile apical granuloma. Studies have confirmed that during the development of these lesions, several

microorganisms, normally residents of the infected pulp space, will be found in the abscessed tissue (van Winkelhoff et al, 1985).

Immunohistochemical markers have provided good evidence for the presence of both Actinomyces israelii and Proprionibacterium propionicum in confirmed well-organized but treatment-resistant periapical tissue lesions (Sundqvist and Reuterwing, 1980; Borssén and Sundqvist, 1981)

Although the debate has been heated at times, the concept of the sterile peri-radicular granuloma must still be regarded as valid

The main targets for treatment are the organism located within the confines of the root canal space, and one can conclude that rarely is there a need for systemic use of antimicrobials to remedy treatment failures[29].

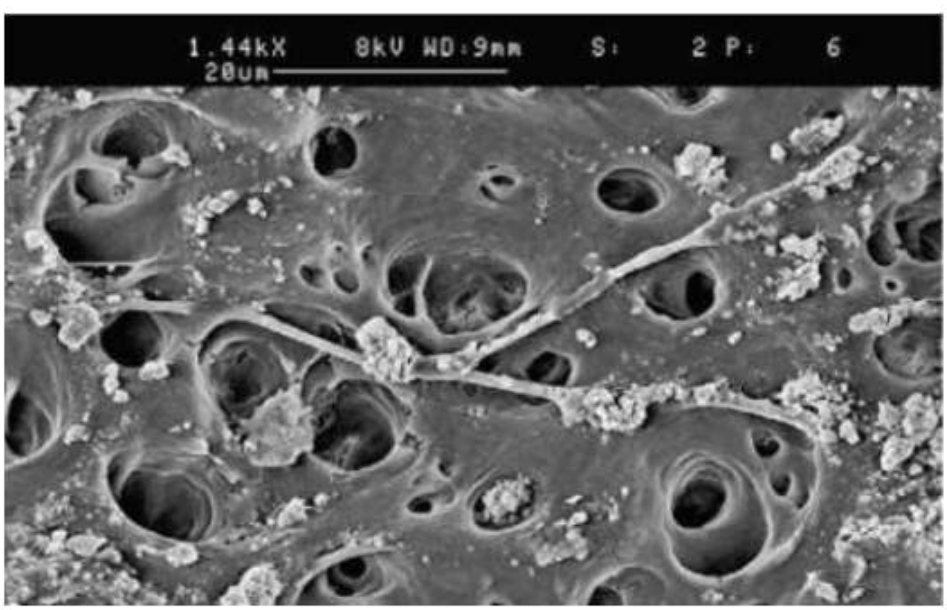
IRRIGATING SOLUTIONS

Sodium Hypochlorite

Sodium hypochlorite (NaOCl) is the most popular irrigating solution. NaOCl ionizes in water into Na1 and the hypochlorite ion, OCl, establishing an equilibrium with hypochlorous acid (HOCl). At acidic and neutral pH, chlorine exists predominantly as HOCl, whereas at high pH of 9 and above, OCl predominates.Hypochlorous acid is responsible for the antibacterial activity; the OCl ion is less effective than the undissolved HOCl. Hypochloric acid disrupts several vital functions of the microbial cell, resulting in cell death.NaOCl is commonly used in concentrations between 0.5% and 6%. It is a potent antimicrobial agent, killing most bacteria instantly on direct contact. It also effectively dissolves pulpal remnants and collagen, the main organic components of dentin. Hypochlorite is the only root-canal irrigant of those in general use that dissolves necrotic and vital organic tissue. It is difficult to imagine successful irrigation of the root canal without hypochlorite. Although hypochlorite alone does not remove the smear layer, it affects the organic part of the smear layer, making its complete removal possible by subsequent irrigation with EDTA or citric acid (CA). It is used as an unbuffered solution at pH 11 in the various concentrations mentioned earlier, or buffered with bicarbonate buffer (pH 9.0), usually as a 0.5% (Dakin solution) or 1% solution. However, buffering does not seem to have any major effect on the properties of NaOCl, contrary to earlier belief [30,31].

There is considerable variation in the literature regarding the antibacterial effect of NaOCl. In some articles hypochlorite is reported to kill the target microorganisms in seconds, even at low concentrations, although other reports have published considerably longer times for the killing of the same species. Haapasalo and colleagues showed that the presence of dentin caused marked delays in the killing of Enterococcus faecalis by 1% NaOCl. Many of the earlier studies were performed in the presence of an unknown amount of organic matter (eg, nutrient broth) or without controlling the pH of the culture, both of which affect the result. When the confounding factors are eliminated, it has been shown that NaOCl kills the target microorganisms rapidly even at low concentrations of less than 0.1%.

However, in vivo the presence of organic matter (inflammatory exudate, tissue remnants, microbial biomass) consumes NaOCl and weakens its effect. Therefore, continuous irrigation and time are important factors for the effectiveness of hypochlorite. Bystro¨ m and Sundqvist studied the irrigation of root canals that were necrotic and contained a mixture of anaerobic bacteria[32].



These investigators showed that using Desired functions of irrigating solutions Washing action (helps remove debris) Reduce instrument friction during preparation (lubricant) Facilitate dentin removal (lubricant) ,Dissolve inorganic tissue (dentin)

Penetrate to canal periphery Dissolve organic matter (dentin collagen, pulp tissue, biofilm) Kill bacteria and yeasts (also in biofilm) Do not irritate or damage vital periapical tissue, no caustic or cytotoxic effects Do not weaken tooth structure Irrigation in Endodontics. 0.5% or 5% NaOCl, with or without EDTA for irrigation, resulted in considerable reduction of bacterial counts in the canal when compared with irrigation with saline. However, it was difficult to render the canals completely free from bacteria, even after repeated sessions. Siqueira and colleagues reported similar results using root canals infected with E faecalis. Both studies failed to show a significant difference in the antibacterial efficacy between the low and high concentrations of NaOCl. Contrary to these results, Clegg and colleagues,in an ex vivo biofilm study, demonstrated a strong difference in the effectiveness against biofilm bacteria by 6% and 3% NaOCl, the higher concentration being more effective[29].

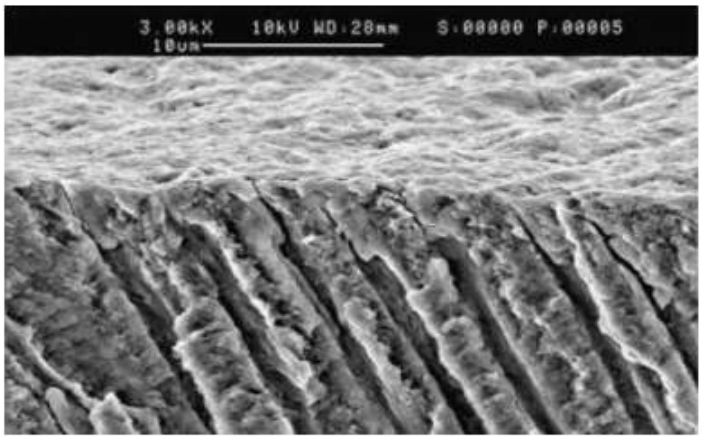
The weaknesses of NaOCl include the unpleasant taste, toxicity, and its inability to remove the smear layer by itself, as it dissolves only organic material. The limited antimicrobial effectiveness of NaOCl in vivo is also disappointing. The poorer in vivo performance compared with in vitro is probably caused by problems in penetration to the most peripheral parts of the root-canal system such as fins, anastomoses, apical canal, lateral canals, and dentin canals. Also, the presence of inactivating substances such as exudate from the periapical area, pulp tissue, dentin collagen, and microbial biomass counteract the effectiveness of NaOCl. Recently, it has been shown by in vitro studies that long-term exposure of dentin to a high concentration sodium hypochlorite can have a detrimental effect on dentin elasticity and flexural strength. Although there are no clinical data on this phenomenon, it raises the question of whether hypochlorite in some situations may increase the risk of vertical root fracture. Bystroem and Sundqvist studied root canals naturally infected, mainly with a mixture of anaerobic bacteria, and showed that although 0.5% NaOCl, with or without EDTA, improved the antibacterial efficiency of preparations compared with saline irrigation, all canals were not bacteria free even after several appointments. No significant difference in antibacterial efficiency in vivo between 0.5 and 5% NaOCl solutions was found in the study. Siqueira et al. using E. faecalis-infected root canals demonstrated the superior antibacterial affect against root canal bacteria of

hypochlorite in comparison with physiological saline. However, no difference was detected between 1, 2.5, and 5% NaOCl solutions[32].

In summary, sodium hypochlorite is the most important irrigating solution and the only one capable of dissolving organic tissue, including biofilm and the organic part of the smear layer. It should be used throughout the instrumentation phase. Hence there is no gold standard of concentration of NaOCl used in irrigation of root canals.

EDTA

Complete cleaning of the root-canal system requires the use of irrigants that dissolve organic and inorganic material. As hypochlorite is active only against the former, other substances must be used to complete the removal of the smear layer and dentin debris. EDTA and CA effectively dissolve inorganic material, including hydroxyapatite. They have little or no effect on organic tissue and alone they do not have antibacterial activity, despite some conflicting reports on EDTA. EDTA is most commonly used as a 17% neutralized solution (disodium EDTA, pH 7), but a few reports have indicated that solutions with lower concentrations (eg, 10%, 5%, and even 1%) remove the smear layer equally well after NaOCl irrigation. Considering the high cost of EDTA, it may be worthwhile to consider using diluted EDTA. EDTA is used for 2 to 3 minutes at the end of instrumentation and after NaOCl irrigation. Removal of the smear layer by EDTA or CA improves the antibacterial effect of locally used disinfecting agents in deeper layers of dentin. EDTA is manufactured as liquids and gels. Although there are no comparative studies about the effectiveness of liquid and gel products to demineralize dentin, it is possible that the small volume of the root canal (only a few microliters) contributes to a rapid saturation of the chemical and thereby loss of effectiveness. In such situations, the use of liquid products and continuous irrigation should be recommended, the canal-wall dentin and should probably be avoided[33].

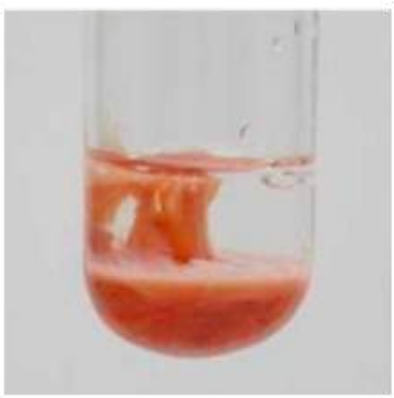


Chlorhexidine Digluconate

Chlorhexidine digluconate (CHX) is widely used in disinfection in dentistry because of its good antimicrobial activity. It has gained considerable popularity in endodontics as an undesired characteristics of sodium hypochlorite (ie, bad smell and strong irritation to periapical tissues). However, CHX has no tissue-dissolving capability and therefore it cannot replace sodium hypochlorite. CHX permeates the microbial cell wall or outer membrane and attacks the bacterial cytoplasmic or inner membrane or the yeast plasma membrane. In high concentrations, CHX causes coagulation of intracellular components. One of the reasons for the popularity of CHX is its substantivity (ie, continued antimicrobial effect), because CHX binds to hard tissue and remains antimicrobial. However, similar to other endodontic disinfecting agents, the activity of CHX depends on the pH and is also greatly reduced in the presence of organic matter[34].

Several studies have compared the antibacterial effect of NaOCl and 2% CHX against intracanal infection and have shown little or no difference between their antimicrobial effectiveness. Although bacteria may be killed by CHX, the biofilm and other organic debris are not removed by it. Residual organic tissue may have a negative effect on the quality of the seal by the permanent root filling, necessitating the use of NaOCl during instrumentation. However, CHX does not cause erosion of dentin like NaOCl does as the final rinse after EDTA, and therefore 2% CHX may be a good choice for maximized antibacterial effect at the end of the chemo-mechanical preparation. Most

of the research on the use of CHX in endodontics is carried out using in vitro and ex vivo models and gram-positive test organisms, mostly E faecalis. It is therefore possible that the studies have given an over-positive picture of the usefulness of CHX as an antimicrobial agent in endodontics. More research is needed to identify the optimal irrigation regimen for various types of endodontic treatments. CHX is marketed as a water-based solution and as a gel. Some studies have indicated that the CHX gel has a slightly better performance than the CHX liquid but the reasons for possible differences are not known[35].However, CHX and NaOCl are not soluble in each other; a brownish-orange precipitate is formed when they are mixed.



Interactions Between Irrigating Solutions Hypochlorite and EDTA are the 2 most commonly used irrigating solutions. As they have different characteristics and tasks, it has been tempting to use them as a mixture. However, EDTA instantaneously reduces the amount of chlorine when mixed with sodium hypochlorite, resulting in the loss of NaOCl activity. Thus, these solutions should not be mixed. CHX has no tissue dissolving activity and there have been efforts to combine CHX with hypochlorite for added benefits from the 2 solutions. The characteristics of the precipitate and the liquid phase have not been thoroughly examined, but the precipitate prevents the clinical use of the mixture. Atomic absorption spectrophotometry has indicated that the precipitate contains iron, which may be the reason for the orange development. Presence of parachloroaniline, which may have mutagenic potential, has also been demonstrated in the precipitate. Mixing CHX and EDTA immediately produces a white precipitate[36].

Although the properties of the mixture and the cleared supernatant have not been thoroughly studied, it seems that the ability of EDTA to remove the smear layer is reduced. Many clinicians mix NaOCl with hydrogen peroxide for root-canal irrigation. Despite more vigorous bubbling, the effectiveness of the mixture has not been shown to be better than that of NaOCl alone. However, combining hydrogen peroxide with CHX in an ex vivo model resulted in a considerable increase in the antibacterial activity of the mixture compared with the components alone in an infected dentin block. However, there are no data concerning the use or effectiveness of the mixture in clinical use[32].

Bio Pure MTAD

Bio Pure (Dentsply, Tulsa Dental, Tulsa, OK, USA) otherwise known as MTAD, is a relatively new root canal irrigant which was introduced by Torabinejad et aL in 2003. This solution is a mixture of 3% doxycycline, 4.25% citric acid and a detergent (0.5% Polysorbate Several studoes have evaluated the effectiveness of MTAD for disinfection of root canals. Torabinejad et ul. have shown that MTAD is able to remove the smear layerǁ‘ and is effective against E. faecalis. Shabahang et al showed that a combination of 1.3% NaOCl as a root canal irrigant and MTAD as a final rinse was more effective than 5.25% NaOCl in disinfecting root canals. However, Tay et aL‘ found that when MTAD is applied to 1.3% NaOC1-irrigated dentine, its antimicrobial substantivity is reduced. They attributed this phenomenon to the

oxidation of MTAD by NaOCl in a manner similar to the peroxidation of tetracycline by reactive oxygen species. In another study, MTAD was significantly very effective against E. faecalis. Baumgartner showed that the infected root canal system was consistently disinfected when a combination of 5.25% NaOC1/15% EDTA was used[37] .However, the combination of 1.3% NaOCl/BioPure MTAD left nearly 50% of the canals contaminated with E.faecalis. Krause et aL revealed that, in the agar diffusion model, NaOCl produced less dilution of bacteria than MTAD or doxycycline. Ghoddusi et al evaluated the effect of MTAD as a final irrigant on bacterial leakage of the root canal, and its interaction with two conventional root canal sealers (AH-Plus or Rickert). According to their findings, it took longer for bacteria to penetrate when either EDTA or MTAD was used for smear layer removal. Furthermore, the root canals obturated with AH-Plus showed significantly longer duration of resistance to bacterial penetration than canals obturated with rickert. Davis et al showed that, using the agar diffusion method, BioPure MTAD produced significantly more zones of microbial inhibition than 5.25% NaOCl, 2% CHX, and Dermacyn (Oculus Innovative Sciences, Petaluma, CA). Newberry et al determined in vitro the antimicrobial effect of MTAD as a final irrigant on eight strains of E. faecalis and to measure the minimum inhibitory concentration (MIC) and the minimum lethal concentration (MLC) of MTAD. After irrigating with 1.3% NaOC1, the root canal and the external surfaces were exposed to MTAD for 5 minutes. The results showed that this treatment regiment was effective in completely heating the growth in seven of eight strains of E.faecalis. The MIC/MLC tests showed that MTAD inhibited most strains of E.faecalis growth when diluted 1:8192 times and killed most strains of E. faecalis when diluted 1:512 times. Recently, Shahnbag et al showed that although the addition of chlorhexidine did not negatively impact on the efficacy of MTAD, the substitution of this antimicrobial agent for doxycycline significantly reduced the efficacy of the solution[38].

Tetra clean

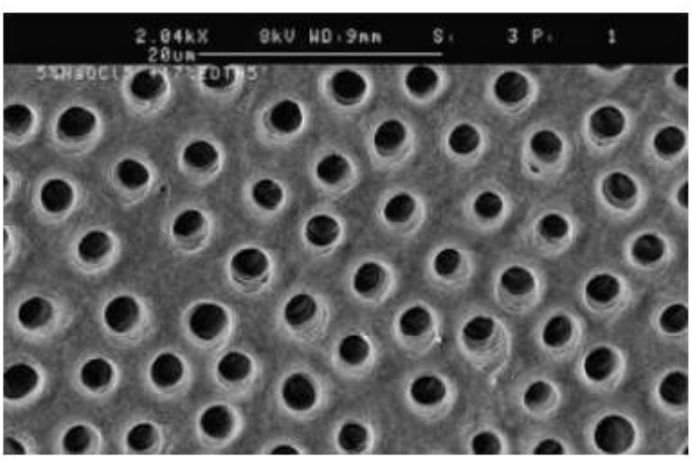
Tetraclean, like MTAD, is a mixture of an antibiotic, an acid and a detergent. However, the concentration of antibiotic (50mg/ml doxycycline) and the type of detergent (polypropylene glycol) are different from those of MTAD. Giardino et al compared the surface tension of EDTA 17%, Cetrexidin, Smear Clear, Sodium hypochlorite 5.25%, with the surface tension of MTAD and Tetraclean. Their

findings demonstrated that sodium hypochlorite 5.25%, and EDTA 17% had the highest surface tension, whereas those of Cetrexidin and Tetraclean have shown the lowest surface tension values. In another study, they compared the antimicrobial efficacy of 5.25% NaOC1, BioPure MTAD, and Tetraclean against E. faecalis biofilm generated on cellulose nitrate membrane filters. Results showed that only 5.25% NaOCl could disintegrate and remove the biofilm at every time; however, treatment with Tetraclean caused a high degree of biofilm disintegration in every considered time intervals as compared with MTAD[38].

CHALLENGES OF IRRIGATION

Smear Layer

Removal of the smear layer is straight forward and predictable when the correct irrigants are used. Relying on EDTA alone or other irrigants with activity against the inorganic matter only, however, results in incomplete removal of the layer. Therefore, use of hypochlorite during instrumentation cannot be omitted.

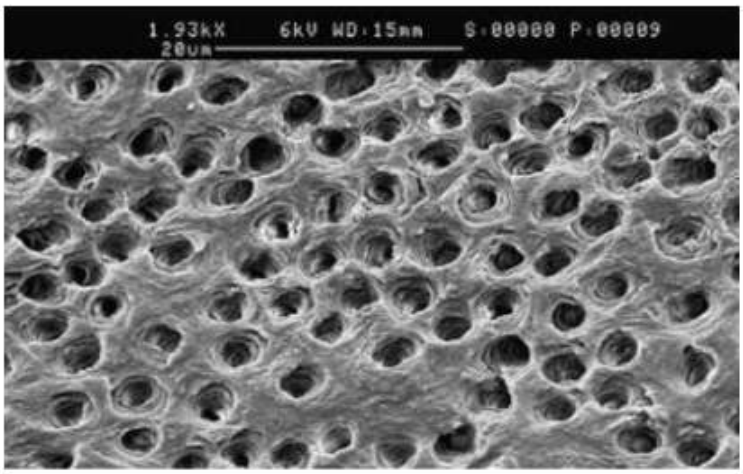


The smear layer is created only on areas touched by the instruments. Delivery of irrigants to these areas is usually unproblematic, with the possible exception of the most apical canal, depending on canal morphology and the techniques/equipment used for irrigation. However, careless irrigation, with needles introduced only to the coronal and middle parts of the root canal, is likely to result in incomplete removal of the smear layer in the apical root canal[32].

Dentin Erosion

One of the goals of endodontic treatment is to protect the tooth structure so that the physical procedures and chemical treatments do not cause weakening of the dentin/ root. Erosion of dentin has not been studied much; however, there is a general consensus that dentin erosion may be harmful and should be avoided. A few studies have shown that long-term exposure to high concentrations of hypochlorite can lead to considerable reduction in the flexural strength and elastic modus of dentin. These studies have been performed in vitro using dentin blocks, which may allow artificially deep penetration of hypochlorite into dentin. However, even short-term irrigation with hypochlorite after EDTA at the end of chemo-mechanical preparation causes strong erosion of the canal-wall surface dentin and maximum time duration is 1-2 minutes.

Although it is not known for sure whether surface erosion is a negative issue or if, for example, it could improve dentin bonding for posts, it is the authors‘ opinion that hypochlorite irrigation after demineralization agents should be avoided. Instead, chlorhexidine irrigation could be used for additional disinfection at the end of the treatment[32].



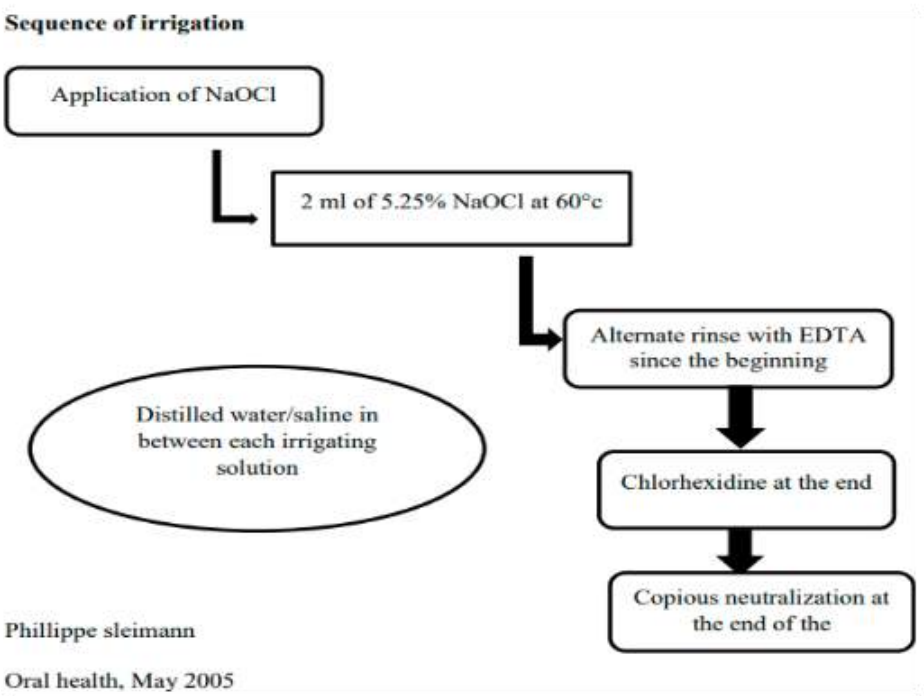
Cleaning of Un-instrumented Parts of the Root-canal System

Irrigation is most feasible in the instrumented areas because the irrigation needle can follow the smooth path created by the instruments. Cleaning and removing of necrotic tissue, debris, and biofilms from untouched areas rely completely on chemical means,

and sufficient use of sodium hypochlorite is the key factor in obtaining the desired results in these areas. A recent study showed that untouched areas, in particular anastomoses between canals, are frequently packed with debris during instrumentation. Visibility in micro-CT scans indicates that the debris also contain a considerable proportion of inorganic material. Although at present it is not known how these debris can best be removed (if at all), it is likely that physical agitation (eg, ultrasound) and the use of demineralizing agents are needed in addition to hypochlorite[39].

Safety versus Effectiveness in the Apical Root Canal

Irrigation must maintain a balance between 2 important goals: safety and effectiveness. This point is particularly true with the most important irrigant, sodium hypochlorite, but other irrigants can also cause pain and other problems if they gain access to the periapical tissues. Effectiveness is often jeopardized in the apical root canal by restricting anatomy and valid safety concerns. However, the eradication of the microbes in the apical canal should be of key importance to the success of endodontic treatment. Sufficient exchange of hypochlorite and other irrigants in this area while keeping the apical pressure of the solutions minimal is the obvious goal of irrigation of the apical root canal. A better understanding of fluid dynamics and the development of new needle designs and equipment for irrigant delivery are the 2 important areas to deal with in the challenges of irrigating the most apical part of the canal[32]



Agitation devices

New agitation devices that rely on various mechanisms of irrigant transfer like the EndoVac system, EndoActivator, sonic agitation etc appear to have resulted in improved canal cleanliness when compared with conventional syringe needle irrigation.

Despite the plethora of in vitro studies, no well-controlled study is available. In addition, no evidence-based study is available to date that attempts to correlate the clinical efficacy of these devices with improved treatment outcomes.

Thus, the question of whether these devices are really necessary remains unresolved[32].

Lasers in irrigation

60

In vitro studies have shown that both CO2 and Xr:YAG lasers possess potent antimicrobial activity, however comparative studies in simulated infected root canals have shown that the effect is either equal to, or weaker than the action of NaOCl irrigation. Hence, it still is a controversy if lasers are an effective way to clean the root canal and more evidence is required[32].

CONTROVERSIES IN INTRACANAL MEDICAMENTS

Calcium Hydroxide

The development and progression of an endodontically induced apical periodontitis are clearly associated with the presence of microorganisms in the root canal system[40]. Thus, conventional root canal treatment aims primarily at eliminating these bacteria as completely as possible. The root canal was cleaned and shaped, ideally to the apical constriction[41] under sufficient irrigation with a potent solution, e.g. sodium hypochlorite. In addition, an interappointment antimicrobial dressing was generally advocated to prevent recovery and multiplication of microorganisms remaining even after careful instrumentation and debridement of the root canal space[42] a popular medicament is calcium hydroxide. Clinically, microbiological samples from initially infected root canals substantiated the potential of calcium hydroxide to eliminate or reduce the total number of cultivable bacteria in the root canal system when the medicament was placed in the root canal for at least one week[43].

Due to the inaccuracy of the sampling method itself, however, there is a risk of obtaining false negative bacterial samples. Thus, it can be speculated that in some teeth periapical healing occurred even when bacteria were left in inaccessible areas of the root canal system, e.g. in the dentinal tubules, following complete instrumentation and placement of an antimicrobial medicament. This may be one reason for the recent controversy about the necessity of an antimicrobial intracanal dressing[42]. It has been reported that calcium hydroxide has the potential to kill bacteria left in inaccessible areas of the root canal system and therefore favours the healing process of periapical lesions[42]. Others have recommended for practical reasons that endodontic treatment should be completed in a single visit (one-visit treatment) without any intracanal dressing[44].

It is argued that bacteria surviving in the root canal system after root canal preparation are entombed by obturating the root canal and perish as a result of lack of substrate[44]. These microorganisms may no longer interfere with the periapical healing process. Likewise, some root canal sealers and gutta-percha cones elicit in vitro an antibacterial activity that may contribute to the elimination of intracanal microorganisms[45]. The present prospective clinical study was initiated to explore the influence of calcium hydroxide applied as an interappointment intracanal dressing on

the healing process of periapical lesions associated with pulpless teeth. For this purpose the prognosis after a two-visit root canal treatment was compared with that following a one-visit treatment.

In conclusion, the promising prognosis of both treatment approaches substantiated the hypothesis that from a microbiological view one-visit root canal treatment with guttapercha cones and a calcium hydroxide-containing sealer created favourable environmental conditions for periapical healing. Thus, one visit root canal treatment is an alternative to two-visit treatment with calcium hydroxide as an interappointment dressing for pulpless teeth associated with endodontically induced lesions[46].

Antibacterial Activity

Calcium hydroxide exerts antibacterial effects in the root canal system as long as a high pH is maintained. An in vivo study showed that root canals treated with Ca(OH)2 had fewer bacteria than did those dressed with camphorated phenol or camphorated mono chlorophenol. Another study reported Ca(OH)2 to be effective in preventing the growth of microorganisms but to a limited extent when compared to camphorated chlorophenol, stressing the necessity of direct contact to achieve the optimum antibacterial effect. It was shown that a 7-day application of a Ca(OH)2 medicament was sufficient to reduce canal bacteria to a level that gave a negative culture. It has also been shown that an aqueous Ca(OH)2 paste and a silicone oil-based Ca(OH)2 paste are effective in the elimination of Enterococcus faecalis in dentinal tubules. Estrela et al demonstrated that both the direct exposure test and the agar diffusion test are useful in establishing the antimicrobial spectrum of Ca(OH)2 and in developing improved infection control protocols. A complete antimicrobial effect was observed after 48 h with both tests, irrespective of the Ca(OH)2 paste vehicle. Another study showed that Ca(OH)2 decreased the numbers of E. faecalis at all depths within dentinal tubules up to 24 h and that less viscous preparations of Ca(OH)2 were more effective in the elimination of E. faecalis from dentinal tubules than were viscous preparations. In a study to evaluate the effect of electrophoretically activated Ca(OH)2 on bacterial viability in dentinal tubules, Lin et al. reported that treatment with electrophoresis was significantly more effective than pure Ca(OH)2 up to depths of 200 to 500 µm. Specimens treated with electrophoretically activated Ca(OH)2 revealed no viable bacteria in dentinal tubules to a depth of 500µm from the

root canal space within 7 days. E. faecalis cells in the exponential growth phase have been shown to be the most sensitive to Ca(OH)2 and are killed within 3s to 10mins.

By contrast, several studies have attested to the ineffectiveness of Ca(OH)2 in eliminating bacterial cells. Two studies revealed that Ca(OH)2 had no antibacterial effect as a paste or as the commercial preparation Pulpdent when used against Streptococcus sanguis. It was also shown that a Ca(OH)2 paste (Calasept; Speiko, Darmstadt, Germany) failed to eliminate, even superficially, E. faecalis in dentinal tubules.21 Safavi et al. indicated that E. faecium remained viable in dentinal tubules after relatively extended periods of Ca(OH)2 /saline mixture treatment. Another study demonstrated that Ca(OH)2 could take up to 10 days to disinfect dentinal tubules infected by facultative bacteria[41].

Siqueira demonstrated that, after 1 week of contact, Ca(OH)2 mixed with saline was ineffective in eliminating E. faecalis and E. faecium inside dentinal tubules. Estrela et al. found that Ca(OH)2 in infected dentinal tubules had no antimicrobial effect on S. faecalis, S. aureus, Bacillus subtilis, Pseudomonas aeruginosa, or on the bacterial mixture used throughout the experiment. It has been revealed that the viability of E. faecalis in infected root dentine was not affected by Ca(OH)2 . In a systematic review to assess the antibacterial efficacy of Ca(OH)2 , Sathorn et al. showed that Ca(OH)2 had limited effectiveness in eliminating bacteria from human root canal when assessed by culture techniques. In a polymerase chain reaction (PCR) study to evaluate the effect of root canal filling with or without prior Ca(OH)2 or 2% chlorhexidine (CHX) on the persistence of bacterial DNA in infected dentinal tubules, Cook et al. showed that 2% CHX treatment followed by canal filling was more effective in removing the DNA of E. faecalis than placement of Ca(OH)2 or immediate canal filling. Furthermore, in failed root canal treatments, a 2% CHX gel was a more effective intracanal medicament than Ca(OH)2 paste against E. faecalis. Krithika datta et al indicated that 2% CHX gel alone was more effective against E. faecalis than was Ca(OH)2 . Another study found that a polymeric chlorhexidine-controlled release device was significantly more effective in reducing intra-dentinal bacteria than was Ca(OH)2.

Combination Of Ca(OH)2 And Chlorhexidine

Chlorhexidine (CHX) is a cationic biguanide whose optimal antimicrobial activity is achieved within a pH range of 5.5 to 7.0. Therefore, it is likely that alkalinizing the pH by adding Ca(OH)2 to CHX will lead to precipitation of CHX molecules, thereby decreasing its effectiveness. It has been demonstrated that the alkalinity of Ca(OH)2 when mixed with CHX remains unchanged. Therefore, the usefulness of mixing Ca(OH)2 with CHX remains unclear and controversial. When used as an intracanal medicament, CHX was more effective than Ca(OH)2 in eliminating E. faecalis from inside dentinal tubules. One report revealed that all of the chlorhexidine formulations studied, including a CHX/ Ca(OH)2 50:50 mix, were effective in eliminating E. faecalis from dentinal tubules, with a 1% CHX gel working better than the other preparations. These findings were corroborated by two other studies in bovine dentine and and human dentine.

Haenni et al. found no additive antibacterial effect by mixing Ca(OH)2 powder with 0.5% CHX. They indicated that CHX had a reduced antibacterial action. However, Ca(OH)2 did not lose its antibacterial properties in such a mixture. An in vitro study showed that 2% CHX gel was the most effective agent against E. faecalis inside dentinal tubules, followed by a Ca(OH)2 /2% CHX mixture, whereas Ca(OH)2 alone was totally ineffective, even after 30 days. The 2% CHX gel was also significantly more effective than the Ca(OH)2 /2% CHX mixture against C. albicans at 7 days, although there was no significant difference at 15 and 30 days. Ca(OH)2 alone was completely ineffective against C. albicans. In an in vivo study using primary teeth, Onçag et al. showed that a 1% CHX-gluconate gel, both with and without Ca(OH)2 , was more effective against E. faecalis than Ca(OH)2 alone over a 48-hour period.

Another study showed that that 2% CHX-gluconate was significantly more effective against E. faecalis than Ca(OH)2 used alone or a mixture of the two. Although this was also confirmed by Lin et al., a study by Evans et al. using bovine dentine concluded that 2% CHX with Ca(OH)2 was more effective than Ca(OH)2 in water. An animal study demonstrated that teeth dressed with CHX for 4 weeks had reduced inflammatory reactions in the periodontium (both apically and marginally) and less root resorption. Waltimo et al. reported that 0.5% CHX-acetate was more effective at

killing C. albicans than was saturated Ca(OH)2, whereas Ca(OH)2 combined with CHX was more effective than Ca(OH)2 used alone[47].

Ledermix

Ledermix is a glucocorticosteroid-antibiotic compound. Ledermix paste was developed by Schroeder and Triadan in 1960, and was released for sale in Europe by Lederle Pharmaceuticals in 1962. The primary interest of Schroeder and Triadan in development of Ledermix paste was based on the use of corticosteroid to control pain and inflammation. The sole reason for adding the antibiotic component to Ledermix was to compensate for what was perceived to be a possible corticoid-induced reduction in the host immune response. The two therapeutic components of Ledermix (i.e., triamcinolone and demeclocycline) are capable of diffusing through dentinal tubules and cementum to reach the periodontal and periapical tissues. Abbott et al showed that dentinal tubules were the major supply route of the active components to the peri-radcular tissues, while the apical foramen was not as significant as a supply route[48]. Various factors can affect the supply of the active components to the periradicular tissues-these include the presence or absence of the smear layer, the presence or absence of cementum, and the presence of other materials within the canal, for example, calcium hydroxide.

Bryson et a1 showed that the Ledermix Paste treated roots had statistically significantly more healing and less resorption than the roots treated with Ca(OH)2. Root filing with Ledermix Paste also resulted in significantly less loss in root mass due to resorption compared to those roots filled with Ca(OH)2. Chen et a1. found that corticosteroid and tetracycline, as anti-inflammatory and anti-resorptive agents, shut down or minimised the inflammatory reaction including clastic-cells mediated resorption, thus promoted more favourable healing than the positive control group which had no intracanal medicaments. Furthermore, they forecasted that in severe traumatic injuries, where a large surface area of periodontal inflammation is expected, removing the pulp and placing corticosteroids into the canal at the emergency visit would become a standard protocol. Trope found no significant difference in the flareup rate among the three intracanal medicaments (Formocresol, Ledermix, and calcium hydroxide). Ehrmann et al found that painful teeth with acute apical periodontitis that had been dressed with Ledermix paste gave rise to less pain than

that experienced by patients who had a dressing of calcium hydroxide or no dressing at all[49].

Kim et al. investigated the effects of Ledermix paste as an intracanal medcament on discolouration of mature teeth. Results demonstrated that after 12 weeks, sunlight exposure had caused dark grey-brown staining of the teeth in the Ledermix groups, but this did not occur when the teeth were kept in the dark. More severe staining was noted when Ledermix paste filled the pulp chamber than when the paste was restricted to below the CEJ. They suggested that if placement of the Ledermix restricted to below the gingival margin, such effects could be minimised. In another study, they investigated the effects of Ledermix paste as an intracanal medicament on discolouration of immature teeth. After 12 weeks, sunlight exposure had caused dark grey-brown staining in the Ledermix groups but this did not occur when the teeth were kept in the dark. More severe staining was noted when Ledermix paste filled the pulp chamber than when the paste was restricted to below the CEJ and when teeth were exposed to sunlight. When compared to the results of a similar study using mature teeth, the results were similar but the immature teeth were more severely stained than the mature teeth. The Ca(OH)2, paste caused an increase in lightness and yellowness in immature teeth[50].

Triple Antibiotic Paste

The infection of the root canal system is considered to be a polymicrobial infection, consisting of both aerobic and anaerobic bacterial. Because of the complexity of the root canal infection, it is unlikely that any single antibiotic could result in effective sterilisation of the canal. More likely a combination would be needed to address the diverse flora encountered. A combination of antibiotics would also decrease the likelihood of the development of resistant bacterial strains. The combination that appears to be most promising consists of metronidazole, ciprofloxacin, and minocycline. Sato et al showed that no bacteria were recovered from the infected dentine of the root canal wall 24h after application of the triple antibiotic paste, except in one case in which a few bacteria were recovered. Hoshino et al investigated the antibacterial effect of a mixture of ciprofloxacin, metronidazole and minocycline, with and without the addition of rifampicin, on bacteria taken from infected dentine of root canal walls.

They found that alone, none of the drugs resulted in complete elimination of bacteria. However, in combination, these drugs were able to consistently sterilize all samples. Iwaya et al reported a necrotic immature mandibular second premolar with periapical involvement and sinus tract. Instead of the standard root canal treatment protocol and apexification, antimicrobial agents (metronidazole and ciprofloxacin) were used in the canal, after which the canal was left empty. Radiographic examination showed the start of apical closure five months after the completion of the antimicrobial protocol. Thickening of the canal wall and complete apical closure was confirmed 30 months after the treatment, indicating the revascularization potential of a young permanent tooth pulp into a bacteria-free root canal space. Takushige et al evaluated the efficacy of poly-antibiotic paste consisted of ciprofloxacin, metronidazole and minocycline, on the clinical outcome of so-called _Lesion Sterilization and Tissue Repair (LSTR)' therapy in primary teeth with peri-radcular lesions. Results showed that in all cases, clinical symptoms such as gingival swelling, sinus tracts, induced dull pain, spontaneous dull pain, and pain on biting disappeared after treatment, although in four cases clinical signs and symptoms were finally resolved only after retreatment using the same procedures. Thus, gingival abscesses and fistulae, if present, disappeared after a few day[50]

CONTROVERSIES IN FORMOCRESOL

Formocresol has been used in dentistry since 100 years and for deciduous teeth pulpotomy since 80 years. The reparative, biologic approach to pediatrics pulp therapy is either devitalization approach of formocresol pulpotomy or pulpectomy. Formocresol was introduced to treat non-vital permanent teeth in the United States by Buckley in 1904 [51]. In 1930, Sweet introduced the formocresol pulpotomy technique. Formocresol has subsequently become a popular pulpotomy medicament for primary teeth. Initially, the technique involved five visits. Sweet reduced the number of visits over the years, because of economic and behaviour management considerations[51]. Doyle et al used a two-visit procedure in their comparison study of formocresol and calcium hydroxide. Within a few years, Spedding et al. and Redig reported the results of a 5-min formocresol protocol, and since that time, complete mummification has been abandoned by the profession[52,53,54] .

By 1960, a single visit procedure was advocated [55]. Studies have shown formocresol therapy to have a success rate between 70% and 90%. Histologic results have been variable in contrast to the high clinical success rate. Formocresol is still considered a gold standard by which all new modalities are compared[56].

Mechanism of action

Formocresol acts through the aldehyde group of formaldehyde, forming bonds with the side groups of the amino acids of both the bacterial proteins and those of the remaining pulp tissue. It is therefore both a bactericidal and devitalizing agent. It kills off and converts bacteria and pulp tissue into inert compounds.Its function is to fasten the live pulps, maintaining them inert and facilitating the conservation of deciduous tooth until their physiologic fall. It has a potent antibacterial action that justifies its use in long curative in endodontic treatment[57].

With formocresol as the pulptomy medicament, a zone of fixation usually is evident where the pulp is in direct contact with the medicament. Coagulation necrosis of the tissue occurs at the amputation site and is supported by the fact that true coagulation necrosis is produced by poisons such as phenol, formaldehyde or mercuric chloride, which denatures the protein of the cells[58]. It has also been shown that formocresol inactivates the oxidative enzymes in the pulp tissue adjacent to the amputation site. It

may also have some effect on hyaluronidase action. Therefore, the protein-binding properties and the inhibition of the enzymes that can break the pulp tissue down together result in 'fixation' of the pulp tissue by formocresol and render it inert and resistant to enzymatic breakdown[57]. Farther away, where the concentration of formocresol is decreased, there is a zone of poor cellular definition and necrosis. Apical to this is a zone of chronic inflammation, which blends into normal tissue[52]. In contrast, Berger reported complete loss of vitality with fibrous granulation tissue in the apical third of the root canal[59].

In a study to know the effect of formocresol on polymorphonuclear cells (PMNs), the lysis of PMNs was observed with high concentrations of formocresol. An interesting finding with low concentrations of formocresol was the significant stimulation of PMN adherence. The authors postulate that stimulation of PMNs by pulpotomy medicaments may contribute to the chronic inflammatory changes seen with their use. Initial stimulation followed by depressions is a well-known response of PMNs following activation by various stimuli. Same activation-deactivation phenomenon was observed clearly with formocresol[60].

Internal resorption may also result in teeth treated with formocresol might be due to the severe damage to the residual tissue, also destroying its capacity to reabsorb. This may be attributed to inflammation of the residual pulp. On the other hand, pulpotomy treatment with formocresol in monkeys has been associated with the formation of reparative dentin. Human studies have not reported the finding of reparative dentin in association with the formocresol pulpotomy. This might be possibly due to the production of reparative dentine on light stimulation like any type of trauma, including formocresol of the pulpal tissue of monkeys[61].

Pharmacokinetics of formaldehyde

Formaldehyde exposure occurs daily as it is present in air, water and food. The World Health Organization (WHO) has estimated daily consumption of formaldehyde to be approximately 1.5-14 mg/day (mean, 7.8 mg/day) [62] . Assuming a contribution of 9.4 mg/day from food, 1 mg/day from inhalation and 0.15 mg/day from water, an adult takes in 10.55 mg of formaldehyde per day [63]. The estimated formaldehyde dose associated with 1 pulpotomy procedure, assuming a 1:5 dilution of formocresol placed on a no. 4 cotton pellet that has been squeezed dry, is approximately 0.02-0.10

mg. Hileman has shown that endogenous levels of metabolically produced formaldehyde range from approximately 3-12 ng/g tissue. This formaldehyde is produced by amino acid metabolism, oxidative demethylation, and purine and pyrimidine metabolism. Exogenous formaldehyde is taken up into the human body via ingestion, inhalation and dermal exposure. Inhaled formaldehyde appears to be readily absorbed by the upper respiratory tract, but it is not distributed throughout the body because it is rapidly metabolized. Ingested formaldehyde is readily absorbed by the gastrointestinal tract and exhibits little subacute toxicity after oral exposure. Exogenous formaldehyde has a biologic half-life of 1-1.5 minutes and is quickly cleared from human plasma[65].

Histological studies demonstrate the true biological damage after formocresol treatment. Physiologically, with the vascular damage, the balance between osmotic pressure and hydrostatic pressure is disrupted in tissue. As a result, there is absorption of inflammatory fluid insult by pulp tissue and decrease in the osmotic pressure. So hemostatic balance is re-established. When this occurs, the constricted pulp cavity must dissipate the pressure changes. If this does not occur, pressure necrosis of the pulp occurs. In addition, lymphatic and venous vascular flow from the coronal pulp must dissipate this excess inflammatory fluid. This excess is distributed apically and to regional vascular vessels. Therefore, the local insult results in systemic distribution [66].

Pharmacokinetics of cresol

The second active ingredient in formocresol, cresol, has received little attention in investigations of formocresol efficacy. Cresol has poor solubility, so it is assumed that it does not enter systemic circulation. Cresol is highly lipophilic and has been shown to completely destroy cellular integrity. This would allow deeper tissue fixation by the formaldehyde component of formocresol. No data exist regarding cresol metabolism or elimination in humans or other mammals, and about environmental sources of cresol to which humans might be exposed. Benzyl alcohol is a by-product of tricresol oxidation.

Benzyl alcohol is oxidized rapidly to benzoic acid, conjugated with glycine in the liver, and excreted as hippuric acid. It has no carcinogenic or mutagenic potential, and the allowable daily intake, as established by WHO is 5 mg/kg [67].

Concerns about formocresol

Concerns about the safety of formocresol have been appearing in the dental and medical literature for more than 20 years. Formaldehyde, a primary component in formocresol, is a hazardous substance. National Institute for Occupational Safety and Health in USA states if formaldehyde exposure occurs at a concentration of 20 ppb (parts per billion) or higher, it is instantly dangerous to health and life.

Studies on formocresol therapy have put the clinical success rate between 70% and 90%. But variable histologic results were also reported in contrast to the clinical success rate. Instead of preserving vital pulpal tissue, chronic inflammation and necrotic tissue were found. Another problem with formocresol is its systemic distribution from the pulpotomy site. Pruhs et al. found a relationship between primary teeth treated with formocresol and enamel defects in the permanent successors. The allergenic and mutagenic properties of formaldehyde have been demonstrated in animal models, but not in humans. Cysts have also been found to be associated with the pulpotomized teeth[68]

Mutagenicity, genotoxicity and cytotoxicity

Exposure of cells to formaldehyde leads to the formation of DPX (DNA-protein cross-links). The most common types of DNA damage induced by formaldehyde are clastogenic lesions, including sister chromatid exchanges (SCEs), micronuclei and chromosomal aberrations, and deletions. It has been proposed that formaldehyde could induce the development of DPX at distant sites, but no convincing evidence has been obtained from in vivo experimental studies.

The recent research by Heck and Casanova showed the development of DPX in nasal tissues and upper respiratory tract associated with high dose exposure of formaldhehyde. DPX does not persist in tissues for more than few hours and undergoes spontaneous hydrolysis or active repair by proteolytic degradation of crosslinked proteins. So role of DPX in formaldehyde-induced carcinogenesis is again questionable [69].

Cytogenetic studies of lymphocytes from rodents following formaldehyde inhalation with exposures ranging from 0.5-1.5 ppm for 6 h/day for 5 days failed to detect either chromosomal aberrations or SCEs at any of the formaldehyde concentrations In vitro

experiments with a Chinese hamster cell line found that DPX and SCE, as a result of formaldehyde exposure, were associated with cytotoxicity, not mutation. In addition, no mutagenesis occurred in cultured human lymphocytes below a formaldehyde threshold of 5 µg/mL in the culture medium.

In one of the dental studies that do not support formaldehyde is a mutagenic, Zarzar et al. performed formocresol pulpotomy on 20 children by using Buckley's original formula. Blood samples were collected from each child immediately before and 24 hours after the pulpotomy. No statistically significant differences were found between the two groups in terms of chromosomal aberrations, chromatid breaks or chromatid gaps. Also, Zarzar et al. concluded that formocresol is not mutagenic[70].

Ribeiro et al. reported two studies that assessed the mutagenic potential of formocresol. With a mouse lymphoma cell line, cultured human fibroblasts and a series of formocresol dilutions similar to clinical doses, these authors found that formocresol did not produce detectable DNA damage and should not be considered genotoxic[71].

The investigations of root canal sealers that contain formaldehyde and produce cytotoxicity are not comparable with formocresol pulpotomy studies. Because large quantities of formaldehyde are produced from sealers than pulpotomy, large quantities of sealers are used. Root canal sealer remains in root canal and forms part of restoration and may lead to further release of formaldehyde[72].

It is summarized that DPX development demonstrated only after a prolonged exposure to formaldehyde at specific contact sites such as nasopharynx. A minute quantity used in pulpotomy for few minutes that will produce distant site genotoxicity is not evidence-based.

Carcinogenicity

In 2004, International Agency for Research on Cancer (IARC) reclassified formaldehyde as a known carcinogen from human probable carcinogen, but according to them, it is an agent that can increase the risk of cancer at some doses. They do not undertake the dose response analyses and possible threshold. The possibility that inhaled or ingested formaldehyde might induce cancer at sites distant from the respiratory or gastrointestinal tracts has been investigated in numerous long-term

toxicity studies performed in rodents. Experimental and epidemiologic research do not support the theory that inhaled or ingested formaldehyde might induce distant site toxicity.

The facts are that formaldehyde occurs naturally throughout the body, there are multiple pathways for detoxification, and only microgram quantities of formaldehyde are applied to pulp tissues during pulpotomy procedures for mere minutes. Considering these facts, exposure of children to the formaldehyde component of formocresol during a pulpotomy is insignificant and inconsequential [72].

Formocresol versus glutaraldehyde

In recent years, glutaraldehyde has been proposed as an alternative to formocresol based on its superior fixative properties, self-limiting penetration, low antigenicity, low toxicity and elimination of cresol. It is a colorless solution that has a mild odour and a boiling point of 183°C to 187°C, is soluble in water, and produces mild acidity on contamination. Glutaraldehyde is a chemically bifunctional reagent, which forms strong intra- and intermolecular protein bonds, leading to superior fixation by crosslinkage. Glutaraldehyde produces a zone of tissue fixation where it is in direct contact with the pulp, while apical to this is a zone of normal tissue with few inflammatory cells. It has been observed that inadequate fixation leaves a deficient barrier to sub-base irritation, resulting in internal resorption. Penetration into the surrounding peri-apical tissue is limited primarily by protein cross-linkage formation. Thus, systemic distribution of glutaraldehyde is limited. Glutaraldehyde is less necrotic, dystrophic, cytotoxic and antigenic, is a better bactericide, and fixes the tissue instantly[73].

Prakash et al. concluded that glutaraldehyde is better fixative and less toxic agent than formocresol. In this study, they compared the clinical and radiological effects of formocresol and glutaraldehyde pulpotomies in various exposed vital human primary molars. The 2% glutaraldehyde compound was promising when compared to ferric sulfate and formocresol in an in vivo study. The only limitations of glutaraldehyde are instability due to short shelf-life and it has to be freshly prepared. In this study, the clinical and radiographic success of formocresol, glutaraldehyde and ferric sulfate were compared as a pulpotomy medicament in primary molars at 3-month intervals

over 1 year. Internal resorption was found in all the medicaments. Clinical success was higher than the radiological success.

One study failed to justify recommendation of 2% buffered glutaraldehyde solution as a substitute to formocresol as failure was observed within 6 months of treatment and failure rate was increased even after and up to 25 months. Internal resorption and external resorption were listed as failures. Resorption rate of pulpotomized teeth was similar to that of other teeth.

Long-term (36 months) success rates of four different glutaraldehyde preparations (2%-buffered and unbuffered, 5%-buffered and unbuffered) as a pulpotomy agent in pulp exposed primary molars were evaluated. The 5% buffered solution group showed highest success rate, whereas 5% unbuffered solution showed the lowest, but as such there was no significant difference found among the four groups. The canal obliteration was noted in 22 treated teeth. The relative high failure rate in this longterm follow-up indicates that clinicians should be cautious before extensively using glutaraldehyde as pulpotomy agent.

Formocresol vs electrosurgery pulpotomy

Another form of non-chemical devitalization developed is electrosurgical pulpotomy. It is a method of cutting and coagulating soft tissues by means of high-frequency radio waves passing through the tissue cells. The advantages of electrosurgical pulpotomy are similar. The self-limiting, pulpal penetration is only a few cell layers deep. There is good visualization and homeostasis without chemical coagulation or systemic involvement. It is less time-consuming than the formocresol approach. Electrocautery carbonizes and heat denatures pulp and bacterial contamination. It may not be suitable if apical root resorption has occurred. Remarkably, Mack and Dean reported a very high success rate with the technique.

Studies show that there is no significant difference between clinical and radiographic success rates for electrosurgical and formocresol pulpotomies. [72],[73] But electrosurgery is considered as sensitive technique. Oztas et al. reported that formocresol pulpotomy technique is histopathologically superior to electrosurgery pulpotomy technique, as they found presence of inflammation, fibrosis, necrosis and resorption. On the other hand, El-Meligy et al. showed that teeth treated by

electrosurgery pulpotomy exhibited less histopathological reaction than formocresol pulpotomy.

Electrosurgery pulpotomy with either mechanical coronal pulp removal or electrical coronal pulp removal induces formation of reparative dentin. This is in the form of bridging at the pulpal amputation sites or along the canal walls. It indicates the present healthy vital pulp efforts to heal the area of insult. This technique also increases the fibroblastic activity at the middle and apical portions of roots with early resorption, as pulp tissue tries to renew itself with proliferation of fibroblasts. On the basis of the use of electrosurgical current intensity, there is a chance of periapical or furcal involvement. Ruemping et al. used low intensity current for electrosurgical pulpotomy during their research so there was no peri-apical or furcal involvement.

Formocresol vs laser surgery

The carbon dioxide laser has wide applications in oral and general surgery procedures involving soft tissue. The laser emits an infrared beam at a wavelength of 10.6 m, has an affinity for water, and is capable of producing well-localized cautery to soft tissue. Tissue is removed by ablation through conversion of the laser beam to heat. Based on these characteristics the carbon dioxide laser appears to have promise as an alternative for pulpotomy therapy.

A study conducted to evaluate the response of the human primary pulp to the carbon dioxide laser and formocresol for vital pulp therapy showed that there were no significant differences between the formocresol and laser groups with respect to symptomatic, clinical or radiographic findings. The histologic observations in this study revealed three interesting effects. First, the laser treatment was at least as effective in minimizing post-treatment inflammation as the formocresol treatment. Second, there was no statistically significant recovery from inflammation between the 28- and 90-day observation period in either the laser or formocresol group. Third, there was a strong and statistically significant inverse correlation between the energy used during the respective laser pulpotomies and the degree of inflammation observed at 28 days.

The histological response of dental pulp after different types of laser irradiation was evaluated in some studies. The results revealed that laser irradiation caused carbonization, necrosis and infiltration of inflammation cells, edema and hemorrhage in the pulp tissue.

The pulp can predictably heal itself when the temperature does not raise more than 5.5 o C above physiological baseline. The higher energy created a thicker char layer over the remaining pulp, which in some way had a favorable effect in reducing the initial inflammatory response in residual pulp.

Formocresol versus calcium hydroxide

Calcium hydroxide was the first agent used in pulpotomies that demonstrated any capacity to induce regeneration of dentin. The high pH of calcium hydroxide wounds the pulp in a manner that permits the intrinsic reparative cascade to begin. Unfortunately, the stimulus evoked by this compound is delicately balanced between one of repair and resorption. The study by Magnusson demonstrated how often the balance is tilted toward the destructive pathway.

Schröder emphasized on the importance of avoiding a blood clot between the amputation site and calcium hydroxide for clinical success. Calcium hydroxide adequately controls pulpal hemorrhage, to permit good contact between medicament and pulpal tissue. This seems to be important in the prevention of internal resorption, post-pulpotomy.

A study conducted to compare the clinical and radiological outcomes following single-visit vital pulp therapy techniques, using two different materials, formocresol and calcium hydroxide in cariously exposed primary molar teeth. This investigation confirms the clinical efficacy of a one-fifth dilution of Buckley's formocresol as an agent in pulp treatment of cariously exposed, vital primary molar teeth. However, calcium hydroxide in its pure, powder form is a clinically acceptable alternative when combined with strict selection criteria for this method of restorative care. There was a statistically insignificant difference in successful clinical and radiological outcome between the two treatment groups. Markovic et al. reported the presence of a dentine bridge above the pulp amputation site radiographically in 47% of pulpotomized teeth using calcium hydroxide. Heilig et al. was performed calcium hydroxide pulpotomy

in 17 carious primary molars using alternative method of hemorrhage control i.e., aluminum chloride. This study suggests that the aluminum chloride-calcium hydroxide pulpotomy may be a viable alternative to formocresol pulpotomies in the primary dentition. Although these findings encourage continued research, including a long-term follow-up, a histologic study is indicated.

Formocresol versus mineral trioxide aggregate

Mineral trioxide aggregate (MTA) is a fine hydrophilic powder developed by Mahmoud Torabinejad in Loma Linda University. It consists of tricalcium silicate, tricalcium aluminate, tricalcium oxide, silicate oxide and bismuth oxide. The US Food and Drug Administration approved MTA in 1998 as a therapeutic endodontic material for humans. Torabinejad et al., Bates et al. and Fischer et al. evaluated the sealing ability of MTA in root canals. MTA is currently being used in pulp therapy and has been shown to provide an enhanced seal over the vital pulp and is nonresorbable. Furthermore, MTA has superior biocompatibility and is less cytotoxic than other materials currently used in pulp therapy.

Previous studies showed that MTA stimulated the release of cytokines and production of interleukin and induced hard tissue formation. Schmitt et al. reported that Tulsa Dental provides MTA as ProRoot. The material can be placed in the tooth with the Tulsa carrier, an amalgam carrier, Messing gun or a hand instrument. Advantage of MTA is that it needed less time for procedures. Some of the main disadvantages are discoloration, costs and accessibility, which may block worldwide distribution of MTA where formocresol is relatively inexpensive and have global accessibility. MTA has also shown to revascularize and promote dentin-like tissue formation in several clinical situations.A histological study to know the effects of gray and white MTA on amputated pulp tissue, along with formocresol as a gold standard suggests that it preserves and regenerates both hard and soft tissues. The nearly normal pulp architecture was found to be intact and continuous odontoblastic layer was seen. While cases treated with white MTA showed dentine bridge formation along with inflammatory cells and areas of partial necrosis, more clinical and radiographic failures were seen with white MTA. The minor difference in composition between gray and white groups accounts for the differences in pulpotomy success rates. The gray MTA contains tetracalcium aluminoferrite while it is absent in white MTA. The

clinical success of formocresol is attributed to its bactericidal characters even though it shows poorly calcified secondary dentin bridging along with complete necrosis and inflammatory cells.

The normal consequence of pulp treatment is internal resorption. It was seen in both formocresol and MTA groups but no explanation for MTA was given as this consequence is not seen in MTA cases[74].

CONTROVERSIES IN OBTURATION

Some of the most controversial aspects of root canal treatment that have been debated for decades are where to terminate apically, cleaning. shaping and obturation procedures. Many of the investigators of the late 19th Century and early 20th Century debated these issues prolifically. using science as the basis for their clinical directives. In some respects, many of these scientifically-based dictates have been abandoned in favorable. of clinical techniques that provide aesthetic radiographic views but do not necessarily support tissue regeneration at the root apex following obturation.

Working length determination guidelines often cite the cementodentinal junction or apical constriction as the ideal position for terminating canal cleaning and shaping procedures and the position to which the filling material should be placed for clarification purposes, the CDJ is a histological. not a clinical. position in the root canal system. Secondly, the CDJ is not always the most constricted portion of the canal in the apical third of the root Thirdly, the distance from the apical foramen to the canal constriction depends on a multitude of factors such as increased cemental deposition or radicular resorption. Both processes are strongly influenced by age, trauma, orthodontic movement. periradicular pathology, or periodontal disease. Especially in periodontal disease states, the CDJ location has no predictable anatomic appearance or location due to resorptive processes or cementa1 depositions that may extend well into the root canal. Therefore, the foramen and CDJ position on the root can be highly variable and can exist anywhere from the direct radiographic apex up to 3 mm coronal to the radiographic apex depending on a particular root morphology (Fig 2) These potential anatomic variations have had a major impact on the precise region or location for determining the working length and termination of root canal cleaning, shaping and obturation. These clinical concerns, along with the integrity of the periradicular tissues have formed the basis for success in prognostic studies that have identified that the optimal result is to end root canal procedures inside the radiographic apex (approximating the CDJ). When cleaning, shaping and obturation are significantly shorter than this (> 2 mm). the success rates drop. When longer than this, especially with filling materials beyond the radiographic apex, an even poorer result is noted[75].

From a realistic viewpoint. however, it is often impossible to know exactly where the apical foramen and apical constriction are located until after the canal has been obturated.

Apical Position of The Obturation Material Historically

Gutta-percha has been the material of choice as a solid core filling material for canal obturation It demonstrates minimal toxicity. minimal tissue irritability and is the least allergenic material available when retained within the canal system. In cases of inadvertent gutta-percha cone overextension into the periradicular tissues. it is well tolerated, as long as the canal is clean and sealed Gutta-percha. however. has been shown to produce an intense localised tissue response in subcutaneous tissues when placed in fine particle form or to stimulate cellular inflammatory factors in macrophages. This potential may impact on some popular obturation techniques Many of the more contemporary obturation techniques advocate canal obturation to within 0.5 mm of the radiographic apex, to the radiographic apex, or beyond, which is confirmed by the presence of a "puff" of filling material. This puff, whilst thought to consist only of root canal sealer. can also be gutta-percha that has been thermoplasticize. Recently, the impact of sealers on cellular elements found in the periradicular tissues has been investigated and the presence of these materials may be responsible for apoptotic changes (programmed cell death) to a greater or lesser extent depending on the type of sealer. In this regard, the question can be asked "Could this process be responsible for the development of periradicular lesions long after the apparent treatment presents as successful'" Whilst empiric observations support a high degree of initial clinical success with techniques that tolerate or encourage the placement of sealer beyond the root end, no long-term prognostic studies have supported this position for the termination of root canal procedures Furthermore, canals with filling material beyond the confines of the root canal system tend to cause more postoperative discomfort. Whilst filling the entire root canal system is the major goal of canal obturation. the apical termination of the root canal filling material has been controversial. If a major goal of the root canal procedure is to create an environment conducive to the regeneration of cementum over the apical foramen, the periodontium that enters the apical foramen in teeth with vital. yet compromised. pulps should not be challenged with the extrusion of root canal filling materials beyond the end of the canal (Fig. 2). This concept has been scientifically

valid for many years and is supported by numerous retrospective studies and reviews, Even in those cases with periradicular radiolucencies. filling beyond the confines of the canal is less desirable, although filling the root canal as close as possible to its terminus is desirable Contemporary endodontic practices and long-term evaluative studies favour and support obturation within the confines of the root canal system in all cases in an attempt to prevent further challenge to the already compromised and challenged periradicular tissues. Recently-advocated obturation techniques supporting the use of resin-based and bonded materials have not had the same extensive evaluation that gutta-percha, when in contact with the periradicular tissues has had[76]

Root canal treatment of maxillary first molar using the Epiphany Soft Resin Obturating System vertical heated compaction (above) represents a 4-month followup assessment. The patient is symptom free and there appears to be some initial resolution of the radiolucency on the mesiobuccal root.

Contemporary Materials For Root Canal Obturation:

The development of contemporary resin-based materials for bonding within the root canal as the root filling has posed some interesting possibilities. questions and challenges. The prime developments to date have been the tandem of Epiphany soft resin. a dual-cured dental resin composite sealer containing a mixture of BisGMA, ethoxylated BisGMA UDMA and hydrophilic difunctional methacrylates. calcium hydroxide. barium sulfate. barium glass and silica fillers, and Resilon'". a hard resin that is a thermoplastic synthetic polymer of polyester called polycaprolactone. Fuithermore. Resilon contains a bio-active glass component along with bismuth oxychloride and barium sulfate) The Resilon ' material is available in cones that are ISO-sized .02 .04 and .06 taper, as well as in accessory sizes. Pellets of the material are also available for softening and delivery via injectable systems Clinically, the materials are used with a primer after the smear layer has been removed. The

resulting obturation within the canal. being a combination of the soft resin sealer and hard core polycaprolactone. is referred to as Resilon"' Epiphany ' sealer monoblock, as it is claimed to seal from dentinal wall to dentinal wall in circumference. Furthermore, the movement of the material into the patent dentinal tubules of the smear layer-free dentine is claimed. The material has excellent flow characteristics during compaction in the root canal via either a cold lateral compaction or warm vertical compaction technique. In the latter scenario. as with guttapercha and sealer, the extrusion of the filling material beyond the root end, especially following over-instrumentation or patency filing is a strong possibility. This then creates a similar challenge to the healing and preferentially the regeneration of the periradicular tissues as does guttapercha and sealer. One study compared Resilon with gutta-percha in terms of the melting point, specific heat capacity, enthalpy change with melting, and heat transfer. It was found that there was no difference in the melting point temperatures for the two materials, but Resilon had a significantly greater specific heat capacity and endothermic enthalpy change. There was a significant difference in the heat transfer test in the temperature increase between gutta-percha and Resilon within 3 mm of the heat source, with gutta-percha having a greater temperature change. They concluded that Resilon may not be thermoplasticized the same as gutta-percha because there is a higher specific heat, higher enthalpy change with melting, and less heat transfer. Moreover. a multitude of questions arise regarding many aspects of these materials. because to date the published literature provides little detail regarding the clinical manipulation of the material or the ultimate tissue responses to the materials or their components Granted that many clinicians. primarily endodontists. have been using the material in their practices. the need for evidence-based information or at least expanded details on the scientific basis for how this material works is imperative Furthermore, long-term to form sealer tags that enhance both the seal of the root canal and the strength of the root[77].

N2 Sargenti paste

It relies heavily on formaldehyde containing paste and indicated undesirable properties.Cases of incomplete seal and apical fenestration formation were formed.On February 1993, the FDA advisory panel confirmed the N2"s that safety and effectiveness remain unproven[83]

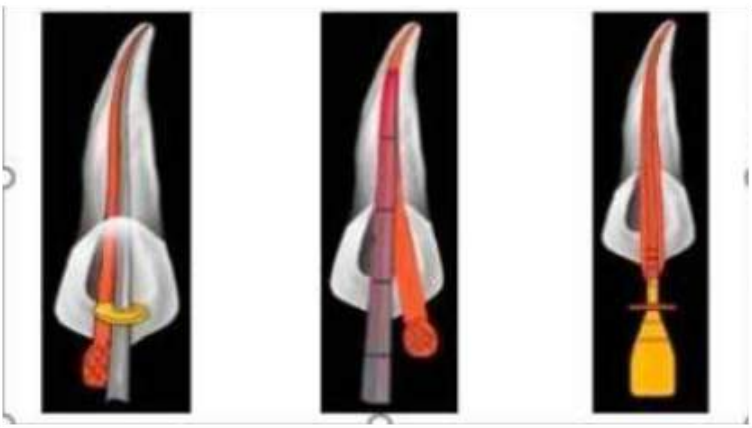
Contemporary Core Filling Materials

Gutta-percha is the standard material of choice as a solid core filling material for canal obturation. It demonstrates minimal toxicity and minimal tissue irritability, is the least allergenic material available when retained within the canal system,and in cases of inadvertent gutta-percha cone overextension into the periradicular tissues, is well tolerated provided the canal is clean and sealed. Chemical solvents have been used for almost 100 years to soften gutta-percha, with methods ranging from merely dipping the gutta-percha cones into the solvent for one second for better canal adaptation, to creating a completely softened paste of gutta-percha with the solvent. Solvents used have included chloroform, halothane, rectified white turpentine, and eucalyptol. Periradicular tissues may be irritated if the solvent is expressed beyond the canal or significant amounts of softened gutta-percha are inadvertently placed into the periradicular tissues. Failure to allow for dissipation of chemical solvents, if volatile, or the removal of excess solvent with alcohol can result in significant shrinkage and possible loss of the apical seal. The use of chemical solvents has been both praised and questioned, but with the advent of thermoplasticized gutta-percha, the need to consider the use of solvents at any time must be questioned. The use of solvents, however, may still be considered for a number of challenges the clinician may face in daily practice, such as the custom fitting of master cones in irregular apical preparations or following apexification[78].

Gutta-percha Cones

The composition of gutta-percha cones is approximately 19% to 22% Balata and 59% to 75% zinc oxide, with remainder a combination of various waxes, colouring agents, antioxidants, and metallic salts.The specific percentages for components varies by manufacturer, with resulting variations in the brittleness, stiffness, tensile strength, and radiopacity of the individual cones attributable primarily to the percentages of gutta-percha and zinc oxide. The antimicrobial activity of gutta-percha is also primarily due to the zinc oxide. In particular, for techniques that use vertical compaction of heat-softened gutta-percha, both the non-standardized and more tapered cones have become quite acceptable[79].

Custom cones can also be developed for canals with irregular or large apical anatomy, Over time, numerous methods have been advocated for obturating the prepared root canal system, each with their own claims of ease, efficiency, or superiority. Most contemporary techniques still rely on gutta-percha and sealer to achieve their goal. Four basic techniques exist for the obturation of the root canal system with guttapercha and sealer: (1) the cold compaction of gutta-percha; (2) the compaction of heat-softened gutta-percha with cold instruments until it has cooled; (3) the compaction of gutta-percha that has been thermoplasticized, injected into the system, and compacted with cold instruments; and (4) the compaction of gutta-percha that has been placed in the canal and softened through the continuous wave technique (Calamus). A multitude of variations on these four basic themes exists. For injectable thermoplastic obturation techniques, gutta-percha may come in either pellet forms or in cannulae.

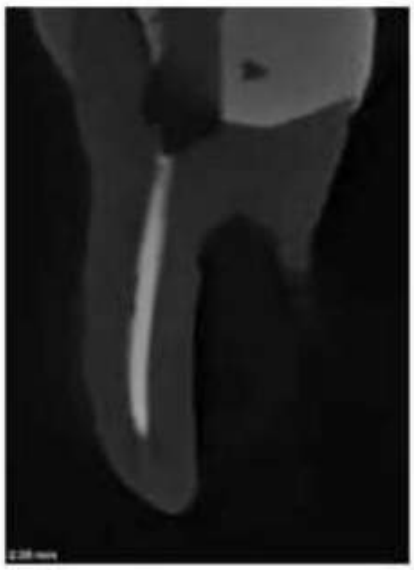


No single technique has proven to have statistically significant superiority when considering both in vitro and in vivo studies, as the success of all techniques is highly dependent on the cleaning and shaping of the canals and the clinician‟s expertise in the use of a particular technique. While many have advocated the use of the lateral compaction technique or a single cone fill (monocone) to achieve a quality apical seal, the technique in itself does not necessarily favor the filling of canal irregularities. Recognizing this, use of a softened gutta-percha technique with heat or chemical softening is required to achieve a thorough obturation. In addition, while filling the entire root canal system is the major goal of canal obturation, a major controversy exists as to what constitutes the apical termination of the root canal

filling material. Working length determination guidelines often cite the cemento dentinal junction or apical constriction as the ideal position for terminating canal cleaning and shaping procedures and placing the filling material. However, the cemento-dentinal junction is a histologic and not a clinical position in the root canal system and, in addition, the cemento-dentinal junction is not always the most constricted portion of the canal (yellow arrows) in the apical portion of the root[80].

Contemporary practices of obturation favour material softening; even this does not guarantee that an impervious seal of the root canal system will be established. Also, with softened gutta-percha obturation techniques there has been a greater incidence of material extrusion beyond the confines of the canal. While softening of gutta-percha may be viewed as routinely desirable, the selective use of this technique solely or in combination with a solid core of gutta-percha must be at the discretion of the competent clinician when anatomy dictates this approach.

Recent research conducted at Nova Southeast University using micro CT scanning technology has shown the effectiveness of scanning for imagery and the greater precision observed compared to standard radiographs. In one example, a mesiobuccal canal was filled using GT® Series X™ obturator and the mesiolingual canal was filled using a single cone technique (ActiV GP). It appeared from one angle that all canals were equally filled. However, closer examination subsequent to filling showed voids using the single cone technique throughout the length of the root filled using this technique[81].



The single cone technique did not produce a monoblock obturation.

The gutta-percha from the GT obturator flowed into the canal isthmus and filled it.

Controversies in obturation of lateral canals

The complexity of the canal anatomy makes it very difficult to efficiently clean, completely disinfect and obturate all ramifications (lateral and accessory canals, deltas, isthmuses) often observed especially at the apical third of the roots. It is well known that in necrotic pulps, these irregularities can harbour infected tissue that could lead to periodontal destruction. The clinical significance of the obturation of these ramifications is at least a matter of discussion. There has been no convincing evidence that obturation of these canals or isthmuses would have an impact on treatment outcome. Despite the controversy, sealing fins and ramifications with a material that possesses antibacterial activity could be beneficial, prolonging the suppression of microbial activity through the action of the root canal filling material[82]. Since the introduction of lasers in endodontics during the early 1970s, there have been several studies regarding the application of this technology as an aid to improve not only the cleansing and disinfection but also the sealing of the root canal system. Treatment of the radicular dentinal walls with the laser has been shown to promote cleaner surfaces when compared with a combination of sodium hypochlorite and ethylenediaminetetraacetic acid (EDTA), which might result in better adaptation of the filling material to the root canal walls. Thus, the application of the Cr, Er: YSGG laser has been shown to provide superior cleanliness of the canals when compared with instrumentation alone[83].

The necessity for the complete obturation of the root canal system and its ramifications seems to be, at the very least, controversial. Sabeti et al., for instance, have reported no difference in healing of apical periodontitis when root canals in dogs were left without obturation after cleaning and shaping procedures, questioning the importance of this phase of the endodontic therapy. According to the authors, –In theory, if we can sterilize the canal and prevent coronal leakage, then a filling should not be necessary‖. However, others have reported the importance of the obturation with thermoplasticized gutta-percha and sealer for the successful outcome of the endodontic therapy. Despite the controversy, one could speculate that filling the main canal and its ramifications with gutta-percha and a sealer with antibacterial properties might be beneficial. Even though the disinfection of the canal system seems to be the most significant factor in root canal therapy, the importance of the obturation should not be overlooked when attempting to maintain the root canal space free of

contamination, increasing the chances of long-term clinical success. Laser devices still need further development, especially when using the technology to clean and shape curved and calcified canals. Zipping and ledging have been frequently reported in the literature which could create difficulties for an adequate obturation. Some canals that received the laser application demonstrated irregularities in the outer walls toward the ‒safe zone‖. However, the irregularities did not influence the quality of the obturation. However, the search for new ways to improve root canal therapy seems to be a reasonable task, and the laser might be a useful instrument in this quest. It can be concluded that treatment with Er, Cr: YSGG laser after mechanical instrumentation allows obturation of a greater number of root canal ramifications by gutta-percha and/or sealer.

Other researchers have shown the importance of combining therapies such as rotary instrumentation using larger apical sizes with the use of calcium hydroxide to reduce the numbers of bacteria in root canals and increase long-term success. In a recent metaanalysis of studies done over the last three decades on optimal obturation length, the results demonstrated that obturating materials extruding beyond the radiographic apex correlated with a decreased prognosis for repair. When faced with the possibility of inadvertent over-instrumentation into neurovascular anatomy, the research provides a substantial number of appropriate caveats.

When Is The Canal Ready To Obturate?

Radicular space obturation is ideally accomplished after cleaning and shaping has been completed to an optimum size. Although there is no universal agreement on what constitutes an optimal size, it seems that the canal(s) should be dry, with no ‒‖weeping‖‖ of fluids into the radicular space. The tooth should ideally be asymptomatic, although those completely instrumented, yet with mild symptoms or even significant symptoms, have been shown to become asymptomatic upon obturation. There are also reports showing the importance of obturating canals following negative bacterial cultures. Sjogren et al found that upon a 5-year recall, 94% of cases exhibiting negative cultures were found to be successful, whereas only 68% of those filled with positive cultures were successful[84].

Influence of Post Space Preparation on Obturation

In order to provide better retention for a core build-up after root canal treatment, it is often necessary to include one or more posts (dowels) The length of the space created to accommodate a post and its time of preparation (immediately following obturation or at a later time) are of concern, as they can affect the quality and the durability of the canal seal. A study by Bourgeois and Lemon in 1981 related that using a hot plugger when making a post space was favorable. A follow-up study by Dickey et al. suggested that if Peeso reamers or chloroform and K-files were used, gutta-percha removal should be delayed by 1 week to allow for setting of the sealer.

The classic literature dealing with the timing of post space preparation has differed regarding its importance. Mattison et al. showed that timing did not matter. More recently, studies have shown conflicting results, as one study with immediate post space preparation gave better results to minimize coronal leakage, while another study showed no difference between immediate and delayed preparation. Another study addressed post spaces made in canals obturated by different filling techniques, including silver points, lateral compaction, warm/vertical compaction, Ultrafil or Obtura and found no significant differences in amounts of leakage. Another issue with respect to post space preparation is that of minimal obturation length (or maximum post space depth). Goodacre and Spolnik recommend post length of at least the same or more as the height of the crown and that 4 to 5 mm of gutta-percha remains apical to the post to maintain an adequate seal. Abramovitz et al. more recently showed that less than 4 to 5 mm of gutta-percha provides an unreliable seal.

Some concern has been expressed about ThermaFil carriers and their potential impedance when creating a post space. Ravanshad and Torebinejad compared metal core ThermaFil obturations notched to fracture 5 to 6 mm from the apex to lateral and vertical compaction obturations with respect to coronal leakage. They found that the ThermaFil group had the highest degree of coronal dye penetration. When comparing ThermaFil plastic and metal carrier obturations following the manufacturer‟s instructions regarding post space preparation, there was very little differences in apical leakage according to Mattison.Another study compared the effects of immediate versus delayed post space preparation on the apical seal using AH Plus sealer and vertical compaction.

Post space depths were all done to allow 4 mm of apical gutta-percha to remain. Teeth in which the post space preparation was delayed for 1 week had significantly more apical leakage than those with immediate post space preparation. Perhaps more convincing evidence of the importance of leaving a minimum amount of apical seal are the findings of Kvist et al. in a clinical study of root canal failures. They found that cases involving post placement had a significantly higher percentage of failures related to apical fillings with less than 3 mm of length[85].

CONTROVERSIES IN POST ENDODONTIC RESTORATION

The restoration of endodontically treated teeth has long been a controversial topic, often approached empirically and based on assumptions rather than scientific evidence. The loss of tooth vitality is not accompanied by significant change in tissue moisture or collagen structure, while endodontic therapy, and, in particular, the use of irrigants such as sodium hypochlorite and chelators, proved to soften dentin[86].

The most important changes in tooth bio- mechanics is attributed to the loss of tissue either at radicular or coronal levels, which points out the importance of a highly conservative approach during endodontic and restorative procedures[87].

Micromorphology of the adhesive interface

A well-structured resin-dentin interdiffusion zone was observed at the interface with radicular dentin using either total-etch or self-etch adhesives; however, this hybrid layer was more uniform when a total-etch system was used. Ferrari et alevaluated the structural characteristics of resin-radicular dentin inter- faces and concluded that the hybrid layer thickness and resin tag density diminished from the coronal to the apical third of a root. In vivo confocal and SEM (scanning electron microscope) microscopy demonstrated that the penetration of adhesives inside radicular dentin proved to be complete in only one- third of extracted teeth in the apical third and in two-thirds of the samples in the middle and coronal thirds and evaluated the micromorphology of failed adhesive inter-faces and found that the failure always occurred between either the hybrid layer and bonding resin or the bonding resin and com- posite resin cement, with higher proportions of interfacial defects at the hybrid layer after long periods of clinical service. These findings demonstrate the limited stability of the hybrid-layer interface[88].

Another in vitro study confirmed the higher occurrence of debonding at the top of the hybrid layer, with either SEM or confocal microscopy. It was also shown that the adhesive interface demonstrates a wellorganized structure with hybrid layer and resin-tag formation where good adhesion is present, whereas a poorly structured interface is visible in most debonded areas[89].

Bond strength and adhesive interface with pulpal-floor and radicular dentin

Adhesion to pulpal-floor dentin measured by microtensile bond strength test proved to be inferior to adhesion to coronal dentin with either a prime-and-bond system (15.6 versus 29.9 MPa) or 2-step self-etch adhesive (22.5 versus 36.0 MPa).Lopes et al [113] have also shown that adhesion to pulpal chamber dentin was more reliable than to root-canal dentin. These findings might be explained by the difference in the collagen cross-linking structure at the different dentin locations. The total-etch technique also appeared to produce [68] higher bond strength values than the self-etching approach. In fact, it was shown that selfetching primers should not be combined with chemical or dual-cured cements, due to the remaining acidic components of the primer[90]. Endodontic irrigants such as chloroform, halothane, hydrogen peroxide, and sodium hypochlorite (NaOCl) reduce bond strength to dentin, while chlorexidine did not affect adhesion.60,61 .The influence of sodium hypochlorite treatment on dentin bond strength might vary with the adhesive used. In addition, the use of NaOCl proved to influence the resin tag morphology; with treatment, resin tags presented a cylindrical, solid shape instead of a hollow, tapered appearance.

Fiber posts provided better bond strength values than ceramic posts. When the tensile force required to dislodge a translucent fiber post cemented by either light-curing adhesive-cement system or dual-curing system was tested, the light-curing system resulted in slightly inferior bond strength values but provided a better adaptation than the dual- curing system.64 When comparing them in a push-out test, the bond strength of fiber post to radicular dentin cemented with either a luting (unfilled or low filler content) or restorative composite resin, [102] higher values were obtained with the restorative composite resins [91].

Bond strength and interface between posts and luting/core composite resin

Following a pull-out test, adhesively cemented carbon-fiber posts presented bond strength values of 25 MPa between post and luting cement. A finite element analysis of the same study configuration did also show that stresses accumulate at the post-cement interface and in the cement bulk itself, lowering stresses in radicular dentin due to [70] the use of a post material of low elasticity modulus. Boschian Pest et al found similar adhesion values between fiber post and cement for unfilled, low-filled (luting), and highly filled (restorative) materials following a push-out test. In a pull-

out test, sandblasting used to create microretentions lowered the bond strength between carbon posts and luting composite resin due to alumina particles impinging carbon fibers[92]. In another invitro study there was no difference in tensile bond strength between composite resin core and sand- blasted or serrated carbon fiber posts. The use of serrated posts appears to be a more reliable approach to increase stability of the post inside the canal[93].

When testing the interface between composite resin cores and smooth fiber or serrated stainless steel posts, higher tensile strength values were obtained with the metal posts, due to the primary influence of macro-mechanical retention. For adhesion between partially stabilized zirconium oxide posts and pressed glass ceramic or composite resin core materials, the use of tribochemical silicoating provided the best retention[94].

The Ferrule Effect

The –ferrule effect‖ is important to long-term success when a post is used. A ferrule is defined as a vertical band of tooth structure at the gingival aspect of a crown preparation. It adds some retention, but primarily provides resistance form and enhances longevity. Stankiewicz and Wilson published a good review of the topic in 2002. A ferrule with 1 mm of vertical height has been shown to double the resistance to fracture versus teeth restored without a ferrule. Other studies have shown maximum beneficial effects from a ferrule with 1.5 to 2 mm of vertical tooth structure.A study by al- Hazaimeh and Gutteridge reported no difference in fracture resistance with or without a 2-mm ferrule using prefabricated posts and resin cement. Clinical benefits achieved by omitting the ferrule preparation includes minimize periodontal effect or trauma of extending the finishing line gingivally. The importance of ferrule is not clear with recent advancements like bonded titanium posts and fiber reinforced composite posts with adhesive resin cements that could provide internal bracing of the root that substitutes for the ferrule effect.

The debate about which post material can sustain higher failure loads (thus longer clinical service) and express more favourable failure modes (thus allow re-restoration) is also still unsolved in literature. However, the fracture patterns were more favourable when a ferrule was present. The majority of the fractures in the teeth without a ferrule were non-restorable. A study by Saupe et al. (57) also reports no

difference in fracture resistance of teeth with bonded posts with or without a ferrule. In some cases, particularly with anterior teeth, it is necessary to perform crown lengthening or orthodontic eruption of a tooth to provide an adequate ferrule.

To crown or not to crown [23]

It should be emphasised that there is no consensus regarding the preferred type of final restoration for endodontic treated teeth. Although the overwhelming majority of the literature supports the need for full coverage restorations of most endodontic treated teeth, and a strong association between the success of endodontic treated teeth and crowned teeth has been shown.

Alternatives have been suggested like complex amalgam restorations, overlays or composite restorations. More recently partial restorations like indirect onlays have been suggested as a restoration that preserves more sound tooth structure than does a full coverage crown while at the same time provides cuspal coverage to protect weakened cusps. The need for crowning a tooth is directly related to its mechanical weakening due to previous restorations, decay and/or endodontic access cavity preparation. No significant biochemical change, indicating that endodontic treated teeth are more brittle, has been demonstrated.

It is now accepted that cuspal deflection and thickness of the residual walls and cusps are the key factors. For this reason, the use of alternative restorations should be considered for certain clinical presentations, due to their ability to preserve thick residual walls better than do crowns. Alternatives include gold crowns and more recently, minimal preparation composite crowns with a 0.5 mm chamfer finish line, bonded with resin cements. Similarly, cuspal coverage direct or indirect composite restorations have been advocated for use in molar teeth so as to eliminate the need for axial wall destruction. [127] [23]

With the improved wear characteristics the newer composites are showing this type of restoration may be an option, particularly in teeth of poorer prognosis, as currently there is sparse long-term information on the longevity of cusp-replacing composite restorations.

It can be stated that the restoration of nonvital teeth has evolved from a completely empirical approach to bio- mechanically driven concepts, the conservation of tissue and adhesion being the most relevant elements for improved long-term success[95].

Endocrowns vs conventional crowns

The true breakthrough in the restoration of endodontically treated teeth was the introduction of adhesion, propelled by the development of effective dentin adhesives. The chief advantage of adhesive restorations is that macro retentive elements are no longer mandatary as long as enough surface is available. With this approach, the insertion of radicular posts has become the exception rather than the rule when applying conventional restorative techniques. In fact, minimally invasive preparations, with maximal tissue conservation, are now considered „the gold standard" for restoring ETT . By following this rationale, endocrowns are applied as a prosthetic option in restoration of endodontically treated incisors, premolars and molars with excessive tissue loss. Pissis was the forerunner of the endocrown technique and has described it as the „mono-block porcelain technique". In 1999, the endocrown was described for the first time by Bindle and Mörmann as adhesive endodontic crowns and characterized as total porcelain crowns fixed to endodontically treated posterior teeth. These crowns would be anchored to the internal portion of the pulp chamber and on the cavity margins, so macro-mechanical retention is provided by the pulpal walls, and micromechanical retention is obtained by the use of adhesive cementation. This method is particularly indicated in cases in which there is excessive loss of tissue of the crown, interproximal space is limited and traditional rehabilitation with post and crown is not possible because of inadequate ceramic thickness. Compared to conventional crowns, endocrowns are easy to apply and require a short clinical time. Low cost, short preparation time, ease of application, minimal chair time and aesthetic properties are the advantages of endocrowns. In addition, endocrowns are also an alternative in teeth with short or atresic clinical crowns, calcified, curved or short root canals that make post application impossible. In a study of 3D Finite Element Analysis of molars restored with endocrowns and posts during masticatory simulation, teeth restored by endocrowns were potentially more resistant to failure than those with fiber reinforced posts [96].

CONTROVERSIES IN ENDODONTIC SURGERY

Apical surgery belongs to the field of endodontic surgery that also includes incision and drainage, closure of perforations, and root or tooth resections. The objective of apical surgery is to surgically maintain a tooth that has an endodontic lesion which cannot be resolved by conventional endodontic retreatment. This goal should be achieved by root-end resection, root-end cavity preparation, and a bacteria-tight closure of the root-canal system at the cut root end with a retrograde filling. In addition, the periapical pathological tissue should be completely debrided by curettage in order to remove any extra-radicular infection, foreign body material, or cystic tissue. Apical surgery has greatly benefited from continuing development and introduction of new diagnostic tools, surgical instruments and materials, making this method of tooth maintenance more predictable. Success rates approaching 90% or above have been documented in several clinical studies[97].

The introduction of cone beam computed tomography (CBCT), also called digital volume tomography (DVT), has had an enormous impact in dentistry, and particularly in surgical fields of dentistry. Whereas conventional computed tomography (CT) provides sliced-image data, CBCT captures a cylindrical volume of data in one acquisition and thus offers distinct advantages over conventional radiography. These advantages include increased accuracy, higher resolution, scan-time reduction, and dose reduction (Cotton et al., 2007). CBCT greatly aids in assessment prior to apical surgery[98].

A study compared CBCT with intraoral periapical radiography in the diagnosis of periapical pathology. In 32 (=70%!) of 46 cases, additional relevant information was obtained with CBCT, including presence and size of apical lesions or presence of an apico-marginal communication. Another study compared CBCT with intraoral periapical radiography (PA) in posterior maxillary teeth referred for apical surgery. CBCT showed significantly more lesions (34%, $p < 0.001$) than PA. Additional findings were seen more frequently with CBCT than PA, including missed canals, presence of apico-marginal communication, expansion of lesions into the maxillary sinus, and sinus membrane thickening. The study clearly showed the limitations of PA compared to CBCT for preoperative diagnosis of posterior maxillary teeth scheduled to undergo apical surgery. Hence, the use of CBCT has been recommended

for presurgical planning, and in particular for planning of apical surgery in multirooted teeth[99].

A surgical approach is more conservative than a non-surgical treatment for certain cases. A common example is a tooth with acceptable endodontics and a new post and crown restoration, but a persistent or enlarging periapical lesion. Breaking or disassembling the crown, removing the post and retreating the canals would be more dramatic, more time consuming, more costly and less predictable than a root-end microsurgical approach[100].

A more critical and difficult issue is the presence of dentinal cracks. The use of an (rigid) endoscope appears to be useful for the detection of dentinal cracks (or of other microstructures) at the cut root face (von Arx et al., 2002, 2003a,b; Slaton et al., 2003). However, the clinical relevance of dentinal cracks observed at the resected root surface has not yet been clarified (Morgan and Marshall, 1999). A recent in vitro study has found that the presence of cracks originating from the root canal negatively influences the seal of root-end filling materials, and is probably of major clinical importance (de Bruyne and de Moor, 2008). The use of ultrasonic tips is one of the alternatives. Although, as they work with vibration and by contacting the root canal walls, there is still a risk of formation of cracks on the surface of the cavity which may lead to apical leakage in the long term. In the recent years, besides ultrasonic tips, lasers are also used in retrograde cavity preparation[100].

After the careful check of the resection plane, a retrocavity is prepared into the rootend. This retrocavity should have a depth of 3 mm and should follow the original path of the root canal. The cavity should also include an isthmus or accessory canal, if present. While the conventional technique of root-end cavity preparation, i.e., the use of a small round bur or of an inverted cone bur in an angled micro-handpiece, was problematic with regard to direction and depth of the retrocavity, the development of sonic- or ultrasonic driven microtips (retrotips) was a major breakthrough in apical surgery, and has considerably simplified the technique of root-end cavity preparation. Elimination or minimisation of the bevel angle is one of the most important benefits of microsurgery. With the traditional rotary bur, the steep angle of 45-60 degrees was recommended. However, there is no biological justification of a steep bevel angle. It was strictly done for better access and visibility. It causes large removal of the buccal

bone along with the root area. Furthermore, bevelling frequently misses the lingually positioned apex, causes elongation canal and reduction of the root diameter, thereby weakening it[101].

For root-end filling, a variety of materials have been propagated in the past. Almost every material that was introduced in operative and restorative dentistry as a temporary (SuperEBA, IRM, Cavit, etc.) or permanent (gold, amalgam, resin composite, glass ionomere cement, compomere, etc.) restoration material was sooner or later also utilized in apical surgery. However, mineral trioxide aggregate (MTA) appears to have become the gold standard for a root-end filling material. All clinical comparative studies published to date have reported higher success rates for MTA than for the competitor material although the differences were not found to be significant (probably due to the number of treated cases). Although MTA is an expensive material and the clinician has to become familiar with its handling, it has major advantages, including excellent biocompatibility, ideal adherence to the cavity walls and low solubility (Poggio et al., 2007), and cementogenesis at the cut root face, with deposition of new cementum onto the exposed dentin and MTA surfaces. The most recently published randomized clinical trial compared MTA to smoothing of the existing orthograde gutta–percha (GP) root filling. Teeth treated with MTA demonstrated a significantly ($p < 0.001$) better healing (96%) than teeth treated with the smoothening procedure only (52%). The results emphasize the importance of placing a root-end filling after apical resection[102].

With regard to the outcome of apical surgery, inconsistent success rates ranging from 44% to 90% were reported prior to the introduction of microsurgical techniques. However, recent studies have shown that the treatment outcome of apical surgery has considerably improved, and the success rates have approached or exceeded 90%. This tendency of consistently high healing rates after apical (micro-)surgery has been substantiated by several clinical studies. Another important issue to consider in the healing outcome of apical surgery is the difficulties and challenges of combined endoperio lesions, in particular the absence of the buccal bone plate with a completely exposed buccal root surface. Only a few clinical studies have compared the healing outcomes in apical surgery of teeth with intact and with missing buccal bone. A 5-year success rates associated with molar apical surgery in consideration of the width of the buccal __bone cuff‘‘ prior to wound closure. Teeth with a width of 3 mm or

greater of cuff had a healing rate of 76%, whereas teeth with no buccal bone cuff had a significantly lower healing rate of 46% ($p < 0.0001$)[103]. Another study reported a successful outcome of 77.5% in apicoectomized teeth with combined endodontic–periodontal lesions, compared to a successful outcome of 95.2% in teeth with isolated endodontic lesions. Teeth with an apico-marginal communication undergoing apical surgery may benefit from further advances and refinement of regenerative techniques[104].

Endodontic Treatment Vs Implant Surgery

One of the major issues confronting the contemporary dental clinician is the treatment decision between extracting a tooth with placement of a dental implant or preserving the natural tooth by root canal treatment. A recent systematic review comparing the two of the most common treatment options – root canals and dental implants – found virtually equal success, or survival rates, between both treatments. Since the comparative analysis uncovered no significant differences in the success rates between the two options, the researchers emphasize that treatment decisions must be based on factors other than outcome, such as case complexity or the patient's individual health and preferences. He recommended treatment must be safe, mindful of the patient's wishes, and should aim at preserving the natural tooth when possible,‖ said Dr. Goldstein. However, despite this similarity, the authors conclude that the priority should always be to preserve the natural tooth before extracting and replacing with an implant[105].

CONTROVERSIES IN SUCCESS Vs FAILURE OF ROOT CANAL TREATMENT SUCCESS VERSUS FAILURE

The highest failure rate (16.6%) was in endodontic retreatment cases. Symptomatic cases were twice as likely to fail as were asymptomatic cases (10.6% versus 5.0%). A Japanese study followed one-visit cases for as long as 40 months and reported an 86% success rate. Oliet again found no statistical significance between his two groups. The majority of the postgraduate directors of endodontics also felt that the chance of successful healing was equal for either type of therapy. The original investigators in this field, Fox et al., Wolch, Soltanoff, and Ether et al., were convinced that singlevisit root canal therapy could be just as successful as multiple-visit therapy[106].

SINGLE VISIT VS MULTIPLE VISIT

Single- versus multiple-visit root canal treatment has been the subject of longstanding debate in the endodontic community. In fact, the attempt to complete root canal treatment in one visit has been documented since the end of the nineteenth century, yet we have not come to a definitive conclusion. Some of the unresolved issues include differences in clinical outcomes, inadequate microbiological control and pain. This controversy can be investigated more systematically with the aid of an evidence-based approach[107]. When clinicians are faced with choices of which treatment should be offered to patients, the central issues that should be considered are effectiveness, complications, cost and probably patient/operator satisfaction. It has been established that the current best available evidence has failed to demonstrate a difference in therapeutic efficacy (healing rates) between these two treatment regimens in teeth with necrotic pulps and apical periodontitis[108]. Complications of these two treatment approaches, though, have not yet been studied systematically.

Pain and swelling are often indicators of an existing disease process associated with an offending tooth. Endodontic treatment aims to reverse the disease process and thereby eliminate the associated signs and symptoms. When the treatment itself appears to initiate the onset of pain and/or swelling, the result can be very distressing to both the patient and the operator. Patients might even consider postoperative pain and flare-up as a benchmark against which the clinician‘s skills are measured. Prevalence of postoperative pain or flare-up is, therefore, one of the influencing

factors when making a clinical decision. Obviously, the treatment with the lower prevalence of postoperative pain is usually the treatment of choice as long as effectiveness and cost are not compromised. Even though postoperative pain in endodontics is not a particularly good outcome measure because it tends to be transient, it has been widely used as an argument either for or against single-visit root canal treatment. A majority of endodontists in the United States 25 years ago believed that there would be more pain if treatment was completed in one appointment. Clinical decision making, however, should be based on the best clinical evidence rather than consensus[109].

Apical periodontitis present

Two studies were available in this category; one prospective cohort (Ng et al. 2004) and one retrospective cohort[110]. Prevalence of postoperative pain was significantly higher in single visit root canal treatment in (P-value < 0.001)[111].The odds of postoperative pain occurring in association with single-visit root canal treatment were 2.8 times that of multiple-visit treatment (odds ratio = 2.8; 95% CI: 1.7–4.7). Eleazer & Eleazer reported opposite results using flare-up rate as an outcome measure. Prevalence of flare-up was significantly higher in a multiple-visit approach[110].

Apical periodontitis absent

Three studies were available in this group; two randomized controlled trials[112] and one prospective cohort study[113]. Postoperative pain was not significantly different between single- and multiple visit root canal treatment in these studies (P-value = 0.23, 0.16 and >0.9 Mann–Whitney U-test, Pearson uncorrected chi-square and Fisher exact test, respectively)[114].

Retreatment cases

Only one study was available in this category, which was a randomized controlled trial[115]. Prevalence of flare-up was significantly higher with a single-visit approach (Pvalue = 0.05; Fisher exact test). The odds of flare-up occurring in single-visit root canal retreatment were 4.9 times that of multiple-visit treatment (odds ratio = 4.9; 95% CI: 1.1–19). The study showed a significant disadvantage of single-visit retreatment in terms of the frequency of flare-up. However, the P-value just reached a significant level (P-value = 0.05).

Compelling evidence indicating a significantly different prevalence of postoperative pain/flare-up of either single- or multiple-visit root canal treatment is lacking. The low level of agreement amongst studies reflects the widely varying measures of pain severity, differences in treatment protocols and patient selection, as well as variability in treatment effects[114].

CONCLUSION

The scientific review presented here suggests that, if many of the different opinions prevailing in the endodontic field are to be resolved, there is considerable room for properly designed clinical studies. The most apparent gap in the published literature is the lack of randomized clinical trials, systematic reviews and meta-analysis which are needed to resolve issues that relate to proper management of pulpal and periodontal wounds, proper medication, and number of appointments for treatment of infected root canals.

Endodontic practice has to be depended on the combination of research work and clinical experience.

There is more than enough scientific literature available about endodontics which may create confusion for practitioners in managing cases. It is quite challenging for the clinician to select the best knowledge and technique to treat his/her patient. Finally it depends on multiple factors such as genetics, age, ethnicity, gender, body and psychological constitution, presence of systemic/debilitating diseases and attitude of patients along with the knowledge and skill of the clinician to bring about the best outcome of the treatment

Hence, clinician with profound knowledge about the disease dynamics, proper skill using proper techniques and studying the human as a whole is very important to get the best result.

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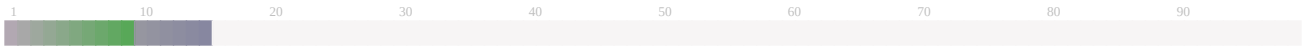

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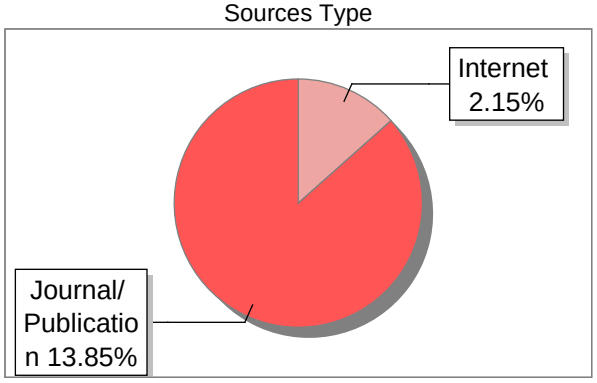

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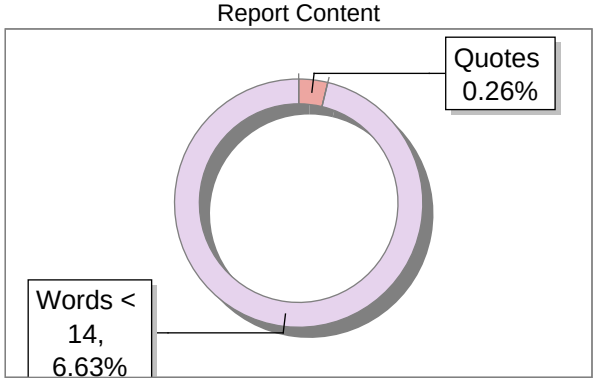

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Comparative evaluation of microleakage in class II cavities restored with snow plow technique using flowable or preheated packable bulk fill composite resin as gingival increment, by dye extraction method – an in vitro study

Abstract:

Context

One of the undesirable characteristics of dental composite resin is the polymerization shrinkage and the associated microleakage leading to failure.

Aim

To comparatively evaluate microleakage in class II cavities restored with snow plow technique using either preheated packable or flowable bulk fill composite resin.

Materials and methods

Fifty sound first molars were selected. Class II mesio occlusal box preparations were made. The test specimens were randomly divided into two groups. Group 1: Tetric N Flow bulk fill and Tetric N Ceram bulk fill co-cured in snow plow technique. Group 2: Tetric N Ceram bulk fill preheated to 60°C and Tetric N Ceram bulk fill co-cured in snow plow technique. Restored teeth were processed for dye extraction.

Statistical Analysis:

Mann-Whitney U test was applied to compare the microleakage between the groups.

Results

Results indicate that specimens in group 2 showed lower microleakage (median 0.041750) when compared to specimens in group 1 (median 0.059400).

Conclusion

The results imply that the preheated packable bulk fill composite resin showed less microleakage as compared to flowable composite while restoring class II cavities by the snow plow technique.

Keywords: Bulk fill, Dye extraction, Microleakage, Preheating, Snow plow

Introduction

Marginal adaptation and flow of dental composite resin remain a challenge while restoring deep class II preparations. To overcome this, the snow plow technique was introduced, in which a less viscous material is applied as gingival increment, overlayed by a more viscous material and co-cured.[1] Another method is by preheating packable composite resin, which ensures increased flow, a higher degree of polymerization and fewer marginal gaps.[2] This study was undertaken to evaluate microleakage in class II cavities restored with packable bulk fill composite resin with either preheated packable or flowable bulk fill composite resin as an initial increment in the snowplow technique.

Clinical relevance of the study – The use of preheated bulk fill composite resins and the snow plow technique of placement has the potential to improve flow and marginal adaptation thereby minimizing microleakage.

Methodology

50 human extracted mandibular molars were selected for this study with the following criteria.

Inclusion criteria – intact, non-carious, permanent mandibular molars.

Exclusion criteria – teeth with pre-existing caries, restoration, cracks, fractures, non-carious lesions like attrition, abrasion. All the selected teeth were cleaned and stored in 0.5% chloramine T solution (Pure-lab, Chem industry, India) for 48 hours, and then washed and transferred to distilled water. Standardized class II mesio occlusal box preparations were made with the following dimensions - 3mm buccolingually and 2mm mesiodistally. The gingival seat of the proximal box was placed 1 mm coronal to the cementoenamel junction. The specimens were then randomly divided into two groups of 25 teeth in each group for restorations. Samples of each group were mounted in contact with each other. Tofflemire matrix band and retainer were adapted to establish contact and to prevent gingival overhang of the restoration. The prepared cavity surfaces were etched with 37 % phosphoric acid (Eco-Etch, Ivoclar Vivadent: Schaan, Liechtenstein) for 15 s, rinsed and dried. Tetric N bond adhesive (Ivoclar Vivadent: Schaan, Liechtenstein) was applied to the

etched surface, gently air-dried, and light cured for 20 seconds.

In group 1, the flowable composite resin Tetric N flow (Ivoclar Vivadent: Schaan, Liechtenstein) was placed as the gingival increment and overlayed with packable bulk fill composite resin Tetric N Ceram (Ivoclar Vivadent: Schaan, Liechtenstein) in 4mm thickness. It was compacted such that the flowable composite resin was displaced into a thin layer. This was co-cured for 20 seconds, known as the snow plow technique. The rest of the preparation was restored with Tetric N Ceram bulk fill composite resin and light cured.

In group 2, Tetric N Ceram packable bulk fill composite resin was placed in the composite warmer (Endoking Dental resin composite heater, Endoking, India) and heated to 60°C. This preheated material was injected into the cavity as the gingival increment and overlayed with Tetric N Ceram packable bulk fill composite resin at room temperature in 4mm thickness and compacted together. This was co-cured for 20 seconds, known as the snow plow technique. The rest of the preparation was restored with Tetric N Ceram packable bulk fill

composite resin and light cured. All restorations were finished and polished.

The samples were then stored in artificial saliva (ICPA Health products, India) at 37°celsius for 24 hours. Just prior to subjecting the test specimens for dye extraction, they were subjected to thermocycling in a thermocycling unit (GSC Global Thermal cycling chamber, India) in a water bath at 5^0C and 55^0C, with a resting time of 30 seconds each, for 500 cycles. For microleakage assessment, the root apices of all the teeth were completely covered and sealed with sticky wax and nail varnish (Disguise Cosmetics, India) was coated onto the crown and root surfaces of the teeth entirely except for 1-2 mm around the margins of restorations. Specimens were then immersed in 2% methylene blue dye (Labogens, India) for 24 hours. After 24 hours, the specimens were rinsed under tap water to remove the traces of the dye. The nail varnish coating was removed using polishing discs (NMD Nexus Medodent, India).

The specimens were placed in vials containing 3 ml of 65 wt % nitric acid (Schwabe, India) for 72 hours. After 72 hours the vials were centrifuged (REMI R 8

laboratory centrifuge, India) at 5,000 rpm for 5 mins. The supernatant from the vials was transferred to cuvettes to be placed in the spectrophotometer. The dye absorbance value was measured in a UV-visible spectrophotometer (UV-1700 PharmaSpec UV vis Spectrometer, India) at 550nm.

Results

The results of the spectrophotometer indicated the dye absorbance of methylene blue at the resin-tooth interface due to microleakage around the restoration. SPSS (Statistical Package for Social Sciences) version 21. (IBM corporation: New York, USA) was used to perform the statistical analysis. A non-parametric test (Mann-Whitney U test) was applied as data showed a non-normal distribution. The level of significance was set at 5%. As shown in Table 1, the median microleakage score in teeth restored with group I was 0.059400 (IQR 0.0137), and group II was 0.041750 (IQR 0.0104). Mann-Whitney U test showed a statistically significant difference between the groups (p=0.001). Graphical representation of the results is depicted in Figure 1.

The results indicated that group II restored with pre-heated packable bulk fill composite resin (60^0 C) and packable bulk fill composite resin co-cured in snow plow technique showed lower microleakage as compared to group I restored with flowable bulk fill and packable bulk fill composite resin in snow plow technique.

Discussion

Placement of dental composite resin restoration requires adequate isolation, predictable adhesion protocol, material selection and appropriate placement technique, all of which can directly impact the outcome of the procedure.

Unlike amalgam, composite resin cannot be easily condensed into the cavity but has to be sculpted to all the regions of the prepared cavity, which in turn affects the proper adaptation of material to the preparation. [3] In addition to that, the cervical proximal margins in class II restorations are often considered challenging, as bonding is often less predictable due to insufficient or inaccessible enamel margins for bonding.[4] This

difficulty in obtaining intimate cavity adaptation will lead to incomplete marginal sealing and microleakage.[5]

There are several other factors that may lead to the increased risk of failure at the gingival margins of deep class II composite resin restorations, such as the exposure of the cavity surfaces to saliva, gingival crevicular fluid or blood and inadequate light penetration to the gingival margin.[6]

One of the most undesirable characteristics of composite resin is the polymerization shrinkage resulting in gap formation and microleakage.[7]

Microleakage has been defined as, "The clinically undetectable passage of bacteria, fluids, molecules or ions between cavity walls & the restorative material applied to it".[8] This may lead to sensitivity, secondary caries, pupal pathosis and restoration failure.[9] There have been a lot of studies done over the years on various methods to minimize the microleakage in composite resin restorations.

Snow plow technique is a new technique in which a less viscous material is applied as gingival increment, overlayed by packable composite resin and co-cured.

Subsequently, the remainder of the preparation is restored using packable composite resin. By ensuring that the flowable material is "pushed" into a highly thinned layer, the negative effects of polymerization shrinkage of a relatively thick layer of flowable, is reduced.[10] An in vitro study by Chuang et al, reported significantly lower microleakage with the snow plow technique using flowable and packable composite resins.[11]

However, in this study, the use of bulk-fill composite resins in the snow plow technique has the added benefit of reduced polymerization shrinkage owing to the incorporation of isofillers and novel photoinitiator ivocerin that improved the depth of cure. Tetric N-Ceram is has shown to exhibit good esthetic properties, easy handling and its clinical longevity. Tetric N-Ceram Bulk Fill and Tetric N-Flow Bulk Fill both contain "ivocerin" as the photoinitiator which is highly photoreactive and provides for increased depth of cure of up to 4mm.[12] It also contains a patented "shrinkage stress reliever" with a low modulus of elasticity(10GPa) that effectively reduces the stress during

polymerization.

The other method employed in the current study is the preheating of composite resins. The warming method is designed to produce a "flowable" viscosity in a packable composite resin. This can be attributed to the thermal energy produced due to preheating that causes the monomers within the resin matrix to move further apart by readily sliding over each other. various studies have shown that preheating composite resins reduces their viscosity and improves the flow, allowing for better adaptation.[13] Studies have also shown an improvement in physical properties, such as a higher degree of conversion and lower polymerization shrinkage.[14,15]

A systematic review by Lopes et al concluded that the preheating of composite resins is safe for clinical use and that there may be some benefit in enhancing the marginal seal without negatively affecting other properties.[16]

The average composite resin preheating temperature found in the literature is 54°C to 68°C, considered a safe temperature range without causing damage to the pulp

tissue.[17,18] Hence in this study, dental composite resin was preheated to 60°C. The temperature of the preheated material does not remain the same throughout the restorative procedure. Studies have demonstrated almost a 50% rapid drop in temperature of the material within 2 minutes of its removal from the heating device.[19]

A pulp temperature rise of more than 5.5°C is considered potentially damaging to the human pulp tissue and the adequate remaining dentin thickness is an important factor that provides a thermal barrier against any harmful stimuli.[20]

After completing the restorations, the specimens were subjected to thermocycling. Thermocycling is an invitro process of subjecting the specimens to extremes of temperature to simulate oral conditions.

To assess the sealing efficiency of the restorative material & microleakage, the specimens were immersed in 2% methylene blue dye for dye extraction because it is economical, and the particle size of this dye is less than the internal diameter of dentinal tubules (1-4 μm) and can show dentin permeability. In the dye extraction

method, teeth are dissolved in acids that release all dye from the interface and the optical density of the solution is measured by adsorbing light via a spectrophotometer. The dye extraction method presents a benefit over the fluid filtration technique, as filtration values tend to diminish over time, as the water penetrates all irregularities until a plateau is reached.[20]

In the present study, results showed microleakage scores in teeth restored with group I with a median of 0.059400 (IQR 0.0137) and in group II with a median of 0.041750 (IQR 0.0104). Group II showed lower microleakage than group I and the results were statistically significant ($P<0.05$). The results indicate that group II comprising teeth restored with pre-heated packable bulk fill composite resin (to 60^0 C) and packable bulk fill composite resin co-cured in snow plow technique showed lower microleakage when compared to group I with teeth restored with flowable composite resin and packable bulk fill composite resin co-cured in snow plow technique.

This can be attributed to the snow plow technique that allows the less viscous material to flow into the

preparation and allows for better marginal adaptation, thereby reducing the microleakage. Also, preheating of the dental composite resin lowers viscosity and thereby improves adaptation along with an improvement of physical properties, such as lower polymerization shrinkage and a higher degree of monomer conversion.

Conclusion

Within the limitations of the present study, it can be concluded that,

- Class II restorations in both the groups, placed in snow plow technique, using flowable bulk fill and preheated packable bulk fill composite resin, exhibited some amount of microleakage.
- Among the two experimental groups, group II samples restored in snow plow technique with pre-heated (60^0 C) packable bulk fill composite resin exhibited lesser microleakage values (Median of 0.041750) than the group I samples (Median of 0.059400). The difference between the two groups was statistically significant.
- The results imply that the preheated packable bulk

fill composite resin as gingival increment in the snow plow technique has shown better marginal adaptation. Thus, reducing microleakage as compared to flowable composite resin, while restoring class II cavities by snow plow technique.

However, further long-term in vitro and in vivo studies are required with the snow plow technique using other bulk fill and packable materials, in much deeper class II cavities and varying preheating temperatures, before we extrapolate the results to clinical situations.

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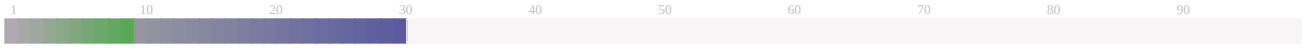

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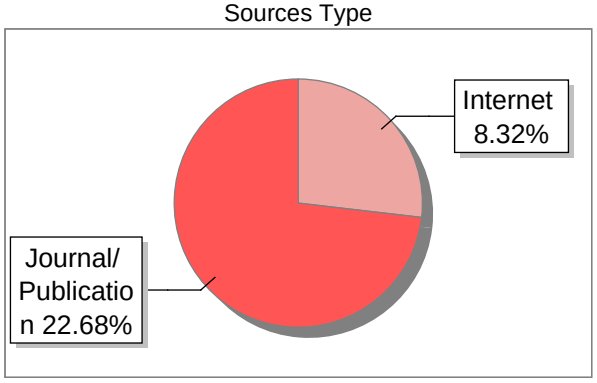

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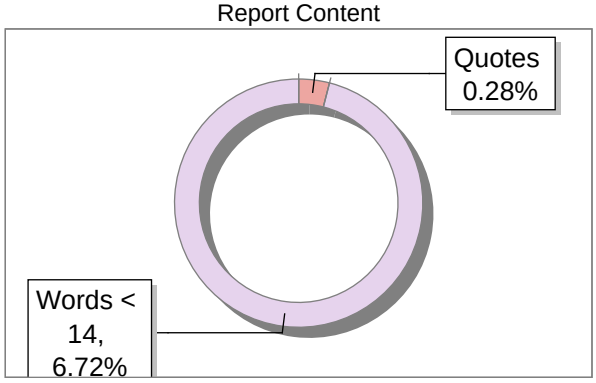

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Abstract:

Context

One of the undesirable characteristics of dental composite resin is the polymerization shrinkage and the associated microleakage leading to failure.

Aim

To comparatively evaluate microleakage in class II cavities restored with snow plow technique using flowable or preheated packable bulk fill composite resin as gingival increment.

Materials and methods

Fifty sound first molars were selected. Class II mesio occlusal box preparations were made. The test specimens were randomly divided into two groups. Group 1: Tetric N Flow bulk fill and Tetric N Ceram bulk fill co-cured in snow plow technique. Group 2: Tetric N Ceram bulk fill preheated to 60°C and Tetric N Ceram bulk fill co-cured in snow plow technique. Restored teeth were processed for dye extraction.

Statistical Analysis:

Mann-Whitney U test was applied to compare the microleakage between the groups.

Results

Results indicate that specimens in group 2 showed lower microleakage (median 0.041750) when compared to specimens in group 1 (median 0.059400).

Conclusion

The results imply that the preheated packable bulk fill composite resin as gingival increment showed less microleakage as compared to flowable composite while restoring class II cavities by the snow plow technique.

Keywords: Bulk fill, Dye extraction, Microleakage, Preheating, Snow plow

Introduction

Marginal adaptation and flow of dental composite resin remain a challenge while restoring deep class II preparations. To overcome this, the snow plow technique was introduced, in which a less viscous material is applied as gingival increment, overlayed by a more viscous material and co-cured.[1] Another method is by preheating packable composite resin, which ensures increased flow, a higher degree of polymerization and fewer marginal gaps.[2] This study was undertaken to evaluate microleakage in class II cavities restored with packable bulk fill composite resin with either flowable or preheated packable bulk fill composite resin as gingival increment in the snowplow technique.

Methodology

50 extracted mandibular molars free of caries, cracks, decay and restorations were selected for this study. All the selected teeth were cleaned and stored in 0.5% chloramine T solution for 48 hours, and then washed and transferred to 0.9% saline solution. Standardized

class II mesio occlusal box preparations were made with the following dimensions - 3mm buccolingually and 2mm mesiodistally. The gingival seat of the proximal box was placed 1 mm coronal to the cementoenamel junction. The samples were randomly assigned into two groups of 25 teeth in each group for restorations. Samples of each group were mounted in contact with each other. Tofflemire matrix band and retainer were adapted to establish contact and to prevent gingival overhang of the restoration. The prepared cavity surfaces were etched with 37 % phosphoric acid for 15 s, rinsed and dried. Tetric N bond adhesive was applied to the etched surface, gently air-dried, and cured for 20 seconds.

In group 1, Tetric N flow (flowable composite resin) was placed as the gingival increment and overlayed with Tetric N Ceram (packable bulk fill composite resin) in 4mm thickness. It was compacted such that the flowable composite resin was displaced into a thin layer. This was co-cured for 20 seconds, known as the snow plow technique. The rest of the preparation was filled with Tetric N Ceram bulk fill composite resin and

light cured.

In group 2, Tetric N Ceram (packable bulk fill) composite resin was placed in the composite warmer and heated to 60°C. This preheated material was injected into the cavity as the gingival increment and overlayed with Tetric N Ceram (packable bulk fill) composite resin at room temperature in 4mm thickness and compacted together. This was co-cured for 20 seconds, known as the snow plow technique. The rest of the cavity was filled with Tetric N Ceram (packable bulk fill) composite resin and light cured. All restorations were finished and polished.

The samples were then stored in distilled water for 24 hours at 37 °C and then subjected to thermocycling using a thermocycling apparatus in a water bath at 5^0C and 55^0C, with a dwell time of 30 seconds each, for 500 cycles. For microleakage assessment, the radicular apices of teeth were sealed with sticky wax and the root and crown surfaces of the teeth were completely covered with nail varnish except for 1-2 mm around the margins of restorations. Specimens were then immersed in 2% methylene blue dye for 24 hours. After 24 hours,

the samples were washed under tap water to remove the traces of the dye. The nail varnish was removed using polishing discs.

The teeth were placed in test tubes containing 3 ml of 65 wt % nitric acid for 3 days. Test tubes were centrifuged at 5,000 rpm for 5 mins. The supernatant from each sample was transferred to cuvettes. The dye absorbance was measured in a UV-visible spectrophotometer at 550nm.

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The results of the spectrophotometer indicated the dye absorbance of methylene blue at the resin-tooth interface due to microleakage around the restoration. SPSS (Statistical Package for Social Sciences) version 21. (IBM corporation: NY, USA) was used to perform the statistical analysis. A non-parametric test (Mann-Whitney U test) was applied as data showed a non-normal distribution. The level of significance was set at 5%. The median microleakage score in teeth restored with group I was 0.059400 (IQR 0.0137), and group II was 0.041750 (IQR 0.0104). Mann-Whitney U test showed a statistically significant difference between the

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Placement of dental composite resin restoration requires adequate isolation, predictable adhesion protocol, material selection and appropriate placement technique, all of which can directly impact the outcome of the procedure.

Unlike amalgam, composite resin cannot be easily condensed into the cavity but has to be sculpted to all the regions of the prepared cavity, which in turn affects the proper adaptation of material to the preparation.[13, 4] In addition to that, the cervical proximal margins in class II restorations are often considered challenging, as bonding is often less predictable due to insufficient or

inaccessible enamel margins for bonding.[3] This difficulty in obtaining intimate cavity adaptation will lead to incomplete marginal sealing and microleakage.[5] [13] Several other factors may contribute to the increased risk of failure at the gingival margins of deep class II composite resin restorations, such as the exposure of the cavity surfaces to saliva, gingival crevicular fluid or blood and inadequate light penetration to the gingival margin.[6]

One of the most undesirable characteristics of composite resin is the polymerization shrinkage resulting in gap formation and microleakage.[7,8, 13,]

Microleakage has been defined as, "The clinically undetectable passage of bacteria, fluids, molecules or ions between cavity walls & the restorative material applied to it".[9] This may lead to sensitivity, secondary caries, pupal pathosis and restoration failure.[3] There have been a lot of studies done over the years on various methods to reduce the microleakage in class II composite restorations.

Snow plow technique is a new technique in which a less viscous material is applied as gingival increment,

overlayed by packable composite resin and co-cured. Subsequently, the rest of the preparation is restored with packable composite resin.[10] By ensuring that the flowable material is "pushed" into a highly thinned layer, the negative effects of polymerization shrinkage of a relatively thick layer of flowable, is reduced. An in vitro study by Chuang et al, reported significantly lower microleakage with the snow plow technique using flowable and packable composite resins.[11]

However, in this study, the use of bulk-fill composite resins in the snow plow technique has the added benefit of reduced polymerization shrinkage owing to the incorporation of isofillers and novel photoinitiator ivocerin that improved the depth of cure. Tetric N-Ceram is characterized by its excellent esthetic properties and easy handling as well as its clinical longevity. Tetric N-Ceram Bulk Fill and Tetric N-Flow Bulk Fill both contain "ivocerin" as the photoinitiator which is highly photoreactive and provides for increased depth of cure of up to 4mm.[12] It also contains a patented "shrinkage stress reliever" with a low modulus of elasticity(10GPa) that effectively reduces

the stress during polymerization.

The other method employed in the current study is the preheating of composite resins. The warming method is designed to produce a "flowable" viscosity in a packable composite resin. The theoretical basis for this behavior is that thermal energy forces the composite monomers or oligomers further apart, allowing them to slide by each other more readily. Studies have shown that heating resin composites lowers viscosity and thereby improves adaptation.[13] Studies have also shown an improvement in physical properties, such as a higher degree of conversion and lower polymerization shrinkage.[14,15]

A systematic review by Lopes et al concluded that the preheating of composite resins is safe for clinical use and that there may be some benefit in enhancing the marginal seal without negatively affecting other properties.[16]

The average composite resin preheating temperature found in the literature is 54°C to 68°C, considered a safe temperature range without causing damage to the pulp tissue.[17,18] Hence in this study, dental composite resin

was preheated to 60°C. The temperature of the heated material placed into the cavity is not the same throughout as there is a rapid dropping of temperature of approximately 50% in 2 min counted after removing the material from the heating device.[19]

A pulp temperature rise of 5.5 °C is considered as the potential damaging threshold for human pulp tissue and the adequate remaining dentin thickness still appears to be one of the most important factors for the protection of the pulp since dentin acts as a thermal barrier against harmful stimuli.[20]

After completing the restorations, the specimens were subjected to thermocycling. Thermocycling is an invitro process of subjecting the specimens to extremes of temperature to simulate oral conditions.

To assess the sealing efficiency of restorative material & microleakage, 2% methylene blue dye was chosen for dye extraction because it is simple and economical, the particle size of this dye is less than the internal diameter of dentinal tubules (1-4 µm) and can show dentin permeability. In the dye extraction method, teeth are dissolved in acids that release all dye from the interface

and the optical density of the solution is measured by adsorbing light via a spectrophotometer. The dye extraction method presents a benefit over the fluid filtration technique, as filtration values tend to diminish over time, as the water penetrates all irregularities until a plateau is reached.[21]

In the present study, results showed microleakage scores in teeth restored with group I with a median of 0.059400 (IQR 0.0137) and in group II with a median of 0.041750 (IQR 0.0104). Group II showed lower microleakage than group I and the results were statistically significant ($P<0.05$). The results indicate that group II comprising teeth restored with pre-heated packable bulk fill composite resin (to 60^0 C) and packable bulk fill composite resin co-cured in snow plow technique showed lower microleakage when compared to group I with teeth restored with flowable composite resin and packable bulk fill composite resin co-cured in snow plow technique.

This can be attributed to the snow plow technique that allows the less viscous material to flow into the preparation and allows for better marginal adaptation,

thereby reducing the microleakage. Also, preheating of the dental composite resin lowers viscosity and thereby improves adaptation along with an improvement of physical properties, such as a higher degree of conversion and lower polymerization shrinkage.

Conclusion

Within the limitations of the present study, it can be concluded that,

- Class II restorations in both the groups, placed in snow plow technique, using flowable bulk fill and preheated packable bulk fill composite resin, exhibited some amount of microleakage.
- Among the two experimental groups, group II samples restored in snow plow technique with pre-heated (60^0 C) packable bulk fill composite resin exhibited lesser microleakage values (Median of 0.041750) than the group I samples (Median of 0.059400). The difference between the two groups was statistically significant.
- The results imply that the preheated packable bulk fill composite resin as gingival increment in the

snow plow technique has shown better marginal adaptation. Thus, reducing microleakage as compared to flowable composite resin, while restoring class II cavities by snow plow technique.

However, further long-term in vitro and in vivo studies are required with the snow plow technique using other bulk fill and packable materials, in much deeper class II cavities and varying preheating temperatures, before we extrapolate the results to clinical situations.

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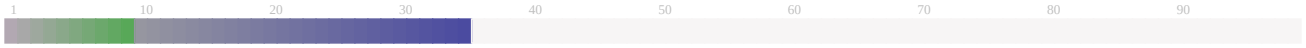

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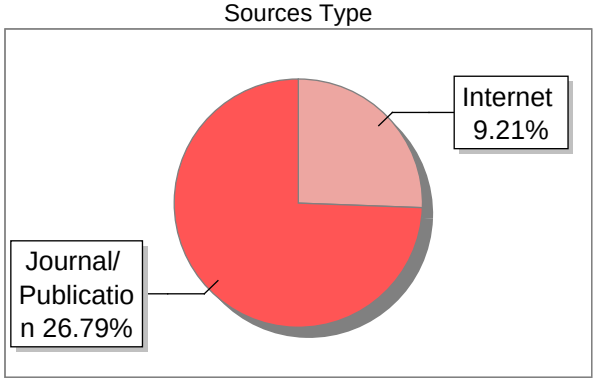

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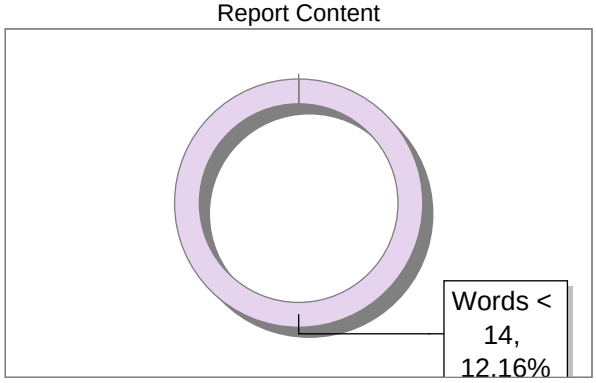

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BACKGROUND

Gingival hyperpigmentation is a significant concern for many patients, presenting challenges for periodontists due to the aesthetic issues associated with dark gums. Approximately 15% of Europeans experience oral pigmentation, with the prevalence rising to 80% in the Asian population. [1] Healthy gingiva can range in color from pale pink to deep bluish-purple, with variations largely influenced by factors such as melanogenesis intensity, keratinization, epithelial thickness, and vascularity. [2] While gingival hyperpigmentation is physiological and does not cause systemic issues, it often becomes an aesthetic concern, especially in individuals with a high lip line or gummy smile. [3,4]

Various techniques have been developed to address gingival hyperpigmentation, including surgical, electrosurgical, rotary, cryosurgical, free gingival grafts, and laser treatments. [5,6] Scalpel surgery is noted for its simplicity, effectiveness, and cost-efficiency. The rotary technique is also relatively easy and safe, allowing for repeat procedures if residual pigmentation remains. The electrosurgical technique works by using electrical energy to disrupt melanin cells in the treatment area. More recently, lasers have gained recognition for their effectiveness in removing melanin pigmentation by ablating epithelial tissues; this process requires the presence of melanin within the laser's penetration range, which absorbs light energy and converts it into heat through photo-thermolysis. [7]

Gingival re-pigmentation can occur post-treatment due to the migration of melanocytes from adjacent areas. This study aimed to evaluate and compare the clinical efficacy of scalpel, rotary, electrocautery, and laser techniques for gingival depigmentation by measuring the reduction in the Dummet Oral Pigmentation Index (DOPI) score from baseline to six months. Additionally, the study assessed pain perception using the Visual Analog Scale and gathered patient preferences regarding their overall treatment experiences.

METHODS

The clinical study received approval from the Research and Ethics Committee and is registered with the Clinical Trials Registry - India (CTRI) [Registration number: CTRI/2017/09/009873].

It utilized a randomized, double-blind (for both patients and evaluators), split-mouth design, with each quadrant of the mouth receiving a different depigmentation technique. Quadrant allocation was determined through random drawing using Microsoft Excel. A total of 51 patients were screened for inclusion and exclusion criteria related to gingival pigmentation, measured using the Dummet Oral Pigmentation Index (DOPI) [8] scoring system. Ultimately, 20 patients (13 females and 7 males, ages 20-35) with a DOPI score of 2 or higher were included. Exclusion criteria included systemic diseases contraindicating periodontal surgery, untreated periodontal or pulpal diseases, dentinal hypersensitivity, pathological hyperpigmentation, chronic smokers, and pregnant or lactating women. A thorough intraoral examination and detailed medical history were conducted to rule out pathological gingival hyperpigmentation.

The primary outcome of the study was the clinical efficacy of the four depigmentation techniques, measured by changes in DOPI scores. Secondary outcomes included postoperative pain assessed through the Visual Analog Scale and patient preferences regarding their overall experiences. To ensure double blinding, clinical settings, operating areas, and instruments were standardized. All procedures were performed by a single trained clinician in a separate room from where evaluations for DOPI scores (at baseline and six months) and pain (at 24 hours and one week) took place. Randomization was coded alphanumerically to maintain blinding, and a statistician analysed coded data to conceal treatment identities.

CLINICAL PROCEDURE

Electro surgery: After adequate anesthesia, BONART ART-E1 Elextrosurgery unit (J02887), Bionart Medical Technology Inc were used for gingival depigmentation. Needle and loop electrodes were used with light brushing strokes and the tip was kept in motion throughout. Prolonged repeated application of electrode to the tissues was avoided to prevent undesired tissue destruction (Figure 1). Patients from all the groups

were instructed to avoid eating hot, hard and spicy food for the first 24 h following the procedure. Antibiotics amoxicillin 500 mg thrice daily for 5 days and to start using 0.2% chlorhexidine gluconate mouth wash from next day, 12th hourly for 1 week.

Diode Laser: After obtaining adequate anesthesia, laser assisted depigmentation was performed using Indium Gallium Arsenide Phosphorous Diode Laser (InGaAsP, Epic™10, Biolase, USA) with strict adherence to safety measures according to manufacturer's instructions. Parameters such as energy output, and pulse duration, were determined prior to the initiation of the procedure. The InGaAsP diode laser (940nm) was set at 2 to 4 W power and tissue ablation was performed with short light paint brush strokes in a horizontal direction to remove the epithelial lining and expose connective tissue bed in a contact, continuous wave mode (Figure 2).

Rotary: After obtaining adequate anesthesia, Gingival depigmentation was carried out using high speed hand piece with a large size flame shaped diamond bur in feather, light brushing strokes supplemented with continuous saline irrigation to remove the pigmented layer and expose smooth and uniform connective tissue bed. Small sized burs were avoided as it has a tendency to make small pits in the area to be corrected. Care was taken to see that all remnants of the pigment layer are removed and the surgical area was covered with a periodontal dressing for a period of 1 week (Figure 3).

Scalpel technique: After obtaining adequate anesthesia, partial thickness flap was raised using bard parker blade number 11/15 from marginal gingiva to mucogingival junction to excise pigmented epithelium completely and connective tissue bed was exposed. The exposed connective tissue was carefully examined and any remaining tissue tags was removed using surgical scissors. Bleeding was controlled using a pressure pack and once hemostasis was achieved, the surgical site was covered by periodontal dressing for a period of 1 week (Figure 4).

Clinical Assessment Dummett oral pigmentation index [8] (DOPI): Based on DOPI scores the intensity of pigmentation was measured at baseline and 6 months postoperatively. 0 = pink tissue (no clinical pigmentation); 1 = mild light brown tissue (mild clinical pigmentation); 2 = medium brown or mixed brown and pink tissue (moderate clinical pigmentation); or 3 = deep brown/ blue–black tissue (heavy clinical pigmentation).

Evaluation of pain response [9,10]**:**

From all the four groups were asked to define the level of pain and discomfort experienced with respective treatment mode by using the Visual Analog Scale (VAS). Pain was assessed on a 10cm horizontal, continuous interval scale with the left endpoint marked 'no pain' and the right endpoint marked 'severe pain'. The patients were asked to mark to according to the level of pain. Scores were calculated as follows: 0 = no pain; 0.1 to 3.0 cm = slight pain; 3.1 to 6.0 cm = moderate pain; 6.1 to 10 cm = severe pain. Pain levels were evaluated at 24 hours and 1 week post-operatively. Each patient was given a separate single assessment sheet for all three time periods so that the patients are not encouraged to refer to the previous VAS markings.

Evaluation of clinical outcome of depigmentation: [13]

Subjects from all the four groups were followed up at a regular interval, for a period of six months. Clinical examination to check for any signs of re-pigmentation was done according to Dummett-Gupta Oral Pigmentation Index scoring criteria given by Dummett C.O. in 1964.

Patient perception of the treatment.

At the day1 and 6 months' postoperative visit patients were asked about comfort during treatment and opinion regarding the overall esthetic outcome respectively. Accordingly, patients were asked to identify the preferred modality.

Statistical analysis

Data analyses were performed using statistical software. To test the statistical significance of difference of quantitative variables, one-way analysis of variance (ANOVA) test with the necessary Bonferroni correction for multiple comparisons was performed. Paired t test was used to test the statistical significance of difference between the baseline and 6-month parameters. P <0.005 was considered statistically significant. All the hypotheses were formulated using two-tailed alternatives against each null hypothesis.

Results

Visual analogue scale score:

The mean VAS scores obtained at 24 h and one week postoperatively for all the four groups (Cautery, Laser, Rotary and scalpel) are presented in table 1. The intragroup comparison of VAS scores of 24 h and one-week post op was made using paired t test and the results found that at1week postoperatively, there was a significant drop in the VAS for all four groups ($P < 0.001$), which was statistically significant. P values as obtained by ANOVA with Bonferroni's correction for multiple comparisons at the day 1 postoperative visit are represented in table 2. The results of intergroup comparison suggested that the laser treated group displayed least amount of pain, followed by cautery, rotary and then scalpel. Difference was statistically significant for cautery v/s scalpel, laser v/s rotary and laser v/s scalpel.

Table 1 Visual Analogue Score (Intra group comparison at 24 h and one-week post op)

Comparison of Clinical pigmentation at baseline and 6 Months

The intra group comparison for changes in area of pigmentation from baseline to 6 months postoperatively was done by paired t test. Mean values for intragroup comparison were calculated and the difference was found to be statistically significant ($P<0.0001$*) for all the four groups (Table 3). The intergroup comparison of effectiveness of depigmentation was as follows Laser ≥ Cautery ≥ Rotary ≥ Scalpel, however difference was not statistically significant ($P \geq 0.05$). Figure 5 depicts the comparison of clinical pigmentation at baseline and 6 months.

Preference of Treatment Procedure

Patients were asked rate each treatment modality of depigmentation in terms of amount of pain and overall esthetic outcome at the end of 6 months. A significantly higher number of patients preferred laser first (40%), followed by rotary (25%) surgical stripping (20%) and cautery (15%).

Discussion

The present study evaluated and compared four gingival depigmentation techniques: surgical stripping, rotary, electrocautery, and diode laser. Clinical outcomes were assessed based on pain perception at 24 hours and one week postoperatively using Visual Analog Scale (VAS) scores, changes in the Dummet Oral Pigmentation Index (DOPI) scores from baseline to six months, and patient preferences based on overall experience.

VAS results indicated that the laser treatment resulted in the least pain, followed by electrocautery, scalpel, and rotary methods. The minimal pain experienced in the laser group is attributed to its disruption of the Na+-K+ pump and the ablation of nerve endings due to protein coagulum formation. [11] Electrocautery also creates a protein coagulum, acting as a biological dressing that reduces pain. In contrast, surgical stripping and rotary procedures leave raw, bleeding surfaces with exposed nerve endings, leading to increased postoperative pain. These findings are consistent with previous studies, showing that lasers provide analgesic benefits that enhance patient acceptance compared to traditional methods. [13]

One-week post-treatment, healing was satisfactory in all groups, except for a slight delay in the electrocautery group. Scalpel and rotary techniques expose the connective tissue bed and depend on tactile sensation, allowing for minimized tissue penetration and wound size. Diode lasers (810 nm GaAlAs and 980 nm InGaAsP) penetrate deeply due to low water absorption, effectively targeting hemoglobin and pigmented tissue, which promotes faster healing. [12,14] These lasers enable controlled cutting with limited necrosis, whereas electrocautery risks damage to surrounding tissues, potentially leading to delayed healing. [9] The findings align with previous studies by Shalu Chandna et al. and Bhusari et al. [15, 16]

After six months, 10% of the laser-treated quadrants showed mild clinical re-pigmentation (DOPI score of 1), compared to 15% in the electrocautery group, 25% in the rotary group, and 30% in the scalpel group, all considered aesthetically acceptable.

The findings of the present study are in comparison with by previous studies by MB Murthy et al. [17] Overall, at Laser and electrocautery group displayed minimal gingival re-pigmentation compared to scalpel and rotary technique. This can be explained by their ability to thermally damage the melanocytes. [18] On the other hand, though surgical stripping or rotary method offers no risk of thermal damage to the underlying structures, they are associated with higher rates of gingival re-pigmentation owing to incomplete removal of hyper pigmented tissue. [19]

Patient ratings indicated a preference for the laser technique, which was favored for minimal pain, shorter operating time, and less bleeding. Electrocautery, while providing good aesthetic outcomes, had drawbacks such as unpleasant odors and delayed healing. The split-mouth design of the study reduced variability and required fewer subjects compared to parallel group designs. [20] Overall, the study concluded that laser depigmentation is the most effective method, although further long-term studies with larger sample sizes and additional clinical parameters are necessary to validate these findings.

Conclusion

Despite the limitations of this study, laser treatment emerged as the most effective modality, offering optimal aesthetics, minimal postoperative re-pigmentation, and higher patient acceptance compared to electrocautery, scalpel, and rotary techniques. However, further large-scale multicentric studies with larger sample sizes are necessary to validate these findings.

Figure legends:

Figure 1: CONSORT flow diagram

Figure 2- Electrocautery depigmentation a) preoperative view b) intra-operative c)immediate post-operative d) one-week post-operative e) six-month post-operative image.

Figure 3- Laser depigmentation a) preoperative view b) intra-operative c) immediate Postoperative d) one-week post-operative e) six-month post-operative image.

Figure 4- Rotary depigmentation a) preoperative view b) intra-operative c) immediate Postoperative d) one-week post-operative e) six-month post-operative image.

Figure 5- Scalpel depigmentation a) preoperative view b) intra-operative c) immediate Postoperative d) one-week post-operative e) six-month post-operative image.

List of abbreviations:

1. VAS: Visual analogue scale
2. DOPI: Dummet Oral Pigmentation Index
3. InGaAsP: Indium Gallium Arsenide Phosphorous Diode Laser

Declarations" Ethics approval and consent to participate: Ethical clearance was obtained by Research and Ethics Committee and the trial is registered at Clinical Trials Registry - India (CTRI) [Registration number: CTRI/2017/09/009873]. Informed consent from the participants was obtained before initiating the treatment procedures.

Consent for publication: The patients were informed that the intraoral images of the surgical area would be utilized for scientific communications, while maintaining the confidentiality of the patient (these points were included in the informed consent).

Availability of data and material: The datasets generated and analysed during the current study is available from the corresponding author on reasonable request.

Funding: Authors did not receive funds for the study.

Acknowledgments: Not Applicable

Conflicts of interest: There are no conflicts of interest

TABLES

	Cautery		Laser		Rotary		Scalpel	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
24 h post op	3.38	1.880649	3.45	1.234376	5.35	2.084403	5.95	2.089447
1week post op	0	0	0	0	0	0	0	0
P value	P<0.0001*		P<0.0001*		P<0.0001*		P<0.0001*	

*Denotes significant difference

Table 2 Visual Analogue Scale (Inter group comparison at 24 h)

Cautery VS Laser	Cautery VS Rotary	Cautery VS Scalpel	Laser VS Rotary	Laser VS Scalpel	Rotary VS Scalpel
P ≥ 0.05	P ≥ 0.05	P<0.0001*	P<0.0001*	P<0.0001*	P ≥ 0.05

*Denotes significant difference

Table 3 Dummett oral pigmentation index (Intra group comparison at baseline and 6 months' post op)

	Cautery		Laser		Rotary		Scalpel	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Baseline	2.55	0.51	2.6	0.50	2.65	0.48	2.7	0.47
6 months	0.15	0.36	0.1	0.30	0.25	0.44	0.35	0.48
P value	P<0.0001*		P<0.0001*		P<0.0001*		P<0.0001*	

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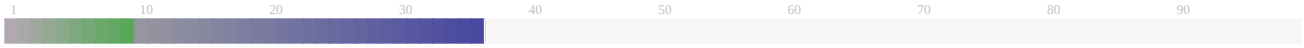

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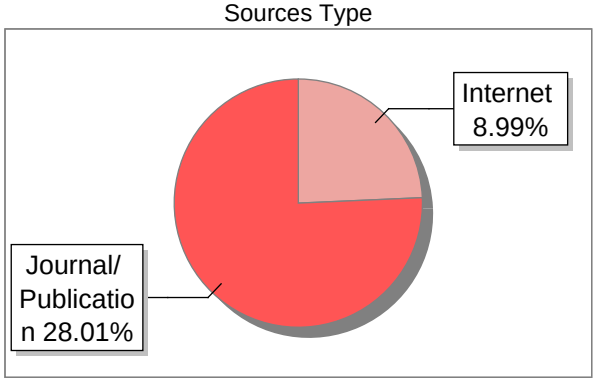

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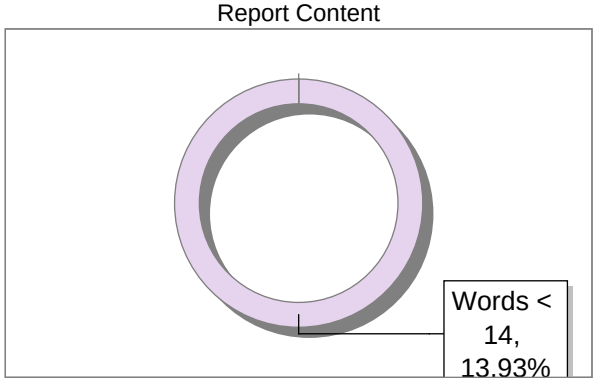

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RESULTS

Visual analogue scale score

The mean VAS scores obtained at 24 h and one week postoperatively for all the four groups (Cautery, Laser, Rotary and scalpel) are presented in table 1. The intragroup comparison of VAS scores of 24 h and one-week post op was made using paired t test and the results found that at1week postoperatively, there was a significant drop in the VAS for all four groups (P < 0.001), which was statistically significant. P values as obtained by ANOVA with Bonferroni's correction for multiple comparisons at the day 1 postoperative visit are represented in table 2. The results of intergroup comparison suggested that the laser treated group displayed least amount of pain, followed by cautery, rotary and then scalpel. Difference was statistically significant for cautery v/s scalpel, laser v/s rotary and laser v/s scalpel.

Table 1 Visual Analogue Score (Intra group comparison at 24 h and one-week post op)

Comparison of Clinical pigmentation at baseline and 6 Months

The intra group comparison for changes in area of pigmentation from baseline to 6 months postoperatively was done by paired t test. Mean values for intragroup comparison were calculated and the difference was found to be statistically significant ($P<0.0001^*$) for all the four groups (Table 3). The intergroup comparison of effectiveness of depigmentation was as follows Laser ≥ Cautery ≥ Rotary ≥ Scalpel, however difference was not statistically significant ($P \geq 0.05$). Figure 5 depicts the comparison of clinical pigmentation at baseline and 6 months.

Preference of Treatment Procedure

Patients were asked rate each treatment modality of depigmentation in terms of amount of pain and overall esthetic outcome at the end of 6 months. A significantly higher number of patients preferred laser first (40%), followed by rotary (25%) surgical stripping (20%) and cautery (15%).

Discussion

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The present study evaluated and compared four gingival depigmentation techniques: surgical stripping, rotary, electrocautery, and diode laser. Clinical outcomes were assessed based on pain perception at 24 hours and one week postoperatively using Visual Analog Scale (VAS) scores, changes in the Dummet Oral Pigmentation Index (DOPI) scores from baseline to six months, and patient preferences based on overall experience.

VAS results indicated that the laser treatment resulted in the least pain, followed by electrocautery, scalpel, and rotary methods. The minimal pain experienced in the laser group is attributed to its disruption of the Na+-K+ pump and the ablation of nerve endings due to protein coagulum formation. [11] Electrocautery also creates a protein coagulum, acting as a biological dressing that reduces pain. In contrast, surgical stripping and rotary procedures leave raw, bleeding surfaces with exposed nerve endings, leading to increased postoperative pain. These findings are consistent with previous studies, showing that lasers provide analgesic benefits that enhance patient acceptance compared to traditional methods. [13]

One-week post-treatment, healing was satisfactory in all groups, except for a slight delay in the electrocautery group. Scalpel and rotary techniques expose the connective tissue bed and depend on tactile sensation, allowing for minimized tissue penetration and wound size. Diode lasers (810 nm GaAlAs and 980 nm InGaAsP) penetrate deeply due to low water absorption, effectively targeting hemoglobin and pigmented tissue, which promotes faster healing. [12,14] These lasers enable controlled cutting with limited necrosis, whereas electrocautery risks

damage to surrounding tissues, potentially leading to delayed healing. [9] The findings align with previous studies by Shalu Chandna et al. and Bhusari et al. [15, 16]

After six months, 10% of the laser-treated quadrants showed mild clinical re-pigmentation (DOPI score of 1), compared to 15% in the electrocautery group, 25% in the rotary group, and 30% in the scalpel group, all considered aesthetically acceptable.

The findings of the present study are in comparison with by previous studies by MB Murthy et al. [17] Overall, at Laser and electrocautery group displayed minimal gingival re-pigmentation compared to scalpel and rotary technique. This can be explained by their ability to thermally damage the melanocytes. [18] On the other hand, though surgical stripping or rotary method offers no risk of thermal damage to the underlying structures, they are associated with higher rates of gingival re-pigmentation owing to incomplete removal of hyper pigmented tissue. [19]

Patient ratings indicated a preference for the laser technique, which was favored for minimal pain, shorter operating time, and less bleeding. Electrocautery, while providing good aesthetic outcomes, had drawbacks such as unpleasant odors and delayed healing. The split-mouth design of the study reduced variability and required fewer subjects compared to parallel group designs. [20] Overall, the study concluded that laser depigmentation is the most effective method, although further long-term studies with larger sample sizes and additional clinical parameters are necessary to validate these findings.

Bottom of Form

Conclusion

Despite the limitations of this study, laser treatment emerged as the most effective modality, offering optimal aesthetics, minimal postoperative re-pigmentation, and higher patient acceptance compared to electrocautery, scalpel, and rotary techniques. However, further large-scale multicentric studies with larger sample sizes are necessary to validate these findings.

Figure legends:

Figure 1: CONSORT flow diagram

Figure 2- Electrocautery depigmentation a) preoperative view b) intra-operative

c)immediate post-operative d) one-week post-operative e) six-month post-operative image.

Figure 3- Laser depigmentation a) preoperative view b) intra-operative c) immediate Postoperative d) one-week post-operative e) six-month post-operative image.

Figure 4- Rotary depigmentation a) preoperative view b) intra-operative c) immediate Postoperative d) one-week post-operative e) six-month post-operative image.

Figure 5- Scalpel depigmentation a) preoperative view b) intra-operative c) immediate Postoperative d) one-week post-operative e) six-month post-operative image.

List of abbreviations:

1. VAS: Visual analogue scale
2. DOPI: Dummet Oral Pigmentation Index
3. InGaAsP: Indium Gallium Arsenide Phosphorous Diode Laser

Declarations" Ethics approval and consent to participate: Ethical clearance was obtained by Research and Ethics Committee and the trial is registered at Clinical Trials Registry - India (CTRI) [Registration number: CTRI/2017/09/009873]. Informed consent from the participants was obtained before initiating the treatment procedures.

Consent for publication: The patients were informed that the intraoral images of the surgical area would be utilized for scientific communications, while maintaining the confidentiality of the patient (these points were included in the informed consent).

Availability of data and material: The datasets generated and analysed during the current study is available from the corresponding author on reasonable request.

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Acknowledgments: Not Applicable

Conflicts of interest: There are no conflicts of interest

TABLES

	Cautery		Laser		Rotary		Scalpel	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
24 h post op	3.8	1.880649	3.45	1.234376	5.35	2.084403	5.95	2.089447
1week post op	0	0	0	0	0	0	0	0
P value	P<0.0001*		P<0.0001*		P<0.0001*		P<0.0001*	

*Denotes significant difference

Table 2 Visual Analogue Scale (Inter group comparison at 24 h)

Cautery VS Laser	Cautery VS Rotary	Cautery VS Scalpel	Laser VS Rotary	Laser VS Scalpel	Rotary VS Scalpel
P ≥ 0.05	P ≥ 0.05	P<0.0001*	P<0.0001*	P<0.0001*	P ≥ 0.05

*Denotes significant difference

Table 3 Dummett oral pigmentation index (Intra group comparison at baseline and 6 months' post op)

*Denotes significant difference

	Cautery		Laser		Rotary		Scalpel	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Baseline	2.55	0.51	2.6	0.50	2.65	0.48	2.7	0.47
6 months	0.15	0.36	0.1	0.30	0.25	0.44	0.35	0.48
P value	P<0.0001*		P<0.0001*		P<0.0001*		P<0.0001*	

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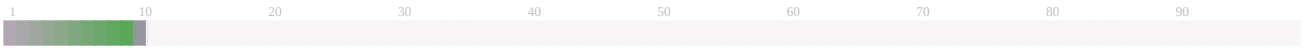

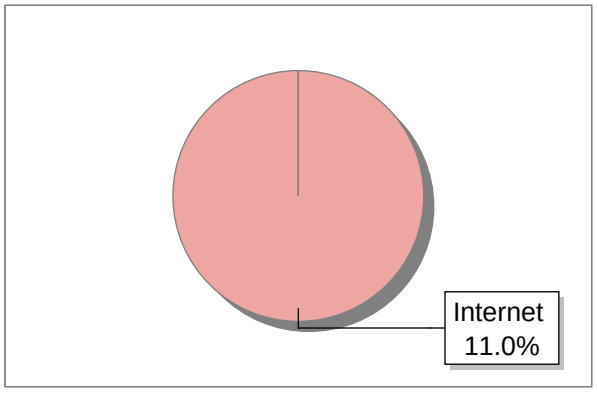

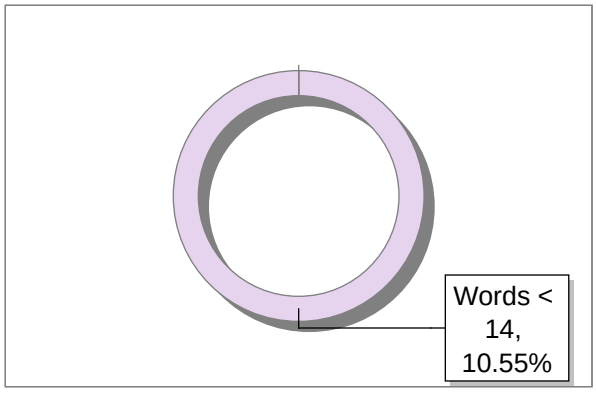

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Title of the article: Comparative evaluation of cytotoxic effect of different intracanal medicaments on the stem cells of apical papilla : A cell culture study

Abstract:

Background

Regenerative endodontics are biologically based procedures to replace damaged structures, including dentin and root structures, as well as cells of the pulp-dentin complex. Success of these regenerative procedures depends on the survival of the stem cells. Antibiotic pastes used for microbial elimination are not used at high concentration because of its potential toxicity to the stem cells.Also, their usage at lower concentration raises many concerns. Phytomedicines because of their good efficacy and lesser adverse effects have been used extensively. Carnosic acid is one such phytomedicine which has proven to have a good effect against degenerative diseases because of their good regenerative potential. Moreover, studies have shown carnosic acid having better disinfection capacity than triple antibiotic pastes (TAP) as intracanal medicament. However, its regenerative potential in endodontics is yet to be known. Therefore, this study aims to investigate the cytotoxicity on the SCAPs of carnosic acid on permanent human teeth in comparison with triple antibiotic paste.

Aim and objective

To evaluate and compare the cytotoxic effect of carnosic acid on stem cells from the apical papilla (SCAPs) of permanent human teeth

Methodology

Stem cells removed from immature teeth were cultivated. After cultivation and third cell passage, modified TAP (metronidazole, ciprofloxacin, and clindamycin) and carnosic acid were placed in cell culture medium. After 1 and 3 days, cell viability in the culture medium was assessed using MTT method ([4,5-dimethylthiazol-2-yl]-2,5-diphenyltetrazolium bromide) and ELISA (Enzyme-linked immunosorbent assay).

Results

Carnosic acid has shown higher absorbance value and hence is less cytotoxic to stem cells than mTAP.

Conclusion

Within the limitations of the current study, it can be concluded that Carnosic acid has a lower cytotoxic effect on the SCAPs than mTAP. Hence, its use as ICM in regenerative endodontics looks promising. However, further clinical studies are required.

Keywords

Carnosic acid, intracanal medicaments, modified triple antibiotic paste, regeneration, stem cells

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Introduction:

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Regenerative endodontics is biologically based procedure intended to replace damaged structures, including dentin and root structures, as well as cells of the pulp-dentin complex and was first introduced by Dr Nygaard Ostby in 1961.[1] Three components of regenerative endodontics include stem cells, scaffold and growth factors.[2] The goals of this procedure comprises symptom elimination and healing, increasing root length and thickness and positive response to vitality testing.[2] Given that the reduction of microbial load in regenerative endodontics is achieved by proper irrigation and dressing, the selection of a proper material might be a critical factor for attaining effective canal disinfection, and the balance between the antimicrobial effect of chemicals and their inertness to stem cells.[3] Calcium hydroxide has been routinely used as intracanal dressing in the regenerative procedure.[4] Due to the polymicrobial nature of the root canal niche, antibiotic paste combinations were tried.[4]

Triple antibiotic paste consisted of metronidazole, minocycline and ciprofloxacin.[1] But the presence of minocycline poses the risk of staining and discoloration of the tooth.[5] Cefaclor, clarithromycin, clindamycin, amoxicillin and other antibiotics have been tried to overcome the problem of discoloration.[5] But, allergic potential, host immune resistance and concentration dependent survival of stem cells continued to be some of the challenges.The cytotoxic effect of TAP on primary pulp stem cells of deciduous teeth has also been reported. Also, there are concerns about the destructive effect of mTAP on the stem cells from the apical papilla (SCAPs) of immature permanent teeth.[4]

Hence, other phytochemicals such as carnosic acid obtained from the leaves of rosemary plant (Salvia rosmarinus) leaves which have both antimicrobial and antioxidant properties as suggested by Neito *et al*.[6] This material has shown good regenerative potential and low tissue toxicity as suggested by Mirza *et al*.[7]

However, there are not many studies comparing the cytotoxicity of carnosic acid and TAP on long term usage as ICM in regenerative procedures. Therefore, this study was designed to assess and compare the cytotoxicity of modified Triple antibiotic paste (mTAP) and Carnosic acid (CA) on Stem

cells of apical papilla (SCAPs) of extracted intact human mandibular third molars.

Subjects and Methods:

SAMPLE SELECTION

After obtaining informed consent from the patients, four healthy immature third molars with open apex (more than 1.5 mm diameter) extracted for orthodontic purpose in the age group of 17-21 years with no history of systemic diseases were extracted to obtain SCAPs. Teeth with caries, previous restoration, endodontic treatment, periapical pathosis and fully developed roots were excluded. Two to five days before tooth extraction, the patients underwent dental prophylaxis, and on the day of extraction, the patients received tooth prophylaxis as well. Before and after anaesthetic injection, patients were asked to rinse their mouth with 0.2% chlorhexidine mouthwash for 30 seconds.

HARVESTING OF SCAPs AND CULTURE

Teeth were extracted with sterile instruments and were immediately placed in sterile phosphate buffered saline (PBS) (™ Media). SCAPs were then isolated from the apical papilla tissue of incompletely developed tooth using sterile tweezers and placed in a digestive solution containing trypsin. It was made sure to change the cell culture medium every two days.Cell passage was performed after cell density in cell colonies reached about 80-70%. Third passage cells were used to assess the cytotoxicity of the drugs. Flow cytometric analysis was performed in the third passage to evaluate the nature of SCAPs and the expression of surface markers.

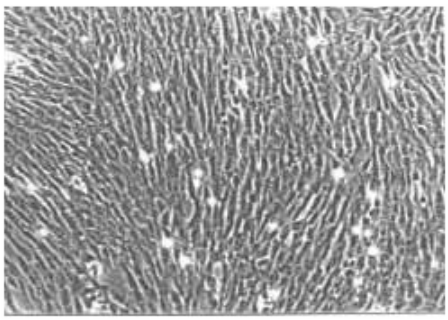

Fig 1- Cell density

PREPARATION OF ANTIBIOTICS

Antibiotic combination consisted of metronidazole (400 mg), ciprofloxacin (500 mg) and clindamycin (500 mg). Enteric coating of these medicines were removed and then crushed with the help of a clean mortar and pestle. Each antibiotic was weighed by a digital scale with an accuracy of 0.000g. Then 50 µg/ml of each medication was prepared and equal proportions of each medication in the prepared concentration was mixed for mTAP. >91% CA (Alpspure Lifesciences Private Ltd) was the other agent used. Solvent used for antibiotics was the cell culture medium. The prepared medications were added to cell culture plates. 24 and 72 hours later, cell viability in the culture medium was evaluated using the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide (MTT) method.

Group I : SCAPs exposed to a combination of mTAP over a period of 24 and 72 hours

Group II : SCAPs exposed to CA over a period of 24 and 72 hours

DATA ANALYSIS

Sample size of 60 was established pertaining to 60 wells in the microtiter plate. Absorbance value of each well for both the groups was measured through ELISA reader (Rayto, RT-2100C).

Statistical analysis was done using SPSS statistical software (version 26.0 IBM Corp.). Statistical tests such as Levene's test for equality of variances and independent t test for equality of means was calculated. The significance level in all tests was kept <0.05.

RESULTS

Group	N	Max (24 hrs)	Min (24 hrs)	Mean	Std. Deviation	p value
CA	60	0.05761	0.04736	0.05249	0.005124	<0.000001
TAP	60	0.04572	0.03802	0.04187	0.003851	

Group	N	Max (48 hrs)	Min (48hrs)	Mean	Std. Deviation	p value
CA	60	0.06043	0.05020	0.05532	0.005116	<0.000001
TAP	60	0.04653	0.03918	0.04286	0.003671	

Table 1 - Absorbance values of CA and TAP group at 24 and 48 hours interval

Absorbance values of the carnosic acid group are higher than the mTAP group both at 24 hours and 48 hours. Hence, CA is less cytotoxic on stem cells of apical papilla tha mTAP as an intracanal medicament.

Fig 2 - Graphical representation of results

DISCUSSION

Restoration of tissue continuity by exactly similar tissues without loss of original architecture & function is known as regeneration.[8] Regenerative endodontics aims at regenerating dentin and pulp like tissue.[2] Teeth with necrotic pulp and immature apex, which do not require post/core were indicated for the procedure.[1] Following proper irrigation protocol and disinfection strategy is very crucial; incomplete eradication of the bacterial load results in the change in stem cells phenotypic expression from dentinogenic to osteogenic type.[9]

Calcium hydroxide intracanal medication upregulates phosphorylated extracellular signal related kinases only at low conc. At higher concentrations, it has shown to affect SCAPs attachment. Different antibiotic combinations have also been tried and tested and have given quite promising results. But the development of resistant bacterial strains, allergic reactions and damage to DNA of SCs is quite concerning and points to look forward towards an alternative.[4]

Carnosic acid looks to be one such alternative in this field. A study by Loussouarn *et al* showed the antioxidant property of carnosic acid is due to the polyphenols present in it.[10] 4 phenolic hydrogen(-OH) inhibits the lipid peroxidation, fosters cell proliferation, mitosis and differentiation resulting in upregulation of the signalling pathway. The antimicrobial action is by interaction with the cell membrane resulting in leakage of cellular components. They interact with the cell membrane, causing change in the genetic material and nutrients, altering the transport of electrons, leakage of cellular components and change in fatty acid. In addition, it also produces an interaction with the membrane of proteins resulting in loss of membrane functionality and its structure.[10] Crozier *et al* reported CA to have anti-allergic potential. It inhibits allergen-induced phase responses including Ca^{2+} mobilization, ROS production and subsequent degranulation and late responses by modulation of tyrosine kinase Syk and downstream effectors TAK1 (Ser412) and Akt (Ser473) as well as NFκB signaling.[11] A study by Mirza *et al* property of carnosic acid to transcript cytoprotective genes.[7] According to

Zampini *et al*. it has a lower minimum inhibitory concentration (MIC) and is effective against multidrug resistant bacteria by acting as an effective pump modulator.[12]

The pluripotency of CA is through the upregulation of the KEGG pathway as described by Ferdousi *et al*. PDGFRB and ROCK1 upregulation is responsible for angiogenic growth and MAPK & IKBKB pathway being responsible for its ability for neo-neuronal growth.[13]

Dessai *et al* reported carnosic acid as an intracanal medicament performs better than triple antibiotic paste and calcium hydroxide to eradicate Enterococcus faecalis from root canal pointing towards its better antimicrobial efficacy.[14] The concentration responsible for antimicrobial action of CA is as low as 6.25-12.5 µM as reported by Othman *et al*.[15]

Mirza *et al* stated that Carnosic acid exerts a neuroprotective role that may serve to strategize novel therapeutic approaches for debilitating neurodegenerative disorders by regeneration.[7] Also, Lou *et al* reported rosemary to have the potential to stimulate hepatocyte proliferation leading to liver regeneration.[16]

The results obtained in this study shows a higher absorbance value for carnosic acid both at 24 hours and at 48 hours interval which is 0.05249 and 0.05532 respectively. Whereas, mTAP shows absorbance value of 0.04187 and 0.04286 at 24 and 48 hours respectively. This suggests the lower cytotoxic levels in the CA group and higher percentage of cell survival and is statistically significant. The reasons associated are the good antimicrobial efficacy at a lower concentration. This low concentration helped in stem cell survival, attachment, differentiation and proliferation. It is pluripotent in nature. Antibiotics have shown detrimental effects on stem cells, whereas carnosic acid has helped in the survival of those SCs.

CONCLUSION

Within the limitations of the current study, it can be concluded that Carnosic acid has a lower cytotoxic effect on the SCAPs than mTAP. Hence, its use as ICM in regenerative endodontics looks promising. However, further clinical studies are required.

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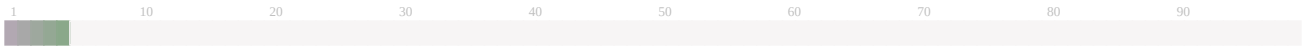

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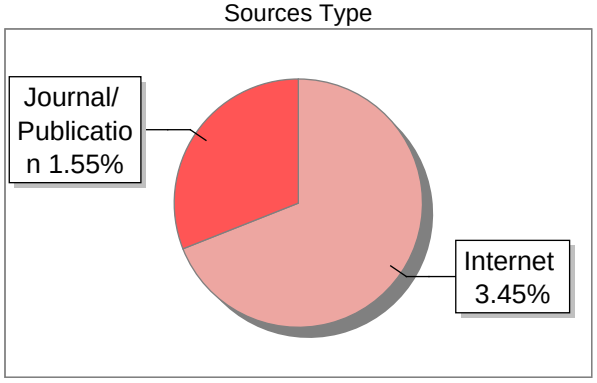

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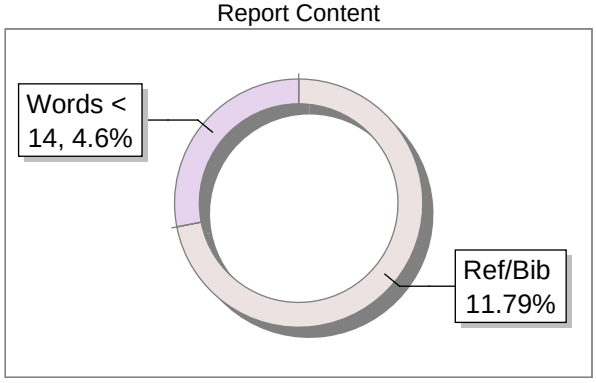

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Treatment of Skeletal Class II malocclusion with Obstructive Sleep Apnoea Using Orthodontic-Surgical Approach

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Abstract:

In the treatment of skeletal class 2 retrognathic mandible, the airway should be considered for the progress and outcome of the treatment, here we present a case of 30 year old male patient with class II skeletal base with maxillary and mandibular dentoalveolar protrusion, with crowding in the maxillary and mandibular arch, increased maxillary mandibular plane angle and increased lower anterior facial height, he had convex profile with potentially incompetent lips .He had nocturnal choking, difficulty in breathing while lying down and snoring suggestive of obstructive sleep apnoea. Bilateral saggital split osteotomy (BSSO) advancement of 8mm and genioplasty of 4mm was done. The post operative orthodontic treatment included settling the bite, monitoring the relapse, and managing the dental space for futu

Keywords: Obstructive sleep apnoea(OSA); Class 2 malocclusion; hyperdivergent facial type

INTRODUCTION

Approximately 14.6% of Indians have class II malocclusion. This circumstance be brought on by a mandibular deficiency or maxillary excess. The dentoalveolar position in growing patients may change if functional appliances are used and cause remodeling of the condyles. In Class II adults with skeletal deformities, Orthodontic camouflage or surgical-orthodontic treatment are the standard methods for treating malocclusion. On the other hand, dental compensation is utilized in orthodontic camouflage therapy to conceal the skeletal disparity. Additionally, the skeletal deformity is corrected with jaw osteotomies that rotate counterclockwise and orthodontic detailing in the surgical-orthodontic option.

Because surgical-orthodontic therapy promotes greater advancement of the mandible and chin and less retraction of the upper teeth, it is more successful in preserving the upper lip profile. As a result, patients with a more severe sagittal jawbone discrepancy—particularly those with mandible retrusion—typically undergo it. Notwithstanding the issues with oral function and appearance, patients with retrusive mandibles—particularly those with profiles resembling birds—need to have their airway health taken into account. When an airway is narrow, a lateral cephalometric film evaluation is necessary.

When the airway is significantly constricted, the AHI Index and polysomnography (PSG) could be necessary to identify if obstructive sleep apnea (OSA) is present.

A case report demonstrated the correction of skeletal Class II malocclusion with retrusive mandible.

CASE REPORT

A male patient named Paged 30 years came to the department with chief complaint of forwardly placed upper front teeth, reduced chin size & difficultyin breathing while lying down,nocturnal choking & snoring Familial malocclusion History:-His father has similar dental problems. He is internally motivated with positive attitude towards orthodontic treatment. On physical examination , he is moderately built with 168 cms in height weighs 64 kgs withmesomorphic body type.Patient had history of restless sleep ,Nocturnal choking & Witnessed apnea during sleep. Patient has undergone Sleep Studywith Somno Touch Resp.

CLINICAL EXAMINATION

Extraoral Examination

There was no evidence of facial asymmetry in the frontal view. The individual had obvious lip incompetence accompanied by a prominent show of upper teeth. His upper

dental midline was aligned with facial midline,mesocephalic head , mesoproscopic face , potentially incompetent lips ,consonant smile , incisorexposure on smile 7mm width ,no gingival exposure on smiling and a mesorrhine nose.

In profile view, Convex facial profile , vertical FMPA , Increased lower facial height ,Straight nasal dorsum ,Average nasolabial angle , Negative lipstep , Deep mentolabial sulcus , Receeding chin ,double chin appearance.

Intraoral Examination

Because teeth 35, 36, and 46 were missing, the molar relationship could not be established. The canine relationship and buccal segment were Class II on the right, end on left side with a deep bite and increased overjet (the overjet measured 9mm, while the overbite measured 6mm) . 15, 18, 26, 32, 36, 42, and 46 of his teeth were teeth 16 and 47 are mesially tilted. A palatal cross bite on tooth 27 was noted. His lower dental arch was ovoid and symmetric, while his upper arch was tapered and symmetric. Overall, there was satisfactory periodontal health. His missing teeth caused spacing in his lower and upper arch.

SUMMARY OF RESPIRATORY ANALYSIS

Increased Respiratory Effort-Related Arousals (RERA): The individual experiences a higher frequency of Respiratory Effort-Related Arousals, indicating disruptions in sleep due to respiratory events.

Desaturation to 85%: Oxygen saturation levels drop to 85%, suggesting significant episodes of oxygen desaturation during sleep. This is a critical concern as it may lead to hypoxemia.

Snoring: The presence of snoring indicates potential airway obstruction or restriction during sleep, contributing to respiratory disturbances.

Radiographic findings

PERMANENT DENTITION,MISSING 36,35,46 RC treated 17 Restored 26

Cephalometric Findings

1. The patient exhibits a Class II skeletal jaw base.
2. An increased mandibular plane angle is observed, measuring at -42 degrees on average, compared to the normal average of 28 degrees.
3. A vertical growth pattern is evident in the patient's facial structure.
4. There is an increased lower anterior facial height.
5. The patient presents with a divergent jaw bas

6. Proclination of the upper incisors to the sella-nasion (SN) plane is observed.
7. Both the upper and lower pharyngeal airways are reduced in size.
8. The upper pharynx measures at -14 mm (normal range: 15-20 mm).
9. The lower pharynx measures at -6 mm (normal range: 11-14 mm).
10. A decrease in mandibular corpus size by 6 mm is noted.
11. The patient exhibits an obtuse chin-throat angle

Sagittal Relation:

1. The patient exhibits a skeletal Class II jaw base.

2. The ANB angle is 7°, indicating a significant discrepancy between the maxilla and mandible positions.
3. The mandibular plane angle is 42°, suggesting a particular orientation of the jaw structures.
4. Points A and B on the FH plane are 16 mm apart.
5. The Wits appraisal measures 5 mm, indicating the degree of maxillary and mandibular discrepancy.
6. The facial angle is 76°, suggesting a retrusive lower jaw.
7. The AB Plane Angle is -11°, further indicating a retrusive lower jaw.
8. Schwarz analysis reveals a maxilla to mandible ratio of 2.14:2.86, signifying an increased maxilla and decreased mandible.
9. Maxillary size is decreased by 2.6 mm, and mandible size is decreased by 5 mm.

Vertical Relation:

10. The patient exhibits a vertical growth pattern, with the maxilla and mandible diverging anteriorly.
11. SN-GO-GN angle is 45°, indicating a vertical growth pattern.
12. FMA is 42°, contributing to the vertical growth pattern

13. The Jaraback Ratio is 61%, confirming a vertical growth pattern.
14. Y Axis N-S-GN is 80°, and Y Axis FH-S-GN is 74°.
15. Upper and lower gonial angles are 45° and 90°, respectively.
16. Basal plane angle is 43°.
17. The J Angle is 85°.
18. N-ANS measures 46 mm, indicating a decreased middle third of the face by 5 mm.
19. U1 to NF shows extruded incisors by 3 mm.
20. U6 – NF reveals extruded upper molars by 2 mm and intruded lower molars by 2 mm.

Soft Tissue Relation:

21. The patient has an average nasolabial angle.
22. A deep mentolabial sulcus is observed.
23. Upper lip thickness is 14 mm, with a basic upper lip thickness of 17 mm.
24. Lip strain is 3 mm.
25. Lower lip thickness is 14 mm, and lower lip length is 54 mm.

26. The soft tissue profile angle is 148°, indicative of a Class II soft tissue profile.
27. The total soft tissue profile angle is 124°, confirming a Class II profile.
28. The soft tissue facial angle is 79°, consistent with a Class II soft tissue profile.

Diagnosis:

29. Skeletally, the patient exhibits a Class II maxilla-mandibular relation with soft tissues matching.
30. A vertical growth pattern and increased lower anterior facial height.
31. Decreased mandibular corpus size is noted.
32. Divergent jaw bases are observed.
33. Dentally, there is a Class II incisor and canine relation, proclined upper incisors and lower incisors, and lower anterior crowding.
34. Increased overjet and overbite are evident.
35. Soft tissue features include a convex facial profile, average nasolabial angle, reduced chin thickness, protruded and incompetent lips, obtuse chin throat angle, double chin appearance, and a deep mentolabial sulcus.

PROBLEM LIST

Class II maxillo mandibular relation with convex facial profile,vertical growth pattern,incompetent & protruded lips d,ecreased upper & lower pharyngeal airway ,double chin appearance ,class II incisor & class II canine relation ,missing -46,36,35 , increased overjet & overbite and crowding in relation to upper & lower anteriors and proclined upper incisors.

AIMS AND OBJECTIVES OF TREATMENT

1. To correct skeletal class II base
2. To correct recessive mandible
3. To correct proclined upper and lower anteriors
4. To achieve ideal overjet and over bite
5. To prosthetic rehablitate -35
6. Achieve class I molar canine and incisor relation
7. To achieve a pleasing soft tissue profile
8. To achieve **ideal dimension of pharyngeal airway.**

TREATMENT PROGRESS

Levelling ,Aligning & Arch coordination-Upper :014 niti ,016 niti,018 niti,17x25 niti,19x25 niti,19x25 s.s

- Lower: 014 niti ,016 niti,018 niti,17x25 niti,19x25 niti,19x25 s.s and 018 AJW

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2.SURGICAL PHASE: • Surgical correction of class-2 by BSSO advancement surgery & Rotational genioplasty

POST SURGICAL CEPHALOMETRIC INTERPRETATION

The post surgical orthodontic treatment skeletal relationship of the patient remained unchanged.The MxMd plane angle changed

VARIABLE	PRETREATMENT	POST-SURGICAL
SNA	77	79
SNB	70	75
ANB	7	4
Wits appraisal	5mm	7mm
Upper incisor to SN	103 (proclined)	102
Lower incisor to mandibular plane angle	97(proclined)	100
Interincisal angle	111(proclined)	110
Maxillary mandibular planes angle	43(vertical growth)	44
Upper anterior face height	46mm	51mm
Lower anterior face height	75 mm	77 mm
Jarabak ratio	61.5	60
Lower incisor to APog line	+10 mm(protruded)	9 mm
Lower lip to Ricketts E Plane	+4 mm	4 mm

3.POST SURGICAL ORTHODONTICS

• Implant assisted Protraction of 47,48,37,38 during post surgical orthodontics to achieve bilateral class 1 molar relation

• Settling posterior occlusion. Prosthetic rehabilitation of 35 using FPD or implant. Retention- lingual fixed Retainer, removable retainer.

DISCUSSION

A large percentage of orthodontic patients have skeletal class II malocclusion. The only options for adults with skeletal class II are surgery or camouflage. Even though the primary reason these patients visit is for cosmetic purposes, a deficient mandible, which is an underlying craniofacial abnormality, frequently acts as a significant risk factor for sleep apnea or breathing disorders during sleep. The likelihood that airway issues will arise in the future and the impact of treatment on the airway should be taken into account when planning the treatment strategy.

The Sleep Questionnaire (FOSQ) is a screening tool used for diagnosis of sleep disorders related to breathing. This self-report measure was initially described by Weaver et al. to evaluate the effects of excessive sleep disorders on a variety of daily routine activities, including general activity level, attentiveness, general productivity, social behavior, and physical intimacy. hyperdiverse facial type with a profile resembling a bird's face. In neonates, congenital micrognathia frequently results in respiratory emergencies. Even though our patient's mandibular retrusion wasn't too severe, we still wanted to take care of his airway. For treating OSA, CPAP therapy is considered the gold standard. In carefully chosen patients, oral appliances such as mandibular advancement devices (MADs) can be used. In addition, candidate cases may be given consideration for soft tissue surgical procedures such as

adenotonsillectomy, nasal, palatal, and tongue surgeries. Specifically, maxillomandibular advancement (MMA) was the primary skeletal correction. Given the patient's profile and primary complaint, OGS is regarded as the primary treatment strategy in this case. Mandibular advancement was taken into consideration because it could enhance his airway volume and facial profile at the same time. The patient's airway space widened significantly overall. Stability during surgery is influenced by the direction of movement, the kind of fixation, the kind of surgical technique, and muscle adaptation. Proffit et al. state that when a patient has rigid internal fixation and their anterior facial height is maintained or increased, the maxilla tends to move upward, which keeps the mandible stable as it moves forward following surgery.

On the other hand, the anterior facial height was lowered during surgery. Within the following surgery, themaxilla rotated in a clockwise direction, and the mandible moved backward and the chin underwent significant remodeling. form. It showed significant surface remodeling and a mild surgical relapse. Patients with Class II malocclusion experience relapses of OGS in advancements greater than 10 mm. Furthermore, the surgery may be the cause of the relapse. According to certain research, the OGS correction of MPA is associated with elongation of the suprahyoid muscle and extension of the pterygomasseteric sling in patients with skeletal Class II malocclusion and high MPA. This may also increase the risk of surgical recurrence. The maxilla was impactioned and rotated counterclockwise as a result of the surgery. These modifications were comparable.

According to Proffit et al.'s findings, the posterior portion of the maxilla remained stable vertically during the first six weeks following the superior repositioning of the maxilla, while the maxilla's anterior portion may move downward. As a result, we presume that while recovering from surgery, even though an auxiliary appliance when theanterior incisor was not utilized, theintrusion was kept up by the continuous arch wire methodology. This condition's explanation could be that the bite force made an effort to keep the upper occlusal plane stationary level while the maxilla rotated clockwise to relapse. It is possible to conduct additional research in this area. In summary, the patient's initial status, could be the cause of the relapse pattern involving hyperdivergent craniofacial morphology and a smaller TMJ form. Another possible explanation is the fixation technique, the surgical design (more mandible advancement), and muscle acclimatization. The misaligned TMJ could pose a threat factor for

MMC's CCWR. When the craniofacial type first appeared, the VME, high MPA, and

Significant AP disparity was present at the same time. Antegonial notching is frequently discussed in relation to mandibular development and Development is one of the seven morphological markers used to forecast growth pattern of the mandible. According to Bjork and Skieller, the mandibular rotation that occurs during growth in reverse has an apex below the gonial angle, which results in a long face by increasing in concavity at the antegonial notch or a facial type that is hyperdivergent, similar to what we saw in our patient.
Greater lower back pain is correlated with a deep antegonial notch in the mandible border.
steeper MPA and AFH that match the patient's initial demonstration. A steeper MPA condition and lower AFH should have resulted in an AOB, however this didn't happen in the anterior region of the maxilla, lower and upper incisors, and the anteromedulla, resulting in VME with a gummy smile.

Overall, there is still room for improvement in a few areas, like the obvious notching at mandibular margin, a typical sagittal osteotomy side effect progression of the jaw. This might have happened as a result of the deep malposition of the lingual proximal segment or antegonial notch split, thin mandible, or poor surgical technique. This can be handled even more by another procedure involving lipofilling or bone grafts. An additional factor is that the lip posture was sagging at the bilateral cheilion, providing the patient with a frowny expression whenever he wasn't smiling. The muscle traction may have been the cause of this. During the mandibular advancement, the depressor anguli oris muscle, which originates from the external oblique line, may change in length and rotation in a counterclockwise direction.
The hyperactive state of the perioral muscle may cause a frowny expression on one's face. One could inject type A botulinum toxin to relax these muscles. Consulting with a plastic surgeon can help to alleviate this issue.
surgeon.

CONCLUSION

Because a retrusive mandible frequently causes airway problems, the airway condition needs to be taken into consideration for patients with skeletal Class II who have a retrognathic mandible in addition to esthetic and functional goals. Additionally, CBCT or an X-ray can be used to confirm the condylar anatomy and assess the likelihood of a relapse following Class II surgical-orthodontic treatment. It may be necessary to overcorrect mandibular advancement in order to make up for the airway patency and skeletal relapse.

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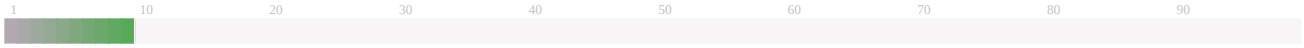

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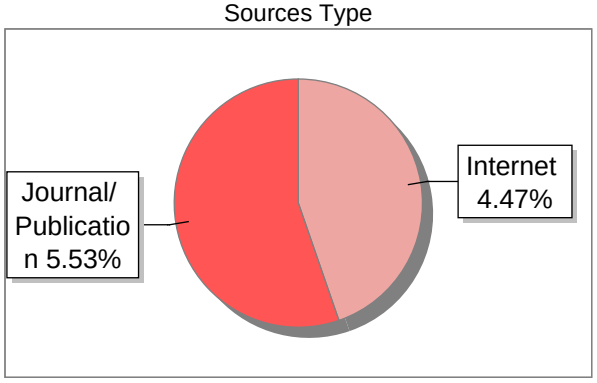

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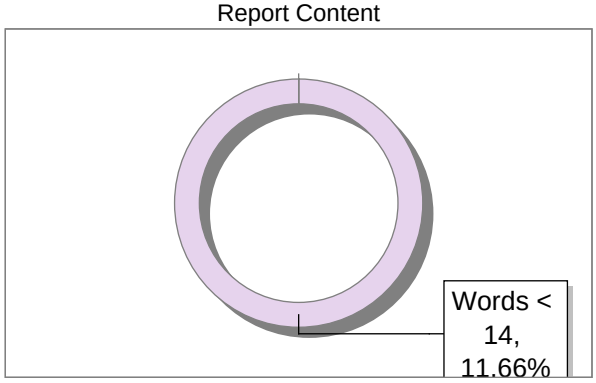

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INTRODUCTION

Advances in technology have greatly influenced the field of dentistry in recent times. The advent of nanotechnology is one such advance that has helped improve the properties of dental materials when incorporated into them. Since dental materials are placed within the oral cavity and are constantly in contact with saliva and water, exposed to temperature changes, masticatory forces and acidic substances consumed by the patient, wearing away of the material has always been a concern. There has thus, always been an interest in developing dental materials with improved lifespan in the oral cavity. Nanotechnology has helped greatly in moving towards achieving this. Various nanomaterials have been incorporated into dental materials to enhance their properties. Graphene is one such nanomaterial and its derivatives have attracted great attention, owing to their excellent physicochemical property, morphology, biocompatibility, multi-differentiation activity, and antimicrobial activity[1]. It is a carbon based nanomaterial consisting of two-dimensional sheets that are made up of sp^2 hybridized carbon atoms bonded together in hexagonal structures[2] .

BACKGROUND:

Graphene was first isolated in 2004 by Novoselov et al.[3], and it consists of two-dimensional sheets that are made up of sp^2 hybridized carbon atoms bonded together in hexagonal structures. It has unique structural, chemical and thermal properties which has led to its utilisation in various fields like biomedical, electronics, energy production, bimolecular sensors etc.

Graphene nanomaterial is available as ultrathin graphite, few layer graphene, graphene oxide[Go], reduced graphene oxide[rGo] and graphene nanosheets.[4] Graphene derivatives are widely applied in the dental fields of restorative materials, adhesives, cements, primers and many more because of properties such as biocompatibility, anti-microbial efficiency and excellent physico-mechanical properties. Pristine graphene - that is graphene in its original, pure, unoxidized form - enjoys superior properties to its oxidized counterpart, but pristine graphene isn't easy to come by and its lack of abundance has held back the development of graphene-based functional devices.[5]

As per literature, there are more than 2,942 studies related to graphene-based materials for dental applications[1]. This emerging research in regard to graphene seems promising and hence has prompted this review of literature with an intent towards evidence based application of graphene in dentistry.

Method of collecting data

Review is facilitated by literature search through online and offline modes, that provided us with 26 relevant publications in regard to graphene and its applications.

PROPERTIES OF GRAPHENE

BIOCOMPATABILITY

When used in dental materials, graphene is in constant contact with the oral tissues and saliva. It is thus essential for the material to be bio-compatible. Researchers have studied its biocompatibility in various studies. They have found various factors to be involved in determining its biocompatibility. Up to date, the affected factors involved concentrations, surface functionalization, and so on. Some researchers showed that the toxicity of Graphene oxide to fibroblast cells was minimal when the concentration of Graphene oxide was lower than 20 µg/ml. whereas, the cytotoxicity of graphene oxide increased when the concentration was up to 50 µg/ml.[6]

Wang et al. investigated the cytotoxicity of graphene oxide in mice and the results demonstrated a dose-dependent toxic behaviour *in vivo.* The cytotoxicity of graphene oxide increased when the concentration was increased.[7] When the concentrations of Graphene Oxide were 0.1 and 0.2 mg, there was no toxicity detected. With the increase concentration to 0.4 mg, chronic toxicity was observed in mice.[7]

Diana et al. investigated the cytotoxicity of GO, nitrogen-doped graphene (N-Gr), and thermally reduced Graphene Oxide (TRGO) on human dental follicle stem cells and analysed the involved specific mechanism. The result showed the lowest cytotoxicity of GO and the highest cytotoxicity of TRGO.[8]

ANTI-BACTERIAL PROPERTY

The anti-bacterial property of graphene has gained interest as it can lead to help achieve infection control when added into dental materials. The antibacterial effect of graphene-based materials was first discovered by Huet al.[9] A complete understanding of the anti-bacterial property of graphene is yet to be completely understood. Many researchers have proposed different theories. Physical damage is induced by blade like graphene materials piercing through the microbial cellular membrane causing leakage of intracellular substance leading to cell death. [10]

Wrapping and photo thermal ablation mechanism could also provoke bacterial cell damage by enclosing the bacterial cells, providing an unique flexible barrier to isolate bacteria growth medium, inhibiting bacteria proliferation, and decreasing microbial metabolic activity and cell viability.[2]

Chemical effect is primary oxidative stress mediated with production of ROS [reactive oxygen species] as excessive intracellular ROS accumulation could cause intracellular protein inactivation, lipid peroxidation, and dysfunction of the mitochondria, which lead to gradual disintegration of cell membrane and eventual cell death.[11]

APPLICATIONS IN DENTISTRY

Graphene added to PMMA

Polymethyl methacrylate resin has been used in dentistry from many decades for fabricating denture bases due to advantages, such as easy manufacturing process, low cost, low modulus of elasticity, easy repair, and good aesthetics. However, the limitations of PMMA [polymethyl methacrylate] such as low mechanical properties, large polymerization shrinkage, and the poor inhibition of biofilm formation reduce the life-span of the material.[12.] In recent studies, researchers have tried the addition of graphene oxide into polymethyl methacrylate for improving the mechanical and antibacterial properties of PMMA.

Because of the mechanical effect of graphene on PMMA, Azevedo et al. has achieved the definitive maxillary full-arch rehabilitation by incorporating Graphene oxide into the PMMA resin. Review after 8 months revealed satisfactory mechanical and aesthetic outcome, indicating that the addition of GO [graphene oxide] to PMMA resin would be a good choice for prosthetic rehabilitation.[13]

Bacali et al. reported on PMMA with graphene-silver nanoparticles (Gr-Ag), and the mechanical properties, hydrophilic abilities, and the morphology of the composites were further evaluated. The results showed that the compression parameters, bending, and tensile strength of the Gr-Ag fillers were significantly higher than the pure PMMA group, indicating that the addition of Gr-Ag improved the mechanical properties of PMMA resin.[14] Moreover, Bacali and his co-workers also assessed the antibacterial properties of Gr-Ag–modified PMMA, and the results confirmed that Gr-Ag–modified groups showed higher inhibition effect in all Gram-negative strain, *Staphylococcus aureus*, *E. coli*, and *Streptococcus mutans*.[14]

Use of graphene in restorative dentistry

It is always desirable for restorative materials to have a prolonged life in the oral cavity. The added advantage of anti-bacterial property of graphene can help in infection control.

Graphene when added to GIC has shown to cause a significant improvement in its mechanical and biologic properties. Fluoride graphene [FG] when prepared by hydrothermal reaction of graphene oxide and mechanically blend with glass ionomer could produce a GICs/FG composites matrix, which could significantly enhance the mechanical, tribological, and antibacterial properties of glass ionomer.[15]

Graphene has been used in various types of dental resins to strengthen bonding and adhesive strength in restorative dentistry. However, if the site it not properly sealed, bacteria can easily access the cured dental tissues through cavities at the tooth restoration interface.[2] In addition, adhering materials onto dentin is challenging since dentin has higher water content compared to enamel and is less mineralized . Graphene nanoplatelets have been studied for antimicrobial and antibiofilm properties and combined with polymer materials to act as better dental adhesive . From the study, the graphene nanoplates inhibited the growth of *S. mutans* bacteria *in vitro* and demonstrated good mechanical performance without decreasing adhesive strength.[16]

Application of graphene in implants

Titanium implants have in recent times become a popular choice of prosthesis to replace missing teeth. Titanium has been shown to have good osseointegration property. At the hard tissue interface, osteogenic properties of implant material are essential for osseointegration while at the soft tissue interface, to ensure a tight epithelial seal preventing bacterial invasion is obligatory . Failure of implants can happen due to poor osseointegration and peri-implantitis of titanium and its alloys.[17]

Therefore, many surface modifications by graphene-based materials have been used to improve the bioactivities of titanium and its alloys. [18] Gu et al. successfully constructed single-layer graphene sheets on the titanium substrates by PMMA-mediated method.[19]The studies conducted showed that graphene sheets exhibited superior adhesion and proliferation properties of human gingival fibroblasts (hGFs), human adipose-derived stem cells (hASCs), and human BMMSCs (Bone Marrow Mesenchymal Stem Cells) compared with the control.[20]

When graphene is coated on titanium substrate, the hydrophobic character of graphene film exerted self-cleaning effect on its surfaces decreasing the adhesion of microorganism including *S. sanguinis* and *S. mutans*.[21]

Additionally, compared to titanium alone, graphene possesses osteogenic property enhancing the expression of osteogenic related genes RUNX2 [Runt-Related Transcription Factor 2, COL-I[CONSTANS-like 1], and ALP[aluerin like protease], boosting osteocalcin gene and protein expression, and consequently increasing the deposition of mineralized matrix [2]

Tissue Engineering

Tissue engineering is being widely used in repairing and regenerating the defects caused by tumours, traumas, infections etc. Scaffolds provide a platform for the attachment, proliferation, and differentiation of different stem cells in the tissue engineering. Many researchers proved that graphene-based materials were suitable for fabricating or coating for scaffolds in the tissue engineering.

A pioneering study demonstrated that graphene and Graphene Oxide can accelerate MSC [mesenchymal stem cell] osteogenic differentiation to different degrees due to π–π stacking, hydrogen bonding, and electrostatic interactions with proteins , which may be the underlying mechanism supporting the coating application.[22]

Teeth whitening

Hydrogen peroxide is a commonly used material for in-office teeth whitening procedures. Though it has proven to be an effective bleaching agent, use of excessive amounts of

hydrogen peroxide is associated with side effects such as teeth sensitivity and gingival irritation.

Su et al have therefore resorted to combining graphene oxide with hydrogen peroxide to improve the efficiency of the process and reduce the potential side effects.[23] The CoTPP [Cobalt-TetraPhenylPorPhyrin]- rGO [reduced Graphene Oxide] nanocomposite can be used as a catalyst to produce more reactions between the staining molecules and H_2O_2, which accelerate the bleaching process.[23] In summary, graphene-based materials are a promising catalyst for tooth whitening application with proper types and concentrations.

Drug delivery

Localised drug delivery systems have garnered the interest of many practitioners as they provide the opportunity to deliver the desired quantity of drug to the site of interest. They also allow the controlled release of the drug. This has led few researchers to look into graphene as an avenue to function as a drug delivery system.

Graphene Nanosheet structure with high surface area and good water dispersibility is a promising candidate for drug carriers toward specific organs[24]. La et al. reported that GO is an efficient carrier for the delivery of therapeutic proteins.[25] They applied GO-Ti [graphene oxide-titanium] implants as carriers to deliver BMP-2 [bone morphogenetic protein 2] for bone regeneration and successfully demonstrated that ionized GO can deliver proteins by binding through electrostatic interactions. Furthermore, they used a GO-Ti substrate for BMP-2 delivery as an osteoinductive and SP as a stem cell recruitment agent for in situ bone regeneration and reported that GO has the potential to sustain the release of BMP-2[25]

Trusek et al. found that GO had the potential in acting as a drug carrier especially in the therapy of dental inflammation[26]

CONCLUSION

Graphene-based nanoparticles are considered a topic of great interest in the field of dentistry. They have shown to be of great benefit in improving upon the performance of various dental materials. Additionally, graphene nanoparticles have been found to have adequate initial biocompatibility in the mouth when it comes to bone and tissue engineering. Addition of graphene has been considered in case of dental cements, adhesives, resins and as bio coatings to implants.

Although graphene has been shown to display relatively good biocompatible qualities in various dental applications from *in vitro* tests, there is still a lack of long-term cytotoxicity studies of graphene nanoparticles in the body, as well as a lack of understanding as to how easily they can be excreted from the body. Various factors such as particle size and concentration have shown to influence the cytotoxicity of graphene. There is thus a need for standardization of biocompatibility requirements for dental applications is also needed with long-term *in vitro* and *in vivo* studies to see the long term health effects.

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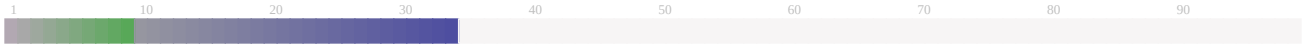

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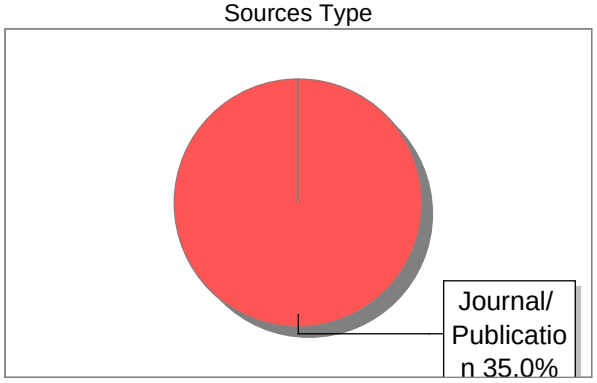

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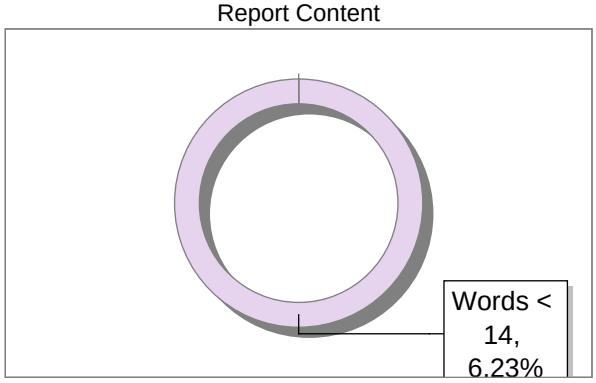

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Virtual and Augmented Reality in Oral and Maxillofacial Surgery- A Narrative Review

Introduction:

Oral and craniomaxillofacial surgery is a specialised field that deals with treating conditions affecting the mouth, jaws, face, head, and neck. Due to the complex nature of these conditions and the delicate anatomy of the affected areas, patients often undergo a CT scan prior to surgery. This scan provides the surgeon with essential imaging data to plan an appropriate surgical approach and to accurately reproduce this plan during treatment. [1].

Digital transformation has brought about various innovations in the field of dentistry, including Augmented Reality (AR) and Virtual Reality (VR). AR is a technology that blends computer-generated images, audio, and videos with real-life surroundings. In contrast, VR is a simulated environment built from computer-generated graphics, sound, and images where users are fully immersed and cannot see the real world. [2], [3], [4].

Computer graphics and sensors have led to new opportunities in diagnostic and operative techniques through VR and AR technologies [5].

History:

Jaron Lanier is credited with coining the term virtual reality (VR) in 1986. It refers to a combination of technological devices, including a computer capable of interactive 3D visualization, head-mounted displays (HMDs), and controllers equipped with one or more position trackers [6].

The first application of virtual reality (VR) in healthcare occurred in the early 1990s. It was used to visualize complex medical data during surgery and to pre-plan surgical procedures [7].

Discussion:

Surgical planning:

VR/AR devices were used in orthopaedic surgeries for complex bones, such as cranio-maxillofacial bones and the hip bone [5].

During maxillofacial surgery, a mixed reality-based system is utilized, which involves a dental cast model and a 3D maxillofacial mesh model. This system synchronizes the movement of the dental cast model in the real world with the 3D patient model in the virtual world. The aim is to make the 3D model move in accordance with the transformation of the dental cast model [8].

In facial contouring surgery, a haptic device is used to simulate reducing a protruded zygoma and inserting a chin implant [9]. VR-based systems have also simulated mandibular angle reduction [10]. Mandibular reconstructive surgery can be greatly improved through the use of 3D virtual planning and computer simulation [11]. A targeted cranio-maxillofacial reconstructive surgery installation that includes an immersive workbench and 3D eyewear can be particularly helpful. The workbench features a semi-transparent mirror and a haptic device designed to enhance the surgeon's immersion during surgical planning. The system was developed based on real surgical procedures, allowing the surgeon to simulate mandibulectomy and fibular transplant using a 3D patient mesh model. It also enables surgeons to test and find the best configurations of vessels and skin paddles [12].

Surgical Navigation:

AR-based technologies have been utilized in various surgical procedures, such as orthognathic surgery, face contouring, bone tumor resection, and neurosurgery. [5]. AR-based navigation systems have been introduced for orthognathic surgery, providing views and virtual surgical plans for guidance. [1],[13-14] Head-mounted devices (HMDs) display virtual surgical plans to aid in repositioning of patient bones during maxillofacial osteotomies. [1].

A system that uses augmented reality technology to perform mandibular angle osteotomy surgery by combining a 3D model of the patient's mandible and a virtual surgical guide model in real-time through a Head-Mounted Display (HMD). This system allows surgeons to accurately follow a surgical guide of the planned position and perform cutting procedures with precision. [15].

The use of markerless AR-based technology has significantly improved the support provided in oral and maxillofacial surgery. This technology enables the matching of a 3D model of a patient's teeth to their actual teeth in a real-time video image, allowing for the tracking of their position. Additionally, it can overlay other 3D anatomical models such as the maxillofacial bone, nerves, and vessels to provide enhanced surgical guidance. [16].

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An immersive workbench system equipped with a haptic device was developed to train for orthognathic surgery procedures. [17],[18]. The system is designed for LeFort 1 procedures and includes functions for bone sawing, drilling, and plate fixing with haptic force feedback. [5].

OssoVR is a virtual reality-based simulation platform that can be used to train for surgical procedures immersively using an HMD and tracked hand-held controllers. The surgeon interacts with the virtual world naturally using his or her hands. [19].

Advantages and disadvantages of Head Mounted Devices:

The use of augmented reality (AR) during surgical procedures improves treatment efficacy and accuracy by providing surgeons with virtual navigation that is contextually blended with the physical surgical field. [20].

With the help of AR guidance, a surgeon can enhance their spatial awareness and perception of the underlying 3D anatomical structures, which can provide an X-ray view of the patient's anatomy. Through AR, the surgeon can project preoperative planning data in the form of task-oriented geometrical primitives such as tumor contour margins, skin incision lines, and craniotomy/osteotomy lines. This property improves the efficiency and accuracy of high-precision surgical tasks, ultimately saving time. [1].

The use of HMDs in AR surgical applications offers improved ergonomics and an intrinsically egocentric viewpoint for the surgeon, compared to traditional computer-assisted surgical systems [21-22].

Limited registration accuracy between the virtual content and real scene is a significant issue for surgical guidance. Additionally, the use of head-mounted displays (HMDs) may cause eye strain due to prolonged concentration on a small screen, leading to visual discomfort. [1].

Accuracy:

We cannot consider the accuracy of the AR system, which refers to the precise positioning of the virtual scene over the surgical real scene, as a reliable benchmark since its definition was inconsistent across various papers. [1].

Conclusion:

AR applications are becoming increasingly popular and are gaining traction in the field of oral and maxillofacial surgery. The quality of the AR experience and the ability to seamlessly integrate the surgeon's perception and efficiency are the key factors that contribute to a successful outcome. The availability of ergonomic head-mounted devices that can ensure the accuracy required for surgical tasks can promote the widespread use of AR guidance in the operating room.

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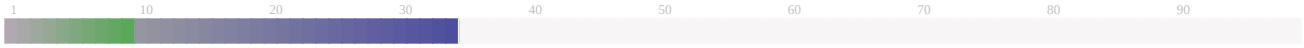

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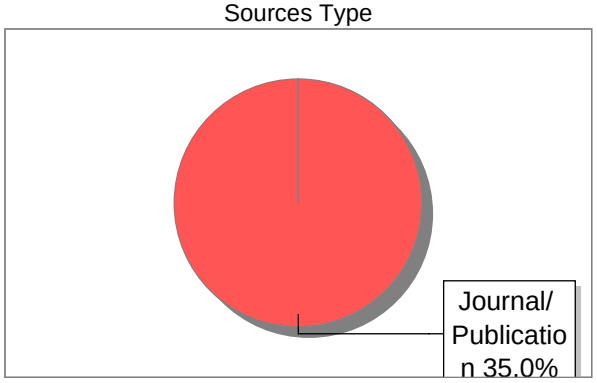

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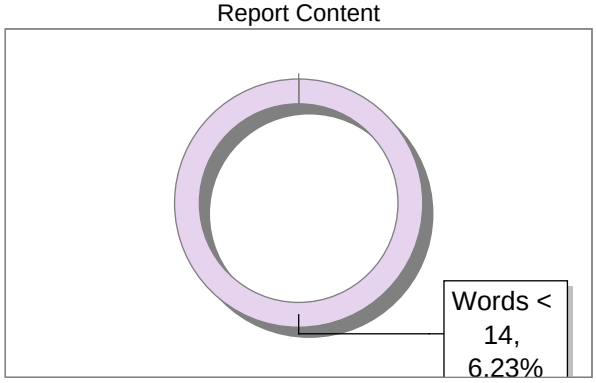

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Virtual and Augmented Reality in Oral and Maxillofacial Surgery- A Narrative Review

Introduction:

Oral and craniomaxillofacial surgery is a specialised field that deals with treating conditions affecting the mouth, jaws, face, head, and neck. Due to the complex nature of these conditions and the delicate anatomy of the affected areas, patients often undergo a CT scan prior to surgery. This scan provides the surgeon with essential imaging data to plan an appropriate surgical approach and to accurately reproduce this plan during treatment. [1].

Digital transformation has brought about various innovations in the field of dentistry, including Augmented Reality (AR) and Virtual Reality (VR). AR is a technology that blends computer-generated images, audio, and videos with real-life surroundings. In contrast, VR is a simulated environment built from computer-generated graphics, sound, and images where users are fully immersed and cannot see the real world. [2], [3], [4].

Computer graphics and sensors have led to new opportunities in diagnostic and operative techniques through VR and AR technologies [5].

History:

Jaron Lanier is credited with coining the term virtual reality (VR) in 1986. It refers to a combination of technological devices, including a computer capable of interactive 3D visualization, head-mounted displays (HMDs), and controllers equipped with one or more position trackers [6].

The first application of virtual reality (VR) in healthcare occurred in the early 1990s. It was used to visualize complex medical data during surgery and to pre-plan surgical procedures [7].

Discussion:

Surgical planning:

VR/AR devices were used in orthopaedic surgeries for complex bones, such as cranio-maxillofacial bones and the hip bone [5].

During maxillofacial surgery, a mixed reality-based system is utilized, which involves a dental cast model and a 3D maxillofacial mesh model. This system synchronizes the movement of the dental cast model in the real world with the 3D patient model in the virtual world. The aim is to make the 3D model move in accordance with the transformation of the dental cast model [8].

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Conclusion:

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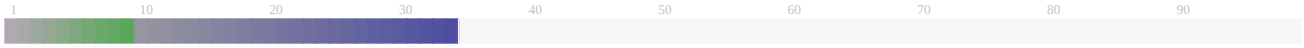

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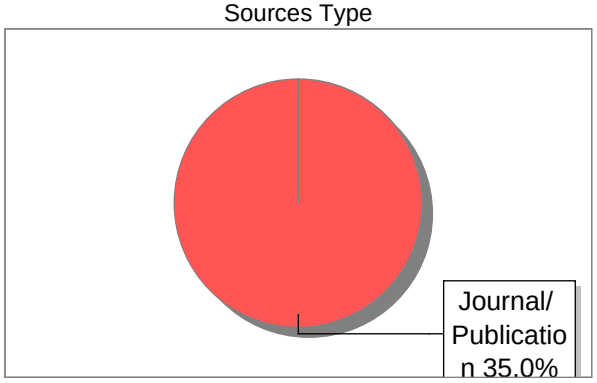

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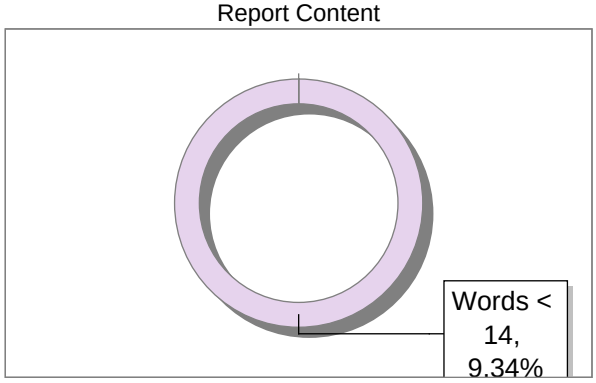

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5	www.jodend.com	1	Publication
6	www.wjoud.com	1	Publication

AESTHETIC MANAGEMENT OF ANTERIOR MIDLINE DIASTEMA WITH DIRECT RESIN COMPOSITES- A CASE REPORT

Introduction

Maxillary anterior spacing or diastema is a common aesthetic complaint among patients.[1] It has been described as spacing between the proximal surfaces of adjacent teeth in the anterior midline measuring > 0.5 mm.[2] The incidence of true maxillary midline diastema is (1.6%) more than that of true mandibular midline diastemas (0.3%).[3] The aetiology of midline diastema is multifactorial, causes being physiological and/ or pathological in nature such as high frenal attachment, incomplete coalescence of the interdental septum, microdontia, presence of a mesiodens, peg-shaped lateral incisors, congenital absence of lateral incisors, pathologies (e.g., cysts in the midline region), habits such as tongue thrusting, and/or lip sucking, discrepancy in the dental and skeletal parameters, and genetics.[4] Based on the etiology, the treatment plan may include a multidisciplinary approach or the closure of the space using direct and/or indirect restorative materials. This further depends on the alignment and dimensions of the teeth being restored.[5] Hence, the assessment of tooth size and distribution of the space manually or using digital smile designing becomes an important tool in providing a natural smile.

The composite resins used for anterior restorations must demonstrate good aesthetic characteristics. Development of composite resins with superior mechanical properties and excellent polishability allows the clinician to mimic the natural dentition and render a long-lasting restoration to the patient. Nanohybrid composites are hybrid resin composites with nanofiller in a prepolymerized filler form, recently launched, that involve a combination of high initial polishing and supreme polish and gloss retention.[6] Additionally, composite resins permit conservative treatment and offer quicker results.[7]

The use of putty index technique aids in acquiring a predictable anterior composite build up. This technique uses an impression of the diagnostic mock up to produce a palatal silicone index. This can be then used to transfer the required anatomy into the mouth during treatment further improving the treatment outcome.[8] This case report describes a direct aesthetic midline diastema closure using putty index technique.

Case presentation A 32-year-old male patient reported to the Department of Conservative and Endodontics, Dayananda Sagar College of Dental Sciences with the chief complaint of spacing in the upper front tooth region. The patient stated that the spacing was causing him social embarrassment and lowering his self-esteem. Patient had no associated symptoms, relevant past dental or medical history. The intraoral examination revealed the presence of midline diastema between maxillary central incisors (~3.5mm) secondary to tongue thrust habit confirmed by performing clinical tests (Fig 1) and spacing between the mandibular incisors. On radiographic examination no evident pathologies were detected. The first line of treatment suggested to the patient was to undergo orthodontic treatment for closure of the diastema and spacing between the mandibular incisors. However, as the patient was not willing for the same and wished for a faster and conservative approach, direct composite restorations for midline closure were considered. Fig 1: Pre-operative intraoral image of patient with midline diastema; (a) Frontal view; (b) Right lateral view; (c) Left lateral view. Closure of midline diastema using a direct composite build up using putty index was planned. Lower teeth spacing was not addressed as patient for not willing for the same. Informed consent from the patient was taken, and complete treatment plan was discussed with the (a) (b) (c)

patient. In first appointment, diagnostic impression and cast were made. Following the dental analysis of the patient, diagnostic wax up done on the cast (Fig 2 (a)) and a putty index was created (Fig 2 (b)). The fit of the putty index in the mouth was confirmed.

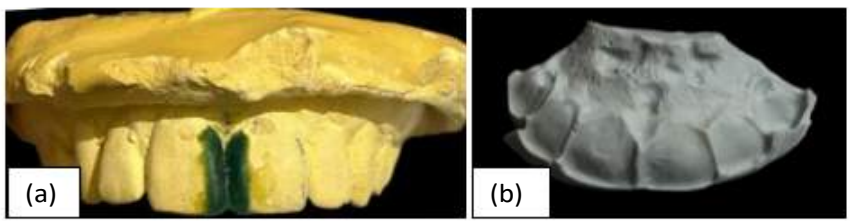

Fig 2: (a) Diagnostic mock up; (b) Silicone putty index

Following oral prophylaxis, shade selection was done using button technique under natural daylight (Fig 3 (a)and (b)). A1 shade of Filtek™ Z350 XT (3M/ESPE, St. Paul, MN, USA) was selected. Split-dam technique was used to isolate the maxillary teeth as the conventional rubber dam placement technique hindered the placement of the putty index palatally. In order to simulate natural A1 shade outlook, the shade A1 dentine and A3 enamel composite resin (Filtek Z350, 3M/ESPE, St. Paul, MN, USA) were used as layers. No preparation was done on the tooth surface prior to restoration. 37% phosphoric acid (Etching Gel, Kerr, USA) was applied on the mesial surface of both the central incisors to be restored for 15 seconds, rinsed for 20 seconds, and dried with oil- free air (Fig 3 (c)). Then, two coats of a single bottle bonding agent (One Coat Bond SL Coltene, Switzerland) were applied using applicator tips (Fig 3 (d)) and polymerized for 20 seconds with an LED light (Bluephase N MC, Ivoclar Vivadent, Schaan, Lichtenstein). Care was taken to apply uniform coats of the bonding agent especially near the gingival area since pooling of the bonding agent compromises solvent evaporation, after careful application of the bonding agent near the sulcus, it was air-thinned using three-way syringe.

A thin layer of A3 shade composite resin was placed palatally on the putty index as enamel and placed into patient's mouth and cured for 40 seconds. A palatal shell of composite bonded to the tooth was formed by carefully removing putty index (Fig 3 (e)) which served as a reference for further placement of composite.

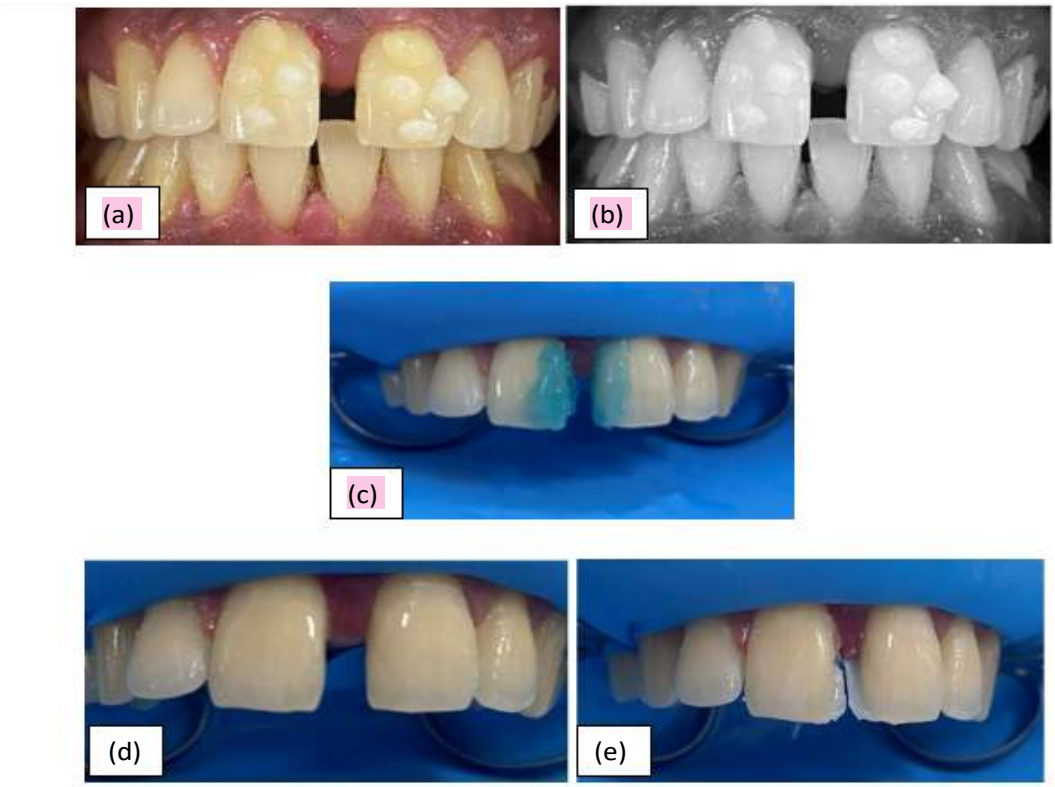

Fig 3: (a) and (b) Shade selection using button technique; (c) Etching using 37% phosphoric acid; (d) Application of bonding agent; (e) Palatal shell.

A1 dentine shade was placed in increments and manually contoured over the mesial surface using a long bladed titanium instrument. Posterior sectional matrix system was used to build the proximal surface of the teeth. A thin layer of A3 shade was used as the top enamel layer. All increments were cured for 40 seconds, both from labial and palatal aspects. The occlusion was verified in both centric and eccentric relations using an articulating paper.

Gross finishing was done using Tungsten carbide bur 134 014 (16 flutes yellow band). Final finishing was done using Shofu Super snap rainbow kit (Shofu INC, Japan). CompoSite Fine polishing tips (Shofu INC, Japan) were used along with polishing paste (Platina Hi-Gloss Composite polishing paste, PrevestDenPro) for polishing. The patient was motivated to maintain oral hygiene and instructed to floss before tooth brushing regularly and to avoid pigmented liquids cause staining of restoration. The patient has been recalled after 6 months for follow up.

Fig 4: (a) Proximal surfaces restored using posterior sectional matrix; (b) Immediate post operative image; (c) Post operative image following finishing and polishing; (e) Palatal aspect of the midline diastema closure. Discussion Various treatment modalities are available for closure of midline diastema such as orthodontic treatment, an indirect ceramic restoration, direct composite resins or an interdisciplinary approach.7 Direct composite resins are indicated for minimal to moderate diastema closure and when preservation of tooth structure is a priority serving as the most conservative approach.4,9 In this case report, a direct composite restoration was used for diastema closure as the patient was not willing to undergo an orthodontic treatment or habit correction and wished for a faster and conservative approach. However, the patient was made aware of the impermanence of such a closure as the aetiology was not address adequately during the treatment. Nonetheless, excellent outcomes have been reported by numerous authors who have used resin composites for diastema closures pertaining to the longevity (88% up to 10 years) and aesthetic outcome of such restorations.5,10,11 Highly aesthetic restorations made up of composite resins are now possible because of constant improvements in techniques, materials, and technology. The introduction of nanometer-sized particles has been one of the latest developments in the field which is thought to offer superior aesthetics and polishability required for anterior restorations. Filtek (a) (b) (c) (d)

Z350 (3M ESPE, St. Paul, MN, USA) employed in this case report, is nanocomposite on the market that contains nanometric particles (nanomers) and nanoclusters (NCs). It shows high translucency, high polish and polish retention similar to those of microfilled composites whilst maintaining the physical properties and wear resistance equivalent to those of several hybrid composites.[12]

Successful restorations rely largely on the effective control of moisture and saliva from the tooth being restored as contamination remains an important cause of bond failure. Therefore, rubber dam isolation was done in this case to prevent moisture contamination. A silicone putty index was used in this case as it perfectly defines the sagittal dimensions, the length, and the incisal edge position, incisal thickness, mesial and distal line angles of the required final restoration; it reduces the need for extensive final finishing and polishing procedures. Hence, the practitioner can fully target the application of composite layers.[8] Putty index technique is easy to perform, and it creates correct midline and optimal contact area. Additionally, this technique allows the clinician in reproducing the palatal anatomy accurately overcoming the most challenging part of anterior restorations.

Dual layering technique was used in this case to mimic the three dimensional appearance of the natural teeth. For an overall shade of A1, Dentine A1 and Enamel A3 was used in layers.

However, there were certain limitations in the case presented such as the impermanence of diastema closure as the aetiology was not address adequately during the treatment. Furthermore, there are some distinct disadvantages of composite restorations as they posses less colour stability compared to ceramics. This of course is related to the degree and quality of polishing but also depends on the patient maintenance.[13]

Conclusion

The clinical outcome of this case report demonstrated that the putty index replicating the palatal region for composite restoration can be a reliable procedure for direct composite restorations. Nanohybrid composites can be used to provide an acceptable color match with a conservative technique. Although some disadvantages are noted, such as discolorations, when applied judiciously, they can serve as the material of choice for patients with aesthetic problems of anterior teeth and with maintainable hygiene practice.

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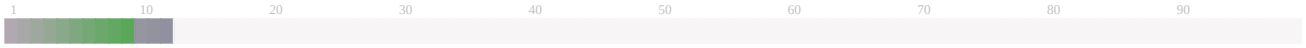

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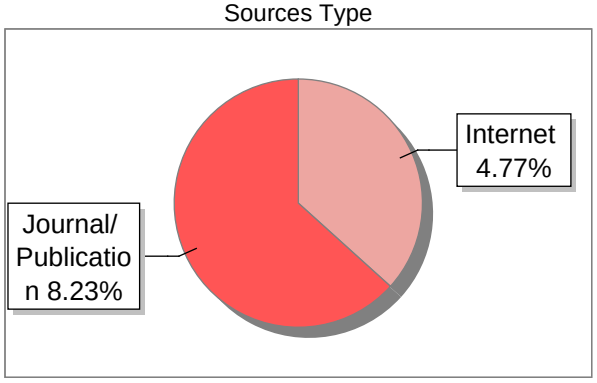

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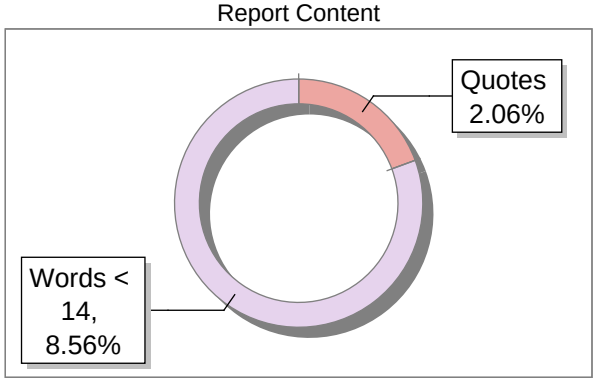

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TITLE:

TO EVALUATE KNOWLEDGE AWARENESS AND OUTLOOK REGARDING TELEDENTISTRY AMONG DENTISTS IN BANGALORE- A CROSS-SECTIONAL STUDY

KEYWORDS: Teledentistry, telemedicine, teleconsultation, Pandemic, awareness, outlook

INTRODUCTION

Oral healthcare is a basic amenity that must be accessible to all. Unfortunately, in today's world, access to healthcare for all is still a challenge due to the lack of availability of doctors and facilities in certain regions of the country due to various factors. In emergent countries, the inhabitants of rural establishments find it difficult to access an oral health care specialist, as they are mostly found in urban cities.[1] One way of overcoming this challenge is by the implementation of teledentistry. Through teledentistry, it is possible to reach patients who do not have access to a dentist or cannot make the visit to the dentist due to barriers such as lack of time, morbidities, disabilities, security concerns, poverty, etc.

Healthcare has been rapidly digitalized in the last few years with the advancement of technology in medicine. This development has become even more pronounced because of the pandemic that hit the entire world with fear and panic of visiting their healthcare providers for regular care, for the fear of contracting the virus. Telemedicine, which had been in use even before the pandemic, became even more popular during the pandemic-induced stringent lockdowns.

Telemedicine is derived from "tele" in Greek, meaning distance, and "menderi" in Latin, meaning to heal.[2] teledentistry involves the use of communication technology for providing dental care, consultation, and awareness in urban as well as rural areas. Using teledentistry, it is easier to identify high-risk populations, arrange for a referral to a dental surgeon or specialist, and encourage locally-based treatment. These save time, productivity as well as travel expenditure for the patient as well as the doctor.[3] Teledentistry can be used in all the specialties of dentistry.[4] Teledentistry has many advantages such as being cheaper than traditional in-person consultations, reduced travel expenses and time, and easier to take multiple opinions from other specialties. There is substantial evidence that proves higher patient satisfaction with e-oral health care. Patients had shown willingness for teleconsultation for a dental problem,

and they were on the whole content due to saved travel time, saved working days, and swift treatment onset.[5]

A few studies conducted showed that the use of teledentistry reduced the time spent by patients in the ED for non-traumatic dental conditions and also allowed the ED doctor to be able to attend to other emergent patients more effectively. The mean waiting time for patient-provider interaction was 40 minutes, mean time spent by dental patients inside the ED room was 46 minutes.[6] Studies conducted on connecting medical personnel to the dentist via teledentistry have shown good responses with only a few technical errors due to a lack of training on how to use the technology provided. [7]. Studies have also been conducted on the awareness and acceptability of teledentistry among patients, with results showing that many were accepting of teledentistry. This study in particular questions the dentists in the city of South Bangalore on their knowledge and acceptability of teledentistry.

This study aims to instill the knowledge, awareness, and implementation of teledentistry among the general practitioners and dentists in Bangalore it is important to assess the awareness and outlook toward teledentistry among them. Hence the study is conducted among general practitioners to know their knowledge, awareness, and outlook toward teledentistry.

MATERIAL AND METHODOLOGY

STUDY DESIGN AND STUDY POPULATION

The study is a descriptive cross-sectional study involving an electronic survey for general practitioner dentists, validated 18 close-ended, self-made questionnaires were incorporated to evaluate the knowledge, outlook, and awareness among the general practitioner dentists residing in south Bangalore. The survey was mailed to a random sample of 120 general practitioner dentists from all 9 specialties with professional experience from 0 to 25+ years. South Bangalore was chosen for this survey due to it being a metropolitan city with good access to the internet as well as dental care.

INCLUSION CRITERIA

All the general practitioners who gave their consent to participate in the study were considered in the inclusion criteria.

DATA COLLECTION AND ANALYSIS

This was a cross-sectional survey-based study, where a validated 18-item questionnaire was distributed via online Google Forms. The survey form comprised 3 parts which included as follows-

1. Part 1: Sociodemographic details
2. Part 2: Questions related to knowledge regarding teledentistry
3. Part 3: Questions relating to assessing the awareness and outlook regarding teledentistry.

The completed questionnaire was collected and subjected to statistical analysis in terms of frequencies (yes or no) with a statistical package for social science (SPSS).

Furthermore, the sample was stratified by qualification and gender to get more representative samples of general practitioner dentists.

RESULTS

A total of 250 general practitioner dentists from all 9 specialties with professional experience from 0 to 25+ years were covered in the study but only 200 participants responded and gave consent to participate in the study. Thus the response rate was 80%.

The majority of general practitioners (90%) had an understanding of teledentistry. 90% of general practitioner dentists think teledentistry helps to seek advice from an expert about a specified patient's problem.

86.7% knew that teledentistry is used for oral health education and continuing education in dentistry.

85% of general practitioner dentists feel teledentistry is a good option rather than in-person examination during a pandemic.

81.7% of general practitioner dentists think t teledentistry is useful; in early diagnosis and easy consultation on oral diseases.

When dentists were asked whether teledentistry comprises the practice of using computers, the internet, and technologies for diagnosis and to give their opinion on a patient's treatment, a high response of 88.3% was obtained.

93.3% of participants agreed that teledentistry lessens chair side time, money, and travel for the dentist and the patient.

The majority of study participants concurred that teledentistry is a good option for the dentist as it reduces personal contact and lessens the risk of contamination during a pandemic.

85 % of participants think that teledentistry can expand the ease of access to specialists in rural and underserved communities for the dental communities for dental needs.

High responses (88.1%) were observed for the question: "Can teledentistry be an addition to regular dental care?".

Regarding the question of whether teledentistry is useful in quick diagnosis and effortless consultation, the response was 81.7%.

Similarly, 67.8% of respondents agreed with the question: "Do you think that teledentistry can be used to train dentists in primary dental care?".

Only a few respondents (45%) believed that teledentistry can violate patients' privacy.

66.1% of participants have had a consultation with a patient using a smartphone and its camera.

When enquired about attending a lecture or course about teledentistry, only 30% of participants responded with 'yes'.

Similarly, only 21% of participants have experience in using teledentistry. 65% of respondents think that teledentistry will be a standard method of oral health care delivery in the future.

66.7% of general practitioner dentists have communicated with the patient during the (pandemic) situation.

A high response of 91.7% was obtained for the question: "Will you practice teledentistry in the future?".

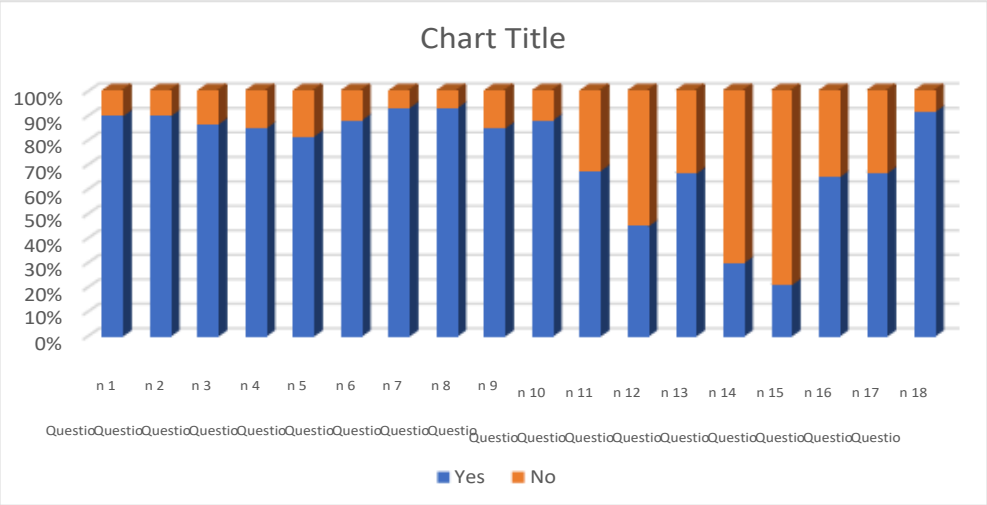

Fig 1: Bar diagram representing the responses to all the questions.

Teledentistry is not a new specialty. It is, in actuality, a different method for providing dental services. The advantage of teledentistry in remote areas cannot be stressed enough. Its application is of greatest significance in rural and urban areas where there is a dearth of specialist consultation. Teledentistry has been advancing since 1994 as a means to allow dental professionals to communicate with one long distance, allow collaboration by multiple practitioners, and involve the exchange of clinical information and images over remote distances for dental consultations and treatment planning. [8]

In the present study, the knowledge and awareness regarding teledentistry were assessed among general practitioner dentists. The majority of practitioners were aware of teledentistry but very few had attended a lecture or hands-on training in using teledentistry.

The majority of participants (86.7%) were aware that teledentistry can be used for dental health education. 93.3% of participants believed that teledentistry lessens chair time, money, and travel for the dentist and the patient. Similar results were seen in a study conducted by Bauer et al. (2001) [9]

The questions regarding the use of teledentistry to seek advice from an expert about the patient's ailment had been agreed upon by 90% of participants. Similar results have been obtained in other studies regarding the same. [10,11]

Noteworthy contrast was found in response to questions like, "Do you think that teledentistry can be used to train dentists in primary dental care?" (67.8%).

In a study aimed at discerning the willingness of patients to undergo online consultation, it was found that a major portion (87%) were inclined towards recommending the use of digital, remote counseling instead of face-to-face appointments with their family and friends, while only 13% were apprehensive of recommending it.[12]

In the present study, it was found that 90% of general practitioner dentists knew teledentistry.

Very few (45%) participants think teledentistry can violate patients' privacy, dentists who are engaged in teledentistry must ensure the safety and security of their systems and transmitted data. User access logs, password protection, and data encryption can help in protecting patient confidentiality.

A study conducted in Saudi Arabia showed that one-third of participants think that teledentistry might breach patient privacy, and it was ranked by participants as one of the most significant hurdles to teledentistry use.[13]

Other studies conducted showed that dentists with 11 to 15 years of experience showed the lowest score for excitement as they were resistant to the new technology not to lose their patient pool.[14]

In other studies conducted it was found that only 74% of dental practitioners feel that dental examinations via computers and intraoral cameras are as precise as dental clinic exams.[15]

The study is limited in the aspect that it included only dentists practicing in south Bangalore who lives in a metropolitan city and have good access to the internet and also that they cannot be used to extrapolate the results to other populations. The study also did not include dental students who are going to be the most influenced by changes such as teledentistry entering clinical dentistry.

Table 1: Sociodemographic characteristics

Age (years)	Frequency(in%)
20-30	73.8
30-40	23
40-50	3.2
Sex	
Male	65.6
Females	34.4

The above table gives the sociodemographic details of the participants of the study. With the help of this data, it was made possible to understand the differences in the adaptability of practitioners with different years of work experience. (Table 1)

Table 2: Dentists from various specialists who participated in the study

Field of specialty	Frequency (in %)
General practitioner	37.70
Oral and maxillofacial surgery	8.30
Endodontics	14.8
Oral Diagnosis/ Radiology	4.66
Orthodontics	2.33
Pediatric Dentistry	16.00
Periodontology	2.33
Restorative dentistry	4.66
Prosthodontic	9.32

The above table gives the distribution of the participants who participated in the study based on their specialty. This data gives insight into what practitioners of different specialties feel they can achieve through teledentistry and are more open to adapting it. For example, in a study conducted. It was seen that the majority of participants selected community dentistry followed by oral medicine, dental hygiene, and orthodontics to be benefited from teledentistry. (Table-2)This reflects a narrower vision of limiting teledentistry to screening, diagnosis, or patient education.[15]

TABLE 3: Response to Knowledge, Awareness, And Outlook-Related Questions

Sl no.	Knowledge, awareness, and outlook-related questions	Yes (%)	No(%)
1	Do you know what teledentistry is?	90	10

2	Do you think teledentistry helps to consult with an expert about a specific patient's problem?	90	10
3	Do you know that teledentistry is used for dental health education and continuing in dentistry?	86.7	13.33
4	Do you think teledentistry is a good option rather than an in-person examination during the pandemic?	85	15
5	Do you think teledentistry is useful in early diagnosis and easy consultation on oral diseases?	81.7	18.33
6	Is teledentistry about the practice of the use of computers, the internet, and technologies to diagnose and provide advice about treatment over a distance?	88.33	11.66
7	Do you think that teledentistry lessens chair side time, money, and travel for a dentist and the patients?	93.33	6.66
8	Do you agree that teledentistry is a good option for the dentist as it reduces personal contact and lessens the risk of contamination during the pandemic?	93.33	6.66
9	Do you think that teledentistry can increase the accessibility to specialists in rural and underserved communities for their dental needs?	85	15
10	Can teledentistry be an addition to regular dental care?	88.1	11.66
11	Do you think that teledentistry can be used to train dentists in primary dental care?	67.8	32.5
12	Do you think that teledentistry can violate patients' privacy?	45	55

13	Have you ever had a consultation with a patient using a smartphone and its camera?	66.1	33.33
14	Have you attended a lecture or course about teledentistry?	30	70
15	Did you think that in the future, teledentistry will be a standard method of oral health care delivery?	21	79.1
16	Did you have hands-on training in using teledentistry?	65	35
17	Have you communicated with any patients during the pandemic situation?	66.7	33.33
18	Will you practice teledentistry in the future?	91.7	8.33

CONCLUSION

The results of the study indicated satisfactory knowledge, awareness, and outlook regarding teledentistry among general dentists. The knowledge and awareness can be improved further by the continuation of dental education programs and awareness campaigns. Concerns such as adaptability to new technology and security risks need to be addressed. With all the technological developments taking place in the field of teledentistry, practitioners may eventually link up to virtual health clinics and an entirely new era of dentistry can be created.[16]

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CONFLICT OF INTEREST: The authors declare no conflicts of interest regarding the publication of this paper.

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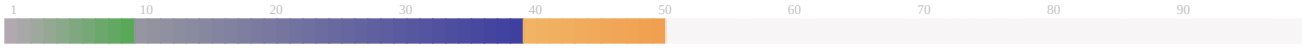

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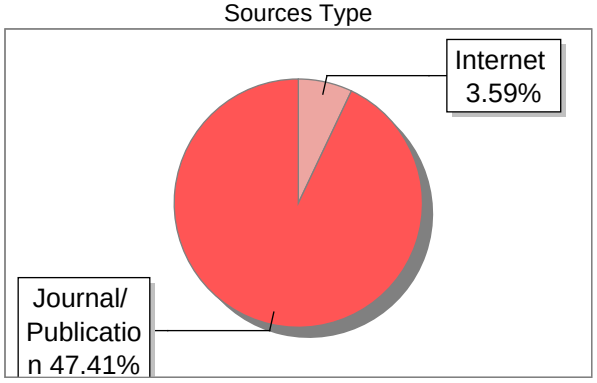

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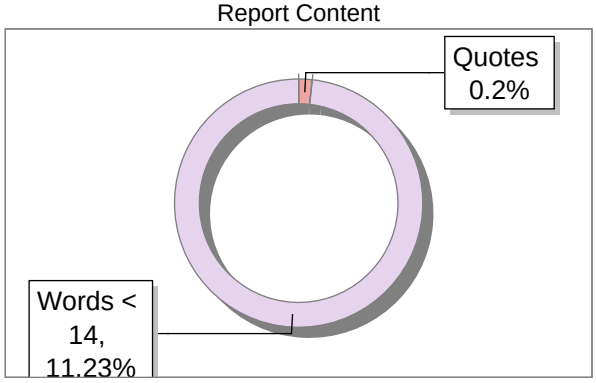

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9	Endodontic treatment of mandibular incisors with two root canals Report of two by Yur-2007	2	Publication
10	medind.nic.in	1	Publication
11	research-advances.org	1	Publication

MIDDLE MESIAL CANAL IN MANDIBULAR I MOLAR: UNRAVEL THE HIDDEN ANATOMY.

INTRODUCTION

The aim of root canal treatment is to eliminate all irritants from the root canal system which include necrotic pulp tissue, microorganisms and their byproducts. Thorough knowledge of the internal dental morphology is extremely important for effective cleaning and shaping the root canal system. Therefore, it is imperative that aberrant anatomy is identified before and during root canal treatment of such teeth. The most frequent type of tooth encountered for endodontic treatment are permanent mandibular molars which is the earliest posterior tooth to erupt. Traditionally, mandibular molars are described as 2-rooted teeth with 2 canals in the mesial root and 1 or 2 canals in the distal root.[1,2]

It has been theorised that secondary dentin apposition during tooth maturation would form dentinal vertical partitions inside the root canal cavity, thus creating root canals. A third root canal may also be created inside the root canal cavity of mandibular molars by this process. Such third canals are situated centrally between the two main root canals, the buccal and lingual root canals. The diameter of those third middle canals is smaller than that of the other two.[3] The probability of a mandibular first molar having a fifth canal is 1–15%.[4]

The presence of a middle mesial canal in a mandibular molar was first reported by Vertucci and Williams.[5] thereafter many case reports presented aberrant canal morphology in the mesial root. Magnification with loupes or microscope improves the visibility and thus helps in the detection of small hidden canals.

The purpose of this article is to report the successful treatment of a clinical case of a mandibular molar with three mesial canals.

CASE 1:

A 23-year old female patient reported with chief complaint of decayed tooth and associated pain over her left mandibular region since 2 weeks. History of presenting illness showed dull, continuous pain on chewing. On intraoral examination, deep carious lesion was present wrt 36. Tooth exhibited no mobility and was tender on vertical percussion. Her medical history was noncontributory. Periodontal probing was within the normal limit.

Preoperative periapical radiograph revealed deep carious lesion involving pulp with widening of apical periodontal ligament space wrt 36 [Figure 1]. The involved tooth gave exaggerated

response to electric pulp tester in comparison to the contralateral tooth. A diagnosis of Symptomatic irreversible Pulpitis with Symptomatic apical periodontitis was made for the involved tooth and endodontic treatment was scheduled. The goal of the treatment was to relieve pain through root canal treatment followed by suitable Post endodontic restoration.

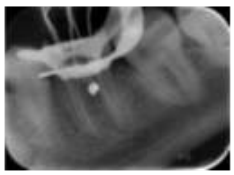
After administering local anesthesia with 2% lignocaine, dam isolation was done and all carious tissue was removed and an adequate endodontic access was made. After pulp extirpation and copious irrigation of the pulp chamber, upon careful examination of the groove between the mesiobuccal and mesiolingual canal orifices, the middle mesial canal orifice was identified with endodontic explorer and the canal subsequently negotiated with 6K file [Figure 2].

Middle mesial in the mandibular first molar was detected using the dental loupes. The working lengths were established with an electronic apex locator, and size 10 K files of 21 mm length were used to confirm three canals in the mesial root radiographically [Figure 3]. Angled radiograph showed Independent mesiolingual canal and middle mesial canal confluent mesiobuccal canal. Distal root canals (DB & DL) were fin type with different port of exit. The canals were instrumented with stainless steel hand instruments – K files of 21 mm length till 20k file. Irrigation was done with copious amounts of 3% sodium hypochlorite and 17% ethylene diaminetetraacetic acid. Rotary instrumentation was carried with Neoendo flex files till 25.4% for each canal and a master cone xray was taken [Figure 4]. The canals after preparation were finally flushed with sterile saline, dried with sterile paper points, and a calcium hydroxide dressing was given and was temporized with zoe cement. At the subsequent visit after a week, the tooth was asymptomatic, all the canals were recapitulated, irrigated, dried and was obturated with gutta percha cones and zoe sealer. A postobturation angled radiograph was taken [Figure 5]. The patient experienced no postoperative sequelae and an appropriate post-endodontic restoration was performed in a subsequent appointment to ensure an adequate coronal seal.

CASE 1:

1. Pre- op

2. Negotiated 3 mesial



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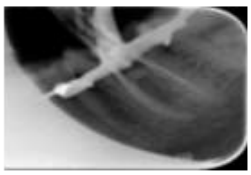
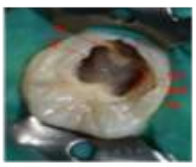
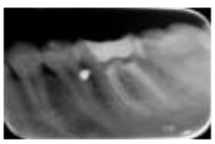


4. Master cone



Canal orifices after cleaning and shaping

5. Immediate post-op (straight view)



Immediate post-op (angled view)

3 month follow up

Post endo ??

CASE 2:

A 48 year old male patient referred from dept of periodontics for intentional root canal treatment wrt 36 and 37. Patients chief complaint was pain in left mandibular region since 1 month. On clinical examination, tooth exhibited grade I mobility wrt 36, grade II mobility wrt 37 with draining pus through gingival sulcus and was tender on horizontal percussion. His medical history was noncontributory. Both tooth were noncarious, but it did not respond to vitality test with thermal or electric pulp tester.

On first appointment, full-mouth scaling was done followed by root canal procedure in relation to 36 and 37. Local anesthesia was administered, and access opening was done under rubber dam.

After pulp extirpation and copious irrigation of the pulp chamber, upon careful examination of 36, the groove between the mesiobuccal and mesiolingual canal orifices, the middle mesial canal orifice was identified with endodontic explorer and the canal subsequently negotiated with 6K file [Figure

2]. The working lengths were established with an electronic apex locator, and size 10 K files of 21 mm length were used to confirm three canals in the mesial root radiographically [Figure 3].

Angled radiograph showed mesiolingual canal and middle mesial canal confluent mesiobuccal canal and Distal root canals (DB & DL) were fin type in tooth 36. Tooth 37 showed 2 mesial and 1 distal canal.

The canals were instrumented with stainless steel hand instruments – K files of 21 mm length till 20k file. Irrigation was done with copious amounts of 5% sodium hypochlorite and 17% ethylene diaminetetraacetic acid. Rotary instrumentation was carried with ProTaper gold file and GP (size F2) for each canal. The canals after preparation were finally flushed with sterile saline, dried with sterile paper points, and a calcium hydroxide dressing was given for 2 weeks and was temporized with zoe cement. Patient did not report for the subsequent appointment after 2 week. Patient reported back after 2 months, all canals were further irrigated with 3% Naocl and calcium hydroxide dressing for 1 week. The tooth was asymptomatic, all the canals were recapitulated, irrigated, dried and was obturated with gutta percha cones and AH plus sealer.

A postobturation angled radiograph was taken [Figure 4]. The patient experienced no postoperative sequelae and access closure was done with composite resin. The patient was referred back to dept of periodontics for further periodontal therapy wrt 36 and 37.

Discussion

The present paper reports the endodontic management of confluent middle mesial canals in the mandibular first molars.
Several studies have been reported with unusual canal anatomy in mandibular first molar. [6,7,8]

A good preoperative radiograph help in preventing missed anatomy, though it has limitations in assessing the number of canals, radiographs taken from at least two different horizontal angles along with careful interpretation will aid in the detection of extra canals.[9] Clinically, the central importance in locating the orifices of the root canals by a proper access cavity preparation, examination of the pulp chamber floor with a sharp explorer, troughing of grooves with ultrasonic tips, staining the chamber floor with 1% methylene blue dye, and performing the sodium hypochlorite "champagne bubble" test, fibrooptic transillumination, visualizing canal bleeding points and the feeling of a "catch" on the canal wall during instrumentation are important aids in localizing root canal orifices.
Advancement of ultrasonic systems become useful tool in exploring and identifying the extra canals by avoiding the bulky head of the conventional hand piece that frequently obstructs the vision.
The radiographic aids in locating the additional canal include: fast break guideline, eccentric location of an endodontic file during working length determination, inconsistent apex locator readings, a sinus tract that traces laterally away from the main canal.[10]

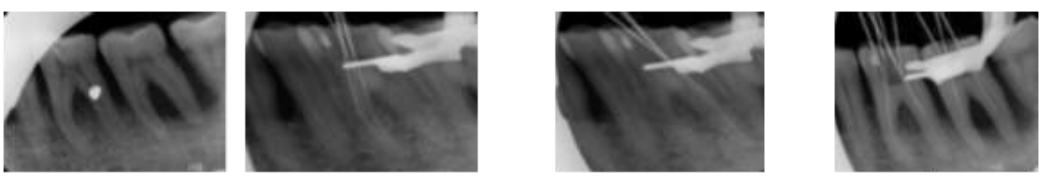
Dental loupes are one of the most common magnification system used in dentistry. It provides better visualization as it enables the clinicain to treat cases which are labeled as having poor prognosis or untreatable. Magnification has been found to increase the detection of extra canals. In this paper, both cases were managed endodontically using dental loupes.

(

Conclusion:

Treating extra canals may be challenging but the inability to find and properly treat root canals may cause failures. Even though the incidence of middle mesial canal is low, every effort made in looking for this canal has a high clinical relevance. A clinician should be vigilant and use additional aids for canal negotiation, whenever an additional or aberrant canal anatomy is suspected.

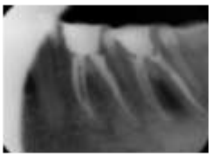
CASE 2



1 Pre- op | 2. Negotiated 3 mesial | Negotiated of distal canals | 3.WL

Canal orifices after cleaning and shaping | Obturation

Master cone



4. Immediate post-op (angled view)

Immediate post-op (straight view)

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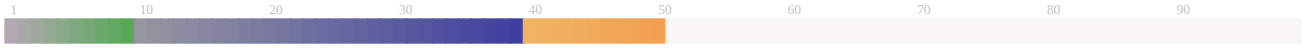

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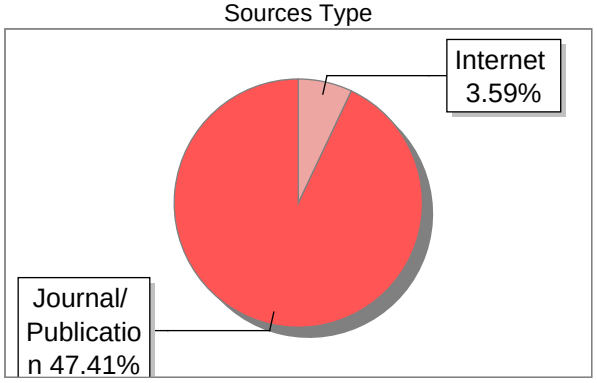

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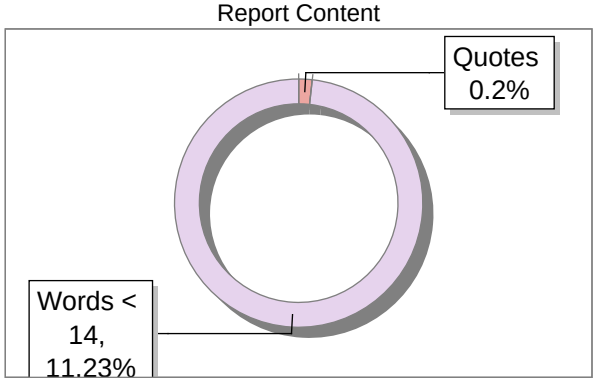

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MIDDLE MESIAL CANAL IN MANDIBULAR I MOLAR: UNRAVEL THE HIDDEN ANATOMY.

INTRODUCTION

The aim of root canal treatment is to eliminate all irritants from the root canal system which include necrotic pulp tissue, microorganisms and their byproducts. Thorough knowledge of the internal dental morphology is extremely important for effective cleaning and shaping the root canal system. Therefore, it is imperative that aberrant anatomy is identified before and during root canal treatment of such teeth. The most frequent type of tooth encountered for endodontic treatment are permanent mandibular molars which is the earliest posterior tooth to erupt. Traditionally, mandibular molars are described as 2-rooted teeth with 2 canals in the mesial root and 1 or 2 canals in the distal root.[1,2]

It has been theorised that secondary dentin apposition during tooth maturation would form dentinal vertical partitions inside the root canal cavity, thus creating root canals. A third root canal may also be created inside the root canal cavity of mandibular molars by this process. Such third canals are situated centrally between the two main root canals, the buccal and lingual root canals. The diameter of those third middle canals is smaller than that of the other two.[3] The probability of a mandibular first molar having a fifth canal is 1–15%.[4]

The presence of a middle mesial canal in a mandibular molar was first reported by Vertucci and Williams.[5] thereafter many case reports presented aberrant canal morphology in the mesial root. Magnification with loupes or microscope improves the visibility and thus helps in the detection of small hidden canals.

The purpose of this article is to report the successful treatment of a clinical case of a mandibular molar with three mesial canals.

CASE 1:

A 23-year old female patient reported with chief complaint of decayed tooth and associated pain over her left mandibular region since 2 weeks. History of presenting illness showed dull, continuous pain on chewing. On intraoral examination, deep carious lesion was present wrt 36. Tooth exhibited no mobility and was tender on vertical percussion. Her medical history was noncontributory. Periodontal probing was within the normal limit.

Preoperative periapical radiograph revealed deep carious lesion involving pulp with widening of apical periodontal ligament space wrt 36 [Figure 1]. The involved tooth gave exaggerated

response to electric pulp tester in comparison to the contralateral tooth. A diagnosis of Symptomatic irreversible Pulpitis with Symptomatic apical periodontitis was made for the involved tooth and endodontic treatment was scheduled. The goal of the treatment was to relieve pain through root canal treatment followed by suitable Post endodontic restoration.

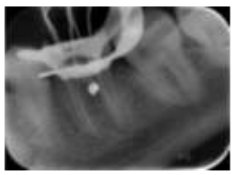
After administering local anesthesia with 2% lignocaine, dam isolation was done and all carious tissue was removed and an adequate endodontic access was made. After pulp extirpation and copious irrigation of the pulp chamber, upon careful examination of the groove between the mesiobuccal and mesiolingual canal orifices, the middle mesial canal orifice was identified with endodontic explorer and the canal subsequently negotiated with 6K file [Figure 2].

Middle mesial in the mandibular first molar was detected using the dental loupes. The working lengths were established with an electronic apex locator, and size 10 K files of 21 mm length were used to confirm three canals in the mesial root radiographically [Figure 3]. Angled radiograph showed Independent mesiolingual canal and middle mesial canal confluent mesiobuccal canal. Distal root canals (DB & DL) were fin type with different port of exit. The canals were instrumented with stainless steel hand instruments – K files of 21 mm length till 20k file. Irrigation was done with copious amounts of 3% sodium hypochlorite and 17% ethylene diaminetetraacetic acid. Rotary instrumentation was carried with Neoendo flex files till 25.4% for each canal and a master cone xray was taken [Figure 4]. The canals after preparation were finally flushed with sterile saline, dried with sterile paper points, and a calcium hydroxide dressing was given and was temporized with zoe cement. At the subsequent visit after a week, the tooth was asymptomatic, all the canals were recapitulated, irrigated, dried and was obturated with gutta percha cones and zoe sealer. A postobturation angled radiograph was taken [Figure 5]. The patient experienced no postoperative sequelae and an appropriate post-endodontic restoration was performed in a subsequent appointment to ensure an adequate coronal seal.

CASE 1:

1. Pre- op

2. Negotiated 3 mesial



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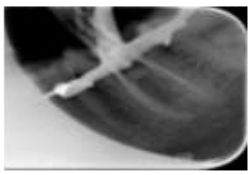
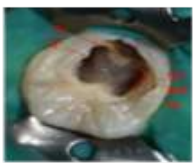
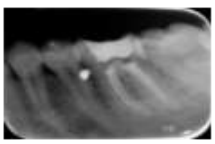


4. Master cone



Canal orifices after cleaning and shaping

5. Immediate post-op (straight view)



Immediate post-op (angled view)

3 month follow up

Post endo ??

CASE 2:

A 48 year old male patient referred from dept of periodontics for intentional root canal treatment wrt 36 and 37. Patients chief complaint was pain in left mandibular region since 1 month. On clinical examination, tooth exhibited grade I mobility wrt 36, grade II mobility wrt 37 with draining pus through gingival sulcus and was tender on horizontal percussion. His medical history was noncontributory. Both tooth were noncarious, but it did not respond to vitality test with thermal or electric pulp tester.

On first appointment, full-mouth scaling was done followed by root canal procedure in relation to 36 and 37. Local anesthesia was administered, and access opening was done under rubber dam.

After pulp extirpation and copious irrigation of the pulp chamber, upon careful examination of 36, the groove between the mesiobuccal and mesiolingual canal orifices, the middle mesial canal orifice was identified with endodontic explorer and the canal subsequently negotiated with 6K file [Figure

2]. The working lengths were established with an electronic apex locator, and size 10 K files of 21 mm length were used to confirm three canals in the mesial root radiographically [Figure 3].

Angled radiograph showed mesiolingual canal and middle mesial canal confluent mesiobuccal canal and Distal root canals (DB & DL) were fin type in tooth 36. Tooth 37 showed 2 mesial and 1 distal canal.

The canals were instrumented with stainless steel hand instruments – K files of 21 mm length till 20k file. Irrigation was done with copious amounts of 5% sodium hypochlorite and 17% ethylene diaminetetraacetic acid. Rotary instrumentation was carried with ProTaper gold file and GP (size F2) for each canal. The canals after preparation were finally flushed with sterile saline, dried with sterile paper points, and a calcium hydroxide dressing was given for 2 weeks and was temporized with zoe cement. Patient did not report for the subsequent appointment after 2 week. Patient reported back after 2 months, all canals were further irrigated with 3% Naocl and calcium hydroxide dressing for 1 week. The tooth was asymptomatic, all the canals were recapitulated, irrigated, dried and was obturated with gutta percha cones and AH plus sealer.

A postobturation angled radiograph was taken [Figure 4]. The patient experienced no postoperative sequelae and access closure was done with composite resin. The patient was referred back to dept of periodontics for further periodontal therapy wrt 36 and 37.

Discussion

The present paper reports the endodontic management of confluent middle mesial canals in the mandibular first molars.
Several studies have been reported with unusual canal anatomy in mandibular first molar. [6,7,8]

A good preoperative radiograph help in preventing missed anatomy, though it has limitations in assessing the number of canals, radiographs taken from at least two different horizontal angles along with careful interpretation will aid in the detection of extra canals.[9] Clinically, the central importance in locating the orifices of the root canals by a proper access cavity preparation, examination of the pulp chamber floor with a sharp explorer, troughing of grooves with ultrasonic tips, staining the chamber floor with 1% methylene blue dye, and performing the sodium hypochlorite "champagne bubble" test, fibrooptic transillumination, visualizing canal bleeding points and the feeling of a "catch" on the canal wall during instrumentation are important aids in localizing root canal orifices.
Advancement of ultrasonic systems become useful tool in exploring and identifying the extra canals by avoiding the bulky head of the conventional hand piece that frequently obstructs the vision.
The radiographic aids in locating the additional canal include: fast break guideline, eccentric location of an endodontic file during working length determination, inconsistent apex locator readings, a sinus tract that traces laterally away from the main canal.[10]

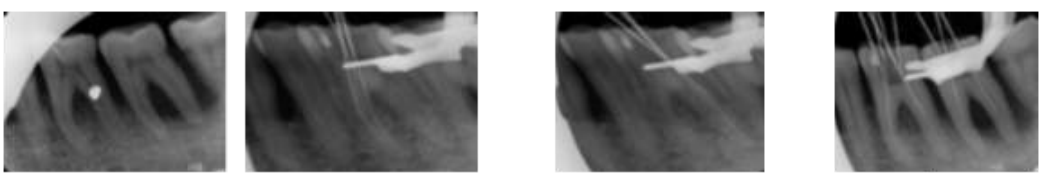
Dental loupes are one of the most common magnification system used in dentistry. It provides better visualization as it enables the clinicain to treat cases which are labeled as having poor prognosis or untreatable. Magnification has been found to increase the detection of extra canals. In this paper, both cases were managed endodontically using dental loupes.

(

Conclusion:

Treating extra canals may be challenging but the inability to find and properly treat root canals may cause failures. Even though the incidence of middle mesial canal is low, every effort made in looking for this canal has a high clinical relevance. A clinician should be vigilant and use additional aids for canal negotiation, whenever an additional or aberrant canal anatomy is suspected.

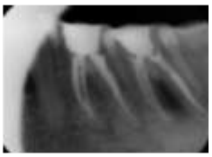
CASE 2



1 Pre- op | 2. Negotiated 3 mesial | Negotiated of distal canals | 3.WL

Canal orifices after cleaning and shaping | Obturation

Master cone



4. Immediate post-op (angled view)

Immediate post-op (straight view)

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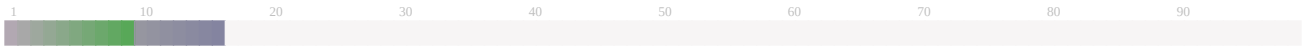

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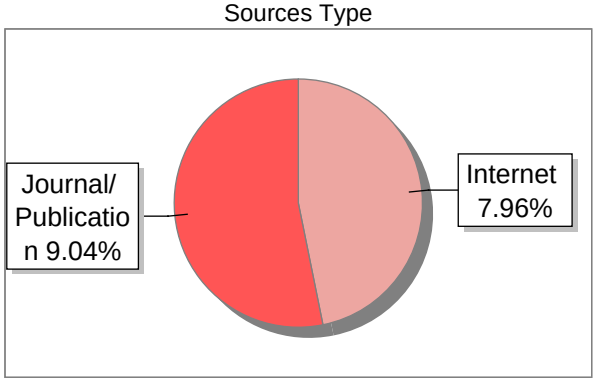

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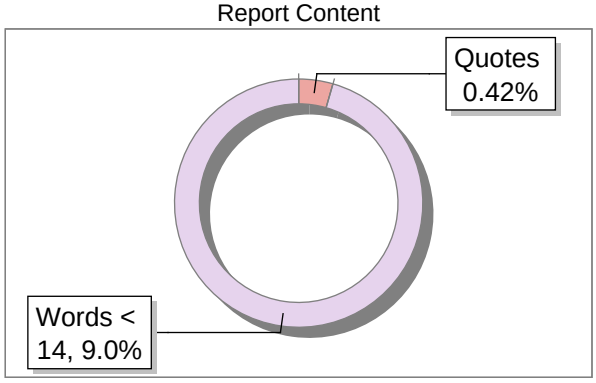

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Comparative evaluation of microleakage in class II cavities restored with snow plow technique using different flowable composite resins as gingival increment followed by packable composite resin restorations – an in vitro dye extraction study

Introduction

Dental composite resins have advanced tremendously to become the most preferred material for direct restorations in both anterior and posterior teeth. The restoration of natural contour of tooth, proximal contacts as well as sealing of the margins is of critical importance.

Despite having good physical and mechanical properties, the main reason for failure of these restorations is the recurrence of caries. Achieving a complete and durable marginal seal in direct composite resin restorations, particularly in class II cavities still poses a challenge.[1] Polymerization shrinkage associated with these materials generates stresses that can damage the bond of the resin composites to the cavity walls, which produces microleakage allowing bacteria and fluids to move via the tooth-restoration interface.[2] This marginal microleakage can produce recurrent caries, hypersensitivity, discolorations, and pulpal lesions, among others.[3]

Polymerization shrinkage in composite resin is governed by various factors, some of which are under the manufacturer's control while others are under the clinician's control. Factors under manufacturers control include type and amount of resin matrix, type and amount of the filler and photo activator system used. Factors under clinicians control include using various techniques such as different incremental placement techniques, using low modulus of elasticity material as the first increment, placing thicker adhesive layers under composites, using fiber inserts and use of various light curing methods such as

ramp curing and pulse curing.[4]

One of the most important factors in the reduction in shrinkage stresses in class II cavities, is the restoration placement techniques. Although incremental technique may be important for adequate light penetration, its disadvantages are the possibility of trapping voids between layers and the formation of oxygen inhibition layer at the surface of the cured layer. Among the placement techniques, application of resin composite in bulk increments of up to 4mm has the advantages of reduced treatment time by reducing the number of increments, enhanced depth of cure owing to the addition of specialized fillers and photo initiators, and reduction in the number of voids.[5]

The recently developed bulk Fill composite resins possess specific characteristics, enabling them to adapt efficiently to the cavity preparation.[6] However in deep class II preparations, marginal adaptation and flow is questionable even with bulk fill resins. To overcome these challenges in class II cavity restorations, snow plow technique was introduced, in which a less viscous material is applied as gingival increment, overlayed by packable bulk fill composite resin and both materials together are co cured.[7] Subsequently, rest of the preparation is completed with packable bulk fill composite resin. This technique has the advantages that the more viscous superficial composite helps in better flow and adaptation of flowable material, better bonding to unset subsequent increment and allows the flowable material to behave as a stress absorber. [8]

SDR plus bulk fill composite resin was developed with a Stress Decreasing Resin (SDR™) technology. It enables bulk-fill up to 4mm instead of placing and curing multiple composite layers in Class I and II restorations. It is indicated to be overlayed with a methacrylate-based universal composite for replacing missing occlusal/facial enamel. The SDR technology is a patented urethane dimethacrylate structure that is responsible for the reduction in polymerization shrinkage and stress.[9] SDR has minimal overall shrinkage

(3.5%) compared to other conventional flowable composites. Lower volumetric shrinkage contributes to overall lower polymerization stress. It also exhibits self levelling technology that promotes excellent cavity adaptation.[10]

Tetric N-Ceram Bulk Fill and Tetric N-Flow Bulk Fill can be applied in "bulk" increments of up to 4 mm as they contain the new light initiator called Ivocerin.[11] As a result of its higher photo-reactivity compared with the initiators contained in other bulk-fill materials, the opacity of the composite resin is also slightly higher. Hence, polymerization is initiated even in very deep cavities and the material is fully cured. It contains an isofiller, a specially conditioned shrinkage stress reliever with a low modulus of elasticity, that attenuates the forces generated during shrinkage and thereby keeps shrinkage and stress during polymerization to a minimum.[12]

The curing shrinkage and its associated stress may be greater for a flowable composite, due to the typically lower filler content, and pre-curing of this liner produces stresses that may compromise its adaptation and sealing of the margins. The composite placement technique in snow plow method ensures that the flowable material is "pushed" into a highly thin layer that is simultaneously cured with the conventional composite, the negative effects of shrinkage of a relatively thick layer of flowable is potentially negated.

A search on literature is limited regarding evaluation of microleakage in class 2 cavities restored with SDR plus bulk fill and Tetric N flow bulk fill composite resin as initial increment in snow plow technique. Hence the current study evaluated microleakage in class 2 preparations restored with SDR plus bulk fill and Tetric N flow bulk fill as initial increment with Tetric N ceram bulk fill composite resin in snow plow technique.

Methodology

50 extracted mandibular molars free of caries, cracks, decay and restorations were selected for this study. All the selected teeth were stored in 0.5%

chloramine T solution for 12 hours, and then washed and transferred to 0.9% saline solution. Standardized class II mesio occlusal box preparations were made with following dimensions - 3mm buccolingually and 2mm mesiodistally. Gingival seat of the proximal box was placed 1 mm above cementoenamel junction. The samples were randomly assigned into two groups of 25 teeth in each group for restorations. Samples of each group were mounted in contact with each other, Tofflemire matrix band and retainer was adapted to establish contact and restored as follows:

GROUP 1 – Flowable bulk fill (Tetric N Flow) and packable bulk fill composite resin (Tetric N Ceram) in snow plow technique. Restoration completed with packable bulk fill composite resin.

GROUP 2 – Flowable bulk fill (SDR plus) and packable bulk fill composite resin (Tetric N Ceram) in snow plow technique. Restorations were completed with packable bulk fill composite resin.

All restorations were finished and polished with soflex discs and points.

The samples were then stored in distilled water for 24 hours at 37 °C and then thermo-cycled for 500 cycles with dwelling time of 30 seconds and transfer time of 5 seconds, between 5°C and 55 °C. For microleakage assessment, the radicular apices of teeth were sealed with sticky wax and root and crown surfaces of the teeth were completely covered with nail varnish except for 1-2 mm around the margins of restorations. Specimens were then immersed in 2% methylene blue dye for 24 hours. After 24 hours, the samples were washed under tap water to remove the traces of the dye. The nail varnish was removed using polishing discs.

The teeth were placed in test-tubes containing 3 ml of 65 wt % nitric acid for 3 days. Test-tubes were centrifuged at 5,000 rpm for 5 mins. Supernatant from each sample was transferred to cuvettes. The dye absorbance was measured in a UV visible spectrophotometer at 550nm.

The results of the spectrophotometer indicate the dye absorbance of methylene

blue in resin-dentin interface which indicates the microleakage of restoration. The results obtained were statistically analyzed and evaluated. Fig 1 SDR plus and Tetric N bulk fill composite resins Fig 2 Standardized class II mesio-occlusal box preparation Fig 3 UV Spectrophotometer

Results

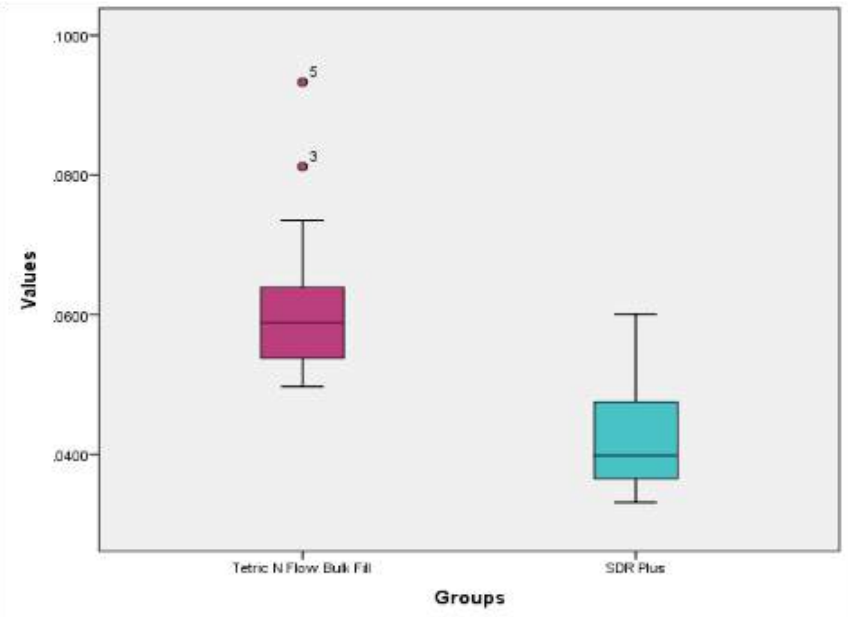
Data showed non-normal distribution, hence non-parametric test (Mann-Whitney U test) was applied. In this study, the microleakage score in teeth restored with group I & II were (IQR 0.0129) & (IQR 0.0116) respectively.

Mann-Whitney U test showed statistically significant difference between the groups (p=0.001). SDR plus bulk fill in snow plow technique showed lower microleakage compared to Tetric N flow bulk fill in snow plow technique.

Table 1: Comparison of the microleakage between the groups using Mann-Whitney U test

Groups	N	Minimum	Maximum	Median	IQR	p value
Tetric N flow Bulk fill	24	.0497	.0933	0.05890	0.0129	0.001*
SDR plus	24	.0331	.0601	0.0398	0.0116	

Fig 4 Box and whiskers graph depicting microleakage values of the two groups



Discussion

Polymerization shrinkage of resin composites is a drawback leading to microleakage that influences success and longevity of restorations. Various techniques and materials have been tried to minimize microleakage.

One such method is the use snow plow technique introduced by Opdam in which a less viscous material is applied as gingival increment, overlayed by packable composite resin and co cured.[7] This improves the marginal adaptation of the material and subsequently reduces the microleakage. Also, the flowable layer acts as a stress absorber, thereby reducing the overall polymerization shrinkage stresses.[8]

An invitro study by Peutzfeldt et al, reported significantly lower microleakage with snowplow technique using flowable and packable composite resins.[13] The literature shows limited studies in this technique with bulk fill composite resin.

Bulk fill composite resins were used in this study, as they exhibit increased depth of cure and reduced polymerization shrinkage.

Tetric N-Ceram is characterized by its excellent esthetic properties and easy

handling as well as its clinical longevity. Tetric N-Ceram Bulk Fill and Tetric N-Flow Bulk Fill both contain "ivocerin" as the photoinitiator which is highly photoreactive and provides for increased depth of cure of upto 4mm.[11] The new "Aessencio" technology is responsible for lowering the translucency of the material during the polymerization process which allows it to blend in seamlessly with the surrounding dental tissues. It also contains a patented "shrinkage stress reliever" with a low modulus of elasticity(10GPa) that effectively reduces the stress during polymerization.[12]

SDR plus is another bulk fill composite resin that was developed with a patented larger molecular weight UDMA resin (molecular weight of 849 g/mol for SDR resin compared to 513 g/mol for Bis-GMA).[17] The SDR technology comprises the unique combination of such a large molecular structure with a chemical moiety called a "Polymerization Modulator" chemically embedded in the resin matrix. The high molecular weight and the conformational flexibility around the centered modulator enables it to dissipate more energy (and store less) during polymerization.[18] It is designed to be overlayed with a methacrylate-based universal/posterior composite for replacing missing occlusal/facial enamel.

A study was done by Kaisarly et al, to evaluate the effect of flowable liners beneath a composite restoration applied via different methods on the pattern of shrinkage vectors.[8] The results showed that flowable liners act as a stress reliever, and recommended to apply a thin or thick layer of flowable liner beneath bulk-fill composites.

A study was done by Tabatabaei et al, to compare the gingival microleakage of Class II composite restorations through three restorative methods, Conventional incremental, open sandwich and snow plow.[7] The results showed that there is less microleakage in snow plow technique in which the intermediate material is used, compared to conventional incremental method.

A study by Sampaio et al, evaluated composite placed with the snowplow

technique versus incremental placement, using the low stress flowable bulk-fill composite (SDR flow) as the first uncured flowable layer.[14] They assessed marginal adaptation with SEM and micro-CT and found that the snowplow method produced fewer gaps than an oblique incremental technique, but similar to a horizontal increment method with conventional composite.

In the present study, SDR plus with Tetric N ceram bulk fill composite resin in snow plow technique (group I) showed lower microleakage with a median of 0.05890 (IQR 0.0129) compared to Tetric N flow and Tetric N ceram bulk fill composite resin in snow plow technique (group II) with a median of 0.0398 (IQR 0.0116). The results were statistically significant ($P<0.05$). This can be attributed to the higher molecular weight of UDMA resin and the polymerization modulator in the resin matrix of SDR which impart flexibility and dissipate energy during polymerization. This results in a minimal overall shrinkage (3.5%) when compared to other flowable composites.[16] And the "Self-levelling" ability provides excellent cavity adaptation and hence good marginal sealing property.[17] This SDR layer overlaid with Tetric N ceram bulk fill composite and cured in snow plow technique, would have improved its adaptation and sealing ability, resulting in reduced microleakage values.

In this study, human permanent mandibular molars were selected as Class II lesions are most commonly encountered in molars. Microleakage is frequently detected on the proximal gingival margins.[19] In this study, class II box cavities were prepared and all the cavities had similar dimensions of 3mm buccolingually and 2mm mesiodistally to standardize the preparation.[21] The gingival margins of the cavities were placed 1mm above CEJ.

After completing the restorations, the specimens were subjected to thermocycling. Thermocycling is an invitro process of subjecting the specimens to extremes of temperature to simulate oral conditions. In the oral cavity, restorations are subjected to both thermal and mechanical stress that also

contributes to the increase of marginal leakage. Thermocycling is widely used method to determine if temperature variation might influence the bond strength and to simulate in vitro thermal changes that occur in the oral cavity.

To assess sealing efficiency of restorative material & microleakage, the most common method is the use of various dyes. In this study, 2% methylene blue dye was chosen for dye extraction because it is simple, economical and does not require any complex laboratory apparatus. Even particle size of this dye is less than internal diameter of dentinal tubules (1-4 µm) and can show dentin permeability.[18] In dye extraction method, teeth are dissolved in acids that release all dye from the interface and optical density of solution is measured by adsorbing light via spectrophotometer. Dye extraction method presents a benefit over fluid filtration technique, as filtration values tend to diminish over time, as the water penetrates all irregularities until a plateau is reached.[20] Hence, dye extraction method was used in our study to evaluate microleakage.

Conclusion

Within the limitations of the present study, it can be concluded that,

- Both bulk fill composite resin class II restorations in the study exhibited microleakage at the tooth restoration interface.
- Snow plow technique of restoring class II cavities with SDR plus and Tetric N ceram bulk fill composite resin showed lower microleakage compared to Tetric N flow and Tetric N ceram bulk fill composite resin in snow plow technique.

Further studies in much deeper class II cavities with gingival margins 1mm below CEJ and different cavity configurations, along with long term clinical trials are needed.

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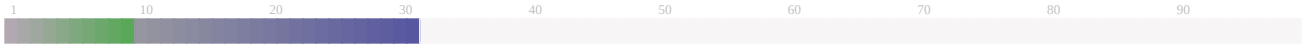

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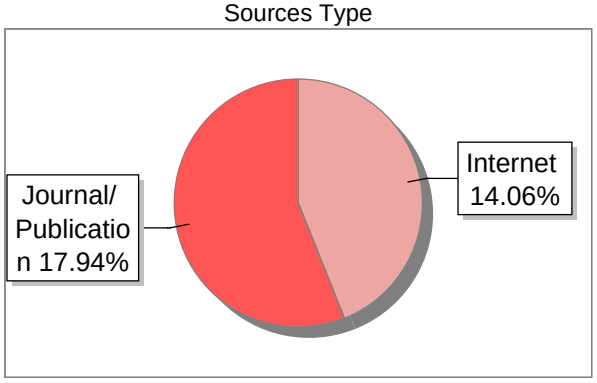

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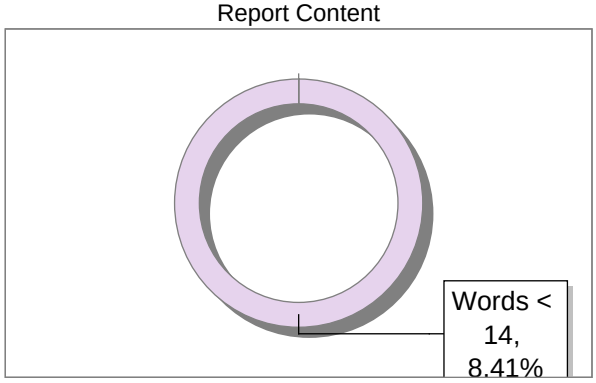

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EVALUATION OF THE ANTIBACTERIAL ACTIVITY OF VARIOUS CONCENTRATIONS OF RAISIN EXTRACT AGAINST STREPTOCOCCUS MUTANTS: AN IN VITRO STUDY

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INTRODUCTION

Dental caries is one of the most common and costly diseases in the world. Although dental caries is rarely life threatening, it is a major problem for health service providers.[1] According to Global Oral Health Data Bank, prevalence of dental caries varies from 49% to 83% across different countries.[2]

In order to decrease the prevalence of caries, an improved understanding of the role of the microorganisms in dental caries is needed. *S. mutans* is considered as the pioneer organism in dental caries. *S. mutans* have a central role in the etiology of dental caries because it can adhere to the enamel salivary pellicle and to other plaquebacteria.[3] Addition of antiplaque or antibacterial agents to dental health care products has been of value in controlling dental caries.

Various products like cholorhexidine, sodium fluoride, xylitol and triclosan have been found very effective in controlling *S. mutans* count.[4] Extracts containing polyphenols of plant origin gained more attention of researchers for their use against drug-resistant pathogens.[5] antibacterials or antibiotics from these sources have been found to work more efficiently with fewer side effects and less cost of production.[6]

Plant-based phenolic metabolites are beneficial to human health because of their potent antioxidant activity and wide range of pharmacologic properties such as antioxidant, anticancer, and platelet aggregation inhibition activities. It is important to stress more on natural products than artificial drugs. Going green has major benefits to patients and also environment.

Fruits like grape contain various nutrient elements, such as vitamins, minerals, carbohydrates, edible fibers and phytochemicals. Polyphenols are the most important phytochemicals in grape because they possess many biological activities and health- promoting benefits. Polyphenolics from grapes and red wines attracted the attention of scientists to define their chemical composition and their properties for human health. [7]

Black grape (*Vitis vinifera*) skin is a great source of phenolic compounds, which contains simple compounds (monomers) to complex tannin type substances (oligomers and polymers). There are many classes of negatively charged polyphenols that have been identified in grapes, such as phenolic acids (benzoic, hydroxycinnamic acids), stilbene derivatives (resveratrol), flavanols (catechin,epicatechin), flavonols (kaempferol, myricetin), anthocyanin and many more.[8]

These polyphenols possess many beneficial effects on human health such as inhibition of free radical damage, antibacterial, antifungal, decreasing the risk of cardiovascular diseases, anticarcinogenic and anti-inflammatory actions on human health.[7] Grape as a whole is generally underutilized and thrown away by the wine factory as waste products. Grape skins are rich sources of anthocyanins, hydroxycinnamic acids, flavanols and flavonol glycosides in which flavanols are mainly present in the seeds.[8]

Black grape have their color because of the presence of anthocyanins, which is present in a huge amount as compared to other polyphenolic compounds. It contains a higher amount of dimers and trimers of epicatechin which possess a higher antibacterial activity than monomer ones.[9] Thus black grape is found to have both antifungal and antibacterial activities.[10] Catechins and other polyphenols are highly negatively charged phytochemicals, which can be related to antifungal

activity of black grape. The phenolic compounds from different parts of grape have showndifferent antibacterial effects. antibacterial activity of fermented grape was either aseffective as or significantly better than whole fruit grape extracts.[11]

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There is scarce literature reporting the antibacterial activity of raisins extract against *S. mutans.*

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Black Grape (Vitis

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v/v)

Hexane (80% v/v)

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The dried and ground raisins (500 mg) were extracted with one litre of ethanol three times by maceration, for up to three days. The resultant extracts were combined and concentrated in vacuo at 40 degree celsius. The concentrated extract was suspended in90% ethanol (250 ml), and then partitioned with 250 ml of hexane three times to afford hexane soluble syrup on drying. Next, the aqueous methanol

extract was partitioned with 250 ml of chloroform three times to give a chloroform soluble extract as per study by Zhu et al [12]

Estimation of minimum inhibitory concentration: [13]

It was done by mixing 90µl test compounds of different test concentration with 10µl Inoculum and was kept in 96 well plates. For Control, 90µl peptone broth without drug was used. The *S.mutans* treated plate was incubated at 37^0C for 24 to 48 hours and optical density at 590 nm was measured using a tecan plate reader. Minimum inhibitory concentration of grape extract giving 50% inhibition of optical density was compared with control.

15 After incubation 20µl Resazurin (1000µg/ml) was added to each well and incubated for 4hr to confirm the viability of culture. Evaluation of ANTIBACTERIAL activity by Well Diffusion Method: The antibacterial activity was determined by well diffusion technique. It was performed on soya bean casein digested agar plates. S. mutans (ATCC 25175) was used as test organism and Ciprofloxacin (100 µg/mL) was used as standard.14 Distilled water was used as a control. S. mutans (100µl) was inoculated on soya bean casein digested agar plates (90 mm). Raisins extract (25 µl), standard ciprofloxacin (25µl) and Control (25µl) for S. mutans were added to the 5mm well on agar plates. The treated plates with S.mutans were incubated at 370C for 24-48 hrs. The Minimum inhibitory concentration of raisin extract was determined by the ability of each substance to inhibit the growth of S. mutans around the 90 mm wells in soya bean casein digested agar plates. (Figure 1) SOYA BEAN CASEIN DIGESTED AGAR PLATESHOWING ZONE OF INHIBITION FIGURE 1

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Various concentrations of raisins were used to find the minimum inhibitory concentration of the extract. At 15.62 µg/well concentration, 15.19 % inhibition was found for raisins extract. The concentration of raisins extract was gradually increased up to a concentration of 1000 µg/well at which the inhibition of 75.98 % was observed. Minimum inhibitory concentration of raisin extract was observed at a concentration of 125 µg/well at which an inhibition rate of 48.65 % was observed.

For ciprofloxacin, 50% inhibition or an MIC value was observed at a concentration of 0.5 µg/well.

Minimum zone of inhibition of 16±0.0 mm was observed at a concentration of 2.5 µg of raisins extract. There was no zone of inhibition found at a concentration of 1.5 µg of raisins extract. Minimum zone of inhibition of 25±0.0 mm was observed at a concentration of 2.5µg for ciprofloxacin.

DISCUSSION

Black grapes have their color because of the presence of anthocyanins, which is present in a huge amount as compared to other polyphenolic compounds. The amount of total polyphenols in the black grape varieties is higher as compared to that of green grape, due to the presence of the anthocyanins. The antibacterial property is also aided by the presence of polyphenols like oleanolic aldehyde, linoleic acid, linolenic acid, botulin, betulinic acid, 5-(hydroxymethyl)-2-furfural, rutin, b-sitosterol, and b-sitosterol glucoside were identified by comparing their physical and spectroscopic values. as an antibacterial agent, these polyphenols can penetrate the semi permeable cell membrane where they react with the cellular proteins. The intention of the current study was to check whether higher concentration gives better efficacy against *S mutans.* This study also evaluated the MIC of raisins extract collectively against *S. mutans.*

A study conducted by Cruz. J.F and Zhu. M [12] using the same method as the present study assessed the MIC of various compounds in raisins extract individually. The results of the study showed that various polyphenols in raisins showed different MIC values against *S. mutans*. The MIC values for different polyphenols were Oleanolic acid (625 µg/ml), Lineoleic acid (488 µg/ml), Rutin (250 µg/ml) and for 5 Hydroxymethyl-2- furfural (31 µg/ml). The results of the current study could not be compared with this study because current study compared the MIC value of raisins extract collectively.

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In the present study we found an MIC value of 125 µg/ml against *S.mutans*. The zone of inhibition was determined by well diffusion technique using soya bean casein digested agar plates and it was found to be 16 mm after incubating it for 48 hours at 37 ^{0}C. The results of the current study could not be compared with that of other studies as this is the first study of its kind which compared the MIC value of raisins extract collectively.

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Firstly, it was an in vitro study; the results cannot be extrapolated to in vivo situation. Secondly, in this study the MIC value for polyphenol components was determined collectively and further studies determining the MIC of individual polyphenol compound in the black raisin extract need to be conducted.

Further studies are recommended using Innovative technologies to obtain the pure black raisins extract and in vivo studies has to be conducted to find the efficacy of black raisins extract. Assessing the ANTIBACTERIAL efficacy against *S. mutans* is asurrogate end point but the true end point is the change in dental caries that has to be detected or find out using longitudinal studies.

Table1: Inhibitory activity of test compounds against test organism

Test Organisms	Test Compounds	Concentration per well	Zone of inhibition (mm)
Streptococcus mutans	**Control**	**-**	**-**
	Ciprofloxacin (Standard)	**2.5µg**	**25±0.0**
	Streptococcus mutans	**2.5mg**	**16±0.0**
		1.5mg	**-**

Table 2: Determination of Minimum Inhibitory concentration of Standard (Ciprofloxacin) against *S.mutans.*

Standard Conc. (µg/well)	*S.mutans*	
	OD	%Inhibition
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0.125	0.51	17.42
0.25	0.45	26.94
0.5	0.31	50
1	0.24	60.81
2	0.18	71.13
4	0.14	77.14
8	0.09	85.48
MIC(µg/well)	**0.5 µg**	

Table 3: Determination of Minimum Inhibitory concentration of raisin extract against *S.mutans*

Sample Conc. (µg/well)	*S.mutans*	
	OD	%Inhibition
0	0.60	0.00
15.62	0.51	15.19
31.25	0.43	28.61
62.5	0.38	37.39
125	0.31	48.65
250	0.26	57.10
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1000	0.15	75.98
MIC (µg/well)	**250µg**	

CONCLUSION

Raisins have been consumed for a long time and are commonly used in various food preparations. The studies have demonstrated an inverse association between intake of raisins and mortality from age related diseases such as coronary heart diseases. Anthocyanins, flavonoids and resveratrol are the major functional components that are responsible for most of biological activities of grape. The health benefits of grape are thought to arise mainly from bioactivities of their polyphenols

Raisins contain polyphenols, antioxidants, flavonoids and iron that may benefit overall human health. Black raisins are found to have antibacterial efficacy against *S.mutans* and also has several other health benefits. It has an MIC value of 125 µg/ml at which the rate of inhibition is 48.65%. The structural diversities and pronounced biological activities of compounds in raisins indicate that raisins are worthy of further studies that may lead to the identification of new functional constituents. Going green has a major benefit to the patients and also to environment thus the usage of raisins should be promoted in daily usage.

ACKNOWLEDGEMENT

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CONFLICT OF INTEREST

There is no conflict of interest

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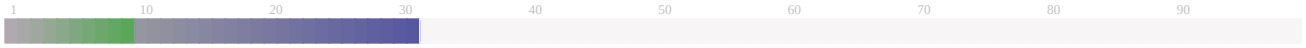

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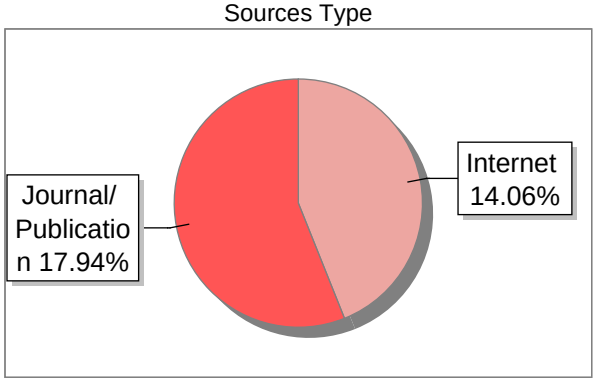

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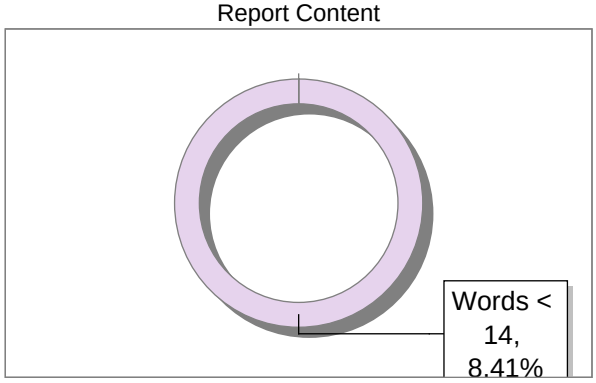

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3	Streptococcus mutans, Caries and Simulation Models by Forssten-2010	4	Publication
4	www.dx.doi.org	3	Publication
5	docview.dlib.vn	2	Publication
6	accjournal.org	1	Internet Data
7	docobook.com	1	Internet Data

EVALUATION OF THE ANTIBACTERIAL ACTIVITY OF VARIOUS CONCENTRATIONS OF RAISIN EXTRACT AGAINST STREPTOCOCCUS MUTANTS: AN IN VITRO STUDY

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   Dayananda Sagar College of Dental Sciences, Bengaluru

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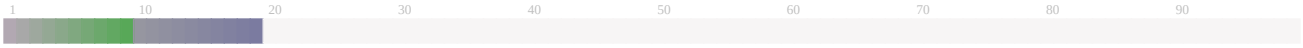

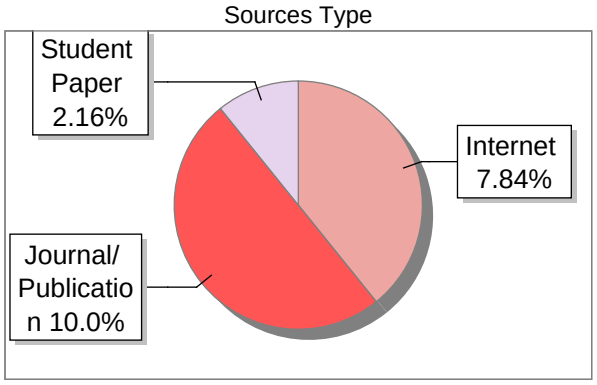

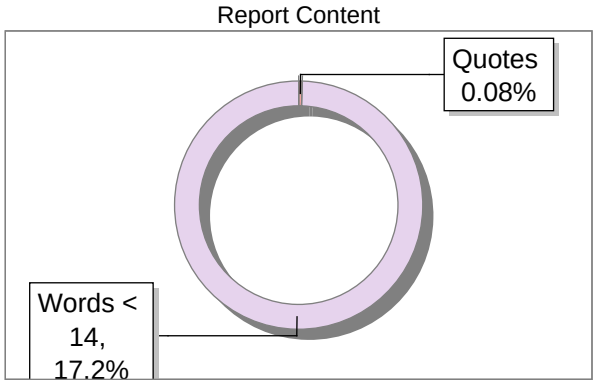

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ATTRITION AS A RISK FACTOR IN INTERDENTAL PAPILLARY HEALTH – A PROSPECTIVE OBSERVATIONAL STUDY

Savita A.M, Jisha S Raj*

INTRODUCTION

The interdental papilla occupies the gingival embrasure, which is the interproximal space apical to the area of tooth contact.[1] The shape of interdental papilla can be pyramidal in the anterior or "col" shaped in the posterior.[2] It acts as a biological barrier and protects the underlying periodontal structures from microbial invasion while playing a crucial role in phonetics and aesthetics.[3] An array of problems arises ranging from phonetics to food impaction and aesthetic disharmony in case of papillary pathology.[4] Hence integrity and preservation of the interdental papilla is an essential part of the functional and aesthetic rehabilitation of dental treatment. The health of interdental papilla is influenced by age, gender, brushing techniques, oral hygiene and clinical crown height.[5, 6]

Attrition is the loss of tooth structure due to mechanical grinding or interaction with other teeth. It is caused by tooth-to-tooth contact, usually where the teeth meet on the incisal or occlusal edges. Well-defined, sharp, flat and shiny wear marks, known as 'facets' appear on molar and premolar tooth cusps or ridges. Attrition on anterior teeth results in matching wear patterns between maxillary and mandibular teeth. Tooth grinding (bruxism) is a main cause of this type of tooth wear.[7] Dental attrition is seen to have a prevalence rate of 29% in the South Indian population[8] and might lead to plaque accumulation and also aggravate the periodontal disease already present. Hence an attempt was made to evaluate the effect of attrition on interdental papillary health.

MATERIALS AND METHODS

SOURCE OF DATA

Study was conducted on out patients reporting to the Department of Periodontology, Dayananda Sagar College of Dental Sciences, Bengaluru.

Male:Female ratio – 1:2

STUDY DESIGN

Experimental method – Prospective observational study

SAMPLE SIZE DETERMINATION

Sample size estimation was done using R-Software 3.4.2 with effect size at 0.2, α error – 0.05 and power – 0.95. The output generated suggested a total sample size of 55.

PARTICIPANTS

Inclusion criteria

- Patients with attrition of either anterior or posterior teeth.
- Patients in the age group of 25-60 years.
- Patients with a minimum of a total of 24 natural teeth.

Exclusion criteria

- Patients diagnosed with Stage I, Stage II, Stage III and Stage IV periodontitis.
- Patients suffering from any form of systemic diseases.
- Patients currently on antibiotic/anti-inflammatory therapy, steroids or hormonal therapy within the past 6 months.
- Patients with history of any dental therapy in the past 14 days.
- Patients with oral abusive habits such as smoking, consumption of alcohol or tobacco.
- Patients diagnosed with any form of psychosomatic disorders.
- Patients with parafunctional habit of bruxism.

CLINICAL PARAMETERS

The study data were entered into a standard proforma.

All the participants were assessed clinically for Plaque Index [Sillness J and Loe H, 1967] [9], Sulcus Bleeding Index [Muhlemann HR, 1971] [10], Papilla Presence Index [Cardaropoli, 2004] [11] and Hooper et al.'s classification for tooth wear [2004] [12].

STATISTICAL ANALYSIS

The data collected from each subject were entered into Excel sheet and a master chart was prepared. The data was analysed using R-Software 3.4.2. The data was tested for normality and following the Pearson's correlation coefficient was computed between tooth wear index, Plaque Index, Sulcus Bleeding Index and Papilla Presence Index. The result was considered statistically significant whenever $P<0.05$.

RESULTS

Pearson's Correlation Coefficient	Tooth wear index vs Plaque index	Tooth wear index vs bleeding index	Tooth wear index vs Papilla presence index
r	0.314	0.6549	0.6696
95% confidence interval	0.1041 to 0.4971	0.5104 to 0.7634	0.5295 to 0.7741
R squared	0.09859	0.4288	0.4484
P (two-tailed)	0.0041	<0.0001	<0.0001
P value summary	**	****	****
Significant (alpha = 0.05)	Yes	Yes	Yes
Number of XY Pairs	82	82	82

A. Correlation between Tooth wear index and Plaque Index

The Pearson's Correlation of Tooth wear v/s Plaque Index was found to be positively correlated (r = 0.314), P = 0.0041 with 95% confidence interval (0.1041, 0.4971) which was seen to be statistically significant. Although there was a positive relation between Tooth wear index and Plaque Index, the contribution to the relation between Tooth wear index and Plaque Index was only 9.86%.

B. Correlation between Tooth wear index and Sulcus Bleeding Index

The Pearson's Correlation of Tooth wear v/s Sulcus Bleeding Index was found to be positively correlated (r = 0.6549), P < 0.0001 with 95% confidence interval (0.5104, 0.7634) which was seen to be statistically highly significant. Further the R-squared was 0.4288, i.e., change in tooth wear index contributed by Bleeding Index was 42.88%.

C. Correlation between Tooth wear index and Papilla Presence Index

The Pearson's Correlation of Tooth wear v/s Papilla Presence Index was found to be positively correlated (r = 0.6696), P < 0.0001 with 95% confidence interval (0.5295, 0.7741) which was seen to be statistically highly significant. Further the R-squared was 0.4484, i.e., change in tooth wear index contributed by Bleeding Index was 44.84%.

DISCUSSION

The interdental papillae which fill the area between the teeth apical to their contact points play a major role by acting as a biological barrier and preventing bacterial invasion, and prevention of food impaction. A missing papilla is visible as a small triangular gap between adjacent teeth which often compromises the esthetics.

Age and sex seem to modify the presence of the interdental papilla. Dental attrition that is caused by tooth to tooth contact is seen to have detrimental effects on the interdental papilla. It causes more plaque accumulation as it leads to reduced crown height which makes it difficult for the patient to maintain oral hygiene.

This study has been done to assess the effect of attrition on interdental papillary health in terms of Plaque index, Sulcus bleeding index and the level of interdental papillary height. It was observed that the mean Plaque index scores, Sulcus bleeding index scores and Papilla Presence index scores were significantly related to Tooth Wear.

According to a study done by Ioannou AL et al.[13] it was concluded that risk indicators for visible papillary absence, sex and age, need to be taken into consideration for careful assessment and meticulous treatment planning with respect to preservation of the interdental tissues.

A study done by Joshi K et al.[14] observed that complete papilla fill was associated with crown width: length ≥ 0.88. The observations of this study are similar to the results of our study. However Handelman CS et al.[6] concluded that tooth wear shortens the clinical crown, and therefore, the measure of clinical crown height can give a false negative result when gingival recession is present. The gingival margin-papillae measurement was not affected by tooth wear and gave a true positive result for gingival recession. It was seen that tooth wear (attrition) was not associated with an increase in gingival recession. The results of our study are in contrary to the observations of this study.

However various confounding factors like age, sex and parafunctional habits like bruxism could have influenced the results of the study which have not been taken into consideration and the sample size is not large enough to generalize the results.

CONCLUSION

According to this study it can be concluded that Plaque index and Sulcus bleeding index measures and level of interdental papillary height is influenced by attrition.

However larger sample size is required to generalise the results and several confounding factors could have influenced the results of this study which have not been taken into consideration. Considering larger samples and addressing the confounding factors mentioned, a further study is required to generalize the results.

CONFLICT OF INTERESTS

There are no conflicts of interest.

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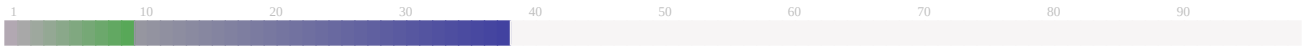

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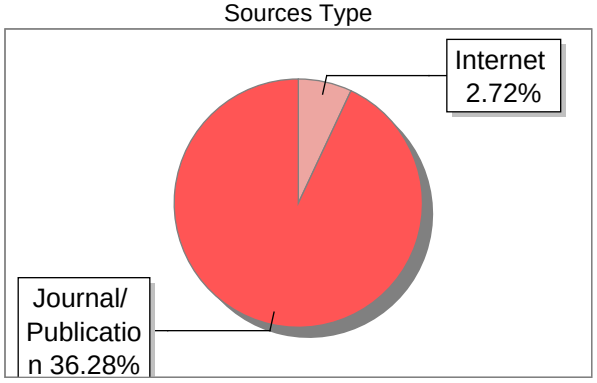

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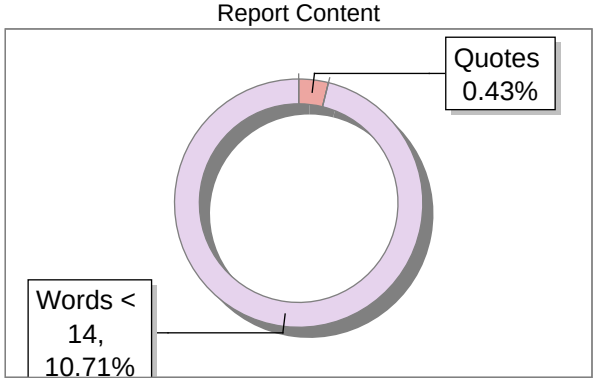

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A COMPARATIVE CLINICAL AND RADIOLOGICAL ANALYSIS TO CORRELATE THE BONE DENSITY AND PRIMARY IMPLANT STABILITY USING CONE BEAM COMPUTERIZED TOMOGRAPHY AND INSERTION TORQUE

INTRODUCTION

The success of any implant procedure depends on a series of patient related and procedure dependent parameters, including general health conditions, biocompatibility of the implant material, the feature of the implant surface, the surgical procedure and the quality and quantity of the local bone.[1] Over the last decade, reconstruction with dental implants has changed considerably. Rather than, merely focussing on the tooth to be replaced, today's implant practitioner considers a broad and complex set of interwoven factors before formulating an implant treatment plan.[2] The success of a dental implant relies heavily on both the quality and quantity of the bone available for implant placement.[3] Bone density is a key factor to take into account when predicting implant stability.[4]

Bone density plays a pivotal role, influencing implant stability, particularly in the mandible compared to the upper maxilla.[5] Misch (2008) used computed tomography (CT) to objectively classify bone density into 5 types based on Hounsefield units (HU). Various imaging techniques, including computed tomography (CT) and cone-beam computed tomography (CBCT), are employed for presurgical and postsurgical examinations, offering 3D perspectives crucial for assessing bone quality.[6]

CBCTs are increasingly being considered essential for optimal implant placement, especially in the case of complex reconstructions.[7] The cone beam configuration is ideal for the maxillofacial region because the dimensions of the beam allow for a panoramic view, sparing patients the radiation exposure of separate scans of the maxilla and mandible.[8] The past two decades have seen continual efforts by manufacturers, researchers and clinicians to improve the success of implant treatment outcomes through evaluation in implant designs, materials and clinical procedures.[9] One such aspect is co-relation of available bone density with primary implant stability.

Primary implant stability, referring to immediate stability post-implantation, is a critical factor in the osseointegration process. Evaluation methods like insertion torque tests and resonance frequency analysis provide noninvasive insights into local bone quality, guiding decisions on immediate loading with prosthetic reconstruction.

Several studies have explored the correlation between bone density, as assessed by CT or CBCT, and primary implant stability. Notably, a study by Isoda et al. demonstrated a strong correlation between specific CBCT-evaluated bone quality and primary implant stability.

This study aims to contribute to this body of knowledge by comparing CBCT-estimated bone density with primary implant stability, using insertion torque measurements. Understanding this relationship enhances the predictability of implant treatment outcomes, facilitating more informed decision-making in clinical practice.

AIMS AND OBJECTIVES

To assess the bone quality with density values obtained by cone beam computed tomography (CBCT) and to determine the correlation between bone density and primary stability of implant by insertion torque value.

MATERIALS & METHODS

The study was done to compare and correlate clinically and radiologically the bone density and primary implant stability using cone beam computerized tomography and insertion torque, on patients who visited the Department of Oral & Maxillofacial Surgery, Dayananda Sagar College of Dental Sciences, Bangalore for implant supported prosthetic rehabilitation. Twenty out- patients with missing single/ multiple teeth and who were suitable for implant rehabilitation were considered for the study.

INCLUSION CRITERIA:

- 20 healthy individuals with edentulous areas in upper and lower jaws in whom rehabilitation with implants was possible were taken up for the study.
- Patients with missing single/ multiple teeth for implant replacement.

EXCLUSION CRITERIA:

- Patients with uncontrolled systemic/ psychiatric illness.
- Patients with previous history of/ undergoing radiotherapy or chemotherapy
- Pregnant patients
- Clinical cases of post implant removal
- Implants placed in sinus lift and immediate extraction sites.

PRE-OPERATIVE ASSESSMENT:

- Patients selected from the above criteria were evaluated and recorded on a custom made Case sheet. (Performa Attached)
- A written informed consent was obtained from all patients and a standardized pre-surgical and surgical protocol was followed for all the patients.
- Pre-operative bone density of implant sites was evaluated using cone beam computerized tomographic scans.
- Bone density measurements were derived using 3DiagnoSys version 4.1 Software It is a licensed product from 3DIEMME Bio imaging Technologies. 3DiagnoSys® is a diagnostic imaging, analyses and 3D simulation software, tailored for the Clinician. 3Diagnosys® software helps to interact with the 3D-model of the Patient, which is obtained by importing TC/CBCT/RM images in DICOM format, in a simple and intuitive way. The tools included in this software are not bound to a morphological reconstructions but are also able to extract from the DICOM data the densitometric

values for a bone functional evaluation.)

- Pre-operative evaluation of bone height and bone width was done using Cone Beam Computed Tomographic scan and appropriate implants were selected to be placed.
- The bone height and width measurements were achieved using the "Carestream Dental Imaging Software v6.13.3.3 CS imaging software" (Fov-15x9cm)"
- All CBCT scans were obtained using the "KODAK 9500machine" (10ma 90 Kvp, 200-micron resolution, 10.9sec exposure, 605mgy per cm2).

SURGICAL PROCEDURE OF IMPLANT PLACEMENT:

1. In all cases Implants were placed under local anaesthesia (2 % Lignocaine hydrochloride with 1:2,00,000 adrenaline).
2. Different implant systems were used and all were root form implants.
3. Surgical preparation and isolation of surgical field was accomplished according to standard operative protocols.
4. Surgical template prepared on the model pre-operatively was used to identify the implant placement site.
5. A Crestal incision was placed with a No.15 BP blade.
6. Mucoperiosteal flap was reflected and alveolar bone was exposed, and the implant placement site was identified by the marking made with the aid of the surgical probe.
7. Osteotomy site preparation was done with a Reduction gear hand piece (1:16/64) with an external irrigation attached to the handpiece.
8. Implant osteotomy was performed using standard sequential drill bits as per the dimensions of the implant.
9. A speed of 800 RPM and torque of 25-30 ncm was standardized for the procedure.
10. The osteotomy was proceeded till the desired depth as per the selected implants.
11. The Orientation of Osteotomy was checked using paralleling pins if two or more implants were being placed using the long axis of the adjacent teeth as a reference plane.
12. The Implant was driven into the osteotomy site using the manual torque wrench till the final depth was reached.
13. All Implants placed were of tapered design and their lengths ranging from8 to 16 mm and diameters from 3-5 mm.
14. After placing the implant, the implant stability was measured manually using the insertion torque test by a torque wrench with calibrations.
15. The insertion torque reading was measured and recorded at the maximum torque resistance achieved.
16. The cover screw over the implant was then placed.
17. Flap closure was done using 3-0 vicryl.

RADIOLOGICAL ASSESSMENT:

Post-operative OPG and IOPA was taken.

POST OPERATIVE PROCEDURE:

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1. Routine Antibiotics and anti-inflammatory drugs were prescribed along with oral hygiene maintenance instructions. 2. Patients were recalled for regular follow ups. 3. Permanent prosthesis was given after 3 months HEIGHT MEASUREMENTS USING CARESTREAM SOFTWARE: Scale: 1-20, Implant site: 9-12 (FIG 1) (FIG 2) WIDTH MEASUREMENTS USING CARESTREAM SOFTWARE:

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Scale: 1-20, implant site:9-12 (FIG 3) (FIG 4) PRE-OPERATIVE BONE DENSITY MEASUREMENTS USING 3DIAGNOSYS VERSION 4.1 SOFTWARE

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(FIG 5) ARMAMENTARIUM FOR IMPLANT PLACEMENT

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Basic armamentarium Reduction gear hand pieces 1:64 and:16 (FIG 6) (FIG 7) ADIN IMPLANT KIT BIOMET 3I IMPLANT KIT (FIG 8) (FIG 9) SURGICAL PROCEDURE PRE OP DIAGNOSTIC CAST IMPLANT SITE MARKING WITH SURGICAL STENT AND STRAIGHT PROBE (FIG 10) (FIG 11)

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INCISION PLACED WITH NO-15 BLADE CRESTAL INCISION (FIG 12) (FIG 13) (FIG 14) (FIG 15) (FIG 16) (FIG 17)

RESULTS

TABLE 1:DISSERTATION CHART

CASE NO	PATIENT NAME	AGE/SEX	IMPLANT SITE	BONE DENSITY (Hu)	IMPLANT SIZE (mm)	INSERTION TORQUE (Ncm)
1	CASE 1	27/F	41	475.663	3.75X13	45
2	CASE 2	22/M	22	246.112	4x13	40
3	CASE 3	19/F	36	495.72	3.75X11.5	55
4	CASE 4	35/M	46	622.001	4.2X16	60
5	CASE 5	35/M	16	261.467	3.75X8	40
6	CASE 6	19/F	46	445.702	3.75X13	45
7	CASE 7	59/F	46	526.827	3.75X13	60
8	CASE 8	59/F	47	573.108	3.75X13	60
9	CASE 9	35/M	36	528.656	4.2X16	60
10	CASE 10	35/M	26	274.744	3.75X8	40
11	CASE 11	36/F	37	452.033	4.2X11.5	40
12	CASE 12	35/M	36	429.832	3.75X16	45
13	CASE 13	43/F	35	562.797	3.75X13	40
14	CASE 14	43/F	36	549.734	3.75X13	40
15	CASE 15	20/M	36	664.002	4.2X11.5	60
16	CASE 16	35/F	14	209.913	3.75X13	60
17	CASE 17	35/F	16	469.218	3.75X8	40
18	CASE 18	35/F	34	667.134	3.3X13	60
19	CASE 19	51/F	16	344.879	3.75X8	50
20	CASE 20	51/F	46	494.260	3.75X13	55

STATISTICS

The statistical analyses were performed using SPSS version 16.0 software (SPSS Inc., Tokyo, Japan). Spearman's correlation coefficient (rs) was calculated to evaluate the correlation among density values and insertion torques. A value of $P < 0.05$ was considered to be statistically significant.

RESULTS

The density value ranged from 209.91 to 667.13 hU. The mean density value and insertion torque of all implants were 464.69 + 135.74 Hu and 49.0 + 8.20 respectively. There was highly significant correlation between bone density and insertion torque (rs 0.89, $P < 0.001$)

Table 2. Age distribution of study population

	Mean	Standard Deviation	Range
Age (years)	36.45	11.96	19-59

Table 3 . Gender distribution of study population

	Number	Percentage
Male	7	35
Female	13	65

Table 4. Mean values of bone density and insertion torque

	Mean	Standard Deviation	Range
Bone density (Hu)	464.69	135.74	209.91-667.13
Insertion torque (Ncm)	49.0	8.20	40-60

Table 5. Correlation between bone density and insertion torque

	Insertion torque (Ncm)	P value
Bone density (Hu)	0.89	<0.001 **

Spearmans correlation test

** P<0.001 highly significant

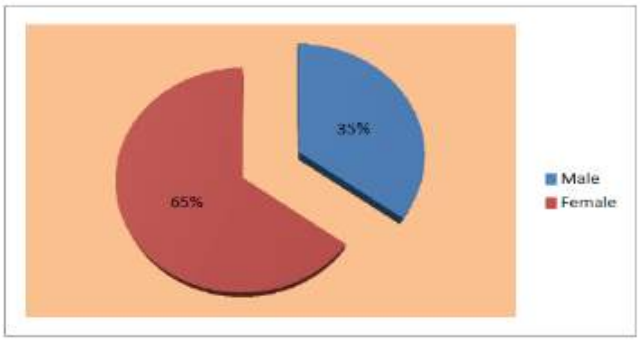

Fig 1. Gender distribution of study population

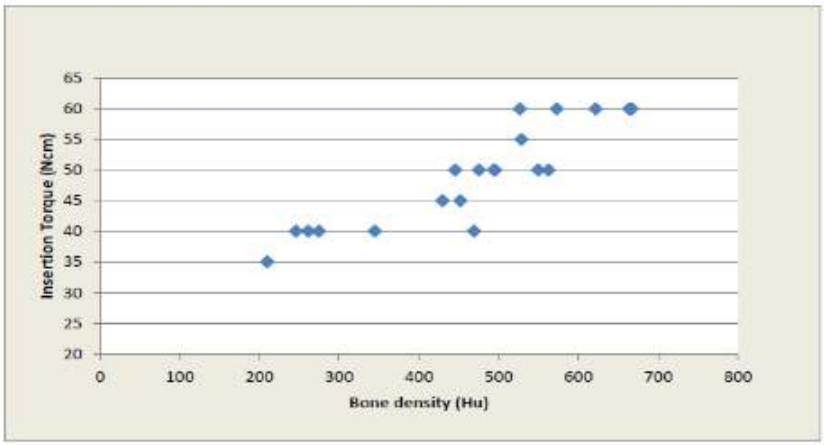

Fig 2. Scatter plot for correlation between bone density and insertion torque

DISCUSSION:

Preoperative evaluation of the quality of bone is important for the clinician to establish an optimum treatment plan for implant supported dental rehabilitation. Accurate information and assessment of the bone density will help the surgeon to identify suitable implant sites and determine accurate implant designs.[1] A precise evaluation of the bone configuration is essential prior to implant placement.[1] One of the most important factors in determining implant success is proper treatment planning and with the advent of advanced Imaging technology, Cone Beam Computerized Tomography (CBCT) is increasingly being considered as an essential tool determining the bone quality and quantity thus helping for optimal Implant planning and placement.[2]

Presurgical dental implant planning for Implant placement requires specific and accurate data to assess the implant site so that the dental implants placed has the greatest chance of success.[3] It has been proven that the success of an inserted implant strongly depends on the quality, beside the quantity, of the surrounding bone (Jaffin & Berman 1991; Jemt et al. 1992).[4]

Several bone classification systems have been proposed for assessing bone quality. In 1985, Lekholm and Zarb used radiographs to subjectively classify bone density into four types based on the amount of cortical and trabecular bone. This classification system has been utilized Worldwide because it is easy to use without considerable investment. Misch (2008) used computed tomography (CT) to objectively classify bone density into 5 types based on Hounsfield units (HU) (Hounsfield 1980). This method allows for a precise and objective assessment of bone quality.[1]

significant correlations between the density values of CBCT and Hounsfield unit (HU) of multi slice CT were also reported in recent studies (Naitoh et al. 2009; Nomura et al. 2010). In a recent study, Pauwels et al. (2013) investigated the correlations between CBCT derived gray values and multi slice CT-derived gray values. The authors found controversial results showing good correlations between CBCT and CT but also large errors when using gray values in a quantitative way. Consequently, deriving bone density values from CBCT images seems controversial. In the literature, there are only limited number of studies about the correlation between bone density estimated by CBCT and primary implant stability.[6]

Primary stability is associated with the mechanical engagement of an implant with the surrounding bone. Where as bone regeneration and remodelling phenomena determine the secondary (biological) stability to the implant. A secure primary stability is positively associated with a secondary stability.[7]

In the present study 20 healthy individuals, who visited the Department of Oral & Maxillofacial Surgery, Dayananda Sagar College of Dental Sciences, Bangalore for implant supported prosthetic rehabilitation were taken up.

When helical CT'S are used, bone density can be obtained in HU. For CBCT, however, there is no standard unit such as HU because no calibration has been conducted as yet. Several studies also reported a high level correlation between the density values of CBCT and HU of multi-slice CT (Aranyarachkul et al. 2005; Naitoh et al. 2009; Nomura et al. 2010).[1] Information about bone density can be obtained preoperatively by radiographic examination. The HU is a standardized scale for reporting reconstructed CT values (Shapurian et al. 2006).

In one of the previous studies 32 helical CT scans of patients were examined, and the recorded mean bone density value ranged from 77 to 1421 (Norton & Gamble 2001). The bone density values from 20 patients evaluated by CBCT reportedly ranged from 238 to 777 (Song et al. 2009). In addition, the bone density values of three human mandibles (dry bone) varied between 267 and 553 HU, with a mean of 113HU (Turkyilmaz et al. 2009). The density values recorded in the present study were similar to those of the bone density values in these reports, and can be considered to correspond to HU evaluated by helical CT. The density values recorded in the present study ranged from 209.91 to 667.13 Hu. The mean density values of all implants were 464.69 + 135.74 Hu.

The study reveals a robust correlation (0.89) between Cone Beam Computed Tomography (CBCT)-derived bone density and implant stability, endorsing CBCT as a valuable tool for preoperative assessment. Previous research also indicates correlations between bone density and implant stability. However, conflicting results exist, with some studies showing no correlations. The present clinical study emphasizes the importance of including cortical bone evaluation in preoperative bone density assessments. CBCT examinations before implant surgery prove instrumental in predicting primary stability, guiding optimal loading times for

implants in prosthetic rehabilitation. While CBCT shows promise, further research is essential to explore correlations across diverse variables influencing implant stability.

CONCLUSION:

In the study conducted in the Department of Oral and Maxillofacial surgery, Dayananda Sagar College of Dental Sciences, we have attempted to assess the bone quality with density values obtained by cone beam computed tomography (CBCT) pre-operatively and to determine their correlation with the insertion torque values recorded during the Implant placement procedure.

From the observations and results obtained We can conclude that, the present study demonstrates the relationship between the bone density values derived from Cone Beam computerized tomography (Hu), located in the maxilla and mandible , and bone quality according to the Lekholm & Zarb classification.

The primary implant stability measured with the insertion torque test (ITV) depends on bone density values, bone quality and implant location. Implants Placed in location with higher bone density have more stability, and we can probably predict the implant insertion torque based on the bone density values (Hu) and the implant location. Finally, with higher bone density values (Hu) and higher primary implant stability measured in ITV values; Hounsfield units can be used as a diagnostic parameter to predict possible implant stability.

This study employs torque wrenches to assess primary stability, as alternative devices for monitoring dental implant stability were prohibitively expensive. There is potential for further enhancement of the study to yield more robust outcomes.

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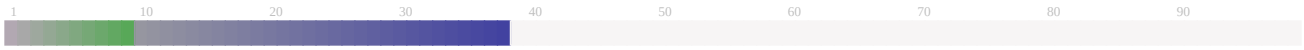

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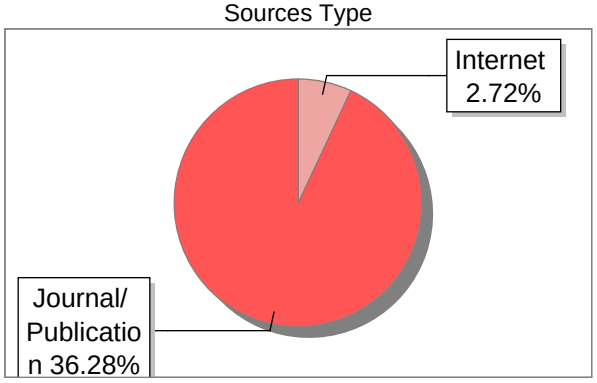

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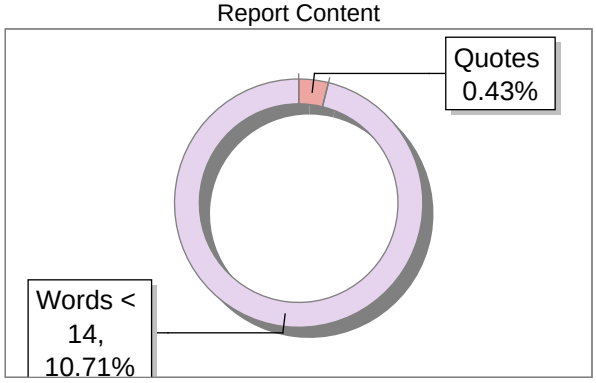

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7	www.doaj.org	1	Publication
8	www.ncbi.nlm.nih.gov	1	Internet Data
9	Bone density assessments of oral implant sites using computerized tomography by I-2007	1	Publication
10	www.rroij.com	1	Publication
11	www.ejomr.org	1	Publication

A COMPARATIVE CLINICAL AND RADIOLOGICAL ANALYSIS TO CORRELATE THE BONE DENSITY AND PRIMARY IMPLANT STABILITY USING CONE BEAM COMPUTERIZED TOMOGRAPHY AND INSERTION TORQUE

INTRODUCTION

The success of any implant procedure depends on a series of patient related and procedure dependent parameters, including general health conditions, biocompatibility of the implant material, the feature of the implant surface, the surgical procedure and the quality and quantity of the local bone.[1] Over the last decade, reconstruction with dental implants has changed considerably. Rather than, merely focussing on the tooth to be replaced, today's implant practitioner considers a broad and complex set of interwoven factors before formulating an implant treatment plan.[2] The success of a dental implant relies heavily on both the quality and quantity of the bone available for implant placement.[3] Bone density is a key factor to take into account when predicting implant stability.[4]

Bone density plays a pivotal role, influencing implant stability, particularly in the mandible compared to the upper maxilla.[5] Misch (2008) used computed tomography (CT) to objectively classify bone density into 5 types based on Hounsefield units (HU). Various imaging techniques, including computed tomography (CT) and cone-beam computed tomography (CBCT), are employed for presurgical and postsurgical examinations, offering 3D perspectives crucial for assessing bone quality.[6]

CBCTs are increasingly being considered essential for optimal implant placement, especially in the case of complex reconstructions.[7] The cone beam configuration is ideal for the maxillofacial region because the dimensions of the beam allow for a panoramic view, sparing patients the radiation exposure of separate scans of the maxilla and mandible.[8] The past two decades have seen continual efforts by manufacturers, researchers and clinicians to improve the success of implant treatment outcomes through evaluation in implant designs, materials and clinical procedures.[9] One such aspect is co-relation of available bone density with primary implant stability.

Primary implant stability, referring to immediate stability post-implantation, is a critical factor in the osseointegration process. Evaluation methods like insertion torque tests and resonance frequency analysis provide noninvasive insights into local bone quality, guiding decisions on immediate loading with prosthetic reconstruction.

Several studies have explored the correlation between bone density, as assessed by CT or CBCT, and primary implant stability. Notably, a study by Isoda et al. demonstrated a strong correlation between specific CBCT-evaluated bone quality and primary implant stability.

This study aims to contribute to this body of knowledge by comparing CBCT-estimated bone density with primary implant stability, using insertion torque measurements. Understanding this relationship enhances the predictability of implant treatment outcomes, facilitating more informed decision-making in clinical practice.

AIMS AND OBJECTIVES

To assess the bone quality with density values obtained by cone beam computed tomography (CBCT) and to determine the correlation between bone density and primary stability of implant by insertion torque value.

MATERIALS & METHODS

The study was done to compare and correlate clinically and radiologically the bone density and primary implant stability using cone beam computerized tomography and insertion torque, on patients who visited the Department of Oral & Maxillofacial Surgery, Dayananda Sagar College of Dental Sciences, Bangalore for implant supported prosthetic rehabilitation. Twenty out- patients with missing single/ multiple teeth and who were suitable for implant rehabilitation were considered for the study.

INCLUSION CRITERIA:

- 20 healthy individuals with edentulous areas in upper and lower jaws in whom rehabilitation with implants was possible were taken up for the study.
- Patients with missing single/ multiple teeth for implant replacement.

EXCLUSION CRITERIA:

- Patients with uncontrolled systemic/ psychiatric illness.
- Patients with previous history of/ undergoing radiotherapy or chemotherapy
- Pregnant patients
- Clinical cases of post implant removal
- Implants placed in sinus lift and immediate extraction sites.

PRE-OPERATIVE ASSESSMENT:

- Patients selected from the above criteria were evaluated and recorded on a custom made Case sheet. (Performa Attached)
- A written informed consent was obtained from all patients and a standardized pre-surgical and surgical protocol was followed for all the patients.
- Pre-operative bone density of implant sites was evaluated using cone beam computerized tomographic scans.
- Bone density measurements were derived using 3DiagnoSys version 4.1 Software It is a licensed product from 3DIEMME Bio imaging Technologies. 3DiagnoSys® is a diagnostic imaging, analyses and 3D simulation software, tailored for the Clinician. 3Diagnosys® software helps to interact with the 3D-model of the Patient, which is obtained by importing TC/CBCT/RM images in DICOM format, in a simple and intuitive way. The tools included in this software are not bound to a morphological reconstructions but are also able to extract from the DICOM data the densitometric

values for a bone functional evaluation.)

- Pre-operative evaluation of bone height and bone width was done using Cone Beam Computed Tomographic scan and appropriate implants were selected to be placed.
- The bone height and width measurements were achieved using the "Carestream Dental Imaging Software v6.13.3.3 CS imaging software" (Fov-15x9cm)"
- All CBCT scans were obtained using the "KODAK 9500machine" (10ma 90 Kvp, 200-micron resolution, 10.9sec exposure, 605mgy per cm2).

SURGICAL PROCEDURE OF IMPLANT PLACEMENT:

1. In all cases Implants were placed under local anaesthesia (2 % Lignocaine hydrochloride with 1:2,00,000 adrenaline).
2. Different implant systems were used and all were root form implants.
3. Surgical preparation and isolation of surgical field was accomplished according to standard operative protocols.
4. Surgical template prepared on the model pre-operatively was used to identify the implant placement site.
5. A Crestal incision was placed with a No.15 BP blade.
6. Mucoperiosteal flap was reflected and alveolar bone was exposed, and the implant placement site was identified by the marking made with the aid of the surgical probe.
7. Osteotomy site preparation was done with a Reduction gear hand piece (1:16/64) with an external irrigation attached to the handpiece.
8. Implant osteotomy was performed using standard sequential drill bits as per the dimensions of the implant.
9. A speed of 800 RPM and torque of 25-30 ncm was standardized for the procedure.
10. The osteotomy was proceeded till the desired depth as per the selected implants.
11. The Orientation of Osteotomy was checked using paralleling pins if two or more implants were being placed using the long axis of the adjacent teeth as a reference plane.
12. The Implant was driven into the osteotomy site using the manual torque wrench till the final depth was reached.
13. All Implants placed were of tapered design and their lengths ranging from8 to 16 mm and diameters from 3-5 mm.
14. After placing the implant, the implant stability was measured manually using the insertion torque test by a torque wrench with calibrations.
15. The insertion torque reading was measured and recorded at the maximum torque resistance achieved.
16. The cover screw over the implant was then placed.
17. Flap closure was done using 3-0 vicryl.

RADIOLOGICAL ASSESSMENT:

Post-operative OPG and IOPA was taken.

POST OPERATIVE PROCEDURE:

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1. Routine Antibiotics and anti-inflammatory drugs were prescribed along with oral hygiene maintenance instructions. 2. Patients were recalled for regular follow ups. 3. Permanent prosthesis was given after 3 months HEIGHT MEASUREMENTS USING CARESTREAM SOFTWARE: Scale: 1-20, Implant site: 9-12 (FIG 1) (FIG 2) WIDTH MEASUREMENTS USING CARESTREAM SOFTWARE:

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Scale: 1-20, implant site:9-12 (FIG 3) (FIG 4) PRE-OPERATIVE BONE DENSITY MEASUREMENTS USING 3DIAGNOSYS VERSION 4.1 SOFTWARE

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(FIG 5) ARMAMENTARIUM FOR IMPLANT PLACEMENT

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Basic armamentarium Reduction gear hand pieces 1:64 and:16 (FIG 6) (FIG 7) ADIN IMPLANT KIT BIOMET 3I IMPLANT KIT (FIG 8) (FIG 9) SURGICAL PROCEDURE PRE OP DIAGNOSTIC CAST IMPLANT SITE MARKING WITH SURGICAL STENT AND STRAIGHT PROBE (FIG 10) (FIG 11)

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INCISION PLACED WITH NO-15 BLADE CRESTAL INCISION (FIG 12) (FIG 13) (FIG 14) (FIG 15) (FIG 16) (FIG 17)

RESULTS

TABLE 1:DISSERTATION CHART

CASE NO	PATIENT NAME	AGE/SEX	IMPLANT SITE	BONE DENSITY (Hu)	IMPLANT SIZE (mm)	INSERTION TORQUE (Ncm)
1	CASE 1	27/F	41	475.663	3.75X13	45
2	CASE 2	22/M	22	246.112	4x13	40
3	CASE 3	19/F	36	495.72	3.75X11.5	55
4	CASE 4	35/M	46	622.001	4.2X16	60
5	CASE 5	35/M	16	261.467	3.75X8	40
6	CASE 6	19/F	46	445.702	3.75X13	45
7	CASE 7	59/F	46	526.827	3.75X13	60
8	CASE 8	59/F	47	573.108	3.75X13	60
9	CASE 9	35/M	36	528.656	4.2X16	60
10	CASE 10	35/M	26	274.744	3.75X8	40
11	CASE 11	36/F	37	452.033	4.2X11.5	40
12	CASE 12	35/M	36	429.832	3.75X16	45
13	CASE 13	43/F	35	562.797	3.75X13	40
14	CASE 14	43/F	36	549.734	3.75X13	40
15	CASE 15	20/M	36	664.002	4.2X11.5	60
16	CASE 16	35/F	14	209.913	3.75X13	60
17	CASE 17	35/F	16	469.218	3.75X8	40
18	CASE 18	35/F	34	667.134	3.3X13	60
19	CASE 19	51/F	16	344.879	3.75X8	50
20	CASE 20	51/F	46	494.260	3.75X13	55

STATISTICS

The statistical analyses were performed using SPSS version 16.0 software (SPSS Inc., Tokyo, Japan). Spearman's correlation coefficient (rs) was calculated to evaluate the correlation among density values and insertion torques. A value of $P < 0.05$ was considered to be statistically significant.

RESULTS

The density value ranged from 209.91 to 667.13 hU. The mean density value and insertion torque of all implants were 464.69 + 135.74 Hu and 49.0 + 8.20 respectively. There was highly significant correlation between bone density and insertion torque (rs 0.89, $P < 0.001$)

Table 2. Age distribution of study population

	Mean	Standard Deviation	Range
Age (years)	36.45	11.96	19-59

Table 3 . Gender distribution of study population

	Number	Percentage
Male	7	35
Female	13	65

Table 4. Mean values of bone density and insertion torque

	Mean	Standard Deviation	Range
Bone density (Hu)	464.69	135.74	209.91-667.13
Insertion torque (Ncm)	49.0	8.20	40-60

Table 5. Correlation between bone density and insertion torque

	Insertion torque (Ncm)	P value
Bone density (Hu)	0.89	<0.001 **

Spearmans correlation test

** P<0.001 highly significant

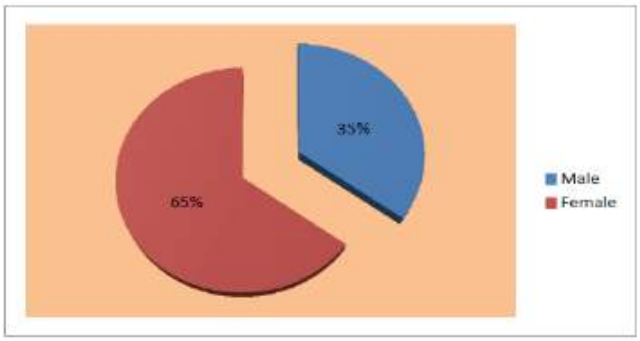

Fig 1. Gender distribution of study population

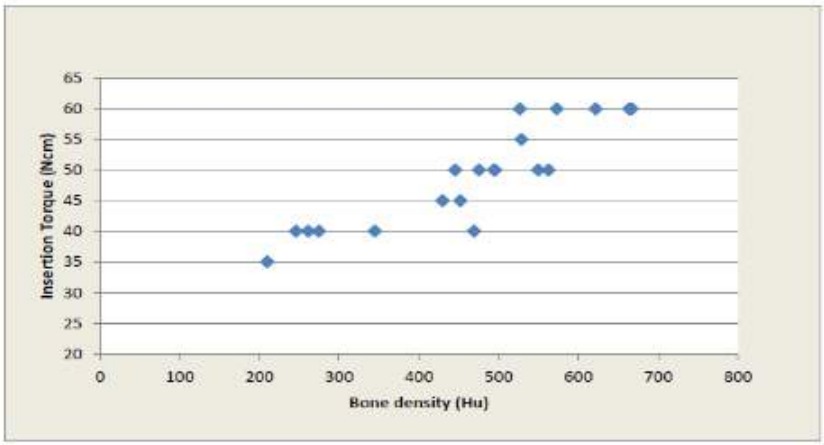

Fig 2. Scatter plot for correlation between bone density and insertion torque

DISCUSSION:

Preoperative evaluation of the quality of bone is important for the clinician to establish an optimum treatment plan for implant supported dental rehabilitation. Accurate information and assessment of the bone density will help the surgeon to identify suitable implant sites and determine accurate implant designs.[1] A precise evaluation of the bone configuration is essential prior to implant placement.[1] One of the most important factors in determining implant success is proper treatment planning and with the advent of advanced Imaging technology, Cone Beam Computerized Tomography (CBCT) is increasingly being considered as an essential tool determining the bone quality and quantity thus helping for optimal Implant planning and placement.[2]

Presurgical dental implant planning for Implant placement requires specific and accurate data to assess the implant site so that the dental implants placed has the greatest chance of success.[3] It has been proven that the success of an inserted implant strongly depends on the quality, beside the quantity, of the surrounding bone (Jaffin & Berman 1991; Jemt et al. 1992).[4]

Several bone classification systems have been proposed for assessing bone quality. In 1985, Lekholm and Zarb used radiographs to subjectively classify bone density into four types based on the amount of cortical and trabecular bone. This classification system has been utilized Worldwide because it is easy to use without considerable investment. Misch (2008) used computed tomography (CT) to objectively classify bone density into 5 types based on Hounsfield units (HU) (Hounsfield 1980). This method allows for a precise and objective assessment of bone quality.[1]

significant correlations between the density values of CBCT and Hounsfield unit (HU) of multi slice CT were also reported in recent studies (Naitoh et al. 2009; Nomura et al. 2010). In a recent study, Pauwels et al. (2013) investigated the correlations between CBCT derived gray values and multi slice CT-derived gray values. The authors found controversial results showing good correlations between CBCT and CT but also large errors when using gray values in a quantitative way. Consequently, deriving bone density values from CBCT images seems controversial. In the literature, there are only limited number of studies about the correlation between bone density estimated by CBCT and primary implant stability.[6]

Primary stability is associated with the mechanical engagement of an implant with the surrounding bone. Where as bone regeneration and remodelling phenomena determine the secondary (biological) stability to the implant. A secure primary stability is positively associated with a secondary stability.[7]

In the present study 20 healthy individuals, who visited the Department of Oral & Maxillofacial Surgery, Dayananda Sagar College of Dental Sciences, Bangalore for implant supported prosthetic rehabilitation were taken up.

When helical CT'S are used, bone density can be obtained in HU. For CBCT, however, there is no standard unit such as HU because no calibration has been conducted as yet. Several studies also reported a high level correlation between the density values of CBCT and HU of multi-slice CT (Aranyarachkul et al. 2005; Naitoh et al. 2009; Nomura et al. 2010).[1] Information about bone density can be obtained preoperatively by radiographic examination. The HU is a standardized scale for reporting reconstructed CT values (Shapurian et al. 2006).

In one of the previous studies 32 helical CT scans of patients were examined, and the recorded mean bone density value ranged from 77 to 1421 (Norton & Gamble 2001). The bone density values from 20 patients evaluated by CBCT reportedly ranged from 238 to 777 (Song et al. 2009). In addition, the bone density values of three human mandibles (dry bone) varied between 267 and 553 HU, with a mean of 113HU (Turkyilmaz et al. 2009). The density values recorded in the present study were similar to those of the bone density values in these reports, and can be considered to correspond to HU evaluated by helical CT. The density values recorded in the present study ranged from 209.91 to 667.13 Hu. The mean density values of all implants were 464.69 + 135.74 Hu.

The study reveals a robust correlation (0.89) between Cone Beam Computed Tomography (CBCT)-derived bone density and implant stability, endorsing CBCT as a valuable tool for preoperative assessment. Previous research also indicates correlations between bone density and implant stability. However, conflicting results exist, with some studies showing no correlations. The present clinical study emphasizes the importance of including cortical bone evaluation in preoperative bone density assessments. CBCT examinations before implant surgery prove instrumental in predicting primary stability, guiding optimal loading times for

implants in prosthetic rehabilitation. While CBCT shows promise, further research is essential to explore correlations across diverse variables influencing implant stability.

CONCLUSION:

In the study conducted in the Department of Oral and Maxillofacial surgery, Dayananda Sagar College of Dental Sciences, we have attempted to assess the bone quality with density values obtained by cone beam computed tomography (CBCT) pre-operatively and to determine their correlation with the insertion torque values recorded during the Implant placement procedure.

From the observations and results obtained We can conclude that, the present study demonstrates the relationship between the bone density values derived from Cone Beam computerized tomography (Hu), located in the maxilla and mandible , and bone quality according to the Lekholm & Zarb classification.

The primary implant stability measured with the insertion torque test (ITV) depends on bone density values, bone quality and implant location. Implants Placed in location with higher bone density have more stability, and we can probably predict the implant insertion torque based on the bone density values (Hu) and the implant location. Finally, with higher bone density values (Hu) and higher primary implant stability measured in ITV values; Hounsfield units can be used as a diagnostic parameter to predict possible implant stability.

This study employs torque wrenches to assess primary stability, as alternative devices for monitoring dental implant stability were prohibitively expensive. There is potential for further enhancement of the study to yield more robust outcomes.

Report- Dr. K Sravani

by Dr. K Sravani

Submission date: 28-Feb-2023 11:19AM (UTC+0530)
Submission ID: 2025052532
File name: MANUSCRIPT_chitosan.docx (60.11K)
Word count: 3185
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EVALUATION OF CLINICAL AND ANTIMICROBIAL EFFICACY OF CHITOSAN NANOPARTICLE GEL (1%) AS A LOCAL DRUG DELIVERY IN CHRONIC PERIODONTITIS PATIENTS- A RANDOMISED CONTROLLED SPLIT MOUTH TRIAL

Background: Periodontitis is a chronic inflammatory disease that affects the supportive tissue of the teeth which eventually leads to tooth loss. There are a variety of grafting materials and barrier membranes that have been used to repair periodontal lesions. Chitosan is a naturally derived polymer that has been extensively investigated for its use as a biomaterial for local drug delivery and anti-inflammatory activity. Recently, chitosan applications in periodontal tissue healing have gained significant interest.

Objectives: The present study was undertaken with the objective of evaluating the efficacy of chitosan nanoparticle gel when used as an adjunct to scaling and root planing in terms of clinical outcomes and antimicrobial activity.

Methods: The study was conducted following a split mouth design in which patients with chronic periodontitis were selected and test and control sites were randomized. Test sites received chitosan nanoparticle gel administration adjunct to scaling and root planning while control sites were subjected to scaling and root planing. Subgingival plaque samples were collected for RT- PCR analysis at baseline and follow up after 6 weeks.

Results: It was observed that there was significant reduction in PI (p- value: 0.002) and PD scores (p-value: 0.001) along with gain in CAL (p-value: 0.001) in the test group when chitosan nanoparticle gel (1%) was used as adjunct to SRP. There was no statistically significant difference seen with mean GI scores (p-value: 0.387). Further, chitosan nanoparticle administration significantly reduced counts of P.gingivalis and T.forsythia in the test sites than the control sites.

Conclusion: Administration of 1% chitosan nanoparticle gel adjunct to scaling and root planning in chronic periodontitis patients resulted in a significant improvement in clinical parameters while exhibiting inhibitory action against the periodontal pathogens P.ginigivalis and T.forsythia.

Keywords: Chitosan, nanoparticles, periodontitis, local drug delivery, microbial analysis, semiquantitative PCR

INTRODUCTION:

Chronic periodontitis is defined as an infectious disease that results in inflammation within supporting tissues of the teeth ultimately leading to progressive attachment loss and bone loss.[1] The incidence and progression of the disease is due to a substantial increase in the number of bacteria colonising the pockets which is further modified by host mediated and environment related factors.

Scaling and Root planing (SRP) is the initial step in the treatment of periodontal diseases and has been used as the "gold" standard therapy in comparison to other therapeutic procedures in both initial phase as well as in maintenance phase of therapy.[2] Clinical effects of SRP include decreased probing pocket depth and gain in attachment level thus resulting in stabilization of most cases of periodontitis. However in the presence of tissue invading pathogens such as Porphyromonas gingivalis(Pg) or Actinobacillus actinomycetemcomitans(Aa), mechanical therapy is not sufficient to eliminate the bacteria from the pockets. Hence despite meticulous treatment, rapid progression of attachment loss and alveolar bone resorption occurs. In such cases adjuvant antimicrobial therapy provides an added benefit.[3]

Systemic antimicrobials are beneficial; however they are associated with certain demerits such as exposing the body to large doses of the drug which can result in antibiotic resistance, hepatic bypass thereby resulting in decreased concentration of drug in GCF[4] and associated with side effects which make them less compliant to the patient. Hence there is a need for the alternative modes of drug delivery which includes the use of controlled release delivery agents directly into the site of requirement.

Studies published in literature have stated that local drug delivery following scaling and root planing offered favorable results in sites that don't respond to conventional therapy[5]and that it should be used as an adjunct and not a substitute for conventional therapy.[6] The ultimate aim is to remove any residual infective or inflammatory element that is still harboring the periodontal tissues that are not accessible by hand or motorized instruments by ensuring the prolonged availability of the drug in sufficient minimum inhibitory concentrations over a required period of time.[5]

There are a variety of commercially available local drug delivery agents such as Actisite (Tetracycline), Atridox (Doxycycline), Arestin (Minocycline), Elyzol (Metronidazole), Periochip (Chlorhexidine), though beneficial but still possess certain limitations such as resistance and substantivity[9]. Hence there is always a quest for newer therapeutic agents which are naturally available and are economical.Chitosan is a linear chain polysaccharide obtained by alkaline deacetylation of chitin. It consists of positively charged amino group (NH_3^+) which on interaction with electronegatively charged surface of bacterial cells causes damage to bacterial cell wall and leakage of cell contents. Chitosan and its derivatives have excellent biocompatibility, biodegradability, selective permeability, mucoadhesiveness, antimicrobial activity, anti- inflammatory, bone repair and wound healing properties and has ability to be processed in different forms (solutions, blends, sponges, membranes, gels, pastes, tablets, microspheres, microgranules) thus used widely in the field of medicine.[9]

There are studies published in literature regarding the efficacy of chitosan in chronic periodontitis patients, its efficacy when used in a gel form, animal studies such as bone formation in rat calvarial defects and invitro studies such as MIC against perio pathogens, anti-inflammatory activity in gingival fibroblasts. To the best of our knowledge, there is no published data regarding the use of chitosan nanoparticle gel as a local drug delivery in treatment of chronic periodontitis as well as its antimicrobial efficacy. Hence the aim of this study was i) to evaluate the clinical efficacy of Chitosan nanoparticle gel (1%) as local drug delivery in patients with chronic periodontitis ii) to evaluate the antimicrobial efficacy of Chitosan nanoparticle gel (1%) as local drug delivery against periodontal pathogens namely Porphyromonas gingivalis and Tannerella forsythia and iii) to compare the efficacy of Chitosan nanoparticle gel (1%) with SRP in the treatment of chronic periodontitis. The study hypothesis was that adjunctive use of Chitosan nanoparticle gel (1%) to scaling and root planing exhibited antimicrobial activity against periopathogens:-P.gingivalis, T.forsythia.

MATERIALS AND METHODS:

The study was designed as a randomized controlled split mouth clinical trial; ethical principles of the Declaration of Helsinki (2002) were followed and was approved by the Institutional Ethical Committee. The study was conducted in the Department of Periodontics, Dayananda Sagar College of Dental Sciences, Bengaluru with enrollment of 26 patients in the age group of

20-60 years after fulfilling the selection criteria. A written informed consent was obtained from all the participants.

RANDOMISATION:

Test and control sites were determined by coin toss method.

ELIGIBILITY CRITERIA FOR PARTICIPANTS:

Patient in the age group 20-60 years diagnosed with chronic periodontitis having probing depths of 5-8mm and clinical attachment level of 3mm were included in the study while those with history of any systemic diseases, periodontal treatment in the last 6 months, pregnant and lactating women, smokers, alcoholics and drug abusers were excluded from the study.

The study was conducted in a split mouth manner in which contralateral sites with probing pocket depth 5-8 mm in similar teeth (premolars and molars) in the maxillary arch were selected. Periodontal parameters like Plaque index (Silness and Loe), gingival index (Loe and Silness), probing pocket depth measurement and clinical attachment loss were recorded using a UNC 15 periodontal probe. The area was isolated, supragingival plaque was removed, sub gingival plaque samples were collected from both test and control sites (**figure 2**). The samples were immediately transferred to Eppendorf tubes containing tris EDTA buffer. Complete scaling was done followed by root planing at the test and control site using area specific curettes (Hu-Friedy 9/10, 15/16, 17/18). After isolation of test site using sterile cotton rolls Chitosan nanoparticle gel was administered using a syringe with a blunt cannula till the entire pocket was loaded with the drug **(figure 3).** The pocket entrance was covered with periodontal pack to retain the material in the pocket **(figure 4).** The vials containing the samples were appropriately labelled and stored at -80^{0} C (**figure 5**). Subjects were called back after 7 days for removal of the periodontal dressing. During this time, they were instructed to refrain from brushing and flossing the area and were instructed not to disturb the area with tongue/finger. They were further instructed not to use any chemical plaque control agents. The subjects were recalled after 6 weeks for assessing the clinical parameters followed by plaque sample collection.

PCR Procedure:

Microbial analysis was done by semi quantitative PCR and agar gel electrophoresis was used for identification and quantification of bacteria namely, P. gingivalis and T. forsythia (**figure 6**).

STUDY OUTCOMES:

The outcomes of the study were 1) clinical parameters namely plaque index, gingival index, probing depths and clinical attachment levels ii) microbial counts of P. gingivalis and T. forsythia.

SAMPLE SIZE DETERMINATION:

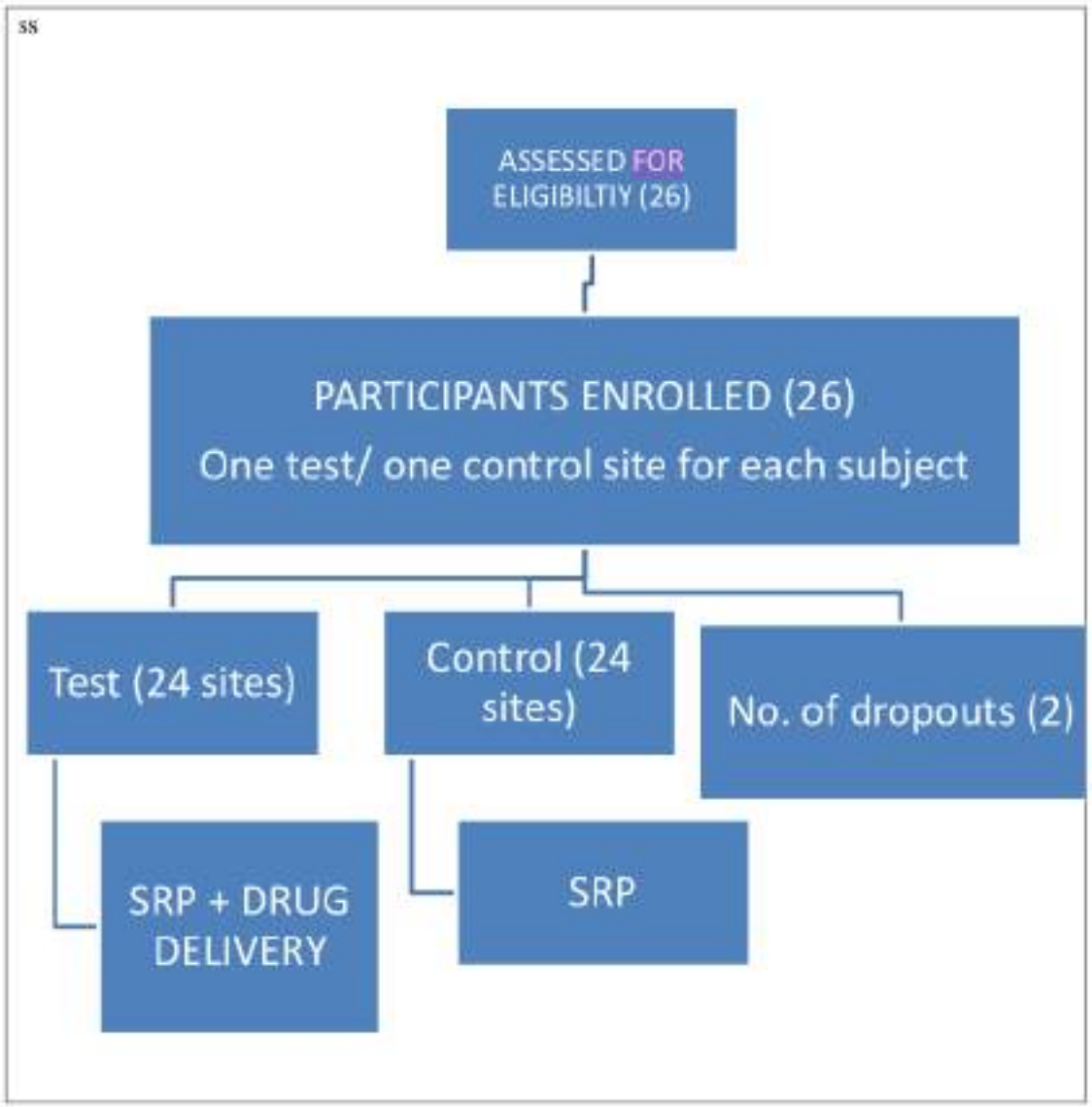
Using G power software version 3.1.9.2, with a power of 0.80, α-error of 0.05 and effect size of 0.5, a sample size of 26 was obtained.

STATISTICAL ANALYSIS:

Normality tests Kolmogorov-Smimov and Shapiro-Wilks tests results revealed that variables do not follow Normal distribution. Therefore, to analyze the data, non parametric method was applied. The study design was a "split mouth design" and hence to compare values between groups and between time points Wilcoxon Signed Rank test was applied. Spearman's Rank correlations were estimated to assess the linear relationship between clinical and microbiological parameters. In the above tests, P value less than 0.05 was considered to be statistically significant. For analysis of the data, SPSS Version 26.0 was used.

RESULTS:

ss


ASSESSED FOR ELIGIBILTIY (26)
PARTICIPANTS ENROLLED (26)
One test/ one control site for each subject
Test (24 sites)
Control (24 sites)
No. of dropouts (2)
SRP + DRUG DELIVERY
SRP

A total of 26 patients were enrolled in the study. 2 patients refused to turn up for follow up and hence remaining 24 were followed up. Demographic data of participants are shown in **table 1**

Intragroup analysis after 6 weeks revealed statistically significant results in test group with respect to PI (p- value:0.002), PD (p-value: 0.001) and CAL (p-value: 0.001) than in control group where PI (p-value: 0.04), PD (p-value: 0.01) and CAL (p-value: 0.04)**(tables 2&3).**

Intergroup analysis after 6 weeks revealed that, there was a statistically significant reduction seen with mean PI (p- value: 0.05) and mean GI (p- value: 0.03) in test group compared to mean PI (p-value: 0.887) and mean GI (p-value: 0.460) in the control group. However mean PD (p- 0.6) and mean CAL (p- 0.3) in the test sites at 6 weeks were not statistically significant compared to mean PD (p-value:0.06) and mean CAL (p-value:0.06) in the control sites **(tables 4&5).**

Intragroup analysis revealed that in the control group, there were no significant reductions in Pg counts (p-value: 0.563) but significant reduction was seen in Tf (p-value: 0.094) while in test group there was a significant reduction in counts of both Pg (p-value: 0.023) and Tf (p-value: 0.007).

Comparison of microbial counts between the test and control sites at baseline did not show any significant reduction in Pg (p-value: 0.600) and Tf (p-value: 0.819). However at the end of 6 weeks, mean Pg counts expressed statistically significant reduction (p-value: 0.007) but no significant reduction seen with Tf counts (p-value: 0.135).

Correlation tests revealed that in control sites the mean PI scores expressed mild correlation with Pg at baseline (R-value:-0.239) as well as at 6 weeks (R-value:-0.267) and also with Tf at baseline (R-value:-0.257) and at 6 weeks (R- value:-0.211) while in test sites there was no correlation with counts of Pg at baseline (R- value: 0.034) and mild correlation at 6 weeks (R-value: -0.127). However no correlation was observed with Tf at baseline (R-value: 0.057) as well as after 6 weeks (R- value: 0.58).

In control sites, mean GI scores expressed moderate correlation with Pg at baseline (R-value:-0.313) as well as at 6 weeks ((R-value:-0.462). Also moderate correlation was observed with Tf at baseline and no correlation at 6 weeks (R-value:-0.45) while in test sites, mean GI scores expressed mild correlation with Pg at baseline (R- value: 0.151) and at 6 weeks (R-value:1.72). A moderate correlation was observed with Tf at baseline (0.383) no correlation at 6 weeks (R-value:0.89).

In control sites, at baseline, mean PD scores exhibited mild correlation with Pg (R-value:0.280) and moderate correlation with Tf (R-value:0.399) while at 6 weeks, mean PD scores exhibited no correlation with Pg (R-value: 0.050) and mild correlation with Tf (R- value: 0.295). In test sites mean PD scores showed mild correlation with Pg (R- value: 0.122) and no correlation with Tf (R-value: 0.005). At 6 weeks also, mean PD scores showed mild correlation with Pg (R-value:0.159) and no correlation with Tf (R-value:-0.034).

In control sites, a moderate correlation of CAL was observed with Pg (R-value:0.313) and strong correlation with Tf (R-value:0.504) **(table 2)**while at 6 weeks, no correlation was observed with Pg (R-value:0.81) and Tf (R- value: 0.304)**(table 3).**In test sites mean CAL scores showed mild correlation with Pg (R-value: 0.168) and no correlation with Tf (R-value: 0.001) **(table 4).**Mean CAL scores showed no correlation with Pg (R-value:0.016) and mild correlation with Tf (R-value:0.170) **(table 5).**

TABLE 1: SPEARMAN'S RANK CORRELATIONS BETWEEN CLINICAL PARAMETERS AND MICROBIOLOGICAL PARAMETERS FOR CONTROL SITE (BASELINE)

		Reduction in PG - Control	Reduction in TF - Control
Mean PI-BL: Control	R-value	-.239	-.257
	P-value	.261	.226
Mean GI-BL: Control	R-value	-.313	-.328
	P-value	.137	.118
Mean PD-BL: Control	R-value	.280	.399
	p-value	.186	.053
Mean CAL-BL: Control	R-value	.313	.504

TABLE 2: SPEARMAN'S RANK CORRELATIONS BETWEEN CLINICAL PARAMETERS AND REDUCTION IN MICROBIOLOGICAL PARAMETERS FOR TEST SITE (BASELINE)

		Reduction in PG - Test	Reduction in TF - Test
Mean PI-BL: Test	R-value	.034	.057
	P-value	.874	.791
Mean GI-BL:Test	R-value	.151	-.383
	P-value	.480	.065
Mean PD-BL: Test	R-value	.122	-.005
	p-value	.570	.982
Mean CAL-BL: Test	R-value	.168	.001
	p-value	.434	.995

TABLE 3: SPEARMAN'S RANK CORRELATIONS BETWEEN CLINICAL PARAMETERS AND REDUCTION IN MICROBIOLOGICAL PARAMETERS FOR CONTROL SITE (AT 6 WEEKS)

		Reduction in PG - Control	Reduction in TF - Control
Mean PI-6W: Control	R-value	-.267	-.211
	P-value	.207	.322
Mean GI-6W:Control	R-value	-.462	-.045
	P-value	.023	.834
Mean PD-	R-value	.050	.295

6W: Control	p-value	.817	.162
Mean CAL-6W: Control	R-value	.081	.304
	p-value	.708	.149

TABLE 4: SPEARMAN'S RANK CORRELATIONS BETWEEN CLINICAL PARAMETERS AND REDUCTION IN MICROBIOLOGICAL PARAMETERS FOR TEST SITE (6 WEEKS)

		Reduction in PG - Test	Reduction in TF - Test
Mean PI-6W: Test	R-value	-.127	.058
	P-value	.554	.787
Mean GI-6W:Test	R-value	.172	.089
	P-value	.422	.678
Mean PD-6W: Test	R-value	.159	-.034
	p-value	.459	.875
Mean CAL-6W: Test	R-value	.016	.170
	p-value	.942	.427

DISCUSSION:

Periodontitis is a chronic inflammatory disease characterized by the interaction between Gram-negative bacteria and the host immune response.[10] It is characterized by periodontal pocket formation, clinical attachment loss and radiographic evidence of bone loss, aggravated by genetic, systemic, environmental and various other acquired factors. The host responds to the invading bacteria with inflammatory and immune response by the production of variety of inflammatory mediators that cause connective tissue and bone destruction.[11]Organisms like Porphyromonas gingivalis, Actinomyces actinomycetemcomitans are tissue invasive in nature

and hence mechanical therapy is not sufficient to eradicate them. Hence there is a need for adjunctive antimicrobial therapy. In our study, the efficacy of chitosan nanoparticle gel was evaluated when used as an adjunctive antimicrobial agent. There were no allergic or inflammatory reactions reported following the application of chitosan in gel form. Owing to its bioadhesive properties, chitosan containing formulations are expected to remain for prolonged time on the application site.[12]To the best of our knowledge this is the first kind of study conducted using Chitosan nanoparticle gel (1%) as a local drug delivery to determine its efficacy against P. gingivalis and T. forsythia in vivo.

It was observed in our study, on intragroup comparison, there were statistically significant reductions observed with PI (p-value: 0.048), PD (p-value: 0.012) and gain in CAL (p-value: 0.046) in control sites as well as PI (p-value: 0.002), CI (p-value:0.001) and CAL (p-value:0.001) in test sites from baseline to 6 weeks. On intergroup comparison between control and test sites, there were statistically significant reductions in mean plaque index (p-value: 0.051) and mean gingival index scores (p-value: 0.003).These outcomes were similar to studies done by Bayati et al where efficacy of chitosan chips in chronic periodontitis patients was evaluated[53] and Akncbay et al where in chitosan incorporated with metronidazole gel and chitosan (1%) were evaluated.[13]

Significant improvements in terms of clinical outcomes namely PI, GI, BOP, PD and CAL were reported by Babrawala et al and Kodega et al in response to use of chitosan membrane and simvastatin and chitosan when used as adjunct to SRP[14,15]. Gayasuddin et al reported favourable outcomes in terms of clinical parameters with the use of chitosan films loaded with metronidazole and levofloxacin than metronidazole and levofloxacin alone.[16]

The present study also observed that there was a significant reduction seen in P. gingivalis (p-value: 0.023) as well as T forsythia (p-value: 0.007) counts in the test compared to control sites. An invitro study done by Costa et al (2014) reported that 1% chitosan had inhibitory action against P.gingivalis, P.intermedia, P buccae, T. forsythia and A acomitans by inhibiting biofilm formation.[25]Another invitro study by Ikinsi et al (2002) showed that chitosan when added to chlorhexidine resulted in greater inhibition of P gingivalis growth than chlorhexidine alone exhibiting antimicrobial effect of chitosan. Aranbicia et al (2013) reported that chitosan particles exhibited antimicrobial activity against P gingivalis and A.acomitans[17] .Other similar studies regarding the significant clinical improvement of gingival health could not be collaborated with

other studies as the detailed perusal of the available literature failed to show any such similar study. Therefore it was not possible to compare our findings related to improvement in both the groups with findings reported by other authors. Thus, the administration of chitosan nanoparticle gel (1%) provided significantly better outcomes after 6 week interval thus justifying the anti inflammatory effect of the drug.

Further in our study, we tried to evaluate radiographically the efficacy of chitosan nanoparticles (1%) in new bone formation in infrabony defects after 24 weeks. But due to the inevitable covid-19 pandemic we could not complete the analysis thus accounting for the limitation of this study. Also periodontitis being a multifactorial disease is associated with a variety of pathogens and hence the efficacy of chitosan nanoparticle gel against all these pathogens needs to be evaluated. Thus, it is recommended that further research should be conducted focusing on the efficacy of chitosan nanoparticle gel (1%) on other periodontal pathogens and also in evaluating the radiographic bone fill in periodontal regeneration so as to better understand the role of chitosan nanoparticle gel among chronic periodontitis patients and patients with stage III periodontitis.

CONCLUSION:

The results of our trial demonstrated that 1% chitosan nanoparticle gel stimulated a significant improvement in clinical as well as microbiological parameters. Hence it can be proposed that the use of chitosan gel (1%) when used as adjunct to scaling and root planing stimulates significant pocket depth reduction, gain in clinical attachment levels thereby enhancing periodontal tissue healing. This can provide a new direction in providing appropriate treatment for periodontal diseases. However further long-term multicentre randomized, controlled clinical trials using different vehicles and concentrations of chitosan should be carried out to ascertain the clinical and microbiological effects of the drug.

REGISTRATION:

The trial is registered in Clinical Trials Registry India (CTRI) under the registration number-CTRI/2019/05/019477.

SOURCES OF FUNDING:

There were no sources of funding.

Report- Dr. K Sravani

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ABSTRACT

Title- Assessment of different irrigation techniques on the penetration depth of different sealers into dentinal tubules by confocal laser scanning microscopy -an in-vitro comparative study

Background: This study intended to assess and compare the efficacy of three final irrigation techniques on the depth of penetration of two root canal sealers into dentinal tubules using Confocal Laser Scanning Microscopy (CLSM).

Methods and Materials: 48 single-rooted mandibular premolars were selected and de-coronated to a length of 12mm. All the samples were prepared using ProTaper gold rotary files and divided into three groups-Group 1-Conventional syringe irrigation (CSI), Group 2- Passive Ultrasonic Irrigation (PUI), and Group 3-Pro-agitator tips system (PATS). Each group was divided into 2 sub-groups- Sub-Group A-AH Plus and Sub-Group B- GuttaFlow Bioseal. Then, sealers were mixed with 0.1% Rhodamine B dye and the samples were obturated. All the samples were sectioned at 2mm and 5mm from the apex and visualized under Confocal Laser Scanning Microscopy (CLSM) (10X) for maximum mean penetration depth and percentage of sealer penetration. Statistical analysis was done using the Independent t-test, and One-way ANOVA test followed by Tukey's Post hoc analysis.

Results: PUI performed better in the apical third whereas, PUI and PATS showed comparable results in the middle third for both depth and percentage of sealer penetration. Amongst the two sealers, GuttaFlow bioseal performed better than AH Plus in both the apical and middle third. These values were statistically significant. ($p<0.05$)

Conclusion: Final irrigation activation with Passive ultrasonic irrigation or Pro Agitator Tips System can significantly improve sealer penetration. The average depth of penetration of GuttaFlow bioseal both at the middle and apical third of the root was significantly superior to AH Plus.

Keywords: AH Plus, GuttaFlow Bioseal, Passive ultrasonic irrigation, Pro-Agitator system, PATS.

Introduction

The successful outcome of the endodontic treatment relies on the complete removal of the infected pulp, efficient disinfection of the root canal with adequate biomechanical preparation, and obtaining a fluid-tight apical seal with obturating materials.[1] The challenges faced during

instrumentation are the cleaning of isthumi, apical delta, and a layer of organic and inorganic material called the smear layer that is formed which may also contain bacteria and their by-products.[2] This layer can prevent the penetration of irrigants and sealers into the dentinal tubules.

Currently, a single irrigant cannot act against both inorganic and organic debris. Hence a combination of irrigants with different properties and modes of action are used.[3] The irrigation protocol recommended is a combination of sodium hypochlorite (NaOCl) a tissue-dissolving agent, and the calcium-chelating agent ethylenediaminetetraacetic acid (EDTA) in conjunction with a normal saline solution.[4] To maximize the effectiveness of the irrigants used, various techniques have replaced conventional syringe irrigation (CSI).

One such technique includes Passive ultrasonic irrigation (PUI) which is one of the most efficient systems in the market.[5] The Pro-agitator tip system (PATS) (InnovationsEndoLtd, India) which was launched in 2017 is an activation system with a sparse number of studies.[6]

Root canal sealers like Epoxy resin-based sealer, AH Plus (Dentsply DeTrey, Konstanz, Germany) have an established record in endodontics and have been used as the gold standard for comparison with other sealers.[7] GuttaFlow Bioseal (GFB) (Coltène/Whaledent AG, Altstatten, Switzerland), is a novel bioactive sealer that has a limited number of studies.[8]

Owing to the importance of proper irrigation and providing a hermetic seal post instrumentation during obturation, the present study aimed to assess and compare the depth and percentage of sealer penetration of two different sealers into dentinal tubules after using three different irrigation techniques by using a Confocal laser scanning microscope (CLSM).

Methods:

The study was approved by the Ethical Committee (KIMS/IEC/D004/2019).

Preparation of specimens

Forty-eight single-rooted human mandibular premolars extracted for orthodontic purposes were selected for the study. The specimens were stored in a 0.5% chloramine-T solution. Radiographs were taken to examine the samples for root curvature and morphological similarity. Only Vertucci's type I configuration, teeth with no curvatures, and mature apices were included in the study. The teeth were de-coronated to standardize the root length of 12mm. The working length (WL) was measured by deducting 1 mm from the length recorded when the tips of the #10K file was visible at the apical foramina. Before instrumentation apices were

blocked using Type II GIC. Canals were then prepared using ProTaper Gold with a torque-controlled motor up to an apical preparation of #F3 (tip size 30 with a taper of 0.09). 5ml of 5.25% NaOCl was delivered between each subsequent file size in all groups using a 30-gauge side-vented needle placed passively.

After instrumentation, the specimens were divided into 3 groups according to the final irrigation protocol.

GROUP 1: Conventional syringe irrigation(CSI)

The final irrigation was done with 2 cycles of 5mL of 5.25% NaOCl and left in the canal for 30 seconds followed by 2 cycles of 5mL of 17% EDTA with the tip of the needle 1 mm short of the working length for 30 seconds. Normal saline was used as an intermediate solution between 2 irrigants.

GROUP 2: Passive ultrasonic irrigation(PUI)

The final irrigation was done with a P5 booster(ACTEON) adapted with a #25 Irrisafe tip placed in the canal 1 mm short of the working length and was activated at a power setting of 4, without touching the wall of the root canal. 5mL of 5.25 % NaOCl with 2 cycles of 30 seconds of activation followed by 5mL of 17%EDTA with 2 cycles of 30 seconds of activation. Normal saline was used as an intermediate solution between two irrigants.

GROUP 3: Pro Agitator Tips System(PATS)

The final irrigation was done using PATS wherein the polymer tip was placed in the canal 1 mm short of working length and was activated using 5mL of 5.25 % NaOCl for 2 cycles of 30 seconds activation followed by 5mL of 17%EDTA for 2 cycles of 30 seconds activation. Normal saline was used as an intermediate solution between two irrigants.

Obturation of specimens

Finally, each specimen was rinsed with 3mL of normal saline and dried with sterile paper points. Specimens from each experimental group were assigned into two sub-groups each:

Subgroups A: AH Plus (Dentsply DeTrey, Konstanz, Germany)

Subgroups B: GuttaFlow Bioseal(Coltène/Whaledent AG, Altstatten, Switzerland)

To facilitate fluorescence under CLSM, both the sealers were mixed with a few grains of Rhodamine B dye and were applied to the root canal using #20 lentulo spiral, and a single cone obturation technique was done. #F3 master cone was coated with the sealer and obturated to the WL. The cone was condensed vertically using a plugger to evenly spread the sealer into the root canal. The teeth were sealed with Cavit at the coronal end. Radiographs were exposed from the facial and proximal surfaces to ensure that no voids were present. Specimens were stored at 37° C and 100% humidity for 7 days to allow the sealer to set completely.

Sectioning:

Specimens were sectioned using a slow-speed microtome saw at 2mm and 5mm from the root apex with water coolant to represent the middle and apical thirds.

Sealer penetration analysis by CLSM:

The slices were observed under a CLSM (Leica Microsystems) under 10X magnification in fluorescent mode. The images were analyzed using LASX software to measure the maximum penetration depth of sealers and the percentage of sealer penetration into the dentinal tubules. Measurements were performed by 1 observer.

Maximum mean penetration depth was obtained by calculating the depth of penetration at 12, 3, 6, and 9's clocks corresponding to the buccal, mesial, lingual, and distal directions, respectively. The sealer penetration depths were calculated for each direction and averaged.

The percentage of sealer penetration was calculated using the following formula: -

Dentin area=Total area-Root canal area

$$\% \text{ of sealer penetration into dentinal tubule} = \frac{\text{area filled by sealer} - \text{root canal area}}{\text{Dentin area}} \times 100$$

Statistical analysis:

Data were analyzed using the statistical package SPSS 22.0 (Chicago, IL) and the level of significance was set at $p<0.05$. Statistical analysis was done using an Independent t-test and One-way ANOVA test followed by Tukey's Post hoc analysis to find out the difference between any 2 groups.

Results:

The mean depth of penetration, within Group 1(CSI), Group 2(PUI), and Group 3(PATS), in the middle third was significantly more than in the apical third in both the subgroups- AH plus and GuttaFlow Bioseal(GFB)(p=0.0001).

When the subgroups were compared GuttaFlow Bioseal showed superior penetration depth compared to AH Plus and the difference was statistically significant(p=0.0001) in all the 3 groups. (Table-1, Graph-1)

When inter-group comparison was done to evaluate the depth of penetration, it was maximum in PUI followed by PATS, and least in CSI in both apical and middle sections (p=0.0001). However, there was no significant difference in the middle third between PUI and PATS groups(p=0.27). Whereas, PUI performed better in the apical third compared to PATS and CSI. The percentage of sealer penetration in both AH plus and GFB groups, superior penetration was seen in the PUI group followed by the PATS group and CSI group in both middle and apical sections.

When compared to the CSI group, the other 2 groups were superior in terms of percentage of sealer penetration.

PATS performed similarly to PUI in the middle third but lacked efficiency in the apical third.($p<0.05$) (Table-2, Graph-2) (Fig 1)

Discussion

The success of endodontic treatment depends on complete canal debridement and hermetic obturation of the root canal.[9] To achieve this, various techniques are available apart from routine treatment options like a combination of irrigants and irrigation activation devices to ensure improved efficiency of debridement and depth of sealer penetration into dentinal tubules which subsequently enhances the quality of obturation.

In the present study, CLSM was used for the evaluation of dentinal tubular penetration using Rhodamine B dye as it does not require sample processing. This ensures that the observations are under normal conditions. Additionally, CLSM does not produce image artifacts and is a non-destructive approach.[10] Rhodamine B helps in accurately determining the depth and percentage of penetration at a relatively lower magnification without disturbing the properties of the sealer.[11]

This study evaluated the efficiency of the irrigation system and the depth of sealer penetration at 2 levels; 2 mm and 5 mm from the apex. This was done since the root apex has 98% of apical ramifications and 93% of lateral canals which are located at apical 3mm of the root canal.[12]

The complete debridement of the canal is only possible with a correct combination of irrigants that act against both organic and inorganic debris in the canal system. NaOCl is the most recommended irrigant that deproteinizes the tissue and has anti-microbial properties which makes it an ideal solution to be used during instrumentation.[6] EDTA a chelating agent is used alternatively with NaOCl to effectively remove the smear layer. Post shaping, it is recommended to thoroughly rinse the canal using aqueous EDTA for at least 1 min using 5 to 10 ml of the chelator irrigant.[13]

The results of the present study corroborated the results in the previous studies with the syringe technique having the least efficiency in smear layer removal.[14,15,16] In contrast, a study conducted by Generali et al. found no difference in CSI, EndoActivator, or PUI for sealer penetration and concluded that sealer penetration into dentinal tubules is more likely to depend on the physicochemical properties of the sealer and on the obturation technique used rather than on the activation of irrigants. The reason for contrasting results can be due to differences in the methodology.[17]

The passive ultrasonic irrigation(PUI) group performed better in both depth and percentage of sealer penetration with AH plus as well as the GuttaFlow Bioseal sub-groups. This could be attributed to the complete shaping of the canal enabling the ultrasonic tip to move freely and the irrigant to penetrate and cleanse even the apical area. Additionally, PUI creates acoustic microstreaming and the cavitation effect inside the root canal that effectively removes the smear layer from the dentinal walls. Acoustic streaming broadly means a rapid movement of fluid in a circular or vortex-like motion around a vibrating instrument corresponding to the patterns of nodes and anti-nodes. However, the intensity of the streaming reduces when the instrument touches the canal wall like in curved canals.[18] Hence in the present study, only teeth with straight canals were included. Acoustic cavitation on the other hand is defined as the creation of new bubbles or the expansion, contraction, and/or distortion of pre-existing bubbles in a liquid, the process being coupled to acoustic energy. These properties of PUI make this method very efficient and superior to other methods.[14]

Pro-agitator tips system (PATS) uses a polymer tip working at 30 psi pressure and 6000 Hz frequency.[6] In the present study, PATS performed similarly to the PUI system in the middle

sections but lacked the same efficiency in the apical sections. Sonic irrigation operates at a lower frequency ranging from 1000 to 6000 Hz than ultrasonic systems making the streaming velocity of the irrigant lower. They have oscillating patterns with one node near the attachment of the file and one antinode at the tip of the file. However, in constrained areas, the sideways movement will not happen but will result in a longitudinal vibration.[19] The present study showed that the middle sections were irrigated better in comparison to the apical section. The probable reason could be that the free movement in the middle third is more compared to the apical third and another reason could be the vertical motion used during its activation. However, more studies are required to confirm this hypothesis.[6] Another study by Eggmann et al concluded that EDDY (VDW GmbH, Munich, Germany), a sonically activated device performed at par with PUI when used in straight and curved canals.[20]

AH Plus is a commonly used epoxy-resin-based root canal sealer with good physiochemical properties and adaptability. It forms sealer tags that penetrates the dentinal tubules forming both mechanical and chemical bond. The chemical bond is formed when the amino groups of the dentinal collagen bond to the epoxy rings of AH Plus.[21]

GuttaFlow Bioseal (GFB) (Coltene/Whaledent, Altstatten/ ¨ Switzerland) is a newer generation of bioactive sealer developed in 2015 with an enhanced ability to penetrate the dentinal tubules and bond rather than simply adhere to both dentin and core material surfaces. GFB consists of gutta percha powder and bioactive glass which forms hydroxyapatite crystals on the surface. There is an increased rate of sodium release due to the presence of bioactive glass which stimulates the formation of mineralized tissues which in turn provides better sealer penetration and better bonding to the root dentin.[22]

In the present study, AH plus performed inferiorly to GuttaFlow bioseal in all three groups. This could be due to the proteolytic action of NaOCl on collagen which makes chemical interaction poor and enhances the gaps at the AH Plus- dentin interface.[21] In addition, AH Plus requires a fluid-free environment for setting whereas GFB being a bioactive sealer sets in when exposed to dentinal tubules which have approximately 20 wt.% water. Also, the property of calcium silicates in GFB induces dentin remineralization and allows slight expansion of the material which is beneficial for the sealing.[22] Additionally, the cause for the better penetration of GFB could be its particle size of approximately 2-10μm when compared to AH plus which presents with a larger particle size of approximately 8-10μm.[14]

The lesser penetration in the apical third of the root canal could be due to a decrease in the

diameter of tubules from the coronal to the apical region. Furthermore, the apical portion of the root canal constitutes various ramifications and dentinal sclerosis may also be present which can be a causative factor for lesser dentinal tubular penetration compared to the middle third.[23]

Conclusion:

Within the limitations of the study, it can be concluded that the depth and percentage of sealer penetration of both the sealers with three different irrigation techniques at the middle and apical third was statistically significant with Passive ultrasonic irrigation performing better at the apical third. Pro-agitator tips system performed at par with Passive ultrasonic irrigation in the middle third but lacked efficiency at the apical sections. GuttaFlow Bioseal performed better than AH Plus at both apical and middle third in all three groups.

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TABLE 1 – Maximum mean penetration depth into dentinal tubules in different groups

	GROUPS	APICAL 2 MM MEAN± SD	MIDDLE 5 MM MEAN± SD
AH PLUS	1A (SYRINGE)	476.96 ± 24.7	1202.57 ± 8.54
	2A (PUI)	895.68 ± 2.96*	1669.99 ± 21.21
	3A (PATS)	884.05 ± 8.25	1670.36 ± 10.79
GFB	1B (SYRINGE)	504.61 ± 5.10	1291.66 ± 3.46
	2B (PUI)	928.23 ± 5.08*	1815.24 ± 17.32
	3B (PATS)	899.59 ± 4.46	1811.17 ± 7.33

SD- Standard deviation

Table 2- Percentage of sealer penetration into dentinal tubules in different groups

	GROUPS	APICAL 2 MM MEAN± SD	MIDDLE 5 MM MEAN± SD
AH PLUS	1A (SYRINGE)	4.96 ± 0.34	27.23 ± 1.71
	2A (PUI)	12.9 ± 0.77*	53.62 ± 1.59
	3A (PATS)	11.06 ± 1.28	48. 55 ± 1.66
GFB	1B (SYRINGE)	7.06 ± 0.21	28.47 ± 0.58
	2B (PUI)	21.12 ± 1.04*	81.28 ± 2.07
	3B (PATS)	12.71 ± 0.77	71.9 ± 2.86

SD- Standard deviation

Graph 1- Maximum mean penetration depth

Graph 2- Percentage of sealer penetration

Figure 1- Confocal laser scanning microscope images of different groups at 2mm and 5mm

Report- Dr. Megha Kachari

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Report- Dr. Mir Shahid Ulla

by Dr.mir Shahid Ulla

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Word count: 422
Character count: 2585

ROLE AND RESPONSIBILITIES OF INFECTION CONTROL COMMITEE

The infection control committee functions to **prevent and control healthcare-associated infections by setting infection control policy and monitoring practices to reduce these risks.**

THE IMPORTANT COMPONENTS ARE:

- Basic measures i.e standard and additional precautions
- Education and training of healthcare workers
- Protection of healthcare workers e.g. immunization
- Identification of hazards and minimizing risks
- Routine practices such as aseptic techniques, handling and use of blood and blood products, waste management, use of single use devices.
- Surveillance
- Incident monitoring
- Research

INFECTION CONTROL COMMITTEE (ICC)

The hospital ICC is charged with the responsibility for planning, evaluation of evidenced – based practice and implementation, prioritization and resource allocation of all matters relating to infection control.

The ICC must have a reporting relationship directly to either administration or the medical staff to promote infection control programme visibility and effectiveness. The ICC should meet regularly (monthly) according to local need.

THE COMMITTEE SHOULD INCLUDE-

1. Chair executive or hospital administrator
2. Hospital microbiologist
3. Infection control nurse
4. Occupational health physician
5. Representative from the major clinical specialities
6. Additional representatives of any other department.

TEAM MEMBERS TO BE AUTHORIZED

- Team should have authority to manage an effective control programme.
- Team should have a direct reporting with senior administration
- Infection control team members or are responsible for day-to-day functions of IC and preparing the yearly work plan
- They should be expert and creative in their job.

THE ROLE OF INFECTION CONTROL TEAM

- To develop an annual infection control plan with clearly defined objective
- To develop written policies and procedures including regular evaluation and update
- To supervise and monitor daily practices of patient care designed to prevent infection.
- To ensure availability of appropriate supplies
- To organize an epidemiological surveillance programme
- To educate all grades of staff in infection control policy, practice and procedures.

RESPONSIBILITIES OF INFECTION CONTROL COMMITTEE

1. Review and approve surveillance and prevention programme
2. Identify areas for intervention
3. To assess and promote improved practice at all levels of heath facility
4. To ensure appropriate staff training
5. Safety management
6. Development of policies for the prevention and control of infection
7. To develop its own infection control manual
8. Monitor and evaluate the performance of programme.

SCOPE OF INFECTION CONTROL

Standard precautions: these measures must be applied during every patient care, during exposure to any potentially infected material or body fluids s blood and others.

COMPONENTS

a) Hand washing
b) Barrier precautions
c) Sharp disposal
d) Handling of contaminated material.

"HAVE A VISION FOR CREATING BETTER HOSPITALS"

Report- Dr. Mir Shahid Ulla

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CODE OF CONDUCT FOR STUDENTS

Dayananda Sagar College of Dental Sciences is committed to the pursuit of high quality education and all round development of its students. Excellence in teaching and learning in this institute revolves around the need of the students, their active participation and well qualified educators trained in their respective fields. The college seeks to instil in all students an independent scholarly learning, critical judgment, academic integrity and ethical sensitivity.

The college will -
• Ensure that teaching and non-teaching staff treat students with utmost regard, dignity and respect as per their individual needs. • Support students when they are fresh adjusting to the new campus and its surroundings and the wider community, make sure that they have a positive experience during their stay in the institution. • Provide top quality student-centric teaching, provide support, advice and guidance, to both undergraduates as well as postgraduate students. • Enable effective engagement with studies through access to high quality Library, IT and specialist laboratory facilities. • Provide clear information about programme costs, payment options and deadlines, together with estimates of any additional costs you may incur.
The College will support you for your studies by -
• Ensuring that students have the sufficient resources to develop their skills needed to succeed in the institution and also make aware to the students, their responsibilities in maintaining academic integrity. • Provide a free and fair solution for formal complaints when such problems remain unresolved • Provide all equipments and clinical material required to hone your clinical skills. • Provide an inclusive environment for overall growth and development, the college encourages students to actively participate in sports and extra curricular activities. • Provide mentoring and counselling sessions periodically.

Students are expected to -

- Treat faculty and co students respectfully, with dignity and courtesy. They should consider them as people with different personalities and requirements.
- Respect the physical environment of the college, including your accommodation, behaving respectfully towards others who are living, learning and working alongside you in our shared environment.
- Utilize the chances and infrastructure provided by the institution to the best extent.
- Should be responsible for his studies and should manage his work responsibly; should actively engage in research, should commit himself to self study, and participate in group work and other activities related to the curriculum.
- Attend his/her classes, practicals and clinic under the guidance of their faculty and clinic mentors.
- Should stick to the stated deadlines and submit their work on time for assessment. They should respond and reciprocate positively against the feedback received.
- Always take permissions in advance from staff/ incharge for any absence and return as soon as possible once the problem/health issue is resolved.
- Make sure that arrangements are made so that payments are done on time which is as prescribed by the institution.

As a student you will -

- Seek help and support at the earliest and in an appropriate manner.
- Seek advice from the support groups set up by the institution, wherever available.
- Be aware of and understand your responsibilities
- Make sure that he/she does not indulge in any activity that brings disrepute to himself/herself or the institution and maintain a high level of academic integrity.

PREDOCTORAL

The curriculum for undergraduate dentistry at Dayananda Sagar College of Dental Sciences has been adopted from the curriculum framed and constructed by the Dental Council of India and also as constituted by the Rajiv Gandhi University of Health Sciences, Bangalore. The Goal of the BDS programme is to produce graduates who are comprehensive clinicians able to diagnose accurately the spectrum of various oral diseases. The graduates will learn the technical knowledge and skills necessary to independently provide patients with comprehensive oral health care. We at Dayananda Sagar College of Dental Sciences imbibe in them leadership skills, to set an example to the society as well as humanitarian beliefs to humanely treat the patients. The students are taught to evaluate research and clinical work which are further used by them as evidence-based practice in the future.

MISCONDUCT

Discipline is one of the core values of Dayananda Sagar College of Dental Sciences and students are expected to be at their best discipline at all times as professionals. Any misconduct is viewed seriously by the institution regardless of whether it violates the law of the land or not. The students are scrutinized by the Institutional Disciplinary Committee in case of any misconduct.

Types of Misconduct

Disciplinary action will be taken for violations or attempted violations such as aiding, abetting, or participating in the planning of an act that would be in violation of institutional code.

The following are types of misconduct.

•Academic Dishonesty or any other form of Dishonesty

•Fabrication of record, Falsification or Forgery

• Stealing.

• Misuse and breakage any equipments and materials that belongs to the institution

• Illegal usage of institutional name or resources

•Physical Abuse and / or sexual abuse

•Ragging

•Obstruction or Disruption of teaching, research, administration, disciplinary procedures, or other college/University activities.

• Inappropriate/ bad behaviour

• Fights and violence

• Substance abuse or misuse

• Unapproved sale/use of institutional infrastructure

• Marshal or carry out any unlawful activity within the institutional jurisdiction.

• Violating laws of the Union of India.

The college has the authority to exercise jurisdiction over misbehaviour that occurs off the campus that would infringe the policies or regulations of the institution if it had occurred within the campus. Specifically, the college has the right to take action over such incidents where any misconduct or illegal activity such as physical abuse, sexual assault, sexual misconduct, sex offenses, physical assault, violence, behaviour that risks the health or safety of any person, stalking, harassment, participation in ragging or other activities that cause or is likely to cause physical injury, or personal degradation or disgrace resulting in psychological harm to any student or other person.

Report- Dr. Nitin

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by Dr. Poukhuan

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Dr. POUKHUAN PANMEI

I YEAR

PREDICTION OF MATURITY STAGES OF THE MIDDLE PHALANX OF THE THIRD FINGER BASED ON MANDIBULAR CANINE CALCIFICATION AND CERVICAL VERTEBRAE MATURITY STAGES FOLLOWED BY ITS CLINICAL VALIDATION - AN ARTIFICIAL INTELLIGENCE STUDY.

BRIEF RESUME OF THE INTENDED WORK

6.1 Need for the study:

Treatment timing is crucial for orthopedic treatment of growing patients. As patients have diverse growth rates, chronological age is not a sound indicator for determining the optimal timing for growth modification treatment.[1] Skeletal maturity refers to the degree of development and maturation of an individual's skeletal structures. The timing of skeletal maturation varies because each person has his or her own biological clock.[2] Assessing skeletal maturity is crucial because it helps orthodontists determine the most appropriate timing and approach for orthodontic treatment.[2]

The developmental status of a growing child can be assessed by using various indicators, which includes chronological age, dental development, secondary sexual characteristics and skeletal maturation. Chronological age is unreliable for assessment of developmental status because of the wide variation in timing and duration of the pubertal growth spurt and other developmental stages.[3]

Lateral Cephalograms have been traditionally used in diagnosis and treatment planning of orthodontic patients. To reduce both radiation exposure and diagnostic cost to the patient, Lamparski was the first to suggest that morphological changes occurring in cervical vertebral bodies during growth could be used to assess skeletal maturation.[3] He assessed the skeletal maturation using cervical vertebrae C2, C3 and C4 by dividing into 6 stages based on the morphological changes.[4] Later in 2005, Baccetti and Franchi made further modification of the cervical vertebrae maturation stages and found that this method was a reliable and valid alternative to radiographic assessment of hand-wrist bones for determination of skeletal age, and this has been supported by several authors.[4]

Studies have shown that relationships between the stages of tooth mineralization of the mandibular canine appear to correlate better with skeletal maturity indicators than the other teeth.[5]

Studies have also shown that significant correlation between stages of canine development and pubertal growth spurt is higher when compared to any other dental parameter so the stages of calcification of mandibular canine can be used as a tool to estimate growth status of an individual.[5]

It is a routine procedure for the orthodontist to take and - wrist radiograph for assessing the skeletal maturation and Cephalometric radiograph to analyze skeletal morphology and direction of growth patterns. Cervical vertebral analysis for the assessment of skeletal maturity and the correlation between Cervical Vertebral images and Middle Phalanx stages provides a way for accurate predictions.[6] The hand-wrist radiograph is the most commonly used method for skeletal-age evaluation.[7] Hagg and Taranger studied pubertal growth from the stages of ossification of the middle phalanx of the third finger of the hand (MP3 stages).[8] Middle Phalanx, a key indicator of skeletal maturation, is closely associated with an individual's chronological age and pubertal growth.[7]

Therefore, the purpose of this study is to predict the maturity stages of the Middle Phalanx of the third finger as an indicator of skeletal age based on the Cervical Vertebrae maturity indicator index and the mandibular canine calcification and to analyze the accuracy of the proposed algorithms using artificial intelligence.

Problem statement:

Traditionally, growing patients need 3 sets of radiographs, namely Orthopantomogram (OPG), Lateral Cephalometric radiograph and Hand-wrist radiograph to determine skeletal maturity. No radiation exposure, even in small doses, is free of risk, particularly in children. Diagnosis and treatment planning in orthodontics is highly subjective and opinion based varying with the knowledge and expertise of the orthodontists, causing inter- and intra-clinician errors. Lateral cephalograms, hand wrist radiograph and OPG have been analyzed by manually tracing which is time consuming and has the disadvantage of being subjected to random and systematic error. Errors mostly occur in landmark identification, which is based on observer experience, landmark definition, and image density and sharpness. To overcome these problems, newer AI technologies have been increasingly applied. It has proven to be reliable and time saving in many aspects. Providing the data is the foundation for development of a well-constructed algorithm model. Hence with high quality and quantity of data, higher accuracy of predictive result and image interpretation can be achieved through machine learning process. In the field of dentistry, a well-

trained AI model can help not only in landmark identification, but in all kinds of linear and angular measurements and volumetric measurements as well. It can save tremendous time by fully automated AI measurements so researchers will have more energy finding new insights within clinical examinations.

Research Question: Can artificial intelligence predict the stages of middle phalanx of the third finger based on mandibular canine calcification and cervical vertebrae maturity indicator?

Null Hypothesis(H_0): Artificial intelligence cannot be used to predict the stages of middle phalanx of the third finger based on mandibular canine calcification and cervical vertebrae maturity indicator.

Research Hypothesis(H_1): Artificial intelligence can be used to predict the stages of middle phalanx of the third finger based on mandibular canine calcification and cervical vertebrae maturity indicator.

6.3 Objectives of the study:

1. To predict maturity stages of the Middle Phalanx of the third finger based on the Mandibular Canine calcification stages and Cervical Vertebrae Maturation Index in the selected Lateral Cephalograms and Orthopantomogram (OPG) using the data obtained from manual tracing.
2. To test and validate the developed algorithm in determining Middle Phalanx of the third finger stages in a different sample of Lateral Cephalograms and OPG.

7. MATERIALS AND METHODS:

7.1 Source of data:

Lateral Cephalograms, OPG and Hand wrist of subjects previously taken for the purpose of diagnosis and treatment planning will be collected from Department of Oral Medicine and Radiology and Department of Orthodontics and Dentofacial Orthopedics, Dayananda Sagar College of Dental sciences, Bengaluru.

Study design: Artificial Intelligence study.

Sample size determination:

The sample size for training in order to derive an Algorithm was calculated using G-power software version 3.1.9.7 by entering the following inputs below in the site.

Test family- F – test

Test type –ANOVA: Fixed effects, omnibus, one-way

Type of power analysis- A priori

Effect size (f) = 0.2

Permissible α error = 0.05

Power (1- β err prob) = 0.95

Number of groups = 3

The sample size is 306 training set and 92 test set (398 sets)

Criteria for Case Selection:

Inclusion criteria:

Cephalometric Radiographs, Hand-wrist radiographs and OPG of subjects between 10 to 14 years showing second (C2), third (C3) and fourth (C4) cervical vertebrae, middle phalanx and mandibular canine completely and clearly with good contrast will be included.

Exclusion criteria:

1. Individuals that were subjected to trauma and/or operation in head and neck region.

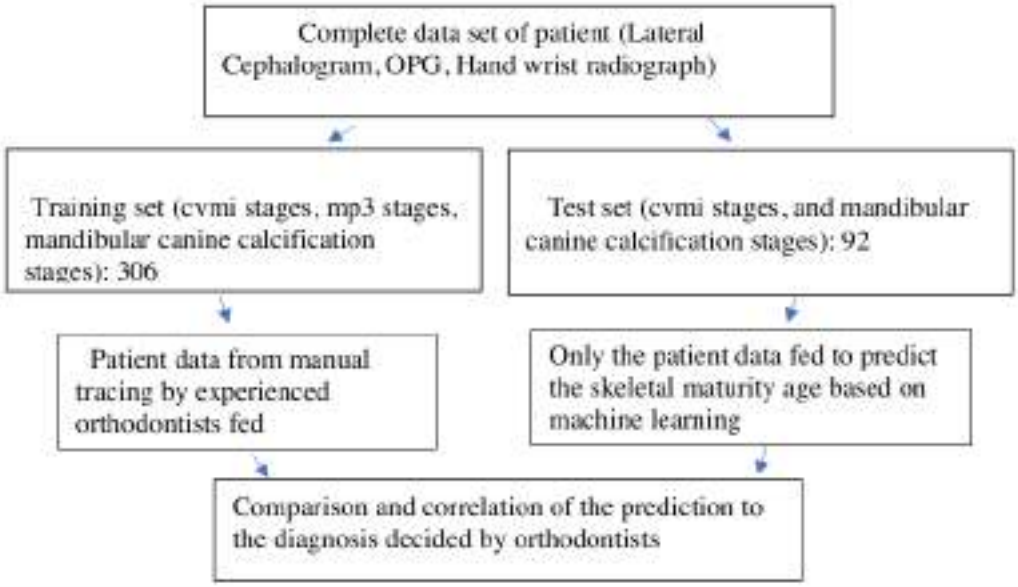
2. Individuals who have any disorder that could interfere with bone development.
3. Individuals with any systemic disease and/or growth and development retardation.
4. Individuals with congenital and/or acquired malformations in head and neck region.

Materials required:

The demographic details such as age will be recorded.

398 Cephalometric Radiographs, Hand-wrist radiographs an OPG of individuals between the ranges of 10 to 14 years which have been taken for the reason other than current study will be taken from the Department of Oral Medicine and Radiology, Dayananda Sagar College of Dental Sciences, Bengaluru.

1. Sidexis Software to mark and measure the points on the cervical vertebrae C2, C3 and C4.
2. Machine learning models will be implemented on Python, Jupiter, Colab and Data Visualization tool (Tableau) which will be developed in Department of Artificial Intelligence and Machine Learning, Dayananda Sagar University, Bengaluru.



For reduction of interpersonal and intrapersonal errors, an expert panel consisting of minimum 4 experienced orthodontists will be asked to check the final treatment for each patient.

Study group:

- Cephalometric Radiographs of 306 individuals in the age group between 10 to 14 years will comprise of 6 study groups based on cervical vertebral maturation stages with 51 sample each.

STAGES	NUMBER OF SAMPLES
CVS 1	51
CVS 2	51
CVS 3	51
CVS 4	51
CVS 5	51
CVS 6	51

- Hand wrist radiographs of 306 individuals in the age group between 10 to 14 years will comprise of 6 study groups based on Hagg and Taranger classification with 51 sample each.

STAGES	NUMBER OF SAMPLES
MP3 F	51

MP3 FG	51
MP3 G	51
MP3 H	51
MP3 HI	51
MP3 I	51

OPG for mandibular canine calcification stages of 306 individuals in the age group between 10 to 14 years will comprise of 5 study groups with 61 sample each.

STAGES	NUMBER OF SAMPLES
STAGE D	61
STAGE E	61
STAGE F	61
STAGE G	61
STAGE H	61

7.2 Method of collection of Data:

Permission :

Permission will be taken from Department of Orthodontics and Dentofacial Orthopedics, Department of Oral Medicine and Radiology and from the Institutional Review Board of Dayananda Sagar College of Dental Sciences to conduct the study.

Sample size to train the AI machine: 306

Sample size to test the AI algorithm: 92

Total Sample size estimation for training AI algorithm: 398

Sample Size Estimation for testing the AI algorithm:

Roughly 30% of sample size which are taken for generating algorithm would be considered as a sample size for testing purpose. And this sample used for testing purpose is selected from a new set of population (new unlabeled lateral cephalograms, OPG).

So that the total sampling size for testing would be 92.

SAMPLING METHOD: Criteria based sampling technique (sequential technique)

- **CEPHALOMETRIC RADIOGRAPHS, HAND WRIST and OPG**:

For the purpose of standardization, cephalometric radiographs will be taken from Sirona Orthophos XG machine (kV- 73, mA- 15, time- 9.4s) using appropriate film position, stabilizing patient position with the help of the ear rods, nasion positioner and orbital rod with standardized exposure parameter having good contrast and density and showing C2, C3 and C4 clearly will be considered.

OPG will be taken under standard head position using laser pointers with exposure paraments of kV-64, mA-8, time- 14.1s.

Hand wrist radiographs (left hand wrist) is taken with exposure paraments of kV-80 mA-14, time-9.1s.

9

The hand wrist is placed flat on the receptor with the fingers slightly apart; when film is viewed, the hand wrist skeleton is observed from the dorsal (posterior or top side) as opposed to the palmer (anterior) surface.

Cephalometric Radiographs, OPG and Hand-wrist radiographs will be acquired in DICOM format and transferred to a personal computer for further image analysis.

CALIBRATION OF THE EXAMINERS:

One trained examiner (S.P) will identify the lank mark points and do the measurements as described in detail methodology earlier. The examiner would undergo a training and calibration session to match the bench mark (R.B.K).

Inter observer co-relation:

Around 30 each of lateral cephalograms, OPG and hand wrist radiograph will be randomly picked up from Department Archives. Land mark marking and measurements would be done by the examiner and the guide separately without one discussing with the other, where data would be compared and subjected to appropriate co-relation test.

A co-relation co-efficient value of 0.8 or more than 0.8 is considered as acceptable value, indicating a high degree of concordance between the examiner and the bench mark suggesting calibration of examiner.

Intra observer co-relation:

Around 10 lateral cephalogram would be randomly picked out of 30 lateral cephalograms that are earlier used for calibration of examiner. After a week the examiner will do repeat assessment and data so obtained would be subjected to appropriate co-relation statistics and if co-relation co-efficient value is 0.8 or more than that it refers to high degree of internal reliability suggesting

intra-examiner calibration. The calibration session will continue until a high co-relation co-efficient (0.8=>0.8) is attained.

- **ANALYSIS OF IMAGE:**

For Determination of Growth and Maturation of individuals from Cephalometric Radiographs, the second (C2), third (C3) and fourth (C4) cervical vertebrae are evaluated as follows:

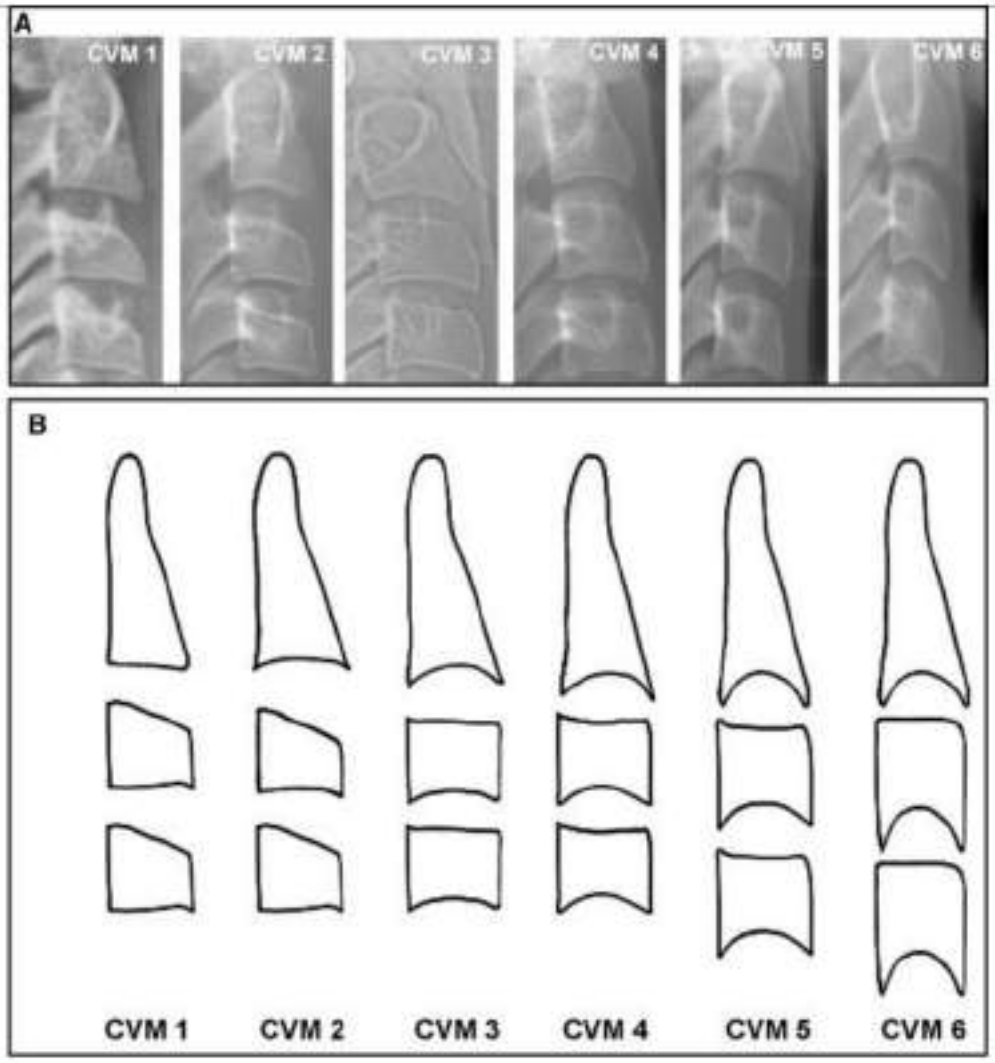


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Table 1: Classification of Cervical Vertebral stages by Baccetti et al. 2005

STAGES	FEATURES	DIAGRAMS

Initiation (CVS 1)	• The lower borders of all the three vertebrae are flat. • The body of C3 and C4 are trapezoidal in shape. • The peak in mandibular growth will occur on average 2 year after this stage.	
Acceleration (CVS 2)	• The Concavity at the lower border of C2 is present. • C3 and C4 are trapezoidal in shape. • The peak in mandibular growth will occur on average 1 year after this stage.	
Transition (CVS 3)	• The Concavity at the lower borders of C2 and C3 are present. • The bodies of C3 and C4 may be either trapezoid or rectangular in shape. • The peak in mandibular growth will occur during the year after this stage.	
Deceleration (CVS 4)	• The Concavities at the lower borders of C2, C3 and C4 are present. • The bodies of C3 and C4 are rectangular horizontal in shape. • The peak in mandibular growth has occurred within 1 or 2 years before this stage.	
Maturation (CVS 5)	• The Concavities at the lower borders of C2, C3 and C4 are still present. • At least one of the bodies C3 and C4 is squared in shape. If not squared, the body of the other cervical vertebra still is rectangular horizontal. • The peak in mandibular growth has occurred within 1 or 2 years before this stage.	

Completion (CVS 6)	• The concavities at the lower borders of C2, C3 and C4 are still present. • At least one of the bodies of C3 and C4 is rectangular vertical in shape. If not rectangular vertical, the body of the cervical vertebra is squared. • The peak in mandibular growth has ended at least 2 years before this stage.	

CHART I: MP3 stages of the third finger were evaluated using R. Rajagopal's 5 observational scheme which is a modification of Hagg and Taranger's observational classification:

a. MP3-F stage: the epiphysis is as wide as the metaphysis. b. MP3-FG stage: the epiphysis is as wide as the metaphysis; a distinct medial and lateral border of the epiphysis forms a line of demarcation at a right angle to the distal border; the metaphysis begins to show a slight undulation. c. MP3-G stage: the sides of the epiphysis have thickened and cap its metaphysis, forming a sharp distal edge on at least 1 side. d. MP3-H stage: fusion of the epiphysis and the metaphysis begins; at least 1 side of the epiphysis forms an obtuse angle to the distal border. e. MP3-HI stage: the metaphysis shows a smooth, convex surface, almost fitting into the reciprocal concavity of the epiphysis. f. MP3-I stage: fusion of the epiphysis and the metaphysis is complete.

CHART 2: The development of mandibular canine was assessed according to Demirjian's stages 6 of dental calcification

Stage 4

D: The crown formation is completed down to the CEJ.
The superior border of the pulp chamber in the uniradicular teeth has a definite curved form, being concave towards the cervical region. The projection of the pulp horns, if present, gives an outline shaped like an umbrella top.

Stage 5

E: The walls of the pulp chamber now forms straight lines whose continuity is broken by the presence of the pulp horn which is larger than in the previous stage.
The root length is less than crown height.

Stage 6

F: The walls of the pulp chamber now form a more or less isosceles triangle. The apex ends in a funnel shape.
The root length is equal to or greater than the crown height.

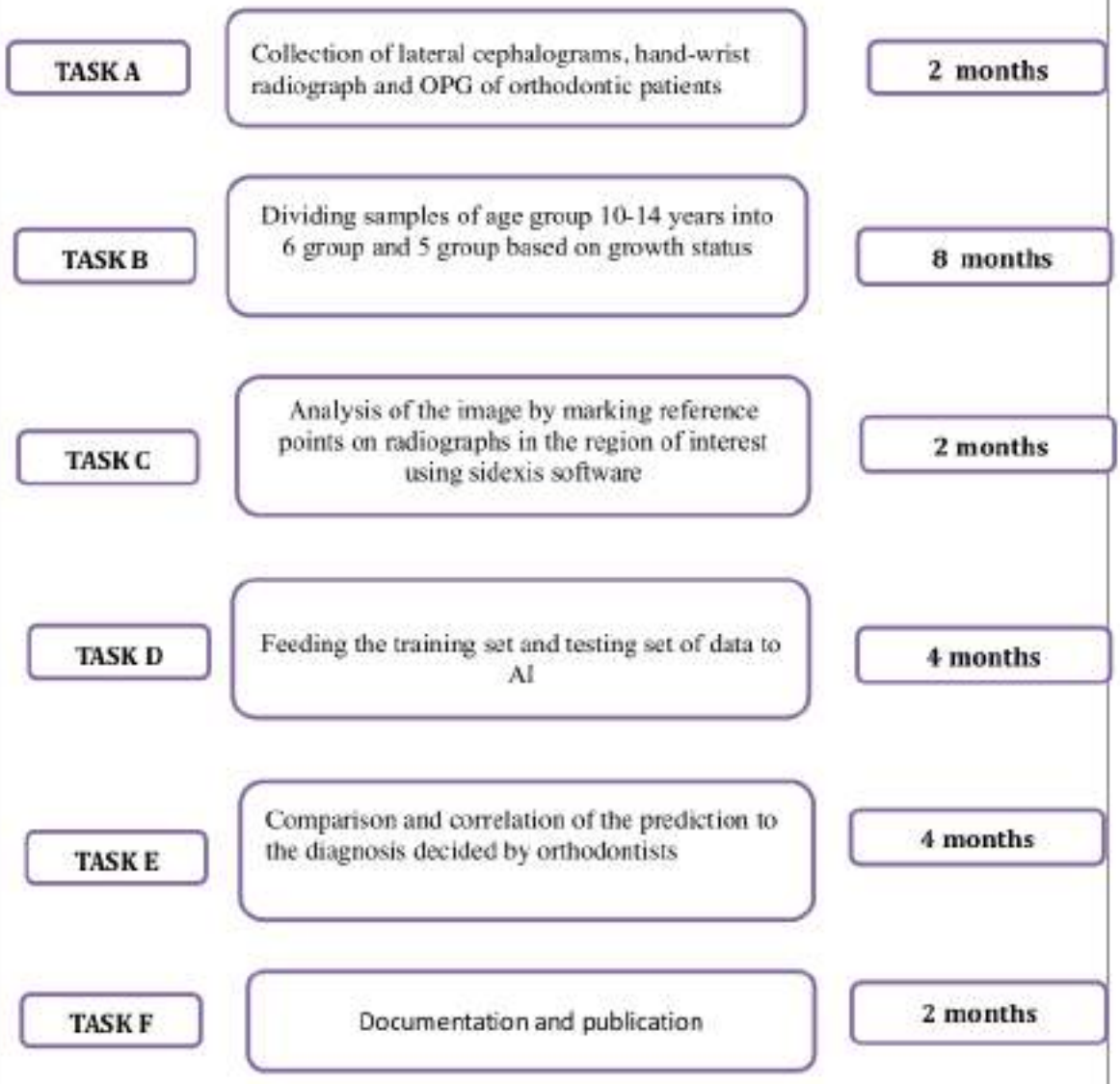
Stage 7

G: The walls of the root canal are now parallel and its apical end is still partially open.

Stage 8

H: The apical end of the root canal is now completely closed.
The periodontal membrane has a uniform width around the root and the apex.

PERT CHART FOR THE INTENDED RESEARCH WORK

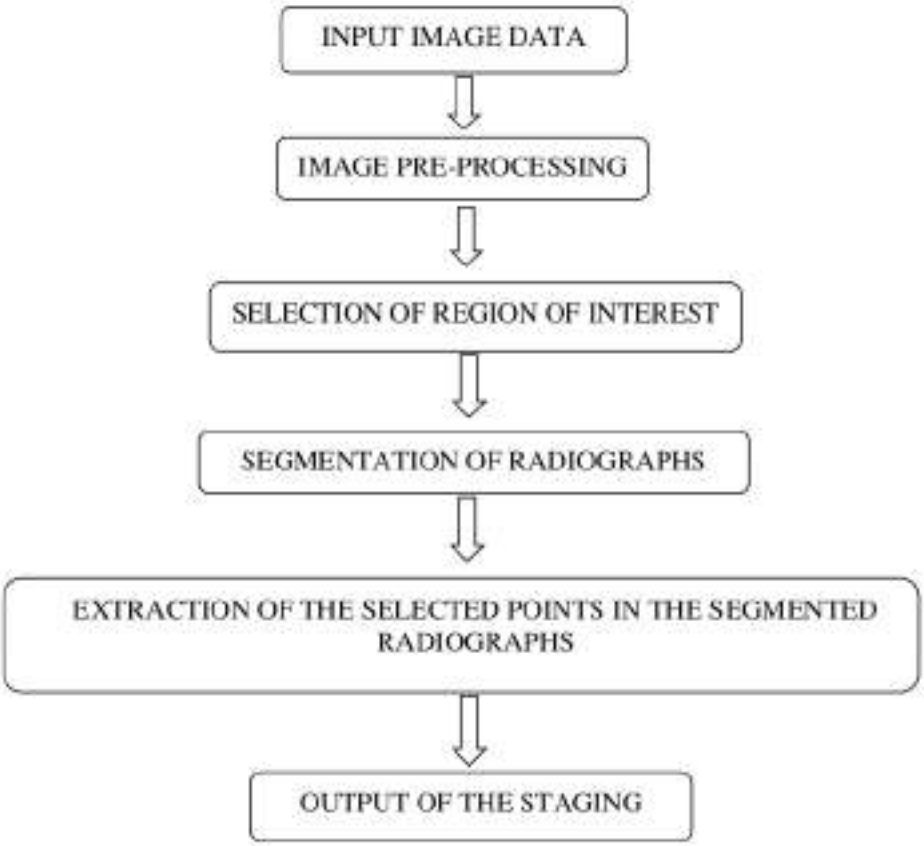


GENERATION OF AI ALGORITHM:

In this study, we will use the semi-supervised method, where-in there will be a set of labelled data and set of unlabeled data.

The Labelled Cephalometric Radiographs, OPG and Hand wrist radiograph for generating Algorithm will be provided in order to construct AI algorithm and obtain Deep Learning AI software.

The work flow of proposed algorithm is as follows:



ALGORITHM VALIDATION:

The new set of unlabeled Cephalometric radiographs, OPG and hand wrist radiograph of 92 images which were not used for the generation of the AI algorithm will be used to test and validate the accuracy of the derived AI Algorithm.

Statistical Analysis:

The data collected for this study will be analysed statistically as follows:

Descriptive Statistics: All categorical variables will be presented in the form of frequency tables along with percentages. The quantitative variables will be described using Mean ± SD/ Median (IQR) based on the verification of normality assumption. The estimates like Mean/ Proportion/ Difference in means/ Difference in proportions will also be expressed with 95% Confidence Interval. Wherever necessary, the data will be presented graphically.

Inferential Statistics: For comparing the MP3 stages based on mandibular canine and cervical vertebrae maturity, One -way Analysis of Variance (ANOVA) will be applied following the post-hoc test separately on day 3 and day 7 among all the three groups, if the data of the three groups follow normality assumptions. If not, Kruskal-Wallis test will be applied with post-hoc test related to Kruskal-Wallis test. The comparison within the group between day 3 and day 7 will be tested using unpaired t-test/ Mann-Whitney U-test (separate samples of 8 are used for both subgroups on day 3 and day 7) will be applied subject to normality assumptions. Any reliability to be established in the study, the intra-class correlation has to be used.

The results will be considered statistically significant whenever $P \leq 0.05$.

Report- Dr. Poukhuan

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Report- Dr. Priya Singh

by Dr. Priya Singh

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File name: tistry_Among_Dentists_in_Bangalore-_A_Cross_Sectional_Study.docx (31.4K)
Word count: 2935
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To Evaluate Knowledge Awareness and Attitude Regarding Teledentistry Among Dentists in Bangalore- A Cross Sectional Study

Abstract

A rapidly developing country like India, still has to face the problems of lack of availability of access to medical and dental care even today. With rapid digitalization happening all across the globe, the idea of using it for clearing the gap between the patient and the dentist is a new revolution in the field of telemedicine. This article evaluates the awareness and attitude of dentists in south Bangalore towards teledentistry. It also includes a discussion based on different questions and how dentists from different specialties and age groups answered them. We can conclude with this article, that, teledentistry is a very viable option for oral health care for those who have difficult in accessing it and that dentists are very open to accept it and adopt it.

Keywords: Teledentistry, telemedicine, teleconsultation, COVID-19, awareness, attitude

INTRODUCTION

Oral healthcare is a basic amenity that must be accessible to all. Unfortunately, in today's world, access to healthcare for all is still a challenge due to the lack of availability of doctors and facilities in certain regions of the country due to various factors. In developing countries, access to qualified medical personnel especially oral health care specialists by inhabitants of rural and remote areas remain a challenge since these personnel are mostly located in urban communities.[1] One way of overcoming this challenge is by the implementation of teledentistry. Through teledentistry, it is possible to reach patients who do not have access to a dentist or cannot make the visit to the dentist due to barriers such as lack of time, morbidities, disabilities, security concerns, poverty, etc. Healthcare has been rapidly digitalized in the last few years with the advent of new technology in medicine. This development has become even more pronounced because of the COVID-19 pandemic that hit the entire world with fear and panic of visiting their healthcare providers for regular care, for the fear of contracting the virus. Teledentistry is not a new concept and one of the earliest teledentistry projects was started by the US military in 1994 to serve the US troops all around the world.[2] Telemedicine, which had been in use even before the pandemic, became even more popular during the pandemic-induced stringent lockdowns. Telemedicine is derived from "tele" in Greek, meaning distance, and "menderi" in Latin, meaning to heal.[3]teledentistry involves the use of technology and telecommunication for dental care, consultation, and awareness in urban as well as rural areas. With the help of teledentistry, one can recognize high-risk populations, arrange referral to a dental surgeon or specialist, and encourage locally based treatment. Together all these lead to a reduction in the waiting period, unnecessary travel, and loss of productivity.[4]Teledentistry can be used in all the specialties of dentistry.[5] Teledentistry has many advantages such as being cheaper than traditional in-person consultations, reduced travel expenses and time, and easier to take multiple opinions from other specialties. Available evidence indicates that e-oral health is associated with higher patient satisfaction and is an effective and reliable method for patients in rural and remote areas. Studies reporting patient satisfaction, all patients had shown willingness for teleconsultation for a dental problem, and they were mostly satisfied due to saved travel time, saved working days, and prompt treatment onset.[6] A few studies conducted showed that the use of teledentistry reduced the time spent by patients in the ED for non-traumatic dental conditions and also allowed the ED doctor to be able to attend to other emergent patients more effectively. The mean waiting time for patients to provider interaction was 40 minutes, mean time

spent by dental patients inside the ED room was 46 min.[7] Studies conducted on connecting medical personnel to the dentist via teledentistry have shown good responses with only a few technical errors due to a lack of training on how to use the technology provided. [8] Studies have also been conducted on the awareness and acceptability of teledentistry among patients and with results showing that many were accepting of teledentistry. This study in particular questions the dentists in the city of South Bangalore on their knowledge and acceptability of teledentistry.

This study aims to incalcate the knowledge, awareness, and practice of teledentistry among the general practitioner it is important to assess the awareness and attitude towards teledentistry among them. Hence the study is conducted among general practitioners to know their knowledge, awareness, and attitude toward teledentistry.

MATERIAL AND METHODOLOGY

STUDY DESIGN AND STUDY POPULATION

The study is a descriptive cross-sectional study involving an electronic survey for general practitioner dentists, a validated 18 close-ended questionnaires were included to evaluate the knowledge, attitudes, and awareness among the general practitioner dentists residing in south Bangalore. The survey was mailed to a random sample of 120 general practitioner dentists from all 9 specialties with professional experience from 0 to 25+ years. South Bangalore was chosen for this survey due to it being a metropolitan city with good access to the internet as well as dental care.

INCLUSION CRITERIA

All the general practitioners willing to participate in the study were considered in the inclusion criteria.

DATA COLLECTION AND ANALYSIS

The questionnaire was distributed via online google forms. The questionnaire comprised 3 parts which included as follows-

1. Part 1: sociodemographic details
2. Part 2: questions related to knowledge regarding teledentistry

3. Part 3: questions relating to assessing the awareness and attitudes regarding teledentistry.

The completed questionnaire was collected and subjected to statistical analysis in terms of frequencies (yes or no) with statistical package for social science (SPSS)

RESULTS

A total of 120 general practitioner dentists from all 9 specialties with professional experience from 0 to 25+ years were included in the study.

The majority of general practitioners (90%) had knowledge and awareness regarding teledentistry.

90% of general practitioner dentists think teledentistry helps to consult with an expert about a specific patient's problem.

86.7% knew that teledentistry is used for dental education and continuing education in dentistry.

85% of general practitioner dentists feel teledentistry is a good option rather than in-person examination during COVID-19.

81.7% of general practitioner dentists think t teledentistry is useful; in early diagnosis and easy consultation on oral diseases.

When dentists were asked about the practice of use of computers, the internet, and technologies for diagnosis and to provide advice about treatment over a distance, a high response of 88.3% is obtained.

93.3% of participants agreed that teledentistry lessens chair side time, money, and travel for the dentist and the patient.

The majority of respondents agreed that teledentistry is a good option for the dentist as it reduces personal contact and lessens the risk of contamination during COVID-19.

85 % of participants think that teledentistry can increase the accessibility of specialists to rural and underserved communities for the dental communities for dental needs.

High responses (88.1%) were obtained for the question: "can teledentistry be an addition to regular dental care?".

Regarding the question of whether teledentistry is useful in early diagnosis and easy consultation, the response was 81.7%.

Similarly, 67.8% of respondents agreed with the question: "do you think that teledentistry can be used to train dentists in primary dental care?".

Only a few respondents (45%) believed that teledentistry can violate patients' privacy.

66.1% of participants had a consultation with a patient using a smartphone and its camera.

When enquired about attending a lecture or course about teledentistry, only 30% of participants responded with 'yes'.

Similarly, only 21% of participants have hands-on training in using teledentistry. 65% of respondents think that in the future, teledentistry will be a standard method of oral health care delivery.

66.7% of general practitioner dentists have communicated with the patient during COVID-19 (pandemic) situation.

A high response of 91.7% was obtained for the question: "Will you practice teledentistry in the future?".

DISCUSSION

Teledentistry is 'not' a new specialty. It is, in reality, an alternative method to deliver the existing dental services. The utility of teledentistry in distant, remote areas cannot be emphasized enough. Its application is of utmost importance and great value in rural and urban areas where there is an unavailability of specialist consultation. Teledentistry has been developing since 1994 as a means to allow dental professionals to communicate with one long distance, allow collaboration by multiple practitioners, and involve the exchange of clinical information and images over remote distances for dental consultations and treatment planning. [9]

In the present study, the knowledge and awareness regarding teledentistry were assessed among general practitioner dentists. The majority of practitioners were aware of teledentistry but very few had attended a lecture or hands-on training in using teledentistry.

The majority of participant (86.7%) was aware of the fact that teledentistry can be used for dental health education. 93.3% of participants believed that teledentistry lessens chair time, money, and travel for the dentist and the patient. Similar results were seen in a study conducted by Bauer et al. (2001) [10]

The questions concerning the use of teledentistry to consult an expert about the patient's problem had been agreed upon by 90% of respondents. Similar results have been obtained in other studies regarding the same. [11,12]

Significant differences were found for the questions like, " do you think that teledentistry can be used to train dentists in primary dental care?" (67.8%).

A study aimed at discerning the willingness of patients to undergo online consultation it was found that the vast majority of patients (87%) were willing to recommend the use of digital, remote counselling instead of in-person appointments with their family and friends, while only 13% were not willing to recommend it.[13]

In the present study, it was found that 90% of general practitioner dentists knew teledentistry. Teledentistry is a new facet of overall patient care that is rapidly increasing in popularity and value, it will produce wonderful advantages for the patients who partake of the vast expertise available through teleconsultation, exchange of information will lead to improved patient care, and the ability to consult more efficiently with colleagues will lead to a greater understanding of the treatment objectives and better treatment outcomes.

Very few (45%) participants think teledentistry can violate patients' privacy, dentists who are engaged in teledentistry must ensure the security of their systems and transmitted data. User access logs, password protection, and data encryption can help in protecting patient confidentiality. A study conducted in Saudi Arabia showed that one-third of respondents think that teledentistry might violate patient privacy, and it was ranked by participants as one of the most significant barriers to teledentistry use.[14]

Other studies conducted showed that dentists with 11 to 15 years of experience showed the lowest score for excitement as they were resistant to the new technology not to lose their patient pool.[15]

In other studies conducted it was found that only 74% of dental practitioners feel that dental examinations via computers and intraoral cameras are as accurate as dental clinic exams.[16]

The study is limited in the aspect that it included only dentists practicing in south Bangalore who live in a metropolitan city and have good access to the internet and also that they cannot be used to extrapolate the results to other populations. The study also did not include dental students who are going to be the most influenced by changes such as teledentistry entering clinical dentistry.

Table 1: Sociodemographic characteristics

Sample characteristics	Frequency
Age (years)	
20-30	73.8%
30-40	23%
40-50	3.2%
Sex	
Male	65.6%
Females	34.4%

The above table gives the sociodemographic details of the participants of the study. With the help of this data, it was made possible to understand the differences in the adaptability of practitioners with different years of work experience.

Field of specialty	Frequency
General practitioner	377%
Oral and maxillofacial surgery	8.3%
Endodontics	14.8%
Oral Diagnosis/ Radiology	4.66%

Orthodontics	2.33%
Pediatric Dentistry	16%
Periodontology	2.33%
Restorative dentistry	4.66%
Prosthodontic	9.32%

The above table gives the distribution of the participants who participated in the study based on their specialty. This data gives insight into what practitioners of different specialties feel they can achieve through teledentistry and are more open to adapting it. For example, in a study conducted. It was seen that majority of participants selected community dentistry followed by oral medicine, dental hygiene, and orthodontics to be benefited from teledentistry. This reflects a narrower vision of limiting teledentistry to screening, diagnosis, or patient education.[1-6]

TABLE 3: Response to Knowledge, Awareness, And Attitude-Related Questions

Sl no.	Knowledge, awareness, and attitude-related questions	Yes (%)	No(%)
1	Do you know what teledentistry is?	90	10
2	Do you think teledentistry helps to consult with an expert about a specific patient's problem?	90	10
3	Do you know that teledentistry is used for dental health education and continuing in dentistry?	86.7	13.33
4	Do you think teledentistry is a good option rather than an in-person examination during COVID-19?	85	15
5	Do you think teledentistry is useful in early diagnosis and easy consultation on oral diseases?	81.7	18.33
6	Is teledentistry about the practice of the use of computers, the internet, and technologies to diagnose and provide advice about treatment over a distance?	88.33	11.66

7	Do you think that teledentistry lessens chair side time, money, and travel for a dentist and the patients?	93.33	6.66
8	Do you agree that teledentistry is a good option for the dentist as it reduces personal contact and lessens the risk of contamination during COVID-19?	93.33	6.66
9	Do you think that teledentistry can increase the accessibility to specialists in rural and underserved communities for their dental needs?	85	15
10	Can teledentistry be an addition to regular dental care?	88.1	11.66
11	Do you think that teledentistry can be used to train dentists in primary dental care?	67.8	32.5
12	Do you think that teledentistry can violate patients' privacy?	45	55
13	Have you ever had a consultation with a patient using a smartphone and its camera?	66.1	33.33
14	Have you attended a lecture or course about teledentistry?	30	70
15	Did you think that in the future, teledentistry will be a standard method of oral health care delivery?	21	79.1
16	Did you have hands-on training in using teledentistry?	65	35
17	Have you communicated with any patients during the COVID-19 situation?	66.7	33.33
18	Will you practice teledentistry in the future?	91.7	8.33

CONCLUSION

The results of the study indicated satisfactory knowledge, awareness, and attitudes regarding teledentistry among general dentists. The knowledge and awareness can be improved further by the continuation of dental education programs and awareness campaigns. Concerns such as adaptability to new technology and security risks need to be addressed. With all the technological developments taking place in the field of teledentistry, practitioners may eventually link up to virtual health clinics and an entirely new era of dentistry can be created.

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DR. AMAN PRASAD SAHA

1st year POSTGRADUATE STUDENT

Assessment and comparison of the stress pattern and displacement of mandibular dentition when subjected to force of varying vectors and magnitude in relation to center of resistance of mandibular dentition during en mass distalisation – a finite element study.

6. BRIEF RESUME OF THE INTENDED WORK

6.1 NEED FOR STUDY:

One of the most challenging malocclusion that poses skeletal problems, and requires dentoalveolar compensation or camouflage treatment is Class III malocclusion.[1] Dental Class III malocclusion, characterized by an reverse overjet, presents significant challenges and functional issues such as tooth wear, speech difficulties, jaw pain, and sleep disorders. The treatment of Class III malocclusion involves various approaches, including orthodontic appliances, surgery, or a combination thereof. A recent finding is that using implants to anchor teeth can help correct many types of malocclusion in adults. This has led to expansion of envelop of discrepancy for camouflage line of treatment using Temporary anchorage devices (TADs).[2]

One of the oldest and well accepted line of treatment for camouflage of class III malocclusion has been the extraction of mandibular 1st premolar for retraction of lower incisors using molars as anchorage for correction of reverse overjet. With advent of bonescrew implants several researchers have shown the non-extraction line of camouflaging of reverse overjet by en-masse distalization of mandibular dentition using buccal shelf screws in class III malocclusions.[3]

Distalization emerges as a pivotal technique for treating malocclusion, providing benefits such as creating space and avoiding extraction. Understanding the relationship between force application, center of resistance, and occlusal plane changes is crucial for predicting successful tooth movement.[4]

Microimplants have shown efficacy in distal en-masse movement, overcoming previous challenges in moving mandibular dentitions. Whole arch distalization without anchorage loss is achievable with careful use of temporary skeletal anchorage devices (TSADs). The concept involves applying a distalizing force to the anterior segment, transmitted along the archwire and proximal contact points, leading to distalization of molars and incisors.[2] In mandible, buccal shelf (MBS) area has found to be with sufficient bone and adequate bone quality for insertion of buccal shelf screw which can be used for anchorage purpose to treat the class III malocclusion via distalization of mandibular teeth.[5]

In orthodontics the biomechanical aspects of the treatment require attention, as there is a relationship between stress and strain and the forces applied. Therefore, it is important to comprehend the nature and impact of the forces.[6] Knowing the exact spot of the CRes is crucial for forecasting how the teeth will move and ensuring that they are shifted effectively during therapy. A study by Jo AR et al showed that the position of the center of resistance of the complete mandibular dentition group was 13.5 mm apical and 25.0 mm posterior to the incisal edge of the mandibular central incisors.[7] The finite element method was introduced in orthodontics as a valuable tool for describing force systems, analyzing structural stress, and predicting displacement patterns. It has also been used to evaluate the risk of adverse events during technical procedures and to simulate different loading systems.[8]

A few studies have been conducted to evaluate the feasibility of moving the entire arch and compare displacement patterns and stress distribution in the mandibular dentition based on retraction hooks of different lengths.[1] However no studies have been conducted to determine the stress pattern and displacement by varying the retraction hook placement and vertical positioning.

Hence the aim of this study will be to assess and compare the stress pattern and displacement of mandibular dentition when subjected to varying force vectors and force values in relation to center of resistance of mandibular dentition during en-masse distalization using finite element analysis.

PROBLEM STATEMENT:

The technique of en-masse distalization in mandible, which involves moving the mandibular teeth backward, offers an effective approach for treating Class III malocclusion.[9] However, this method may introduce stress patterns along the periodontal ligament which leads to displacement of lower dentition in posterior direction.[10] The effect of the distalization force vector on the entire mandibular dentition and the mandibular occlusal plane has not been extensively studied. Hence the relationship between the distalization force vector and the center of resistance of mandibular dentition needs to be studied for optimal control of rotation of mandibular occlusal plane due to relative extrusion or intrusion of incisors and molars when the force vector varies with respect to center of resistance of dentition.[11] Clinical understanding of these force vectors and the stress pattern induced in periodontal ligaments clinically pose a challenge to a researchers. Hence finite element analysis (FEA) serves as an effective approach to simulate the biomechanical response of teeth and appliances under various loading conditions.[8]

Insufficient literature exists regarding the precise position and length of the retraction hook for en-masse distalization in class III malocclusion, coupled with the optimal force needed for efficient tooth movement and stress management. This study aims to aid clinicians in determining the exact position and length of the retraction hook for mandibular en-masse distalization, facilitating optimum tooth movement.

NULL HYPOTHESIS (H_0):

There is no significant impact of variation in distalization force vector and magnitude on the stress distribution pattern and displacement in mandibular dentition during en-masse distalization.

RESEARCH QUESTION:

Does the variation in distalization force vector and magnitude in with respect to center of resistance of mandibular dentition impact the stress distribution pattern and displacement of mandibular dentition during en-masse mandibular distalization?

RESEARCH HYPOTHESIS (H_1):

There is a significant impact of variation in distalization force vector and magnitude on the stress distribution pattern and displacement in mandibular dentition during en-masse distalization.

6.3 OBJECTIVE OF STUDY:

Primary Objective:

- To assess and compare the effects of different point of force application on the stress pattern in mandibular dentition during en-masse distalization.
- To assess and compare the effects resulting from variation of distalization force vector on the displacement pattern of mandibular dentition.

Secondary Objective:

- To determine the appropriate orthodontic force magnitude needed for en-masse distalization of the mandible, to fulfill the secondary objective of the study.

7. MATERIALS AND METHODS:

7.1 STUDY DESIGN:

A Finite Element Analysis (FEA) study design.

7.2 METHODOLOGY:

PROCEDURE :

The following steps will be followed:

1. **Construction of geometric model and conversion into finite element model:**

   A geometric model of the entire mandibular arch excluding 3rd molar will be created through computed tomography scan and converted into 3D step file format through a reverse engineering technique (ANSYS software version 14).

2. **Defining the nodes and mesh:** Finite element model will be created by meshing the assembled model into nodes and elements.

3. **Material property:**

   The teeth will be modified with proper crown to root ratio and leveled. The PDLs, brackets, archwire, retraction hooks, and buccal shelf screw will be assembled into the biological models.[1] The PDL will be modeled with a consistent thickness of 0.2 mm, as suggested by previous FEM studies. The gingival soft tissue will have an average thickness of 1 mm to determine the position of the miniscrew head. The brackets will have a slot of 0.022x0.028 inches and will be placed in the center of the clinical crown of each tooth. The main archwire will be a 0.019x0.025-inch SS wire, attached to all the brackets.[1] The model will have retraction hooks modeled with a 0.036-inch SS wire and placed in three different locations, 1. Mesial to the lower canine, 2. Distal to the canine, 3. Between the two premolars, at 4 different heights (The hooks will be 0, 3, 5, & 7 mm from the archwire). The position of the center of resistance of the complete mandibular dentition group will be modeled at 13.5 mm apical and 25.0 mm posterior to the incisal edge of the mandibular central incisors.[7] A buccal shelf screw will be modelled as a titanium alloy bonescrew (1.6mm diameter, 8mm long, 0.2mm thread ridge, and 0.6mm thread pitch with an elastic modulus of 110 (GPa) and Poisson's ratio of 0.34, and placed at the mandibular buccal shelf (MBS) on the buccal bone lateral to the distal root of the second molar about 4 mm buccal to the cemento-enamel junction (CEJ).[1]

Figure : Variation of force vector by altering the retraction hook lengths & positions

The material properties, including Young's modulus and Poisson's ratio, were based on previous FEM studies (Table 1).[1]

Material	Young's modulus (MPa)	Poisson's ratio
Alveolar bone	2.0E+03	0.30
Teeth	2.0E+04	0.30
Bracket	2.0E+05	0.30
Stainless steel wire	2.0E+05	0.30
Titanium miniscrew	110,000	0.34

Table 1: Material properties required by the finite element model.[1]

4. Data representation:

x-axis: labio-lingual direction of the anterior teeth and mesio-distal direction of posterior teeth [1]

y-axis: inciso-gingival direction of all teeth [1]

z-axis: mesio-distal direction of anterior teeth and the bucco-lingual direction of posterior teeth (Figure 1).[1]

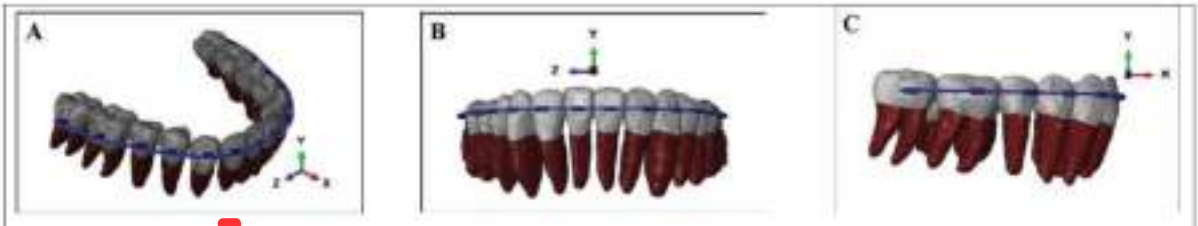

Figure 1: The orientation of the model: (A) overall, (B) frontal and (C) lateral views.[1]

5. **Defining the boundary condition**: The boundary condition, in the finite element model will be defined at all the peripheral nodes of the bone with the degree of movement in all directions.
6. **Loading configuration:** To simulate the distalization of the entire lower dentition, a single force vector (200 g) [2,15] from the retraction hook to the miniscrew for all the different hook lengths and positions will be applied. The patterns of stress distribution in the PDL and the movement of the teeth based on the color of graphic outputs will be evaluated and compared.[1]

   The force magnitude will then be varied between 150-200g to test for the most optimum value needed for en-masse distalization of the mandibular dentition.
7. **Solving the system of linear algebraic equation:** The sequential application of the above steps will leads to a system of simultaneous algebraic equations where the nodal displacements are the unknown.
8. **Interpretation of the results:** With the above steps the problem loaded to the FEM model will be solve and the results are interpreted as principal stress which is presented in results and described in discussion.

7.2 Does the study require any investigation or interventions to be conducted on patients or other humans or animals? If so, please describe briefly:

- No.

7.3: Has ethical clearance been obtained from your institution in case of 7.2

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Running title - ENDODONTIC MANAGEMENT OF FUSED MANDIBULAR FIRST PREMOLAR

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TITLE : A RARE CASE OF NON-INVASIVE ENDODONTIC MANAGEMENT OF FUSED MANDIBULAR PREMOLAR USING CONE BEAM COMPUTERISED TOMOGRAPHY - A CASE REPORT

ABSTRACT

Fusion is a rare developmental anomaly which is described as the union of two normally separated tooth germs. It can be either complete or partial ,or may have separate or fused canals depending on the developmental stage of the teeth when the union occurs, and is uncommon in the permanent posterior dentition. Endodontic treatment of fused teeth present diagnostic and technical challenges and requires special care and careful management because of their abnormal anatomy. This paper reports a case of fusion between mandibular left second premolar and supernumerary tooth and describes the endodontic and restorative management applied.

Key-words: Endodontic therapy; Fusion; Mandibular first premolar; Supernumerary tooth

INTRODUCTION

The morphological and anatomical changes in teeth can be classified in terms of shape, size, union, number, structure and colour. Gemination and fusion are the two irregularities in tooth development with close similarity but inherited by different aetiology.[1] The fusion of teeth occurs through the union of two normally separated tooth germs. Depending upon the stage of development of the teeth at the time of union, fusion can be either complete or incomplete. If this contact occurs early, before calcification begins, the two teeth will be completely united to make one large tooth. If the contact of teeth occurs later, when some of the tooth crown has completed its formation, there will be the union of the roots only. The dentin is always continuous in cases of true fusion. The fused tooth may have separate or fused canals.[2] Gemination occurs when one tooth bud attempts to divide leading to two completely or incompletely separated crowns with one root or passage. Developmental dental anomalies can be congenital or inherited, acquired or idiopathic. The terms "double tooth", "double formations", joined teeth", or "fused teeth" are used to describe fusion and gemination.[3]

The aetiology of developmental anomalies like fusion remains unknown; however, the effect of pressure or physical forces producing close contact between two developing tooth germs has been reported as a possible cause. Other contributing factors include genetic predisposition and racial differences.[4] The fusion has a higher incidence in deciduous dentition (0.5%–2.5%) than in permanent dentition (0.1%–1.0%). Fused teeth are found predominantly within the anterior region, in which frequently affected are incisors and canines and they are more often in the mandible.[5] These anomalies may be bilateral or unilateral.

Supernumerary teeth are defined as those in addition to the regular series of deciduous or permanent dentition and are the main reason for dental anomalies. Supernumerary teeth may be single or multiple, unilateral or bilateral, and in one or both jaws.[6,7]

In clinical situations, fusion is a union of two teeth, with separated tooth buds leading to the formation of a joined tooth with the confluence of dentine, on the other hand, gemination has a bifid crown and a common root and root canal.[8]

This paper reports a rare case of endodontic and restorative management of fused mandibular first premolar.

CASE REPORT

A 53-year-old male patient reported to the Department of Conservative Dentistry and Endodontics with a chief complaint of continuous pain in the left mandibular posterior region. There was no history of any hereditary conditions or any trauma. The patient's medical history revealed well-controlled type II diabetes mellitus, hypertension and no history of drug allergy.

Intraoral examination revealed mandibular left first premolar with a broad crown and distinct developmental occluso-gingival groove between the affected premolar and supernumerary tooth [Figure1(a,b)]. The probing depth was within the normal limits and there was a mild Grade I mobility and mild gingivitis in the lower anterior region. Despite the presence of the grooves, there was no discernable separation between the two teeth. The affected tooth had deep bucco-cervical caries. A well-localized swelling was noticed on the buccal mucosa with respect to the involved tooth. There is a history of extraction of 31.

Preoperative radiographs revealed a union between the mandibular left first premolar and supernumerary tooth and the presence of coronal caries involving the pulp and widening of PDL space of 34. The mesiodistal width of the fused tooth was wide and two root canals were present [Figure 2(a,b)]. The CBCT gave a three-dimensional view of fused teeth, as well as all the root canals in transverse, axial, and sagittal sections. [Figure 8]

The occurrence of fusion was only unilateral. Mild tenderness on percussion was observed.

The fused teeth were not responding to heat, cold, or electrical pulp testing. Based on clinical and radiographic examinations, a diagnosis of chronic periapical periodontitis was established and treatment consisted of endodontic therapy followed by reconstruction of hard tissue by restorative treatment.

Figure 1(a,b): Clinical view of the fused teeth #34 before treatment.

Figure 2(a,b): Radiograph showing teeth with separated pulp chamber and two root canals

After establishing the treatment plan, the patient signed an informed consent. The tooth was anaesthetized, and an access cavity was prepared under rubber dam isolation. The coronal portion of the root canals was enlarged using Gates-Glidden drills no.1-4(Mani Inc.). The access preparations became a single cavity after coronal enlargement [Figure 3]. The working length was determined using an electronic apex locator (Propex; Dentsply Maillefer) and confirmed radiographically [Figure 4]. Cleaning and shaping of the root canal system was completed by the ProTaper rotary system (Dentsply Maillefer, Switzerland). Canals were copiously irrigated with 2.5% sodium hypochlorite, followed by normal saline. The canals were dried, calcium hydroxide was placed for 1 week with lentulospiral (Mani Inc., Japan) and the access cavity was temporized with Cavit G (3M ESPE, Germany). After a week, the tooth was asymptomatic, root canal was obturated by using single cone technique and bioceramic sealer was placed (septodont) [Figure 5,6]. The access cavity was then sealed with resin composite (Z250, Dentsply) [Figure 7].

Figure 3; Access opening done on 34

Figure 4: Working length determination

Figure 5: Master cone confirmation

Figure 6; Postobturation radiograph

Figure 7: Clinical view of resin composite restoration

Figure 8; Cone-beam computerized tomography (CBCT) of the fusion tooth. (a) unilateral fusion of the left lower premolar and supernumerary tooth. (b) An ill-defined radiolucency about 3.57mm x 3.82mm x 3.25mm (supero-inferior x antero-posterior x medio-lateral) was noted along apical one-third of #34 (c) Two separate coronal pulp chambers of the fusion tooth. (d) Fusion of pulp mesial and distal roots at apical one-third region.

DISCUSSION

Management of a deformed tooth, such as fusion is often a challenge to the dentist. Studies show fusion is thought to affect 0.5%-2.5% of the primary dentition and affects permanent teeth with an even lower frequency. Fusion can occur between two teeth, between normal and supernumerary teeth, or between a tooth and an unerupted crown (9). Many a times fusion is often confused with the process of gemination, especially when a supernumerary tooth fuses with a permanent tooth.

According to Mader, the "two-tooth rule" may be helpful in differentiating fusion from gemination. If fused teeth are counted as one and the number of teeth in the dental arch is less than normal, then it may be considered as fusion. However, when the anomalous tooth is counted as one and the number of teeth in the dental arch is normal, then it can be either gemination or fusion between a normal and a supernumerary tooth (10).

The characteristics of double tooth have been explained in Table:1

Table :1 Depicts the differences in characteristics of fusion and gemination

Characteristics	Fusion between two normal set of teeth	Fusion between normal tooth and supernumerary tooth	Gemination
Common location	Anterior mandible	Anterior maxilla	Anterior maxilla
Dentition	Adjacent tooth is missing	Normal complement of teeth	Normal complement of teeth
Quadrant involved	Unilateral	Unilateral	Unilateral
Clinical appearance	Unsymmetrical, crooked	Unsymmetrical, crooked	Symmetrical halves, Bifid crown
Radiographic appearance	Mostly two pulp chambers and root canals	Variable	Single root with one canal
Joined tissues	Enamel, dentin and cementum	Enamel, dentin and cementum	Enamel ,dentin, cementum and pulp

CBCT scans and an operative microscope can be valuable in diagnosing fusion by providing detailed 3D images of tooth structure and root canal localization in cases of complex and varied morphology. In the present case, CBCT enables three-dimensional image reconstruction and provides a more detailed view of the complex root canal system morphology.[11]

Alteration in tooth shape can result in changes in dental and periodontal anatomy, and these changes contribute to plaque retention, a higher risk of caries formation, and associated periodontal problems. The treatment approach for fused teeth varies based on the involvement of deciduous or permanent tooth. The deciduous teeth may require no treatment. In case of permanent tooth waiting until late adolescence for aesthetic considerations and opting for non-surgical root canal therapy in cases of common pulp chambers with independent root canals are indeed reasonable approaches. When the affected tooth is supernumerary, it is best to remove it. When the affected teeth have a common pulp chamber with independent root canals, it is better to adopt more conservative approaches. So, non-surgical root canal therapy is preferred(12,13).

On the basis of the clinical appearance, presence of groove on occluso-cervical direction, and radiographic and CBCT findings the diagnosis was confirmed as a fusion of a mandibular permanent left first premolar with supernumerary teeth presenting with two roots and two canals. Successful endodontic management of a fused mandibular second premolar with a supernumerary tooth that has a bizarre anatomy needs deliberation and clinician should be cautious of every detail of the tooth morphology in order to improve the success rate. Indeed, a collaborative multispecialty approach, where dentists with various specialities work together, is beneficial for achieving successful outcomes in complex treatment plans.

CONCLUSION

Fusion is a developmental anomaly that is often confused with gemination, but confirmed by proper clinical and radiographic examination. Since it is a developmental disturbance which can be encountered by the dentist in the clinics, complete and thorough knowledge of etiology, pathogenesis, and numerous treatment modalities available will contribute to the success of esthetic rehabilitation of the patient.

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CONFLICT OF INTEREST STATEMENT

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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FIGURE LEGENDS

Figure 1(a,b): Clinical view of the fused teeth #34 before treatment.

Figure 2(a,b): Radiograph showing teeth with separated pulp chamber and two root canals.

Figure 3: Access opening done on 34

Figure 4: Working length determination

Figure 5: Master cone confirmation

Figure 6 : Post obturation radiograph

Figure 7: Clinical view of resin composite restoration

Figure 8: Cone-beam computerized tomography (CBCT) of fused tooth.

(a) unilateral fusion of the left lower first premolar and supernumerary tooth.

(b) An ill-defined radiolucency about 3.57mm x 3.82mm x 3.25mm (supero-inferior x antero-posterior x medio-lateral) noted along apical one-third of #34

(c) Two separate coronal pulp chambers of the fused tooth.

(d) Fusion of pulp mesial and distal roots at apical one-third region.

TABLE LEGEND

Table :1 Depicts the differences in characteristics of fusion and gemination

Characteristics	Fusion between two normal set of teeth	Fusion between normal tooth and supernumerary tooth	Gemination
Common location	Anterior mandible	Anterior maxilla	Anterior maxilla
Dentition	Adjacent tooth is missing	Normal complement of teeth	Normal complement of teeth
Quadrant involved	Unilateral	Unilateral	Unilateral
Clinical appearance	Unsymmetrical, crooked	Unsymmetrical, crooked	Symmetrical halves, Bifid crown
Radiographic appearance	Mostly two pulp chambers and root canals	Two distinct roots	Single root with one canal
Joined tissues	Enamel, dentin and cementum	Enamel, dentin and cementum	Enamel ,dentin, cementum and pulp

Report- Dr.Ambili C

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Report- Dr.Deepak

by Dr. Deepak

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RAJIV GANDHI UNIVERSITY OF HEALTH SCIENCES, KARANATAKA

DR. DEEPAK K JAYAPRAKASHAN

I MDS

"DEVELOPING AND VALIDATING AN ARTIFICIAL INTELLIGENCE ALGORITHM FOR PREDICTION OF IMPLANT SIZES TO BE USED IN MANDIBLE USING CONE BEAM COMPUTED TOMOGRAPHY IMAGES - AN ARTIFICIAL INTELLIGENCE STUDY"

6.1 NEED OF THE STUDY :

- A dental implant is a sophisticated and highly effective dental prosthesis that is a viable substitute for a missing natural tooth. The dental implant is meticulously engineered to replicate a genuine tooth root's anatomical structure and physiological capabilities, thereby furnishing a robust and steadfast base for a prosthetic tooth.

- The primary goal of dental implants is to provide stable and long-lasting support for artificial teeth. If the implant is too small for the available bone it may not provide sufficient stability leading to potential failure.

- On the other hand, an implant that is too large may cause damage to surrounding structures or compromise the implant's stability.

- Implant size determination manually involves measuring bone width and length using CBCT scans. Disadvantages include potential human error, limited accuracy and the risk of miscalculations leading to improper implant selection, compromising stability, osseointegration and overall success of the dental implant procedure.

- To overcome these problems newer artificial intelligence (AI) technologies such as convolutional neural network may be applied. AI has the potential to complement CBCT by enhancing the prediction of dental implant systems and sizes.

- While CBCT provides detailed imaging, AI algorithms can analyse vast datasets improving accuracy, speed and customization. AI's ability to learn from diverse cases

enhances predictions, contributing to more precise implant planning compared to CBCT alone.

6.3 OBJECTIVES OF THE STUDY :

Primary Objective

To generate an algorithm for predicting implant sizes to be placed in mandible after assessing the available bone width and height using CBCT Dicom images.

Secondary Objective

To test and validate the algorithm for predicting which implant size to be used in the mandible after assessing bone height and width with the help of CBCT images

7. MATERIALS AND METHODS:

7.1 SOURCE OF DATA:

- CBCT images of subjects reporting to Department of Oral Medicine and Radiology, Dayananda Sagar College of Dental Sciences (DSCDS), Bengaluru will be taken for diagnosis and treatment planning of implant placement.
- CBCT images of subjects will be collected from ORAL-D Diagnostic center and other CBCT Centers across Bengaluru city.

7.2 METHOD OF COLLECTION OF DATA:

- **PERMISSION**: Permission will be taken from Department of Oral and Maxillofacial Surgery and from the institutional review board of Dayananda Sagar College of Dental Sciences to conduct study.

- **SAMPLE SIZE DETERMINATION**: The sample size for training in order to derive an AI algorithm will be calculated using data based on the study by Sevda Kurt Bayrakdar, Kaan Orhan, Ibrahim Bayrakdar, Elif Bilgir, Matvey Ezhov, Maxim Gusarev and Eugene Shumilov.

  The details are given below.

  Prevalence (p): 75%

  q(1-p): 25%

  Allowable error: 5%

  $N = \frac{z2\ (\alpha/2)pq}{L2}$

  N= Sample size

  Z= 78.4

  α= 0.05

  p= Prevalence = 75%

  q = (1-p) = 25%

  L= 5% of p = 5% of 75% = 3.75

  Zα/2= 1.96

  $N = \frac{(1.96)2 \times 75 \times 25}{(3.75)2}$

  N = 512

- **SAMPLING METHOD**: Convenience sampling.
- **STUDY DESIGN**: Diagnostic Accuracy Design
- **STUDY DURATION**: 18 Months

CRITERIA FOR CASE SELECTION

INCLUSION CRITERIA:

- CBCT images of subjects between the age range of 18 and 65 years
- CBCT images of subjects with edentulous area in mandible.

EXCLUSION CRITERIA:

- Subjects unfit for dental implant placement such as patients with existing medical conditions and/or bone disorders.

STUDY METHOD

Materials required:

- CBCT DICOM images from the Department of Oral Medicine and Radiology, DSCDS, Bengaluru &
- CBCT DICOM images obtained from CBCT Centers across Bangalore City.
- A Convolutional Deep Neural Network algorithm.
- Standard Implant Dimensions from Nobel Biocare, Straumann, NORIS Health Implant System & Osstem.

Study group:

CBCT images of subjects reporting to Department of Oral Medicine and Radiology, DSCDS, Bengaluru with edentulous tooth region(s) in the mandible & CBCT Centers across Bangalore city.

CONE BEAM COMPUTED TOMOGRAPHY IMAGES:

- For the purpose of standardization, CBCT images taken from ORAL-D & Department of Oral Medicine and Radiology ,Dayananda Sagar college of Dental Sciences with standardized exposure parameter having good contrast and density and showing Mandibular canal, Mental foramen and Bone height and width in the edentulous areas clearly will be considered.
- Images of predicted implant placement on CBCT by manual method will also be acquired.
- CBCT images will be acquired in JPG format and transferred to a personal computer for further image analysis and comparison will be with AI generated implant placement planning using the selected implant systems namely, Straumman, Nobel-BioCare, Noris & Osstem.

DATA TO BE FED TO DEEP NEURAL NETWORK FOR TRAINING AND GENERATION THE ALGORITHM:

- *Standard distance between implant and adjacent teeth:* 1.5mm
- *Standard distance between two implants:* 3mm
- *Standard distance of the implant from mandibular canal and mental foramen*: 2-3mm

CALIBRATION OF THE EXAMINERS:

One trained examiner will identify the implant site measurements and do the tracing in CBCT scans. The examiner would undergo a training and calibration session to match the benchmark.

Inter observer co-relation:

• Around 20 CBCT scans would be randomly picked up from the Data base used for the study. Implant site bone measurements would be done by the examiner and the guide separately without one discussing with other. Then the data will be compared and subjected to appropriate co-relation test [kappa statistics, intra class coefficient test].

• A co-relation co-efficient value of 0.8 or more is considered as acceptable value, indicating a high degree of concordance between the examiner and the benchmark suggesting calibration of examiner.

Intra observer co-relation:

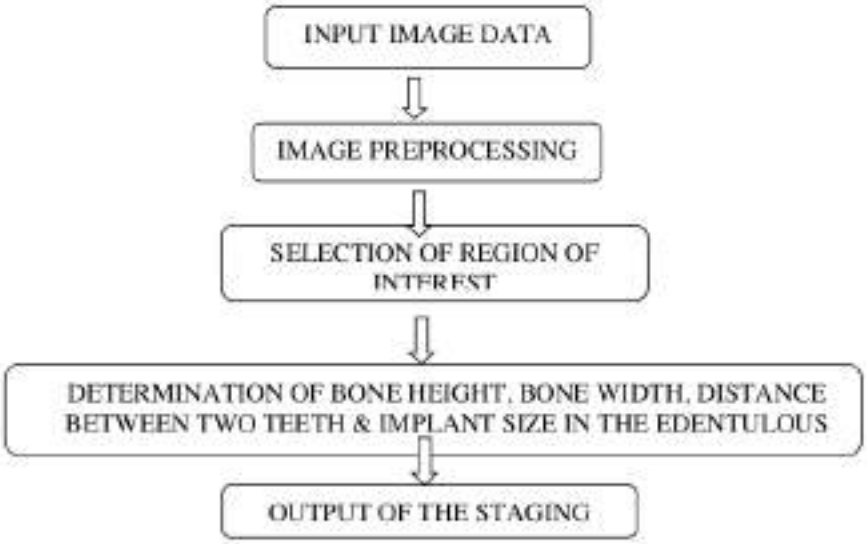
• Around 10 CBCT scans would be randomly picked out of 20 CBCT scans that are earlier used for calibration of examiner. After a week the examiner will do repeat assessment and data so obtained would be subjected to appropriate co-relation statistics and if co-relation co-efficient value is 0.8 or more than that it refers to high degree of internal reliability suggesting intra-examiner calibration. The calibration session will continue until a high co-relation co-efficient (0.8 = > 0.8) is attained.

ANALYSIS OF IMAGE:

- For determination of bone height and width available for implant placement from CBCT, images are evaluated as follows:
- Identification of mandibular canal and mental foramen and the height of bone available to place implants will be performed. Different Implant sizes of the brands Noeris, Straumann, Nobel biocare, Osstem will be fed to the algorithm.
- These measured data will be given as input to train the Artificial Intelligence Algorithms, and the predicted type of implant size to be placed will be obtained as a result of these algorithms .

GENERATION OF AI ALGORITHM:

- The 512 labelled CBCT images for generating Algorithm will be provided in order to construct AI algorithm and obtain Deep Learning AI software.
- Among the 512 labelled CBCT images, some images will be randomly picked and Reproducibility test will be conducted to validate the constructed Deep Learning AI Algorithm.
- The work flow of proposed algorithm is as follows:



ALGORITHM VALIDATION:

The new set of unlabeled CBCT images which are not used for the generation of the AI algorithm will be used to test and validate the accuracy of the derived AI Algorithm.

CONFUSION MATRIX:

The confusion matrix will be generated from the computer system automatically. Sensitivity, specificity, precision, recall, F1 score (Dice Coefficient) and accuracy will be analyzed using this confusion matrix. If any other relevant test is found appropriate during the time of data analysis will be dealt accordingly.

- **STATISTICAL ANALYSIS:**

  Data will be entered in the excel spread sheet. Statistical Package for Social Sciences [SPSS] for Windows Version 22.0 Released 2013. Armonk, NY: IBM Corp., will be used to perform statistical analyses.

- **Descriptive Statistics:** All categorical variables will be presented in the form of frequency tables along with percentages. The quantitative variables will be described using Mean± SD/ Median (IQR) based on the verification of normality assumption. The estimates like Mean/ Proportion/ Difference in means/ Difference in proportions will also be expressed with 95% Confidence Interval. Wherever necessary the data will be presented graphically, wherever necessary.

- **Inferential Statistics:** Paired t-test will be applied following normality assumptions. If not, a non – parametric Wilcoxin Signed Rank test will be applied. The reliability statistics in terms of sensitivity, specificity, positive predictive value, negative predictive value and accuracy will be computed. The results will be considered statistically significant whenever $P \leq 0.05$

Report- Dr.Deepak

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Report- Dr.Divya Kantharaju

by Dr. Divya Kantharaju

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Comparative Assesment Of Injectable Platelet Rich Fibrin And Xenograft (Sticky Bone) With Advanced Platelet- Rich Fibrin Plus For The Treatment Of Horizontal Bone Defect I Periodontitis By Assessing Gingival Thickness And Bone Fill. A Randomized Controlled Clinical Trial

Need for the study:

Periodontitis is a chronic inflammatory disease that causes destruction of tooth apparatus attachment. In addition to decreasing bone height, periodontal disease modifies the morphologic characteristics of bone and causes several patterns of bone loss, with horizontal bone loss being the most frequent detrimental pattern.

As per the literature, the horizontal bone loss with a prevalence of 92.2% has received only 3.7% treatment modalities .Several treatment modalities have been attempted through the years including various bone grafts, combination of membrane and graft materials, use of enamel matrix protein and recombinant human bone morphogenic protein. Horizontal bone loss typically continues with soft tissue loss , making grafting challenging at the site.

The regenerative approach in dentistry frequently employs platelet concentrates (PCs) that are "autologous in origin" and have a high concentration of platelets, growth factors, and leukocytes

As third-generation PC, based on the low-speed centrifugation concept (LSCC) such as advanced-PRF (A-PRF), advanced-PRF+ (A-PRF+), injectable-PRF (i PRF), and titanium-PRF (TPRF) were introduced where in by reducing the relevant centrifugation force (RCF) for advances in PRF matrices with an enhanced number of inflammatory cells and platelets. Thereby, histological analysis of APRF(1500rpm) observed a significantly higher numbers of neutrophilic granulocytes, a leukocyte subfamily, compared to that of PRF .The formulation of the A-PRF+ preparation is further enhanced by lowering the centrifugation speed (1300rpm) with a centrifugation time of eight minutes. A-PRF+ represents a more effective and faster regeneration and helps in the development of hard and soft tissue healing as well as pain alleviation. Injectable PRF (i PRF) is prepared with centrifugal speed of 3300 rpm for two minutes and also being considered as a potential regenerative agent for improving the handling qualities of bone grafts in periodontal defects ,there by Sticky bone accelerates tissue healing and minimizes bone loss during healing period.

Intra-marrow penetration (IMP) or decortication is the intentional drilling of holes (1-1.5

mm) traversing from the cortical bone directly inside of the cancellous bone, which aids in cytokines and growth factors which further attract progenitor cells, enhancing revascularization and new bone regeneration.

Cone Beam Computed Tomography (CBCT) produces three dimensional anatomical images and also has the ability to collect and generate data at higher resolutions with relatively low radiation dose. CBCT in periodontology has been used in assessment of periodontal defect measurements, furcation involvement and evaluation of outcomes succeeding regenerative surgery. It has also been applied for visualizing and precisely measuring soft tissues of the periodontium .

Hence an attempt is made to evaluate and compare sticky bone (i PRF + xenograft) with APRF+ in the treatment of horizontal bone defects in periodontitis by assessing gingival thickness and the bone fill using CBCT.

Problem statement:

Periodontal disease alters the morphologic features of bone, where in, it was observed that vertical bone loss with a prevalence of 7.8% has received 96.8% treatment options whereas horizontal bone loss, with an overwhelming prevalence of 92.2%, received only 3.2% treatment modalities.

As a human autologous product, A-PRF+ has the potential to improve periodontal repair and is effective in treating intra bony periodontal defects. as well as sticky bone, may function as a framework or protective membrane, both externally and internally, to the periosteum and the alveolar bone, further, it minimizes the micro and macro motility of the grafted bone, enabling favourable bone augmentation throughout the healing period without the use of a GBR membranes.

Thus, an attempt is made to compare sticky bone (i PRF + xenograft) with APRF+ in the treatment of horizontal bone defects in periodontitis by assessing gingival thickness and the bone fill by using CBCT.

Research Question:

Is A PRF+ more effective in improving gingival thickness and bone fill in horizontal bone

defects associated with periodontitis when compared with sticky bone (i PRF + xenograft) ?

Null Hypothesis (H_0):

The use of APRF+ may not be effective in improving gingival thickness and the bone fill in horizontal bone defect associated with periodontitis when compared with sticky bone (i PRF+ xenograft) .

Research Hypothesis (H_1): -

The use of APRF+ may be effective in improving gingival thickness and bone fill in horizontal bone defect associated with periodontitis when compared with sticky bone (i PRF+ xenograft) .

Objectives of the study:

1. To asses Gingival thickness and the bone fill using Open Flap Debridement (OFD) plus APRF+ and intra marrow bone penetration in horizontal bone defects associated with periodontitis by using Cone Beam Computed Tomography

2. To asses Gingival thickness and the bone fill using Open Flap Debridement (OFD) plus sticky bone (i PRF+ xenograft) and intra marrow bone penetration in horizontal bone defects associated with periodontitis by using Cone Beam Computed Tomography.

3. To asses Gingival thickness and the bone fill by Open Flap Debridement (OFD) and intra marrow bone penetration in horizontal bone defects associated with periodontitis by using Cone Beam Computed Tomography.

4. To compare Gingival thickness and bone fill between Open Flap Debridement plus APRF+ and intra marrow bone penetration , Open Flap Debridement plus sticky bone (i PRF+ xenograft) and intra marrow bone penetration and Open Flap Debridement plus intra marrow bone penetration in horizontal bone defects associated with periodontitis by using Cone Beam Computed Tomography.

6. MATERIALS AND METHODS:

6.1 Source of data:

Subjects reporting to the Department of Periodontology, Dayananda Sagar College of Dental Sciences and Hospital, Bengaluru

Method of collection of data:

A brief case history will be recorded and an informed consent will be obtained from all the subjects

Study design: Randomized Comparative Parallel Open Study Design

Sample size determination

Analysis: A priori: Compute required sample size

Input:

Effect size f = 0.6 α err prob = 0.05

Power (1-β err prob) = 0.8

Numerator df = 10

Number of groups= 3 Number of covariates= 1

Output:

Noncentrality parameter λ = 19.4400000

Critical F = 2.0261430

Denominator df = 50

Total sample size = 54

Actual power = 0.8028330

2
The sample size has been estimated using the G Power software v. 3.1

3
Considering the effect size to be measured (f) at 60% power of the study at 80% and the margin of the error at 5%, the total sample size needed is 54. Anticipating 10% attrition during the follow up periods, the sample size is increased to 60 , So, each group will consist of 20 samples.

Criteria for Case Selection:

Inclusion criteria:

1. Periodontitis – stage 2 or 3 (As per AAP 2017 classification)
2. Probing pocket depth 6 to 8 mm
3. Sites with horizontal bone defects as seen in digital radiographs

Exclusion criteria:

1. Patients with history of any drug allergy
2. Patient with systemic diseases
3. Pregnant and lactating mothers
4. Smokers ,alcoholics and drug abusers
5. Patients who received periodontal therapy 6 months prior to study

Method of preparation of Sticky bone:

Preparation of i-PRF

A 10 ml Blood sample will be taken from the patients forearm and collected in a non silica coated yellow cap tube of 10 mL i-PRF is prepared by spinning at 3300 rpm for two minutes[2] of centrifugation. The tube obtained after completion of centrifugation shows two different layers with superficial layer being clear liquid PRF and bottom layer being RBCs. The clear fluid is extracted using syringe and then mixed with xenograft which is allowed to rest for five to ten minutes for polymerization in order to produce sticky bone. The advantage of using sticky bone is that the graft becomes embedded in the matrix of PRF, that itself will stabilize the bone graft. It can be molded or cut into desired shape and can be packed easily to the defect site.

Preparation of A- PRF+

A 10 mL of blood sample will be taken from the patients forearm and collected in a glass

tubes with red cap. A-PRF + is prepared by spinning at 1300 rpm for 8 minutes . Once the centrifugation is completed, translucent white fluid filled with a clot in the center and the remnants of the blood in the bottom of the test tube will be visible.

Intra-marrow penetration

Intra-marrow penetration will be performed interdentally on the cortical defect bone with micromotor handpiece and a round surgical bur of 1mm diameter with copious irrigation of water until the cancellous bone is exposed.

Report- Dr.Divya Kantharaju

ORIGINALITY REPORT

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by Dr. Kaveesha

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DR KAVEESHA MISRA

1st YEAR POST GRADUATE STUDENT

" A COMPARITIVE STUDY TO ASSESS THE ACCURACY OF DIGITAL IMPLANT IMPRESSION WITH CONVENTIONAL OPEN TRAY IMPLANT IMPRESSION FOR PARTIALLY EDENTULOUS ARCH – AN IN VIVO STUDY"

6. BRIEF RESUME OF THE INTENDED WORK

6.1 Need of the Study

A dental implant, a key treatment for both complete and partial edentulism, has become an integral modality in dentistry. It offers several advantages over conventional fixed partial dentures, including a high success rate (exceeding 97% for 10 years), a reduced risk of caries and endodontic issues in adjacent teeth, improved preservation of bone in the edentulous site, and diminished sensitivity of adjacent teeth.

The advent of digital technology has revolutionized the lives of individuals globally, influencing both personal and professional spheres. In dental implant surgery, digital technology enables the creation of surgical guides that precisely determine the implant site. However, a dilemma persists regarding the choice between conventional and digital workflows for fabricating implant-supported reconstructions. Consequently, the decision to adopt a digital or conventional workflow for the fabrication of implant-supported fixed dental prostheses (ISFDPs) can be a challenging task for many dental clinicians.

Ensuring the accuracy of implant impressions is a critical step in the construction of implant-supported prostheses. The focus during the process of making implant impressions is on precisely reproducing the implant location in three dimensions in relation to other structures in the oral cavity.

Numerous in vitro studies have been conducted on digital systems. The essential need for scientific validation and evidence pertaining to the clinical and technical feasibility is crucial for comprehending the influence of the ongoing trend toward digitalization on potential modifications to existing conventional protocols in fixed prosthodontics. Nevertheless, given the distinctions between in vivo and in vitro conditions, there remains a necessity for clinical studies to further investigate this matter..[1]

Conventional Workflow :[2]

Open tray splinted impression technique ⇨ Elastomeric impression material ⇨ Type IV low expansion stone

Advantages of digital over conventional workflow [3]are as follows- less chair time, more comfortable and convenient experience for patient as well as the dentist. Increased patient motivation since the introduction of intra-oral scanner and the individual is much more integrated in the process.

Disadvantages of digital implant impression technique [3]are as follows- lack of knowledge among dentists as mastering the skill requires training and experience. The identification of deeply positioned gingival margins is difficult, and IOS scanning is especially problematic in cases of hemorrhage, as it might hide the prosthetic edges and cause the scan to be imprecise. The initial cost of the system is expensive.

Problem Statement

The main aim of modern dentistry is to restore the patient to normal profile, function, comfort, esthetics, speech, and health. Dental implants are increasingly used to replace missing teeth. Rather than removing sound tooth structure and crowning two or more teeth, increasing the risk of decay, endodontic therapy, and splinting teethtogether with pontics, which may have the potential to decrease oral hygiene ability and increase plaque retention, a dental implant may replace the missing teeth.

Although the conventional method remains the most used for implant impressions, it is burdened by its cumbersome nature. In contrast, digital scanning has gained popularity due to its reported comfort for patients and purported equal or superior accuracy compared to traditional impression techniques. However, there is a scarcity of clinical evidence supporting the advantages of digital scanning.

There are no studies to the best of my knowledge regarding clinical evaluation of digital vs conventional implant impression accuracy for two adjacently placed implants. Hence present study attempts to evaluate the accuracy of digital implant impression with conventional open tray technique for two adjacently placed implants.

Research Question

Is there a difference in accuracy of digital implant impression using intraoral scanner (TRIOS) compared to conventional open tray implant impression?

Null Hypothesis

There may not be a difference in accuracy of digital implant impression using intraoral scanner (TRIOS) than conventional open tray implant impression.

Alternate Hypothesis

There may be a difference in accuracy of digital implant impression using intraoral scanner (TRIOS) than conventional open tray implant impression.

Aim

To assess and compare accuracy of digital implant impression using intra-oral scanner (TRIOS) with conventional open tray implant impression.

Objective

- To assess the conventional elastomeric impression using open-tray technique.
- To assess the digital impression technique using intra oral scanner (TRIOS)
- To compare the accuracy of digital impression technique using intra oral scanner (TRIOS) with conventional elastomer impression using open-tray technique.

7.2 METHOD OF COLLECTION OF DATA (INCLUDING SAMPLING PROCEDURE, IF ANY):

This *in vivo* study will be conducted in the Department of Prosthodontics, Dayananda Sagar College of Dental Sciences, Bengaluru for the duration of 18 months. Laboratory analysis using extra-oral lab scanner will be done in Confident lab, Bengaluru. Material will be collected from regular commercial channels.

Sample size estimation was done using G*Power 3.1 by feeding the following input values:

Test Family - Paired t test.

Statistical Test - Difference between two dependent means (matched pairs)

Effect size (d) - 0.6

Permissible α - 0.05

Permissible β - 0.2

Power (1- β) - 0.8

No. of Groups - 01

After entering the above inputs and selecting the t test the software calculated the total sample size as **35.** Both the procedures will be done on all 35 samples

Group A: Group A consists of conventional open tray technique.

Group B: Group B consists of digital implant impression using TRIOS 3 Shape intra oral scanner with connecting polymer scan bodies

Inclusion Criteria:

- 2 adjacent implants
- Age group : 19 to 74 years
- Informed consent

Exclusion Criteria:

- non parallel implants – angulation > 30 degree
- Porous cast (air entrapment in cast)

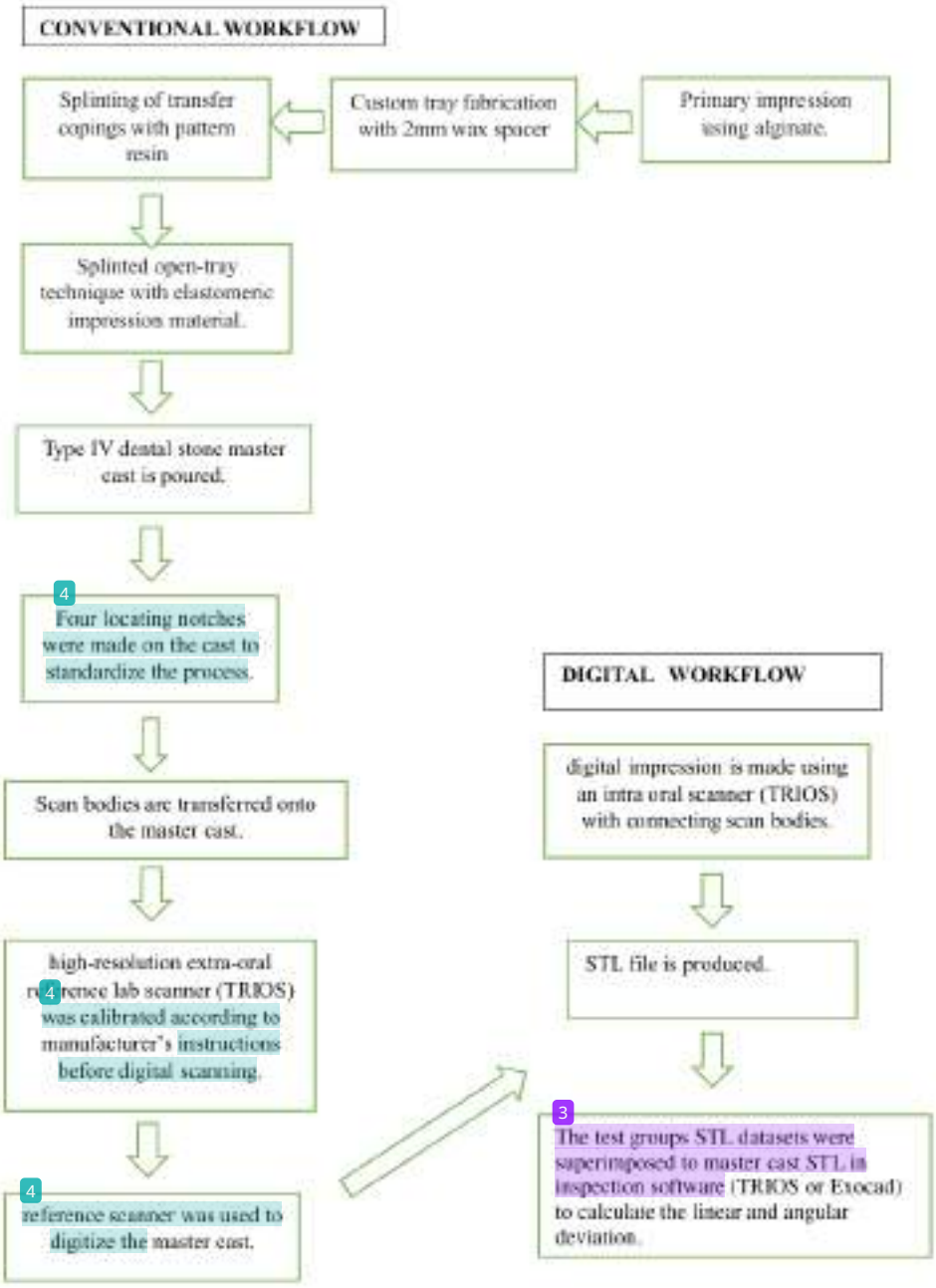
Material and equipment:

- Irreversible hydrocolloid impression material (Zhermack, Tropicalgin)
- Self-cure resin
- Modelling wax (Hindustan modelling wax no. 2)
- Pattern resin (GC Pattera Resin 1-1PKG)
- Open Tray Impression Copings (NORIS)
- Type IV dental stone (GYPROCK Die Stone Plaster)
- Lab Analogue (NORIS)
- Elastomer Impression material (Aquasil- Dentsply sirona)
- Scan bodies (NORIS)

- Intra oral scanner (TRIOS 3 SHAPE)
- Reference Lab scanner (TRIOS)
- Dental Floss
- Software (3 SHAPE or Exocad)

Methodology:

A conventional and digital implant impression procedure is performed on each patient.



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Report- Dr.Kavitha M

by Dr. Kavitha M

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A Comparative Assessment of the Effect of Irrigating Solution on the Micro-hardness and Roughness of Root Canal Dentin in Deciduous Teeth: An Invitro Study.

Abstract

To Compare and assess the effect of irrigating solutions on the micro-hardness and roughness of root canal dentin in deciduous teeth. Sixty, non-carious extracted human primary incisor teeth were selected. The crowns of the teeth were sectioned and the roots were separated longitudinally to get one twenty specimens. These specimens were then divided into four groups according to the irrigating solutions used. The solutions used were 0.5%NaOCl, 2.5% NaOCl solutions, 3% H2 O2 and distilled water. Then, the specimens were subjected to micro-hardness and roughness testing. The data were analyzed using ANOVA and Tukey's multiple comparison tests. The results of this study indicated that all the irrigating solutions used decreased the micro-hardness and surface roughness of root dentine when compared with distal water, maximum changes was seen in 2.5% NaOCl followed by3% H2 O2 and minimum changes was seen with 0.5% NaOCl with micro-hardness and roughness. Within the limitation of this study, it is concluded that 0.5% NaOCl solutions seems to be an appropriate irrigation solution, because of its harmless effect on the micro-hardness and surface roughness of root canal dentin.

Key words: *Primary root dentin, Irrigating solution, micro-hardness, surface roughness*

INTRODUCTION

The success of the root canal therapy in primary teeth is determined by through removal of debris and necrotic tissue. Due the presence of complex root canal system in primary teeth complete removal of bacteria by cleaning with endodontic instruments is unattainable. That is why root canal irrigants along with root canal preparation is considered[1].

The choice of irrigating solution in the pulpal therapy of primary teeth should consider the differences among the dentin substrata and not be irritating to the periapical tissues. It is very important to avoid harming the germ of the permanent successor tooth because the physiologic root resorption allows the apical extrusion of the cleanser[2].

Commonly used irrigating solutions used in primary teeth Sodium Hypochlorite, H2O2, Chlorohexidine Gluconate, EDTA, Citric acid, MTAD.

Sodium Hypochlorite solution (NaOCl) ranging from 0.5% to 5.25% has been recommended for use in endodontics. Sodium Hypochlorite concentration 0.5% and greater than that will effectively remove organic component of the dentin and changes their component.[3]

H2O2 is a widely used irrigating solution for disinfection and sterilization. It is available in various concentrations1% to 30%. H2O2 acts as an oxidizing agent. H2O2 produce hydroxyl free radicals (-OH), which attack several cell components such as proteins and DNA. Thus, act as effective irrigating solutions in pulp therapy[4].

A strong relationship exists between micro-hardness of dentine and restorative bond strength. Any change in the micro-hardness of the root dentin may adversely affect sealing ability and adhesion of dental material such as resin cements and root canal sealers to dentin. So micro-hardness provides a first step toward predicting behavior of dentin/restoration interfaces[5].

Irrigating solutions used in pulp therapy clean the dentin surface, and may interfere with the chemical structure of dentin, altering the calcium/phosphorus (Ca/P) ratio of the surface[6].

In turn, the mechanical, chemical, and physical properties of dentin structure changes. It has been noted that micro-hardness and roughness are sensitive to composition and surface changes of tooth structures [7]. Hence, the present study was undertaken to evaluate the effect of widely used irrigating solutions on the micro hardness and roughness of primary tooth root canal dentin.

MATERIAL AND METHODS:

The present study was approved by ethical committee of RGUHS. It is a non-randomized comparative In-vitro study. Sixty extracted human primary anterior teeth having no caries and hypoplastic defects were considered were collected in Department of Pediatric and Preventive Dentistry, V. S. Dental College and Hospital, Bangalore. Teeth were stored at 37 ^{0}C in buffered saline solution. Testing of micro-hardness and surface roughness was carried out at RV Engineering College, Bangalore, India.

Sample selection criteria was extracted primary maxillary and mandibular incisor teeth without resorption and anterior teeth with resorbed roots less than or up to 2/3rd of root were selected. Teeth excluded was anterior carious primary teeth, fractured tooth, restored tooth, tooth with external root, resorption more than 2/3rd of root and hypo plastic tooth.

SPECIMEN PREPARATION:

The crowns of the teeth is decoronated at cemento enamel junction (CEJ) using a high-speed diamond point under water-cooling. Then, each root is separated longitudinally using a diamond disc under water-cooling. Thus, 120 specimens are obtained. These specimens are then examined under stereomicroscope to eliminate the teeth with cracks and other specimens are added to compensate for them.

The specimens are then ground-polished with water cooled carborandum disc. Final polishing were carried out in felt cloth and buff by using 0.05 µm size aluminum oxide powder mixed with distilled water (Fig-2)

A plastic ring is taken and auto-polymerizing acrylic resin is put inside the ring. The specimens were embedded in auto-polymerizing acrylic resin, leaving the polished dentin surface exposed. After curing of the resin, the ring is removed and re-polishing of specimens is done. (Fig -4)

GROUPING

A total of 120 specimens are then divided into four groups with 30 specimens in each group according to the irrigating solutions used.

Exposed dentin surfaces are immersed in plastic jar containing irrigating solutions.(Fig-5)

Group 1: 5 ml, 0.5% NaOCl for 15 min.

Group 2: 5 ml, 2.5% NaOCl for 15 min.

Group 3: 5 ml, 3% Hydrogen peroxide for 15 min.

Group 4: 5 ml, Distilled water for 15 min (control).

At the end of active treatment period (15 min), the samples are rinsed with distilled water and dried. Every group is then divided into two subgroups of 15 each. Group 1a, 2a, 3a, 4a will be used to determine the micro-hardness of root dentin and Group 1b, 2b, 3b, 4b will be used to determine the surface roughness of root dentin.

The specimens given above in group (a) is subjected to micro-hardness testing using Vickers hardness tester. (Fig-1)

The specimens given above in group (b) are subjected to surface roughness and will be monitored through the surface roughness tester. (Fig- 1).

DETERMINATIONOFMICROHARDNESS

The specimens were mounted on stage of Vickers micro-hardness tester (Matsuzawa – MMT 5421X, Japan). The mid-root portion is halfway from the outer surfaces was focused for testing. Indentations were made with Vickers diamond indenter using 100 gm load with a dwell time of 10 seconds.

These indentations were measured and converted into Vickers hardness number (VHN) values by the monitor

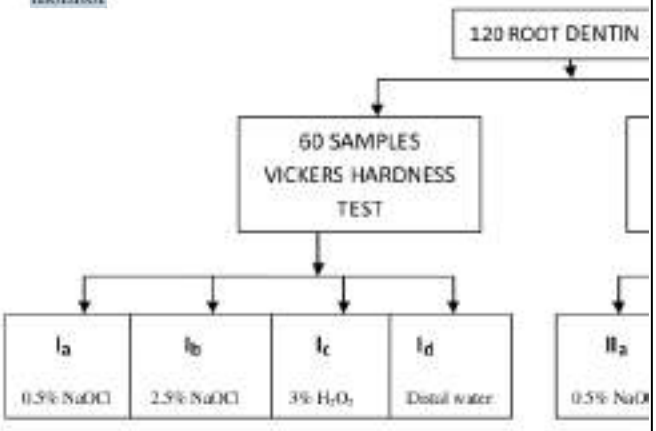


Fig – 1: Flow chart representing the methodology adopted determination of micro-hardness and surface roughness.

DETERMINATION OF SURFACE ROUGHNESS

The specimens were placed on the flat table surface of roughness tester (SURFCOM 130A) and the needle of the tester was on the mid root region of the tooth surface. The machine was then made to record the surface roughness values of root dentin by travelling on the surface along the length. The values were displayed digitally on the screen of the roughness tester. These values were expressed as Ra (µm).The Ra parameter describes the overall roughness of the surface and is defined as the arithmetical average value of all absolute distances of the roughness profile from the centre line within the measuring length. (Fig -7)

Fig -2 Specimen preparation – Root Dentin

Fig–3:Four irrigating solutions: 0.5% Naocl, 2.5% Naocl, 3% H2O2, Normal Saline

Fig – 4: 120 Extracted primary tooth specimens mounted on Acrylic

Fig – 5: Specimens submerged in irrigating solutions

STATISTICAL ANALYSIS:

The teeth were analyzed statistically using One-way analysis of variance (ANOVA) and the comparison of means was conducted using Tukey's multiple comparison tests. The testing was performed at the 95% level confidence ($p<0.05$). The Statistical software namely SAS 9.2, SPSS 15.0, Stata 10.1, MedCalc 9.0.1, Systat 12.0 and Ra environment ver.2.11.1 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

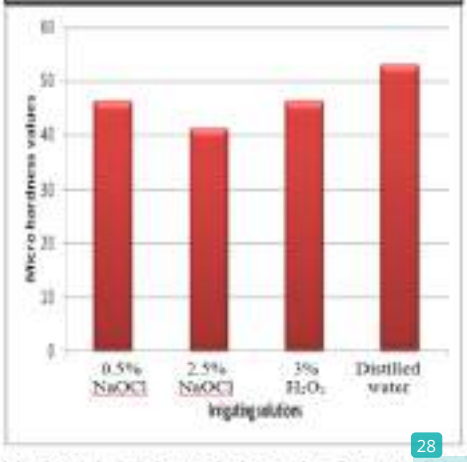
Results:

Table 1 -Mean of micro-hardness values in VHN of all groups

TREATMENT GROUPS	0.5% NaOCl 1a	2.5% NaOCl 2a	3% H_2O_2 3a	Distilled water 4a	P value
VHN VALUES (Mean± SD	46.27±1.53	41.20±1.74	46.20 ±3.23	53.00 ±1.60	< 0.001**

Graph – 1 shows the plot of micro-hardness for each irrigating solution.

GRAPH 1: Micro-hardness v/s Irrigating solutions



All three irrigating solutions (1a, 2a, 3a) showed a statistical significant reduction in micro-hardness when compared to 4a (Control group). Maximum changes in the micro hardness were seen in 2.5% NaOCl (2a). 0.5% NaOCl (1a) and 3% H2O2 (3a) showed considerable changes in micro hardness. (Table -1)

Table-2:Pair-wise comparison of micro hardness by post-hoc Tukey test:

Treatment Groups	0.5% NaOCl 1b	2.5% NaOCl 2b	3% H_2O_2 3b	Distilled water 4b	P value
Surface roughness	0.97± 0.12	1.28± 0.63	1.03±0.12	0.74± 0.16	0.001 **

Group 1a with Group 4a. , Group 2a with Group 4a, Group 3a with Group 4a showed a suggestive strong significant changes when compared with control group. Group 1a with Group 2a, showed a suggestive significant change. Group 1a with Group 3a did not show any significance, Group 2a with Group 3a also showed a suggestive strong significant difference in Tukey's multiple comparison tests

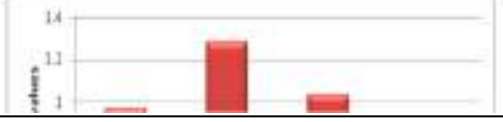
Pair wise comparison	Difference	P value
0.5% NaOCl (1a)- Distilled water (4a)	-6.733	<0.001**
2.5% NaOCl (2a)- Distilled water (4a)	-11.800	<0.001**
3% H_2O_2(3a)- Distilled water (4a)	-6.800	<0.001**
0.5% NaOCl (1a)-2.5% Naocl (2a)	5.07	0.011*
0.5% NaOCl (1a)-3% H_2O_2(3a)	0.07	0.99
2.5% NaOCl 2a)-3% H_2O_2(3a)	-5.000	<0.001**

COMPARISON OF SURFACE ROUGHNESS IN FOUR GROUPS OF SAMPLES STUDIED:

TABLE 3 shows the mean of surface roughness values Ra of all groups. ANOVA test showed that there was a major significant difference between each group.

TABLE - 3 Mean of surface roughness values Ra of all groups.

GRAPH 2- Surface Roughness v/s Irrigating solutions



Graph – 2 shows the plot of surface roughness values (Ra) for each irrigating solution. Group 2b and Group 3b showed a statistical significant reduction in surface roughness when compared to Group 4b (distilled water). Maximum changes in the surface roughness were seen in Group 2b(2%NaOCl). Group 3b showed considerable changes in surface roughness when compared to Group 1b. The results suggest that there is a maximum change in the surface roughness with 2.5% of NaOCl when compared with other irrigating solutions in the study.

There was major significant difference seen in Group 2b compared to Group 4b. There was significant difference seen in Group 3b compared to Group 4b. There was no significant difference seen when Group 1b compared with Group 4b. Moderate significant change seen when compared Group 1b with Group 2b. There was no statistical differences seen with Group 1b, Group 2b with Group 3b.

Table – 4: Pair wise comparison of Surface roughness by post-Hoc Tukey test

Pair wise comparison	Difference	P value
0.5% Nanol (1b) - Distilled water (4b)	0.230	0.247
2.5% NaOCl (2b) - Distilled water (4b)	0.543	<0.001**
3% H_2O_2(3b) - Distilled water (4b)	0.292	0.091+
0.5% NaOCl (1b) -2.5% NaOCl (2b)	-0.312	0.063+
0.5% NaOCl (1b)-3% H_2O_2(3b)	-0.062	0.958
2.5% NaOCl(2b)-3% H_2O_2(3b)	0.250	0.184

DISCUSSION:

Pulp therapy includes mechanical instrumentation in addition with antimicrobial and tissue solvent irrigation as tooth has zones unreachable to debridement, such as accessory canals, ramifications, and dentinal tubules. Therefore, it is imperative to use auxiliary solutions that cause disinfection of these areas, mainly because infected primary teeth can harbor micro-organisms inside the dentinal tubule[10] in the same way permanent teeth do[11]. Irrigation is currently the best method to flush away loose, necrotic materials but if they are accidentally pushes deeper into the canal apical tissues, the periapical tissue and permanent bud are compromised [12].

Many researchers have studied the effect of several cleansers on the permeability of the dentine using methods that involve bacteria or radioisotopes, with different methodologies [12]. In addition, they increase the dentin permeability by removing the smear layer[13,14] ,which facilitate the instrumentation and promote the cleaning and disinfection of the root canals. In addition, they should be soluble in water and biocompatible to the peri-apical tissue [11].

In the present study, primary anterior teeth were selected, to help in separating these single rooted teeth longitudinally with ease to expose the root dentin surface, testing was done on mid-root region. This was done to minimize the effect of structural variations of different teeth and to establish a sensible baseline for valuation.[15]

In this study, the endodontic irrigating solutions were considered on root canal dentin surface for 15 min, to obtain optimum results as suggested by Chethan and Uppin[7].

Micro-hardness of the dentin depends on the quantity of calcified matrix permm^2, and its

determination provides indirect evidence of mineral loss or gain in the dental hard tissue.

Micro-hardness testing one of the easiest, non destructive mechanical characterization methods [17]. Thus, this method was used in this study.

However, the result provided by micro-hardness testing alone may then be complimentary and thus the use of another method is necessary for comprehensive understanding of the surface changes. Thus, surface roughness measurement has also been incorporated in this study to determine the surface changes of dental hard tissues.[7]

In our study root dentin of the primary incisor showed VHN value of 53 when tested with distilled water (control group) which correlated with the other study [14, 1]. Distilled water had no effect on dentin surface, thus it was taken as the control group in the study.

The results of the present study indicated all the 3 irrigating solution decreased significantly the micro-hardness of the primary tooth root dentin (Table 1) when compared with control group ($P<0.05$).similarly all irrigating solutions showed significant change in the roughness of root dentin when compared with control group. (Table 3)

Sodium hypochlorite (NaOCl) is frequently used endodontic irrigant. It is available in different concentration ranging from 0.5% to 5.25% 16. NaOCl is a strong base (pH>11).

NaOCl causes protein description from hydroxyapetite surface. Thus effecting modulus of elasticity and flexural strength.[7]

It is extremely irritating to peri-apical tissues, especially at high concentrations. Therefore it should be used at the lowest effective concentration and should not be forced beyond the apex. Dakin's liquid (0.5% NaOCl neutralized with boric acid) is the most frequently used solution to irrigate primary teeth, because it is less irritating the periapical tissue [12]. Hence 0.5% NaOCl and 2.5% NaOCl was considered in the study. Present study it is observed in Table 2 maximum decrease in the micro-hardness was seen with 2.5% NaOCl (Group 2a) with 41.2 VHN and significant changes seen in 3% H2O2 (Group 3a) with 46.2 VHN and 0.5% NaOCl (Group 1a) with 46.27 VHN.

Kinney et al. suggested that the decrease in hardness is caused by a decrease in rigidity of intertubular dentin matrix caused by heterogeneous distribution of the mineral phase within the collagen matrix. Oliveira et al. stated that the use of 1% NaOCl for 15 min was enough to reduce dentin micro-hardness in permanent root dentin [11].

Fernanda Miori et al[12] stated 1% NaOCl induced changes on micro-hardness when compared with water on root dentin of primary teeth which substantiated with our study were changes in micro-hardness was seen with 0.5% NaOCl (Group1a) with 46.27 VHN when compared with distilled water (Group 4a) with 53 VHN as observed in Table 1($p<0.001$).

Hydrogen peroxide (H2O2) is available in various concentrations from 1% to 30%. H2O2 degrades to form water and oxygen. At high concentrations, hydrogen peroxide is not well tolerated in the body and might play a role in the development of cervical resorption [16]. So 3% H2O2 was taken in study.

H202with pH of 1.7 influences the inorganic parts of the dentin through acid demineralization[7]. 3% H2O2 (group3a) showed significant reduction in microhardness when compared with control group.

Removal of smear lay by irrigants increases the surface roughness. For the smear layer removal after applying these solutions to the endodontic surfaces, dentinal tubules become patent and the surface roughness increases. This could be of clinical benefit as in the case of micromechanical bonding of the adhesive materials that require the presence of irregularities on the surface of the adherend into which the adhesive can penetrate[17]. However, excessive expansion of this area could be followed by the formation of voids, which interfere with the spreading of material on the dentin surface, thus compromising the interface and decreasing adhesion leading to bacterial penetration and apical leakage 8.

0.5% NaOCl did not show statistically significant influence on the roughness. This concentration is used frequently in endodontics of primary root canals since it has less irritant potential than 2.5% NaOCl and 5.25% NaOCl.

The significant changes in roughness observed following the2.5% NaOCl treatment showed its potent direct effect on the organic and mineral content of dentin (Borges et al.,2007),which correlated with our study showing 0.5% NaOCl(Group 1b) showed slight increase in the surface roughness value of 0.97 Ra, when compared to distilled water (Group 4b) 0.74 Ra which is seen in Graph 2 and significant changes was seen in the higher concentration of 2.5% NaOCl(Group2b) with value of 1.28 Ra when compared with control (Group4b) as tabulated in Table 2.

3% H2O2 showed changes on surface roughness of permanent root dentin; correspondingly our study also showed changes in surface roughness of primary teeth with 3% H2O2 (Group 3b)with 1.03Ra when compared to the control group distilled water(Group 4b) with 0.74 Ra seen in Table 2 .

3%H2O2(Group 3b) with surface roughness value of 1.03Ra compared with 2.5% NaOCl(Group 4b)value 1.28 Ra did not show significant changes among the two irrigating solutions where 2.5% NaOCl reduced the microhardness to the maximum when compared with 3% H2O2 in Table 4.

The chemical agents used in the present study are the most frequently employed during root canal therapy of primary teeth. All agents influenced the physical properties and structure of dentin surfaces. Least changes seen in root dentin microhardness and surface roughness among all the irrigating solutions used in our study is 0.5% NaOCl.

Studies on the physical properties are significant to provide clinicians with an understanding of how these tissues respond under clinical conditions and for predicting the behavior of the tooth/restoration interface in a clinical setting. In conclusion, when considering the physical, structural approaches and the chemical agents studied, 0.5% NaOCl promoted the smallest alterations in the surface roughness, micro hardness, and structure of pulp chamber dentin in primary teeth. This clearly indicates that 0.5% NaOCl is a better irrigating solution in primary dentin.

This study showed the opportunity to make use of large amount of the irrigating solutions in close contact with flat dentin surface. In clinical circumstances this may not be the case as root canal system has intricate morphology. Hence, more questions needs to be answered as to the extent to which these chemical alterations may affect the adhesion of sealers to the treated surfaces.

It is noteworthy that the irrigating solutions used in this study were of restricted concentrations. Therefore, the effect of various concentrations and application time on dentin micro hardness and roughness can be further estimated in a wider range of similar studies.

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EVALUATION OF INJECTABLE PLATELET RICH FIBRIN WITH XENOGRAFT (STICKY BONE) FOR THE TREATMENT OF HORIZONTAL BONE DEFECT IN PERIODONTITIS BY ASSESSING BONE FILL. A RANDOMIZED CONTROLLED CLINICAL TRIAL.

INTRODUCTION:

Periodontitis is a chronic inflammatory disease that alters the morphologic features of bone in addition to reducing its height and also leads to various pattern of bone loss among which horizontal bone loss being the most common destructive pattern,[1]which is a termed as zero wall defect and the treatment of such defect is a challenge confronting the clinician but has received scant attention.[1]As per the Literature, the vertical bone loss with a prevalence of 7.8% has received 96.8% treatment options, whereas horizontal bone loss with a prevalence of 92.2% has received only 3.7% treatment modalities.[2] Several treatment modalities have been attempted through the years including various bone grafts, combination of membrane and graft materials, biological substitute like enamel matrix protein and recombinant human bone morphogenic protein have been evaluated for the treatment of horizontal bone defects. However, the outcome of these treatment modalities has been different with varying degrees of improvement for different techniques, but all the studies have shown an immense success rate in vertical and furcation defects.[3,11]

Platelet rich fibrin (PRF) forms three-dimensional fibrin matrix that may further serve as a scaffold for tissue regeneration by acting as a barrier membrane in guided bone and tissue regeneration procedures and simultaneously enriching with growth factors responsible for wound healing. The development of an injectable formulation of PRF (termed as i-PRF) has been pursued with the aim of using platelet concentrate in liquid formulation which can be combined easily with various biomaterials. The effectiveness of i-PRF with xenograft (Sticky bone) in vertical alveolar defects, ridge augmentation for implant placement and in treatment of periimplantitis have shown a positive clinical and radiographic outcome.[4,b] i-PRF permits the incorporation of graft without the use of anticoagulants or additives, thereby forming a well-agglutinated "Steak for bone grafting.

Hence this study was done to assess the clinical and radiographic effectiveness of i-PRF in comparison to open flap debridement in horizontal bone defects.

MATERIALS AND METHODS:

Study design

The study was prospective, 6-month follow-up, concurrent parallel randomized clinical controlled trial evaluating the clinical and radiologic effects of sticky bone used in the surgical treatment of Horizontal bone loss. The study was approved by the Ethical Committee of the Institution, Dayananda Sagar College of Dental Sciences, Bangalore (IEC no 32.IRB.2019). The study fulfilled the requirements of the "Declaration of Helsinki" as was adopted by the 18thWorld Medical assembly in 1975 and revised in Edinburgh (2000).

Patient Selection

The study was done on 45 stage II and stage III periodontitis[8] patients referred to the outpatient Department of Periodontics, Dayananda Sagar college of Dental Sciences & Hospital, Bangalore. They were screened during consultation and participants were explained about the need, study design and potential benefits as well as the potential risk of the study. A written informed consent was obtained before the commencement of the trial. The treatment and follow up were carried out between September 2020 and January 2022. The modified CONSORT guidelines were followed to report the trial.

Inclusion and Exclusion Criteria

The patients in age group between 25 to 45years diagnosed with stage 2 or stage 3 periodontitis with probing depth of 5 to 8mm, sites with horizontal bone defect as evident in digital radiographs were include in the study. The patients with compromised general health, smoking, pregnancy, or lactation and Patients who have received periodontal therapy 6 months prior to the study were excluded from the study.

Initial Therapy:

Initial therapy consisted of scaling and root planing of involved teeth in the planned quadrant using hand curettes and an ultrasonic device under local anesthesia. A periodontal re-evaluation was done six weeks after phase I therapy.

Clinical measurements:

Relative probing pocket depth and relative clinical attachment level using UNC -15 periodontal probe and an acrylic stent were measured at six aspects of each teeth: mesio buccal,

mid buccal,disto buccal , mesio lingual, mid lingual and disto lingual at baseline, three months and six months follow up.

Radiographic examination:

Intraoral periapical radiographs were obtained using a long-cone parallel technique and a phosphor plate with a sensor holder to evaluate the level of alveolar crest. Radiographs were analysed with Carestream CS system.

The level of alveolar crest was calculated at baseline, after 3 months and 6 months and were stored in the computer for assessment. At baseline the distance from the CEJ (Cemento enamel junction) to the base of the defect (BD) was measured (CEJ to BD). Post-operative measurement from CEJ to the alveolar crest (AC) was done (CEJ to AC) after three months and six months. The Defect fill was measured by subtracting the distance (CEJ to BD) from (CEJ to AC).[9] The standardization of radiographic interpretations was done by an expert radiologist. The radiographic measurement was performed using Autodesk AutoCAD 2013 Version software.

Surgical Interventions:

The surgical procedures followed for Group A, B, and C included anesthetization of the surgical sites with 2% lidocaine 1: 80,000. Buccal and lingual sulcular incisions were made and a full thickness mucoperiosteal flap was elevated. The periodontal surgical procedure fully exposed the horizontal defects and preserved the marginal gingiva and interdental tissue. Meticulous defect debridement and root planing were carried out to remove subgingival plaque, calculus, inflammatory granulation tissue, and pocket epithelium (Figure 1). In Group B, in addition, IMP was performed with a micromotor handpiece and round carbide bur with copious irrigation of water at a depth of 0.2 mm (Figure 2). In Group A following the debridement and IMP; Sticky bone was placed in the decorticated area as well as at the level of defect (Figure 3). In all the groups to achieve primary closure, direct interrupted sutures with 3-0 silk were performed.

Postsurgical instructions were given. Post operative care included oral administration of amoxicillin 500 mg, every eight 8 hours for five days and diclofenac sodium 50 mg+paracetamol (Acetaminophen) 325 mg every 12 hours for three days. Sutures were removed 1-week post-surgery. The patients were recalled after four weeks, eight weeks ,12

weeks and 24 weeks for oral hygiene reinforcement and oral prophylaxis. The clinical parameters PPD, CAL, and Defect depth were recorded at 12- and 24- weeks follow-up period.

STATISTICAL ANALYSIS:

Sample size:

The sample size was estimated using the G Power software v. 3.1.9.2. Considering the effect size to be measured (f) at 53%, power of the study at 80% and the margin of the error at 5%, the total sample size needed was 39. Anticipating 10% attrition during the follow-up periods, the sample size was increased to 45. This was divided in to three groups of 15 participants each.

Randomization:

Block randomization was performed with computer assisted software for random allocation of the subjects to any of the three groups. The allocations were concealed in opaque sealed envelopes which were sequentially numbered. An experienced periodontist who was blinded to the study procedure collected all clinical data at the baseline and during follow-up visits while another experienced periodontist carried out the procedure.

Statistical method:

Statistical Package for Social Sciences [SPSS] for Windows Version 22.0 Released 2013. Armonk, NY: IBM Corp., was used to perform statistical analyses. Descriptive analysis of all the explanatory and outcome parameters was done using frequency and proportions for categorical variables, and Mean & SD for continuous variables. Kruskal Wallis test followed by Mann Whitney Post hoc test was used to compare the mean study parameters between 3 groups at different time intervals. Friedman's test followed by Wilcoxon Signed Rank Post hoc test was used to compare the mean study parameters between different time intervals in each study group. The level of significance was set at $P<0.05$.

RESULTS:

Forty-eight patients were assessed for eligibility. Among these, 45 patients (Age range, 25-45years) who satisfied the inclusion criteria were enrolled in the study. Healing was uneventful in all cases with no adverse effects. Drop outs are presented in the consort flowchart.

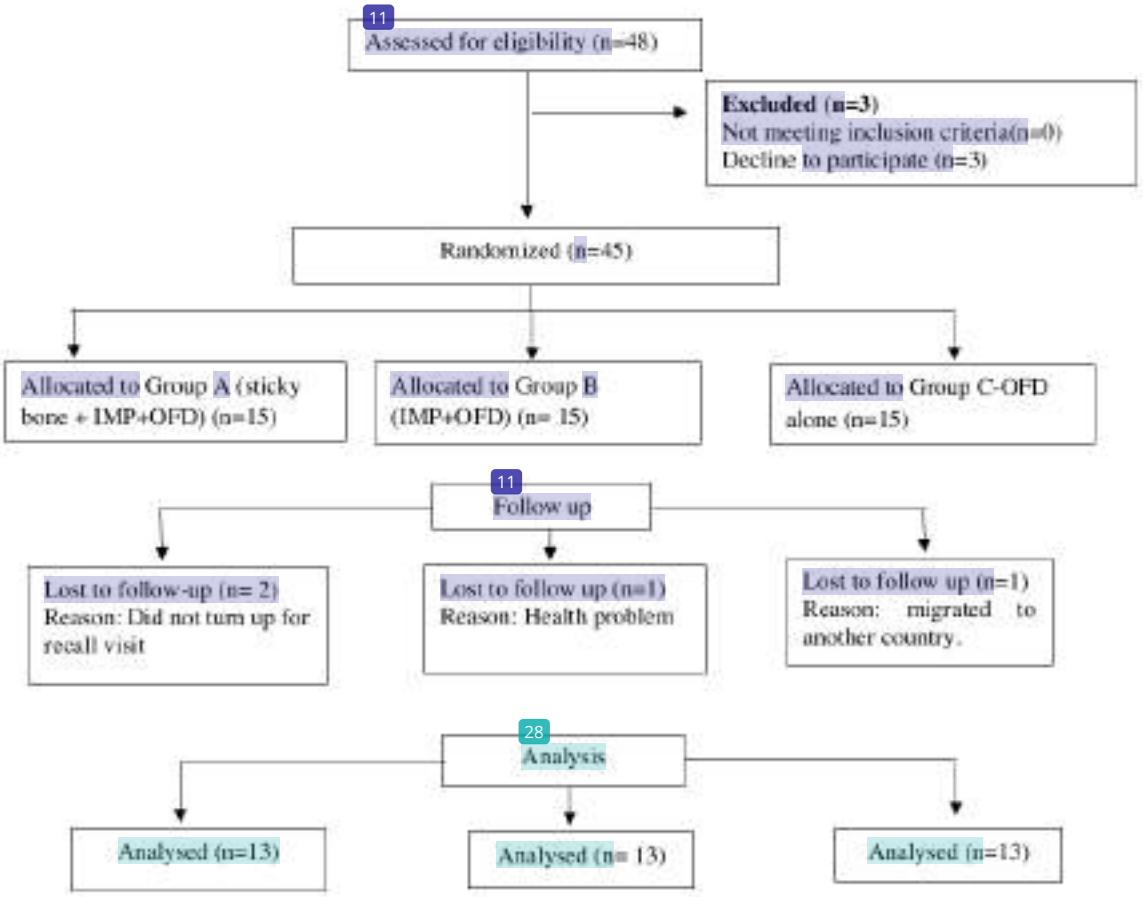

Figure 4: Consort Flow chart

Probing Pocket Depth (PD):

On Intergroup comparison of mean probing depth (PD) at baseline interval, no statistically significant difference (P=0.28) between Group A (5.38), Group B (5.57) and Group C (5.77) mean values were observed whereas on six month follow up statistically significant difference among all three groups were observed (P<0.001). The post hoc analysis revealed a statistically significant reduction in probing depth in Group A as compared to Group B with a *P* value <0.001 and Group C with a P value<0.001. (Table 1)

Table 1: Comparison of mean values of different study parameters between three groups at 6 Months period using Kruskal Wallis Test followed by Mann Whitney post hoc Test

Parameter	Groups	N	Mean	SD	Min	Max	P-Value [a]	Sig. Diff	P-Value [b]
PD	Group A	14	2.16	0.23	2	3	<0.001*	A vs B	<0.001*
	Group B	14	2.79	0.44	2	4		A vs C	<0.001*
	Group C	13	3.25	0.25	3	4		B vs C	0.003*
CAL	Group A	14	0.05	0.15	0	1	0.007*	A vs B	0.37
	Group B	14	0.11	0.19	0	1		A vs C	0.009*
	Group C	13	0.40	0.45	0	1		B vs C	0.03*
Defect depth	Group A	14	1.07	0.35	0.8	2.0	0.001*	A vs B	0.008*
	Group B	14	1.60	0.53	0.6	2.5		A vs C	0.002*
	Group C	13	2.04	0.82	0.3	3.4		B vs C	0.04*

* - Statistically Significant

Note: a. P-value derived by Kruskal Wallis Test; b. P-value derived by Mann Whitney's Post hoc Test

Clinical attachment level (CAL)

The mean of CAL at baseline in the three groups showed a similar range which was not statistically significant (P=0.26) whereas on six month follow up statistically significant difference among all three groups were observed (P=0.007). The post hoc analysis revealed a statistically significant gain in CAL in Group A as compared to Group B and Group C with P= 0.009. (Table 1)

Defect depth (DD)

On intergroup comparison of mean defect depth (DD) at baseline interval, no statistically significant difference (P=0.64) between Group A (2.72), Group B (2.76) and Group C (2.92) mean values were observed whereas on six month follow up statistically significant difference among all three groups were observed (P=0.001). The post hoc analysis revealed a statistically significant reduction in defect depth between Group A and Group C (P=0.002), followed by Group A and Group B (P=0.008) and Group B and Group C(P=0.04). (Table 1)

Defect Fill Percentage (DF %)

The DF percentage was calculated based on the linear radiographic depth of the defect obtained from PSP using the following formula

$$DF\% = \frac{\text{Baseline defect depth- Defect depth at 6 months}}{\text{Baseline defect depth}} \times 100$$

The mean DF% in group A was found to be 61.09% compared to group B and Group C which showed a DF% of 42.93 % and 33.08% respectively (p<0.001). The post hoc analysis revealed a highly statistically significant difference between Group A and Group C (P<0.001). (Table 2)

Table 2: Comparison of mean percentage of defect fill between 3 groups using Kruskal Wallis Test followed by Mann Whitney post hoc Test

Time	Groups	N	Mean	SD	Min	Max	P-Value [a]	Sig. Diff	P-Value [b]
6 Months	Group A	14	61.09	9.75	33.3	71.4	<0.001*	A vs B	0.001*
	Group B	14	42.93	12.55	6.7	59.3		A vs C	<0.001*
	Group C	13	33.08	13.69	16.7	75		B vs C	0.004*

* - Statistically Significant

Note: a. P-value derived by Kruskal Wallis Test; b. P-value derived by Mann Whitney's Post hoc Test

DISCUSSION:

This study was conducted to evaluate the efficacy of i-PRF plus bone graft (sticky bone) along with IMP in the treatment of horizontal defects in chronic periodontitis subjects. The study comprised of three groups namely Group A (Sticky bone along with IMP and OFD), Group B (IMP along with OFD) and Group C (OFD alone).

Platelet-rich fibrin (PRF) is 2nd generation PCs that were formerly described by Choukroun et al (2001).[16] Over the past decade since PRF was developed and many clinicians now have observed the potential use of liquid version of PRF termed as injectable PRF. Choukroun and Ghanaati analyzed systematically the influence of the relative centrifugation force on leukocytes, platelets, and growth factor release within liquid PRF matrices. It was reported that low-speed centrifugation concept enriches growth factors, platelets, and leukocytes within liquid PRF-based matrices.[17] In our study we used 3300 rpm for 2 min to

obtain i- PRF for the preparation of sticky bone, according to the technical notes given by Mourão et al 2015.[18] Since i-PRF is a novel invention, most of the research work in regenerative therapy has been conducted in animal studies and clinical trials in the field of advanced surgical procedures in implantology. The present study as per thorough literature search was the first of its kind where Sticky bone had been evaluated clinically and radiographically in the treatment of horizontal defects.

In our study, Group A in which Sticky Bone along with IMP and OFD was performed, exhibited highly significant reduction in the mean PD (3.2± 0.39) and CAL gain (2.52± 0.46) at 6 month follow up. Approximately 61.09% of DF was observed in Group A, which was highly statistically significant as compared to Group B and Group C. In our study, interestingly, we found highly significant improvements in both clinical and radiographic parameters in Group A when compared to Group B and Group C.

Intramarrow penetration is the intentional drilling of holes through the cortical bone into the cancellous bone or the removal of cortical bone to expose cancellous bone thereby enhancing the healing process by promoting bleeding and allowing progenitor cells and blood vessels to reach the bone-grafted site more readily.[14] In the experimental Group B, IMP along with OFD was performed, wherein, a mean PD reduction of 2.83±0.17 and CAL gain of 0.55±0.31 at six months follow up were noted. These findings were similar to the studies conducted by Debnath & Chatterjee[10] and Crea et al[15] where in the mean PD reduction and mean CAL gain of >2 mm in test site were statistically significant.

The bone defect fill at 6-month follow-up was 42.93% in Group B, which was comparatively higher than the mean DF (39.02%)in the study done by Debnath & Chatterjee.[10] Ghaysh et al., evaluated the contribution of IMP to the outcomes of OFD for the treatment of intrabony defects, which revealed a significant reduction in the defect depth from baseline to 6 months follow up (13.6±2.79).[14]

This is the first study of its kind as comparison of i-PRF (sticky bone) along with IMP with OFD was evaluated in treatment of horizontal bone defects. Although there was a statistically significant difference noticed in clinical and radiographic parameters in all the three groups, Group A (i-PRF + IMP) exhibited much better results in terms of improvement in the clinical parameters and defect fill with a higher marginal bone level at 6 month follow up.

The PD and CAL evaluated in the study at baseline was equivalent in all the study groups. At the 6th month follow-up, a significant reduction in PD as well as a gain in CAL were obtained in Group A, which was statistically significant as compared to Group B and C. Although intergroup comparison stated Group A to be statistically significant as compared to Group B and C which was attributed to the potential role of Sticky bone as biomaterial. The sticky bone stabilises the bone graft in the horizontal defect site, hence quickening the tissue healing and minimizing bone loss during the healing phase. The mouldable nature of sticky bone allows it to adapt appropriately to the horizontal bone defect, thus preventing the micro and macro movement of the graft particles. Hence the volume of augmentation was maintained during the healing period as well as, the fibrin interconnection minimised soft tissue in growth in to the sticky bone graft. Majzoub et al. (1999) stated that incorporation of IMP into the surgical site creates a close spatial correlation between angiogenesis and bone formation, therefore the companionship of IMP cannot be evicted. The vessel-rich medullary opening space would facilitate capillary sprouting and enhance vascular access into the surgical site. A local increase in bone morphogenetic proteins and other growth factors from the injured cortical surface, endosteal area, and wounded vessels area can enhance further new bone formation. Thus, the statistically significant difference observed in Group A was the synergistic effect of sticky bone and IMP.[9]The use of sticky bone along with IMP in the treatment of horizontal defects presents with better clinical and radiographic outcomes. Further, intergroup comparison of sticky bone along with IMP showed significantly higher difference as compared to IMP alone. However, in terms of percentage of defect fill, Group A shows better results than Group B which could be attributed to the ability of i-PRF to release higher concentrations of various growth factors and induced higher fibroblast migration and expression of PDGF, TGF-β, and collagen 1, and its higher BMP and cytokine release[19]; further, the use of bone graft has contributed to the improvement in the defect depth reduction from baseline to 6 months. The use of sticky bone along with IMP is an effective treatment modality in improving the bone fill in horizontal alveolar bone defects associated with periodontitis.

Considering the limitations of the present study a greater number of multicentre trials and longitudinal, prospective studies with longer follow-up should be carried out in different ethnic groups with a larger sample size to determine the efficacy of i-PRF (sticky bone) in horizontal defects with standard clinical parameters.

CONCLUSION:

The concept of growth factor enriched bone graft matrix prepared using autologous fibrin glue (AFG), first introduced by Sohn, has been in existence since 2010. This provides stabilization of the bone graft, acceleration of tissue healing, and minimizes bone loss during the healing phase. The combination of sticky bone along with various growth factors hastened the healing process and is very efficacious in the regeneration of the lost tissues. Sticky bone not only enhances the rate of new bone formation but also increases the quality (density) of the newly formed bone.

The results of the present study suggest that the addition of sticky bone and IMP to an OFD procedure used to treat horizontal defects could result in a significant improvement in clinical and radiographic outcomes in well-maintained periodontal patients, with particular benefits in terms of radiographic bone fill. Horizontal defects, being the most prevalent form of periodontal defects, demand more attention by researchers, and the use of autologous growth factor delivery systems in the form of i-PRF offers a new dimension in their management.

CONFLICT OF INTEREST AND FUNDING:

The authors report no conflict of interest.

REGISTRATION:

The trial is registered at Clinical trial registry of India (CTRI). The registration number for this trial is CTRI/2022/04/042145.

Report- Dr.Mrudula I

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Dr. NEHA PATIL

I YEAR

EFFECT OF PILOT HOLE DIMENSION ON MICROMOTION AND STABILITY OF MINI SCREW IMPLANT: AN IN VITRO EXPERIMENTAL STUDY FOLLOWED BY ITS CLINICAL VALIDATION

6. BRIEF RESUME OF THE INTENDED WORK

6.1 Need for the study:

Orthodontic anchorage has been defined as "resistance to unwanted tooth movement." One of the important factor in orthodontic treatment is to maintain sufficient anchorage control in order to create appropriate force system that will provide desired treatment results. Mini-screw implants which are also called as temporary anchorage devices (TADs) are small titanium alloy or stainless steel surgical bone screws placed into either buccal or palatal alveolar bone have become accepted component for anchorage in orthodontic treatment[1]

There are self tapping and self drilling type of mini screw implants(MSI) available for use based on mode of placement of these screws in to the alveolar bone. Both are considered to be effective anchorage units.[2] Pilot hole drilling is a prerequisite for self tapping mini screws where a deep indentation is done in to the alveolar bone to increase the ease of placement of mini screw implant in to the bone. Pilot holes also act as a guide and decrease the possibility of resistance or torque generated while drilling mini screw through the dense bone.[3]

Micromotion of mini screw implant is the relative displacement of implant with in the bone when subjected to orthodontic forces and it could be a significant risk factor for long term stability of the mini screw implant, because excessive micromotion can damage the callus and vascular structures formed at implant bone interface as part of bone healing resulting in fibrous encapsulation of the implants instead of direct bone contact. Micromotion is a particularly serious problem for (Mini screw implants) MSI, because, unlike dental endosseous implants, MIs are loaded before the interfacial bone is completely healed and the secondary stability is established. This means maintaining micromotion during MSI healing below a certain threshold would be one of the most important factors to consider to avoid premature MSI failure. Variations in the threshold of implant micromotion may depend on the implant material, surface characteristics and mode of placement and loading protocols. For the immediately loaded implants, as is the case with MSIs, the optimal threshold for successful

outcome was reported to be <30 μm. Providing MSIs with sufficient primary stability is an important measure to suppress micromotion.[4] Cortical bone quality, especially the thickness, is a key factor in achieving MSI primary stability.[5,6] However, MSI primary stability established during MSI implantation does not last long and it decreases over time, putting MSIs at risk of developing micromotion. Histologic studies have shown that the cortical bone within 0.2-0.5 mm from the MSI is over compressed and severely damaged during MSI placement. Although cortical bone is stronger than cancellous bone, its higher stiffness and lower fracture strain make it more susceptible to compression damage. The process of cortical bone remodeling which lasts for months, may account for most of the MSI healing period. In this critical period, in which weakened cortical bone cannot support the MSI, the stability of MSIs will be dependent on the cancellous bone. In other words, the cancellous bone needs to provide stability to the MSI, allowing it to pass through this critical period until the cortical bone remodeling is completed.[7,8]

Considering above statement, where cancellous bone is a source of stability for long term stability of the implant, the placement of pilot holes into the cancellous bone to ease the placement of mini screw implant and its effect on stability and micromotion of miniscrew implants needs to be studied as there is lack of literature regarding this.

Problem statement:

While various benefits of pilot holes have been suggested, the effects of altering pilot hole diameters and the depth of pilot hole drilling in to the bone before placement of MIs on primary stability of MSIs remain unclear. There is no clear cut pilot hole dimensions has been mentioned for the mini screw implant to be used. Hence any increase or decrease in depth and diameter of the pilot hole in relation to the size of the self tapping mini screw implant used needs to be studied.

As controlling micromotion of mini screw implants contributes to their long term stability, it become important to study the effect of pilot hole size in the cancellous bone on the relative micromotion and stability of the mini screw implant for their long term success.

Research Question:

Is there any effect of pilot hole dimensions on micromotion and over all stability of mini screw implant?

Null Hypothesis(H_0):

There may be no effect of pilot hole dimensions on micromotion and stability of mini screw implant.

Research Hypothesis(H_1):

There may be effect of pilot hole dimensions on micromotion and stability of mini screw implant.

6.3) Objectives of the study:

1. To identify the effects of varying pilot hole length and diameter on the extent of micromotion of mini screw implant.
2. To validate the micromotions and its relation to the stability of implants in an in vitro model.
3. To clinically validate the invitro results

7. MATERIALS AND METHODS:

7.1 Source of data:

a) FEM models simulating the each group to be obtained from ANSYS 14 software.

b) Sample for the study which is a freshly sacrificed goat mandible will be collected from nearby butcher shop. No goat will be sacrificed for purpose of the study.

c)Patients undergoing orthodontic treatment in the department of orthodontics and dentofacial orthopaedics in Dayananda Sagar College of Dental Sciences.

d) Experimental protocols will be conducted at department of orthodontics and dentofacial orthopaedics in Dayananda Sagar College of Dental Sciences.

Study design:

1) FEM study to identify the maximum permissible limit of micromotions for the optimal stability of mini screw implant by varying pilot hole dimensions.

2) Validation of micromotions in FEM findings on the stability of the implants in - In vitro study model.
3) In vivo validation of invitro findings.

Sample size determination:

Sample size was calculated using G-Power software version 3.1.9.7, by entering the following inputs below in the site.

Test family- F tests

Test type – Repeated measures ANOVA: Fixed effects, omnibus, one-way

Type of power analysis - A priori

Input parameters:

Effect size f = 0.4

α error prob = 0.05

Power (1- β err prob) = 0.8

Number of groups = 3

Output parameters:

Noncentrality parameter λ: 12.1500000

Critical F: 2.7694309

Numerator df: 3

Denominator df: 56

Total sample size: 72

Actual power: 0.82

Criteria for sample Selection:

Inclusion criteria:

1. Area of Goat mandible with bone density similar to human bone by calculating Hounsfield units (HU).
2. Goat Mandible with full set of dentition.
3. Freshly cut Goat mandibles will be used.
4. Patients undergoing orthodontic treatment in the department of orthodontics and dentofacial orthopaedics in Dayananda Sagar College of Dental Sciences.

Exclusion criteria:

1. Area of Goat mandible which do not correspond to human bone density.

2. Pilot drills with diameter other than 1.0mm, 1.1mm and 1.2mm

Materials required:

1. ANSYS FEM software.
2. Fresh mandible of goat sacrificed for meat purpose having density equivalent to or similar to human bone
3. Mini screw implant with diameter 1.3 and length 8mm
4. Pilot drill with diameter 1.0mm, 1.1mm and 1.2mm and length 4mm, 6mm, 8mm.
5. Implant stability meter
6. Customized smart peg
7. Sensors for detection of micro motions of implants when loaded.

7.2 Method of collection of Data:

Permission:

Permission for selection and conducting the intervention on animal specimens for the study will be obtained from: Principal, and Head of Department of Orthodontics and Dentofacial Orthopedics

METHODOLOGY

A) FEM analysis:

To simulate conditions of a clinical setting, mini screw implant and bone models with pilot holes will be generated using computer aided design.

Length of mini screw implant will be standardized to be 8mm and diameter 1.3mm.

Pilot holes with diameter 1.0mm, 1.1mm and 1.2mm will be designed in bone FEM models.

Within each diameter of pilot hole model, again three sub models will be created with Pilot holes length 4mm, 6mm, 8mm.

Bone specimens will be created with constant cortical bone thickness of 2mm.

Total number of bone specimens will be 9 by combining 3 different lengths with 3 diameters of pilot holes.

All 9 bone specimens will be of same dimension with height 10mm and diameter 3mm.

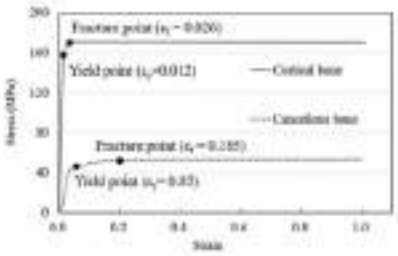
Based on the literature, the entire cancellous bone was assumed to retain its structural integrity throughout the MSI healing period. A recent finite element model (FEM) study showed that compression damage sustained by cancellous bone during MSI placement is minimal as compared with that by cortical bone.[8] Other histologic studies showed that cancellous bone, even when damaged, can recover much faster than cortical bone.[9]

All of the 9 mini screw implants and bone models will be imported into FEM software and will be meshed using 3 dimensional tetrahedron elements with 4 corner nodes.

The material properties to be used in the FEM are summarized below:

Material	Elastic modulus (GPa)	Poisson's ratio	Yield strain	Plastic modulus(GPa)	Fracture strain
Ti6Al4V	114	0.31	-	-	-
Cortical bone	13.7	0.3	0.012	0.76	0.026
Cancellous bone	0.9	0.3	0.05	0.03	0.185

Elastoplastic stress-strain relationships of the human cortical and cancellous bones as reported in the literature:[5]



Assuming that the orthodontic forces applied to the MIs during their healing period are the principal cause of MI micromotion, a typical loading condition will be simulated by applying a horizontal force of 1.5 N to the MI head.

The data will be recorded at 3 locations:

a) Top surface

b) Midplane

c) Bottom surface of inner cortical bone

The average of data from 3 locations will be considered as average micromotion.

B) INVITRO VALIDATION OF MICROMOTIONS ON STABILITY

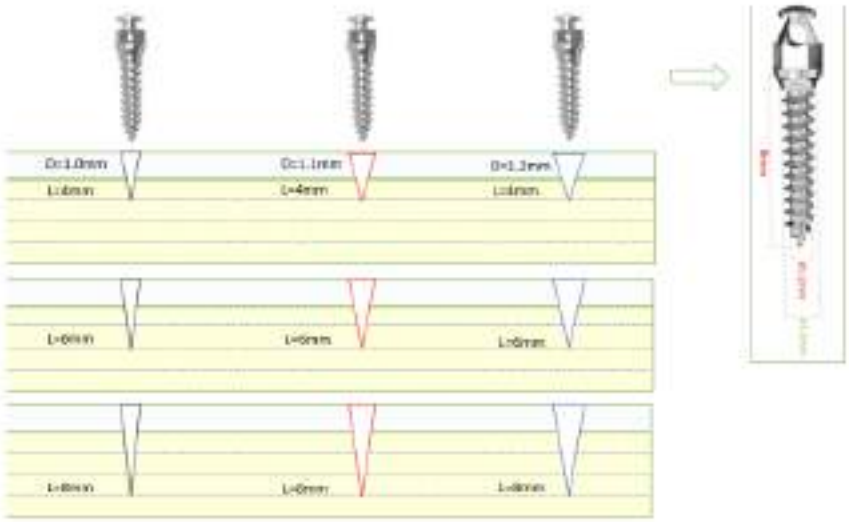
The numerical results obtained through FEM will be validated through an in vitro study.

For this study, mandible of goat which is freshly sacrificed for meat purpose is subjected to spiral 3D CT scan for density matching. The area of bone which matches with the density of human mandible in Hounsfield units will be considered for invitro experiment. The area with similar density will be marked on either side of the goat mandible with marking pencil.

For this study, mini screw implant with diameter 1.3mm and length 8mm is kept constant and pilot drill dimensions are varied.

Pilot drill with diameters 1.0mm, 1.1mm and 1.2mm are categorized into Group A, Group B, Group C and respectively.

Length of the pilot drill is varied and categorized into 3 sub-groups (A3, A6, A9 etc..) under each group.



Mini implants will be placed into their respective pilot hole drilled. Post placement of mini screw implant, implant stability meter is used to measure primary stability. The stability meter will be customized to attach the implant with the smart peg using a connector. Insertion and removal torque will be measured using torque meter and, micromotion will be measured for each of the mini screw implants placed using sensors.

C) IN VIVO VALIDATION OF MICROMOTIONS ON STABILITY

To validate the above results, clinical test will be performed. Pilot hole dimension which showed the best results in the above tests will be used for clinical validation. To evaluate the results, minimum follow up of 6 months will be done.

Statistical analyses:

The data collected for this study will be analyzed statistically as follows:

Descriptive Statistics: All categorical variables will be presented in the form of frequency tables

along with percentages. The quantitative variables will be described using Mean ± SD/ Median (IQR) based on the verification of normality assumption. The estimates like Mean/ Proportion/ Difference in means/ Difference in proportions will also be expressed with 95% Confidence Interval. Wherever necessary the data will be presented graphically, wherever necessary.

Inferential Statistics: For comparing groups between different diameters, one way analysis of variance (ANOVA) will be used following post hoc test, subjected to normality assumption. If not, Kruskal Walli's test will be applied with post-hoc test. Multiple correlation between implantation depth into cancellous bone and micromotion taking all 4 groups and related sub groups into consideration, co-efficient of determination of r^2 will be computed to find out the contribution of each one of them towards variation in micromotions. Results will be considered statistically significant if $P \leq 0.05$.

Report- Dr.Neha

ORIGINALITY REPORT

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PRIMARY SOURCES

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Report- Dr.Nikhil

by Dr. Nikhil

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RAJIV GANDHI UNIVERSITY OF HEALTH SCIENCES, KARANATAKA

DR . SAI NIKHIL REDDY

I MDS

DEVELOPING AND VALIDATING AN ARTIFICIAL INTELLIGENCE ALGORITHM FOR MEASURING OPTIMUM BONE DIMENSIONS IN MANDIBULAR ANTERIOR REGION BETWEEN THE MENTAL FORAMEN ON EITHER SIDE USING CONE BEAM COMPUTED TOMOGRAPHY SCANS - AN ARTIFICIAL INTELLIGENCE STUDY

6.1 NEED OF THE STUDY :

- Adequate mandibular bone dimensions ensures implant stability and load distribution, sufficient bone length achieving satisfactory primary stability and prevents encroachment on vital structures. Inter-tooth distance is also crucial in implant planning for selection of size, aesthetics, prosthetic design and biomechanical stability. Hence measuring available bone dimensions is crucial for successful implant placement.[1]
- The available bone at implant sites is measured using CBCT scans which provide a unique imaging analysis of proposed implant sites by reformatting the image data to create several imaging modalities. Traditionally, these measurements are done manually .
- However manual measurements on CBCT images is time consuming and has the disadvantage of being subjected to random and systematic errors. To overcome these problems newer AI technologies such as CNN have been increasingly applied.
- Deep convolutional neural network is a type of deep learning architecture which focuses on simulation of human intelligence adopted by machines based on the information they collect.
- Bone quantity evaluation in dental implantology is crucial. It is an essential step for dental implant treatment planning. The result of faulty consideration during pre-surgical planning often leads to implant-related complications. The success of dental implant treatment is principally related to bone quality of patients, patient evaluation, and good treatment planning [2].

- The precise measurement of bone architecture with conventional 2D radiography is limited by the difficulty in assessing hard tissue morphology and both the quality and quantity of bone. There is little information about the buccolingual and cross-sectional dimension resulting in inadequate identification of critical structures and restriction of spatial data for vital structures [2].
- Cone-beam computed tomography (CBCT) provides a unique imaging analysis of proposed implant sites by reformatting the image data to create several imaging modalities. The specific software used for creating the images utilizes multiple tools, which can precisely mark the vital structures and provide a 1:1 image for accurate measurements. The utility of CBCT for dental implant treatment planning has been well investigated [3] .However, analyzing CBCT scans requires a specific level of training and expertise. This analysis is time-consuming, involving hundreds of images .Learning is an essential part of the human brain which creates intelligent behaviour.
- Accurate mandibular canal (MC) detection is crucial to avoid nerve injury during surgical procedures. Moreover, the anatomic complexity of the interforaminal region requires a precise delineation of anatomical variations such as the anterior loop (AL) [4].
- Artificial intelligence (AI) is defined as the branch of computer science focused on a simulation of human intelligence adopted by machines based on the information collected.These principles relate to the algorithms used in knowledge representation and their implementation [5].
- The purpose of this study was to verify the diagnostic performance and assess the reliability of an artificial intelligence system based on the deep convolutional neural network method to measure optimum bone dimensions in mandibular anterior region between the mental foramen on either side using cone beam tomography scans .

PROBLEM STATEMENT :

- Manual measurements on CBCT images is time consuming and has the disadvantage of being subjected to random and systematic errors. Most errors occur in landmark identification which is based on observer's experience, landmark

definition, image density and sharpness. To overcome these problems newer AI technologies have been increasingly applied.

- A well-trained AI model can assist not only in landmark identification but also in various linear, angular and volumetric measurements accomplishing these tasks efficiently in a short period of time.

.3 OBJECTIVES OF THE STUDY :

Primary Objective

- To measure bone height and bone width and inter-tooth distance using CBCT data and measuring tools in mandibular anterior region i.e., between the mental foramen on either side.
- To develop an AI algorithm for predicting bone height and bone width and inter-tooth distance using deep neural network in mandibular anterior region i.e., between the mental foramen on either side.

Secondary Objective

To test and validate the algorithm in order to assess the accuracy of predicting bone dimensions in mandibular anterior region i.e., between the mental foramen on either side .

7. MATERIALS AND METHODS:

7.1 SOURCE OF DATA:

- CBCT images of subjects reporting to Department of Oral Medicine & Radiology, DSCDS, Bengaluru and CBCT centers across bengaluru city .Patients with edentulous areas in the mandibular anterior region (between the mental foramen on either side) seeking and consenting for dental implant rehabilitation would be selected for the study.

7.2 METHOD OF COLLECTION OF DATA:

- **PERMISSION**: Permission will be taken from Department of Oral and Maxillofacial Surgery and from the institutional review board of Dayananda Sagar College of Dental Sciences to conduct study.

- **SAMPLE SIZE DETERMINATION**: The sample size for training in order to derive an AI algorithm will be calculated using data based on the study by Sevda Kurt Bayrakdar, KaanOrhan, Ibrahim Bayrakdar, Elif'Bilgir, MatveyEzhov, Maxim Gusarev and Eugene Shumilov.

The details are given below.

Prevalence (p): 75%

q(1-p): 25%

Allowable error: 5%

$$N = \frac{z2\,(\alpha/2)pq}{L2}$$

N= Sample size

Z= 78.4

α= 0.05

p= Prevalence = 75%

q = (1-p) = 25%

L= 5% of p = 5% of 75% = 3.75

$Z\alpha/2$= 1.96

$$N = \frac{(1.96)2 \times 75 \times 25}{(3.75)2}$$

N = 512

- **SAMPLING METHOD**: Convenience sampling.
- **STUDY DESIGN**: Artificial intelligence study design
- **STUDY DURATION**: 18 Months

CRITERIA FOR CASE SELECTION

INCLUSION CRITERIA:

- CBCT images of subjects between the age range of 18 and 65 years
- CBCT images of subjects with missing teeth and requiring dental implant placement will be included.

EXCLUSION CRITERIA:

- CBCT Images showing generalized extensive bone resorption in the edentulous areas
- CBCT images of subjects with existing implants
- CBCT images of subjects with generalized periodontal disease

STUDY METHOD

Materials required:

- CBCT DICOM images from the Department of Oral Medicine and Radiology, DSCDS, Bengaluru and other CBCT centers across Bengaluru city .
- A Convolutional Deep Neural Network algorithm

Study group:

- CBCT images of patients reporting to Department of Oral Medicine and Radiology, DSCDS, Bengaluru, with edentulous anterior tooth region in the mandible requiring and consenting for dental implant rehabilitation will be included.

CONE BEAM COMPUTED TOMOGRAPHY IMAGES:

- For the purpose of standardization, CBCT images taken from ORAL-D& Department of Oral Medicine and Radiology ,DayanandaSagar college of Dental Sciences with standardized exposure parameter having good contrast and density and showing Mandibular canal, Mental foramen and Bone height and width in the edentulous areas clearly will be considered.

DATA TO BE FED TO DEEP NEURAL NETWORK FOR TRAINING AND GENERATION THE ALGORITHM:

- Identification of anterior loop of the mental nerve and measurement of the distance from the crest of the alveolar bone to the lower border in the mandibular anterior region i.e., between the mental foramen on either side.
- Measurement of the buccolingual bone width available in mandibular anterior region i.e., between the mental foramen on either side ..
- Measurement of the length of the edentulous space available in mandibular anterior region i.e., between the mental foramen on either side .
- Measurement of inter-tooth distance available in mandibular anterior region i.e., between the mental foramen on either side

CALIBRATION OF THE EXAMINERS:

One trained examiner will identify the implant site measurements and do the tracing in CBCT scans. The examiner would undergo a training and calibration session to match the benchmark.

Inter observer co-relation:

• Around 20 CBCT scans would be randomly picked up from the Data base used for the study. Implant site bone measurements would be done by the examiner and the guide separately without one discussing with other. Then the data will be compared and subjected to appropriate co-relation test [kappa statistics, intra class coefficient test].

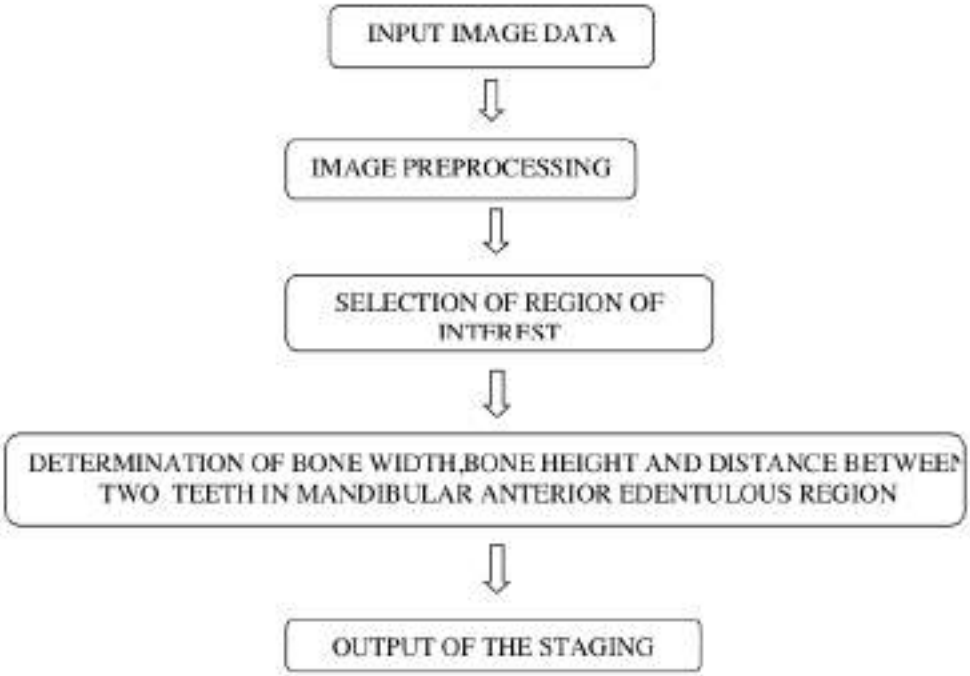
• A co-relation co-efficient value of 0.8 or more is considered as acceptable value, indicating a high degree of concordance between the examiner and the benchmark suggesting calibration of examiner.

Intra observer co-relation:

• Around 10 CBCT scans would be randomly picked out of 20 CBCT scans that are earlier used for calibration of examiner. After a week the examiner will do repeat assessment and data so obtained would be subjected to appropriate co-relation statistics and if co-relation co-efficient value is 0.8 or more than that it refers to high degree of internal reliability suggesting intra-examiner calibration. The calibration session will continue until a high co-relation co-efficient (0.8 = > 0.8) is attained.

GENERATION OF AI ALGORITHM:

- The 512 labelled CBCT images for generating Algorithm will be provided in order to construct AI algorithm and obtain Deep Learning AI software.
- Among the 512 labelled CBCT images, some images will be randomly picked and Reproducibility test will be conducted to validate the constructed Deep Learning AI Algorithm.
- The work flow of proposed algorithm is as follows:



ALGORITHM VALIDATION:

The new set of unlabeled CBCT images which are not used for the generation of the AI algorithm will be used to test and validate the accuracy of the derived AI Algorithm.

- **STATISTICAL ANALYSIS:**

Data will be entered in the excel spread sheet and analyzed . Statistical Package for Social Sciences [SPSS] software will be used to perform statistical analyses.

- **DESCRIPTIVE STATISTICS:**

Descriptive statistics of the explanatory and outcome variables will be calculated by mean, standard deviation/median and IQR (based on normalcy test- Shapiro wilk test for quantitative variables, frequency and proportion for qualitative variables.

- **SENSITIVITY ANALYSIS:**

sensitivity, specificity, positive prediction value negative prediction value and accuracy will be applied to compare the manual tracing with digital method.

Report- Dr.Nikhil

ORIGINALITY REPORT

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Report- Dr.Pavithra

by Dr. Pavithra

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COMPARATIVE EVALUATION OF PAIN EXPERIENCED WITH NEEDLELESS JET INJECTOR (INJEX) AND CLASSICAL NEEDLE INFILTRATION DURING SCALING AND ROOT PLANING IN PATIENTS WITH PERIODONTITIS- A SPLIT MOUTH RANDOMIZED CONTROLLED CLINICAL TRIAL

Abstract

Background: The treatment of periodontitis primarily consists of mechanical debridement carried out by means of thorough scaling and root planing that might sometimes be a painful procedure which requires the administration of some form of local anesthesia. INJEX is needleless jet injector which deliver local anesthesia without subjecting the patient to the unpleasant experience of feeling the pain of "the needle". Thereby, the jet syringe enables the patient to develop a more positive approach towards the dental treatment by eliminating his/her greatest fear.

Objective: The present study evaluates the efficacy of Jet anesthesia (INJEX) and compare with the classical needle infiltration for pain caused during administration and after the completion of scaling and root planing.

Methodology: 30 patients with probing depth of 5mm or more and visual analogue scale (VAS) score of ≥30mm on probing were selected and asked to assess the pain by VAS immediately after administration of anesthesia and after completion of the treatment.

Results: VAS score during administration of anesthesia in Group 1 was lower compared to Group 2 ($p < 0.03$) and onset of anesthesia was faster in Group 1 ($p<0.01$). No statistically significant results seen in VAS score during scaling and root planing among both groups.

Conclusion: Thus, the data suggest that administration of anesthesia using INJEX was less painful, equally efficacious in anesthetic effect, which was seen during scaling & root planing. INJEX was also found to be faster in induction of anesthesia compared to classical needle infiltration.

Keywords: Needleless anesthesia, INJEX, Jet anesthesia

Introduction:

Treatment of periodontal disease includes measures such as self-performed plaque control, professional scaling, root planing and surgical management of periodontal pockets. The success of it, depends mostly on the effective removal of supragingival and subgingival bacterial biofilms and the smear layer, which contains bacteria, bacterial endotoxins, and contaminated root cementum.[1]

Mechanical non-surgical therapy, or Scaling and Root planing (SRP), is the most commonly performed procedure which can be painful.[2] To make the procedure comfortable for the patient and to facilitate the clinician's ability to provide care, requires the use of local anesthesia.[3] A large proportion of scaling and periodontal debridement procedures performed involve nerve block or infiltration anaesthesia.[1]

Injection anaesthesia may be carried out alone or in conjunction with topical anaesthesia.[1] One of the most distressing aspects of dentistry for the average dental patient is the fear and anxiety caused by the dental environment, particularly the dental injection, i.e., syringe and needle which is referred as "NEEDLE PHOBIA" or BLENOPHOBIA.[2] The pain of needle insertion, duration of action and inconvenience of soft tissue anaesthesia limit patient acceptance. Efficacy, uncontrolled spreading and undesirable taste limit the use of topical agents (Milgrom et al. 1997). There is therefore a need for a fast-acting anaesthetic that is simple to apply and painless.[1]

Needleless devices have been developed as an alternative medium to deliver anesthesia which uses pressure to force the anesthetic solution safely into oral tissues. The anesthetic solution infiltrates the tissue in the tiny droplet form, which is immediately taken up by the myelin sheath of the nerve with an onset of action of approximately in 1 milli second. This amount is most effective in localizing its effect without producing an effect on systemic blood level hence helpful in cardiac patients. In dentistry it can be successfully used as anesthetic

device for curettage and scaling, mental and nasopalatine blocks, cementing crowns, jackets, bands and clamps; copper tube impressions, gingivectomies, direct pulp injections, biopsies and pointing abscesses for incision and drainage procedures.[2]

The objective of the needless jet injection is to deliver local anesthesia without subjecting the patient to the unpleasant experience of facing the "needle" and to achieve adequate anesthesia that should be acceptable to the patients.

The present study was conducted with an aim to assess the pain experienced during administration of jet anesthesia and during scaling and root planing and compare it with classical needle infiltration anaesthesia.

Materials and methods:

This present randomized controlled split mouth clinical trial was conducted on both male and female individuals in the age group of 18-70 years, who reported to Department of Periodontics, Dayananda Sagar College of Dental Sciences, Bangalore. All selected patients were explained about the need, design of the study and its potential benefits who signed an informed written consent prior to commencement of the study. The study was approved by the Ethical Committee of the Institution, Dayananda Sagar College of Dental Sciences, Bangalore. A split-mouth design was followed and the anesthesia was administered in maxillary or mandibular quadrants, which were chosen randomly, in each subject. Thirty subjects in the age group between 18-60 years with minimum five teeth in each quadrant that had not received periodontal debridement in last 12 months and pocket depth of more than or equal to 5mm but less than 8 mm on at least 2 or 3 teeth adjacent to each other on both sides either maxilla or mandible excluding third molars and with VAS score of 30-80mm on probing were included in the study. Subjects who are allergic to local anesthetic agents, on pain medication who have ulcers or abscess, who are in immediate need of surgery, with systemic diseases or conditions, pregnant or lactating, smokers, alcoholics, drug abusers and with CNS depression were excluded from the study.

Procedure:

Based on the above-mentioned inclusion and exclusion criteria, total of 30 subjects were selected and randomly allocated into two groups making it a total of 60 sites in a split mouth design. Ultrasonic scaling was performed for all the patients in the first visit and the patient was recalled after 1 week for root planing. Local infiltration anesthesia is administered through jet injector (INJEX) in group 1 (Experimental) with 30 sites both buccal and palatal aspect. INJEX, needle free jet injector was used in this study. The injector consists of a head assembly with glass fill chamber holding up to 0.3 ml of local anesthetic solution, the body with a cocking

lever and discharge button and extend a tip and sheath which can be changed between each patient. The glass chamber was filled with 2% lidocaine with 1:80000 adrenaline. INJEX was gently placed perpendicularly against the area to be injected with sheath in complete contact with the gingiva.

Local infiltration anesthesia is administered through classical needle injection technique in group II (control), that is, the opposite side of experimental group. The same volume and concentration of anesthesia was used in group II.

The onset of anesthesia was assessed in both the groups immediately after the administration of anesthesia using timer every 10 seconds until the numbness have been achieved, following which root planing was performed using Gracey's area specific curettes. Pain assessment was done immediately after administration of anesthesia and immediately after root planing, by asking the patient to mark his level of pain on VAS scale of 100mm length, with the left end point marked "no pain" and right end marked "worst pain imaginable".

The sample size has been estimated using the G Power software v. 3.1.9.2 Considering the effect size to be measured (d) at 47% for one-tailed hypothesis and 95% confidence interval, power of the study at 80% and the margin of the error at 5%, the total sample size needed is 30.

Computer assisted software will be used to generate random sequence (Block Random allocation) which will follow random allocation of teeth requiring root planing to either group I or group II. Random allocation will be done by the person who is not involved in the study. Allocation Concealment will be done by concealing the allocation sequence from the operator in an envelope and will be revealed by the third person at the moment of assignment.

Statistical analysis was performed using Chi- square test, Mann whitney test and Wilcoxon Signed rank test.

Observation and Results:

The present study was designed as single blinded, Split mouth, Randomized controlled clinical trial. A total number of 30 patients reporting to Department of Periodontology, Dayananda Sagar College of Dental Sciences, Bangalore were enrolled based on the inclusion and exclusion criteria and were included in the study between January 2020 and September 2021. Computer assisted software was used to generate random sequence (Block Random allocation) which followed random allocation of teeth requiring root planing to either group I or group II. Random allocation was done by the person who is not involved in the study.

In 30 patients included in the study, 60% were males and 40% were females with mean age of 37.50 ± 10.13 years (Table1).

The mean duration of onset of anesthesia on buccal aspect in group 1 was 32.52 seconds and in group 2 was 48.76 seconds. The mean difference of onset of anesthesia on buccal aspect was -16.24 seconds (P<0.001). The mean duration of onset of anesthesia on Lingual/Palatal aspect in group 1 was 28.62 seconds and in group 2 was 45.48 seconds and the mean difference was -16.86 seconds (P<0.001) which was statistically significant. (Table 2)

VAS score in group 1 during administration of anesthesia was 1.93±1.82 and in Group 2 was 2.90±1.35 and the mean difference was found to be -0.97 (P<0.03) which was statistically significant.

VAS score during Scaling and Root planning in Group 1 was 0.30±0.54 and in Group 2 was 0.13±0.51 with mean difference of 0.17 (P<0.06) with test group experiencing more pain during treatment compared to control group. However, the difference was not statistically significant. (Table 3).

In test group, mean VAS score of 1.93±1.82 was found during administration of anesthesia and during the treatment, VAS score of 0.30±0.54 was observed with P<0.001. In control group,

VAS score of 2.90±1.35 and 0.13±0.51 with P<0.001 during administration and during Scaling and root planing was observed, respectively. (Table 4).

Discussion:

The present study was designed to assess the efficacy of needle-less jet injector (INJEX) in providing a pain free experience during administration of anesthesia and during Scaling and root planing as well as to assess the onset of anesthesia. Subjects were asked to assess their pain perception using VAS during the administration of anesthesia and during the procedure. In the present study, a baseline VAS pain score of ≥ 30 mm during probing is included, which was in accordance with the study conducted by Magnusson et al, 2003 and Gupta et al, 2017.

Periodontal probing was used at baseline to screen for pain sensitivity, whereas the effect of the anesthesia was assessed during SRP.

The primary means of determining efficacy of jet injector was the measurement of treatment-associated pain. The use of the VAS for scoring pain has been validated in a variety of studies for different conditions including rheumatoid arthritis (Scott & Huskisson 1976) and temporo-mandibular disorder pain (Le Resche et al. 1988). The reliability of the VAS has been demonstrated previously by Luria in 1975, by using the test/re-test method for repeated measures of subjective sensations. The reliability of the VAS was shown to be excellent (kappa 0.82). Thus, the VAS represents appropriate methods for measuring subjective pain. However, the subject nature of VAS may over or underestimate the efficacy of the test group.[1]

The results of this study indicate that the mean value of VAS in control and test group was 2.90±1.35 and 1.93±1.82 respectively. The difference between the VAS scores of control and test group is statistically significant ($P < 0.03$). The VAS score of test group (INJEX) was much lower than control group. In a study conducted by Gupta et al, 2017, where they have compared the effectiveness of EMLA and needleless jet injection "MADAJET XL" for non-surgical periodontal debridement, the mean VAS values were lowest with Jet injection among the three groups ($p<0.001$) which is in accordance to our study. Additionally, the difference of this study is that we evaluated the efficacy of INJEX during Scaling and Root planing in a split-

mouth design. The advantage of the split-mouth design is the fact the comparison of anesthesia in the same individual eliminates the effect of confounding variables, as each participant serves as his/her own control.[4]

The mean age of male subjects (n = 18) was 37.3 and the mean age of female subjects (n = 12) was 37.6. There are no statistical differences between age and gender-related efficiency and acceptance of these two methods which correlates with findings of Saravia et al. (1981) who reported no age differences on method preference.[5] This study included equal number of maxillary and mandibular teeth (n=30 each) and there was no statistical difference between maxillary and mandibular scores.

The results of our study are contrary to Arapostathis et al. 2010, who reported more negative experiences with pressure anesthesia using INJEX as 73% children preferred the traditional needle method.[2] Similarly, Dabarakis et al. 2007, in their study reported only 17.6% patients' preference for pressure anesthesia; whereas 52.8% patients preferred classical injection technique.[6] Geenan L et al, 2004, also concluded that non needle phobia patients in their study did not prefer the needle free INJEX system above the classical local injection for restoration.[7] Makade et al.2014, with Madajet also demonstrated higher discomfort but significantly less fear with jet injection in adult patients.[2] Oliveira et al. 2019 with Comfort-In and Ocak et al.2020 with Injex on the other hand found no difference in pain during anaesthesia when comparing these devices with conventional anaesthesia.

Needleless jet injectors offer some advantages over traditional needle syringe, especially that it is fast and easy to use.[5] In this study, the onset of anesthesia on both buccal and lingual aspect with INJEX was much lower compared to Needle infiltration which is in accordance to the study by Sachin Makade, et al, 2014, where the total duration of anesthesia was significantly more ($P < 0.001$) with classical needle infiltration (mean 50 ± 9.32 min) when compared to pressure anesthesia (20.75 ± 3.53 min). However, Dabarakis et al, 2007, concluded that there

was no statistically significant difference between Injex and the needle injection technique in onset of anesthesia to achieve pulpal anesthesia.

Various anesthetic solutions such as lidocaine, articaine, mepivacaine with different concentration ranging from 2% to 5% have been used in previous studies. The type, amount and concentration of anesthetic solution along with the amount of vasoconstrictor affect the anesthetic result. Dabarakis et al. 2007, in their study found that 3% mepivacaine used with pressure anesthesia did not produce pulpal anesthesia.[2] Hence, in our study, 2% lignocaine with epinephrine 1:80,000 was used with both the anesthetic techniques for completion of scaling and root planing.

Bennett et al. 1971, in their radiographic and histologic study supported pressure anesthesia as it provides penetration and infiltration roughly comparable to that produced by needle injection to near 1 cm depth, with the use of quantities up to 0.2 ml/injection; as it is the concentration gradient of anesthetic solution diffusing into the surrounding tissue determines how much anesthetic reaches a nerve. According to literature provided by manufacturer very little anesthetic solution is needed to form a wheal which effectively gives adequate anesthesia to carry out restorative procedures. Hence, 0.3 ml of anesthetic solution was deposited buccally and lingually.[2]

There were few limitations experienced with INJEX. According to the manufacturer, the ampoule has to be placed on the attached gingiva at an angle of 90° directly above the tooth to be anesthetized. There was difficulty in positioning the device perpendicular to the gingival tissue, particularly in palatal/Lingual region. No problems were noticed during anaesthesia of the buccal aspect of the maxillary and mandibular anterior teeth and maxillary posterior teeth, while there was difficulty to adequately use the device for delivering anesthesia on the lingual/palatal aspect of these teeth which resulted in leakage of anaesthetic solution and bitter taste. This can be avoided if the anaesthetic delivering segment forms a 45° angle with the

mainbody of the device, as per MADAJET XL design, which may permit better and easier positioning to the gingival tissue such that there is complete contact of the entire device's tip surface with the gingival tissue, which may result in less chance of leakage of anaesthetic solution). Other limitation of the device that was experienced during the study is that the few subjects indicated fear during the delivery of anesthesia via INJEX due to "pop" sound, produced due to the release of pressure during the administration. Further, treatment procedures where wide area needs to be anesthetized, INJEX may not be ideal option for administering anesthesia as it can be used only for administering infiltration anesthesia.

Within the scope of the study, we may conclude that needleless jet injection (INJEX) can be considered as an alternative technique for administering infiltration anesthesia for Scaling and root planing.

Conclusion:

From the results of this study, it can be concluded that,

Pain was not there during administration of anesthesia using Jet Injector (INJEX) & the anesthesia procedure was comfortable. However, mild discomfort was experienced by the patient during administration of Infiltration anesthesia using classical needle injection.

Though pain during Scaling and root planing was not there with both techniques, INJEX induced anesthesia faster as compared to classical needle infiltration.

Overall, INJEX not only provided sufficient anesthesia necessary for Scaling and Root planing, but also made the process of administration pain-free. Thus, needleless jet Injector (INJEX) appears to show promise which can be explored with further studies.

The jet syringe might enable the patient to develop a more positive approach towards the dental treatment by eliminating his/her greatest fear & this too can be evaluated in future studies.

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Tables:

Table 1. Age and Gender

Table 1. Age and gender distribution among study subjects			
Variable	Category	n	%
Age	18-30 yrs.	6	20.0%
	31-40 yrs.	16	53.3%
	> 40 yrs.	8	26.7%
		Mean	SD
	Mean & SD	37.50	10.13
	Range	18 – 64	
Gender	Males	18	60.0%
	Females	12	40.0%

Table 2. Onset of Anesthesia:

Table 2. Comparison of mean duration of onset of Anaesthesia (in secs) on buccal & Lingual / Palatal region between 2 groups using Mann Whitney Test						
Region	Group	N	Mean	SD	Mean Diff	P-Value
Buccal	Group 1	30	32.52	11.97	-16.24	0.001*
	Group 2	30	48.76	19.41		
Lingual / Palatal	Group 1	30	28.62	10.47	-16.86	0.001*
	Group 2	30	45.48	19.40		

Table 3. VAS Scores between two groups

Table 3. Comparison of mean VAS scores during administration of anaesthesia & during SRP between 2 groups using Mann Whitney Test						
Time	Group	N	Mean	SD	Mean Diff	P-Value
During administration	Group 1	30	1.93	1.82	-0.97	0.03*
	Group 2	30	2.90	1.35		
During SRP	Group 1	30	0.30	0.54	0.17	0.06

	Group 2	30	0.13	0.51		

Table 4: VAS Scores among each group

Table 4. Comparison of mean VAS scores between during administration of anaesthesia & during SRP in each group using Wilcoxon signed rank Test						
Group	Time	N	Mean	SD	Mean Diff	P-Value
Group 1	During administration	30	1.93	1.82	1.63	<0.001*
	During SRP	30	0.30	0.54		
Group 2	During administration	30	2.90	1.35	2.77	<0.001*
	During SRP	30	0.13	0.51		

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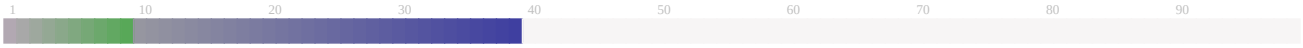

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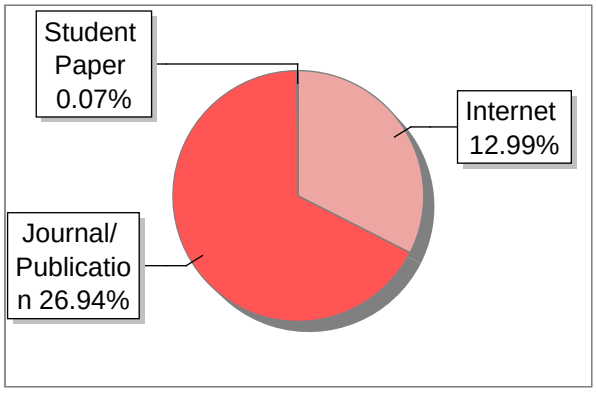

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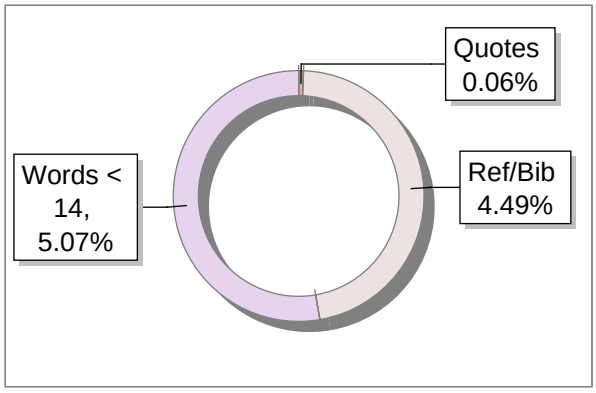

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INTRODUCTION

Laser is an acronym for light amplification by stimulated emission of radiation. If we had asked any one about lasers 10 years ago they would have told you about president regan's star wars space-based missile defense system, or may be about James bond almost being cut into two, by auric goldfinger's lasers or any number of science fiction scenarios. Today every one knows about lasers and each one could give you a different example of how one's friend underwent a laser surgery for his eye and does not need glasses, how a cousin had a laser gynecology surgery etc.

The truth is lasers are all around us not only in medicine, but in our daily life like for example check out glossaries at the super market, your C.D. ROM or a portable stereo. Now laser has finally made into dentistry through laser research in dentistry.

The first use of lasers in dentistry started in 80's lasers in dentistry is available today in different wavelengths and different mediums, regardless of the wavelength used, lasers offer a variety of advantages to the dentist. Also, the new laser systems available are small and less expensive compared to their older counterparts.

This dissertation tries to make an attempt to have a better under standing of working of lasers and their usage in various clinical situations, in dentistry.

HISTORY OF LASER

Light has been used as a therapeutic agent for many centuries. In ancient Greece, the sun was used in heliotherapy, or the exposure of the body to the sun for the restoration of health. The Chinese used the sun to treat such conditions as rickets and skin cancer. Indians in 1400BC used to use an exogenous photosensitizer to absorb light and render a therapeutic effect. The photosensitizer drug they used was psoralens, obtained from plants to treat vitiliogo. The Egyptians also used psoralens to treat skin diseases like leukoderma. In 1974, it was found that psoralens combined with exposure to ultra violet radiation were indeed effective in the treatment

of psoriasis and vitiligo. This use of light for treatment of various pathologies is referred to as phototherapy.

Einstein's atomic theories on spontaneous and stimulate emission can be credited as the foundation for laser technology. His article "The stimulated emission of radiant energy" published in 1917 is acknowledged as the main basis for amplified light.

Nearly 40 years later, American physicist Towens first amplified microwave frequencies by the stimulated emission process and called it as MASER (microwave amplification by stimulated emission of radiation).

In 1958 Schowlow and Towens discussed extending the maser principle to the optical portion of the electromagnetic field, hence it was called as LASER (Light Amplification by stimulated emission of laser)

In 1960 first working laser, a pulsed ruby laser that emitted light of 0.694 μm wavelength was developed by Maiman of Hughes Research Laboratories.

In 1961 Snitrer developed neodymium laser. This was the 2nd laser to be developed. Dental laser research began in 1963 at the University of California. First report of laser exposure to vital human teeth appeared in 1965, when Leon Goldman applied two pulses of ruby laser to the tooth of his brother, Bemard, who was a dentist. According to their report patients experienced no pain and there was only superficial damage to the crown (Goldman et al., 1965). Unfortunately results of other early dental research with ruby lasers were not as promising as this (Adrain, 1971). Most of the experiments produced unfavourable results, which may be attributed to the destructive interaction of ruby laser with dental hard tissues (Taylor et al., 1965). The histological studies of the effects of ruby laser showed that it was of little use as a dental tool (Thomas, 1967). This inspired most of the researchers to investigate high energy lasers which were needed for the removal of tooth structures.

Around 1980's the use of carbon dioxide laser came into existence with the wavelength of 10.6 μm. Studies showed that though it could be used to incise and coagulate tissues, its use to induce resistance to acid penetration of enamel could not be obtained. Attempts to use this laser for sealing of pits and fissures and for welding of materials such as

hydroxyapatite to enamel were unsuccessful, due to the excessive high temperature generated during the process (Stewart et al., 1985).

The first report of dental application of neodymium laser to vital oral tissues in experimental animals was that of Yamamoto and others from Tohoku University School of Dentistry in Japan (Yamamoto and Ooya, 1974). In a series of experiments it was determined that Nd:YAG laser was an effective tool for inhibiting incipient caries both in vitro and vivo (Yamamoto, 1974). In May 1990 Food and Drug Administration (FDA), U.S.A. cleared the use of Nd:YAG laser intraorally.

EARLY DENTAL LASER RESEARCH

Date	Investigators	Laser	Subject	Results
1963	Stern & Sonnaes	Ruby	Enamel & Dentin Effects	Un favorable
1965	Gold Man et al	Ruby	Vital Tooth (Case Report)	Promising
1968	Taylor et al	Ruby	Oral Tissue Effects (In vivo)	Un favorable
1971	Lobene et al	CO_2	Enamel and Dentin effects	Promising
1972	Adrian et al	Ruby	Pulp effects (in Vivo)	Un Favorable
1972	Stern et al	CO_2	Enamel & Dentin effects	Favorable
1974	Kantola	CO_2	Enamel & Dentin Effects	Favorable
1977	Yamamoto & Ooya	YAG	Caries prevention	Favorable
1977	Lenz et al	Argon	Surgical application (Case report)	Promising
1977	Adrian	Nd: YAG	Pulp Effects (In vivo)	Questionable
1980	Yamamoto &	Q-	Caries Prevention	Favorable

	Sato	switched YAG		

REVIEW OF LITERATURE

Sheldon Peck et al (1967) studied the observable effects of pulsed ruby laser irradiation on enamel and dentin. Several extracted non-carious maxillary central incisors were longitudinally bisected, yielding faciolingual cross-sections. Some of these sections were further prepared by removal of a portion of the lingual enamel, leaving a window of remaining dentin for direct laser penetration. An ivorine maxillary central incisor was selected as a control substance for laser impact. He also conducted tests to determine effect of the focused laser beam on air fired powdered porcelain. A ruby laser beam 6,943Å was focused by a plano-convex lens to a 1mm, target area. The normal enamel surfaces, after exposure to ruby laser beam shows funnel shaped cratering effect. The dentin showed dark, pinpoint speckling sub-adjacent to the based enamel. Direct laser impact into dentin result in a shallow, irregular crater surrounded by a diffused brownish black-pigmented area.

Thomas. E. Gordon et al (1970) described laser welding of fixed and removable partial prostheses done on the master cast at energy levels ranging from 6 to 12 joules, with pulse length of approximately 4m secs. The inaccuracies in assembly caused by transfers from master cast along with investment and heat distortion are avoided and (laser-welded joints had strength compatible with the adherent strength of substrate metal). Anatomic form of the inter proximal region is not obliterated with maximum esthetic in the anterior section of the mouth.

James. C. Adrain et al (1971) determined the histologic and morphologic pulpal response to laser irradiation and the relationship between the amount of energy deposited and the degree of pulpal response. The threshold of pulpal response to laser beam irradiation was in the vicinity of 2, 540 joules. In this study, graduated amounts of energy 1,870 to 3,300 joules /cm² were applied to the surface of the teeth. The resulting pulpal

response was examined and graded according to the following histologic criteria

Grade O, normal	: These teeth looked normal.
Grade 1, Minimum reaction	: Edema, Vascular dilatation, hemorrhage and occasional interstitial polymorpho nuclear leukocytes.
Grade 2, Moderate reaction	: Necrosis in the odontoblastic layer.
Grade 3, Severe reaction	: Generalized necrosis with additional features of minimum and moderate reaction.

Thus he concluded that pulpal responses were dependent on the amount energy deposited.

Ralph. H. Stern et al (1972) suggested that superficially lased dental enamel exhibited an increased resistance to penetration and demineralization when exposed to an acidic environment. Intact tooth enamel from humans was exposed extra-orally to a super-pulsed, Co_2 laser at energy densities of 10 to 15 joules / cm^2. The enamel exposed to lasers were caries free even though environment was conducive for caries.

John. M. Young (1977) described some of the dental applications of non-destructive laser imaging or holography. And used it to study the stress transmission in major connectors, using double-exposure interferometry. The final objective of this research was to develop scientific design criteria for constructing prostheses based upon the uniform application of the forces of occlusion to the supporting tissues.

Harvey Apothekev et al (1984) compared non-precious units that have been laser welded with those conventionally soldered. Seven identical bridges of three units were cast in an alloy composed of Ni, Cr, Mo & Be. One served as a control, while the remaining were cut in the same place of these three were soldered with a gas oxygen torch. The other three were welded with a Nd-YAG LASER. It was found both of them exhibited porosities but laser welded bridges showed superior strength properties close to uncut bridge.

Terry. D. Myers et al (1985) demonstrated that the lased enamel surface was more resistant to in vitro demineralization than non-lased

enamel. Thirty recently extracted human teeth with pit and fissure incipient caries lesions were used, clinical criteria for acceptability were visible staining, catch of an explorer and radiographic evidence that there was no involvement of the dentin. The teeth was cleaned with pumice and placed in an ultrasonic bath for 15 minutes. A mode-locked Nd:YAG laser model with a wavelength of 1060Å, a pulse energy of 3.4 mJ, a pulse duration of 30 psec (30 x 10^{-12} seconds), and a repetition rate of 1 pulse/sec was used. The lesion was divided in half; half was subjected to the YAG Laser, and half untreated to serve as control. During the actual lasing of the lesion, vaporization occurred with the formation of a small white cloud and a popping sound. This proved that the YAG laser has a potential to remove organic and inorganic debris from pits and fissures without causing pulpal or enamel injury.

R. Strang et al (1988) described that the laser is a device which is capable of producing an intense beam which is collimated, monochromatic and coherent and the possible benefits of the "soft laser" in dentistry and the guidelines on its safe use in dental practice, and its advantages over the conventional treatment procedures as it reduces bleeding, promotes wound healing and the procedure produces minimum pain.

Lyndon. F. Cooper et al (1988) evaluated the shear strength effect of laser pretreated dentin/composite bond. SEM analysis was also used to further study the lased dentin surfaces. Thirty intact, non-carious human molars were collected and washed in detergent, debrided of all soft tissue, and cleansed ultra sonically in de-ionized distilled water (DDW) for 5 minutes. The teeth were divided into 3 groups. Twenty teeth were obliquely sectioned from the buccal cusp tip to a point 1 to 2mm apical to cemento enamel junction (CEJ). Exposing a planed dentinal surface exhibiting a minimum diameter of 1cm. Ten additional molars were obliquely abraded on the buccal enamel surface to create a flat, polished enamel surface of not less than 0.6 cm in diameter. Of the 20 sectioned molar teeth, 10 were immediately stored DDW. The remaining 10 were mounted individually in modeling plastic and the cut dentin surface was laser-irradiated. The 10 lased and unlased dentinal sections were washed for 30 seconds in 2% sodium hypochlorite and rinsed for 30 seconds in DDW. Dentin samples were coated with Scotch bond adhesive twice and excess removed. The composite was placed into 0.45 mm diameter, and polymerized to lased and unlased surfaces. The mean shear strengths of lased dentin section to

unlased dentin sections indicated a 300% increase in bond strength of a self curing composite via scotch bond adhesive to the dentin surface. Thus he concluded that laser-irradiated dentin produced a surface morphology that enhanced the mechanical bond of the composite adapted to the undercuts and spaces between the dentinal projections in a manner similar to that of acid etching techniques on enamel and electro chemical etching of metals.

E.T. Neiburger et al (1988) measured the intensity of reflected Co_2 laser light and its thermal effects on adjacent structures. A Co_2 laser with 0.3 mm beam diameter, 0.5 second pulse and power density of 15,000 w/cm². The laser light was focused on a standard stainless steel periosteal elevator with both flat and curved surfaces; laser light was reflected it diverged, producing a larger but less energy dense beam. The reflected laser light was directed from the instrument to a strip of thermal adding machine paper that changed permanently to various shades of blue at different heat levels. Two methods were used to calibrate the temperature color change:

1. Thermal paper was wrapped around a thermometer and slowly exposed at various distances from a focused infrared heating lamp.
2. Thermal power was brought in contact with a soldering iron powered by a variable transformer. Using a thermometer attached to the soldering tip.

Varieties of heat exposures were recorded on the thermal paper. The paper burned (350 + °C) at distances of 1.0 to 5.0 cm. Charring occurred at distances of 5.5 to 6.0 cm. Dark blue color (53°C) appeared in the form of concentric circles at 7.0 cm. The color lightened (47°C) and the circle expanded at distances of 10 to 7 cm from the focal point. The color faded and was not recorded at distances farther than 17.0 cm. Thus because of the wide, circular, energy-dense patterns of reflected laser light produced reflective surfaces, it is necessary to widely shield operator adjacent tissues, and instruments.

Petra Wilder – Smith et al (1988) investigated soft laser treatment of hypersensitive dentin, gingivitis, pulp-capped teeth, herpes labialis, and nausea. The patients were evaluated for various symptoms. After treatment with laser, they showed no changes. These clinical trials demonstrated no advantage in augmenting or replacing conventional treatment of these conditions with soft laser therapy.

M.A. Pogrel et al (1989) described the ability of Co_2 laser to vaporize soft tissues with little bleeding, pain, swelling, or wound healing by evaluating the laser on 27 patients requiring soft tissue pre-prosthetic surgery, including frenectomies, tuberosity reduction, hyperplasia removal and sulcus deepening. And concluded that it had several advantages as follows: -

1. Laser surgery is precise and self-sterilizing.
2. It is relatively blood-less.
3. It is relatively pain-free.
4. Postoperative edema and swelling appear to be minimal.

T.L. HANSSON (1989) described the application of infra-red laser for the fast removal of intra-articular inflammation of TMJ in five different patients who did not respond to standard therapy. The parameters of clinical evaluation were maximum mouth opening and subjective pain. Infra red laser of 700 Hz frequency for 3 minutes was applied for five consecutive days on the skin over the painful area of the TMJ.

M.A. POGREL et al (1990) compared carbon dioxide laser, liquid nitrogen cryoprobe and conventional scalped excision for speed and mode of healing of the wounds created on the shaved abdomen of rats. Twenty-four rats under general anesthesia were used. The skin was subjected to three laser burns at 5W, 10W, and 20W with the use of a 1.0 mm diameter focused beam, Crywound was produced with the use of a 7.5 mm diameter round cryoprobe in a double freeze technique of 1 minute for each freeze with a 5 minutes thaw between freezes, and the 2 cm scalped incision was made. The rats were monitored at daily intervals and six killed at 1 day, 4 days, 7 days and 14 days respectively. Later the skin containing the wounds fixed in 10% buffered formalin and observed. Both laser and diathermy wounds were initially weaker than scalpel incisions eventually reached same strengths, laser wounds were the first to epithelialize, followed by scalpel wounds, with cryosurgery wounds the slowest to epithelialize.

M. Fentzen et al (1990) described that lasers are heat-producing devices converting electromagnetic energy into thermal energy. These lasers are used in oral surgery for cutting or coagulating soft tissues or in welding of dental prostheses. New types of lasers have offered non-thermal modes

of tissue interaction, called photoablation, photodisruption and photochemical effects.

Kenneth L. Zakariasen et al (1991) discussed the positive research findings about laser etching and laser preventive therapy and said that directing short bursts of laser energy at enamel surfaces is relatively simple task but the effects and safety is more complicated. He used both Co_2 laser and Nd:YAG lasers for his study. He said that laser etching could provide a more consistent etched surface than acid etching. And the laser treated enamel showed less surface demineralization.

M. Midda et al (1991) described that clinical lasers are two types; soft lasers act as an aid in healing. Surgical hard lasers can cut both hard and soft tissues and replace the scalpel and drills. The most commonly used laser systems, are the argon, Co_2 and Nd:YAG systems. The Nd:YAG engine provides hand-pieces of similar size to conventional instrumentation and are being fed by a fibre-optic 'cable' for intra oral use. The Co_2 laser is widely used in oral surgery. The procedures with lasers can usually be performed without a local anesthetic and sterilizes the area as it cuts. Further more the Nd:YAG lasers can be used for caries removal, endodontics and gingival curettage.

Laurence J. Walsh et al (1992) described the unique interactions of particular laser wavelengths with tissues and restorative materials. There is no one laser, which is suitable for use in all laboratory and clinical procedures in the field of implantology. All lasers are capable of generating thermal effects, considerations should be given to the extent to which energy will be absorbed or reflected by the target material, injudious use of lasers can cause thermal injury to implants as well as to bone and soft tissue.

Carl. M. Block et al (1992) examined the effects of laser irradiation in vitro

(1) On the surface properties of plasma sprayed titanium and plasma sprayed hydroxyapatite-coated titanium dental implants.

(2) On the potential to sterilize those surfaces after contamination with spores of Bacillus subtilis.

Surface effects were examined by scanning electron microscopy, energy dispersive spectroscopy, and x-ray diffraction after laser irradiation at 0.3, 2.0 and 3.0 W using either contact or non-contact hand pieces. Melting, loss

of porosity and surface alterations were observed on both types of implants with the lowest power setting. For sterilization study, both types of implants were first sterilized by exposure to ethylene oxide and then contaminated with spores of B. Subtilis. After laser irradiation, the implants were transferred to sterile growth medium and incubated. Laser irradiation did not sterilize either type of implant.

E. Jeff Burkes et al (1992) observed tooth structure and pulpal temperature changes in extracted human teeth subjected to a pulsed Er:YAG (2.94 μm) laser. Two teeth were irradiated while dry and three teeth while moistened by fine water mist. When the dry teeth were irradiated, there was minimal enamel ablation. SEM of the resulting surface showed rounded fragments of enamel rods, enamel melting, cracks and smooth-edged voids. Intra pulpal temperature measured by thermal sensor rose more than 27°C. When the laser application on the teeth was pulsed with a constant fine water mist, enamel and dentin were efficiently ablated. SEM of the resulting surface showed fissures and conical craters with sharp enamel projections remaining. Intrapulpal, temperature rose an average of 4°C. These results indicate that pulsed Er:YAG (2.94 μm) used with a water mist removes enamel and dentin without producing significant pulpal temperature changes.

Marylin Miller et al (1993) described the overview of laser systems and their dental applications. He stated that the recent developments in laser dentistry have led to an increasing acceptance of this technology by both the dentists and the general population. Hence we should balance our eagerness to apply these promising new tools with an appropriate measure of caution and safely measures.

Robert M. Pick et al (1993) described the important differences between lasers, there numerous clinical applications (Biopsies, removal of tongue lesions bloodlessly, exposure of implants, frenectomy and crown lengthening). And their advantages such as a bloodless operative and postoperative course.

Kim Kutsch (1993) concluded that all lasers are not created equally although there is obvious overlap, with Co_2, Nd:YAG and Argon lasers.

Lasers are the principal instruments for rapid cutting, minor tissue removal and polymerizing composite resins.

Joel. M. White (1993) studied the use of laser on dental hard tissues, evaluated restorations and tooth vitality in teeth treated three years earlier. All teeth remained vital and asymptomatic. Restorations placed after caries removal was intact and clinically serviceable. There was no histological evidence of pulpal reaction after one week or one month when enamel was exposed to laser, at laser parameters up to 3 W and 20 Hz (150 mJ/pulse) for two minutes.

Yoshio Yamagishi et al (1993) studied the welding of titanium with a normal pulse Nd:YAG laser. Laser welding is effective when performed in an argon atmosphere. The specimens were etched, and they were made to undergo a three point bending test and Vickers hardness test. There was a significant relationship between bending strength and the irradiation atmosphere, the irradiation ion intensity and the combination of atmosphere and intensity. Thus he concluded laser welding was effective when performed in an argon atmosphere.

Cary. H. Ganz (1994) designed a in vitro study to test the safety of Co_2 laser which he used around two different types of implant surfaces, hydroxyapatite coated and commercially pure titanium, in a pig mandible. He subjected the implants to specific amounts of laser energy and then evaluated for temperature change at five different sites. The Co_2 laser when used at clinically applicable power densities of 2 and 4 watts in continuous wave for up to 4 seconds did not cause a temperature change in excess of 7°F.

David. K. Oyster et al (1995) studied the temperature changes at the bone-titanium implant interface when Co_2 laser was used to:

1. Uncover the implant at second stage surgery.
2. "Decontaminate" exposed implant threads.

SEM was used to characterize surface changes of lased implants, either uncontaminated or contaminated with blood or saliva. He placed the first

sample of implants in fresh, pig mandible and covered with a flap of gingiva. The overlying tissue was removed with a Co_2 laser at different power levels. Temperatures were measured with thermocouple. In the second sample, 5 mm – 4 mm bony dehiscences were created and exposed fixture threads lased at varying times and power levels. SEM revealed no gross surface changes in lased uncontaminated implants, but laser treatment alone of contaminated implants failed to completely remove saliva or blood.

Robert. A. Convissar et al (1995) reported cases of dental lasers used as adjuncts to delivery of removable prosthetic care, and compared it to conventional techniques. He used lasers as adjuncts to removable prosthetic care in the following procedures.

1. Soft tissue tuberosity reduction.
2. Torus / exostosis reduction.
3. Treatment of denture stomatitis.
4. Removal of hyperplastic tissue.

The patients in these cases were treated with specific wave lengths of lasers, i.e. Co_2 or Nd:YAG, and this showed superior results than conventional methods.

James Q. Swift (1995) studied the heat generation of dental implants exposed to the Co_2 laser. A total of 90 trials were performed. A complete factorial (3 x 3 x 2) experimental design was used to evaluate the interactions among laser wattage output (4, 8 and 15 watts), duration of exposure time (1, 5 or 15 seconds) and variations in emission conditions (Pulsed or continuous laser mode). Linear increase in temperature greater than 50ºC was observed with increase in wattage output or duration of exposure time. The pulse mode generated significantly less heat. Thus caution should be used when using the Co_2 laser for second stage dental implant surgery.

WeiTe Victor Lee et al (1997) proposed a study to determine the fatigue life of metal ceramic alloy castings laser welded under three different conditions. Fifteen laser welded Olympia alloy (Au:51.5%; Pd:38.5%; In:8.5%; Ga:1.5%) were divided into three groups of five samples, with different gap distances between the welded halves (0.0mm gap distance, 1st group; 0.3 and 1.0 mm gaps respectively in second and third groups). Each sample was tested to failure in load fatigue at 30 Hz in a fatigue testing device using an applied stress of 35,000 psi. Analysis of variance showed

that the 0.0 mm gap specimens had the greatest number of cycles to failure. There was no significant difference between the other two groups. All failures occurred at the edge of the weld.

Mona K. Marci (1997) compared the effectiveness of a low energy laser used in the treatment of denture – induced mucosal lesions with conventional methods. 18 men were selected and divided into three groups of six according to the treatment (denture removal, relined dentures given with temporary tissue treatment and application of laser irradiations for the lesions while continuing to wear the denture). Oral hygiene and nutrition were maintained. Clinical histologic and densitometric assessment were made. The results revealed that lesions treated with laser irradiation exhibited clinically superior healing and increase in the optical density of bone underneath irradiated lesions. Thus the laser treatment on both soft and bone showed subsequent improvement of denture foundation.

Chengfei Zhang et al (1998) proposed the effectiveness of Co_2 laser therapy in the reduction and elimination of dentinal hyper-sensitivity in vivo and its thermal effects on tooth surfaces in vitro. Twenty-three patients with 91 sensitive teeth were irradiated with 1W, Co_2 laser in a continuous wave mode time ranging from 5 to 10 seconds. Hyper sensitivity was assessed by a blast of air from a dental syringe. Pain was subjectively evaluated on a scale ranging from 0 to 3 by the patient.

0 = No discomfort
1 = Mild discomfort
2 = Moderate pain
3 = Severe pain

Thermal effects were measured by thermography using 10 extracted human teeth after laser treatment. Co_2 laser treatment reduced dentinal hypersensitivity by 50% after 3 months with no adverse effects. Thermography revealed no temperature increase on irradiated tooth surfaces subjected to water coolant. Thus, he concluded that the Co_2 laser is useful in the treatment of cervical dentinal hypersensitivity without thermal damage to pulp.

Russel R Wang et al (1998) studied the reason for shallow welding-depth and extensive surface damage by using numerical heat transfer simulation for pure titanium material. Test cases using pure gold were

analyzed for comparison and a multiple-pulsed alternative method was also examined for pure Ti material. And he concluded that,

- With single-pulse laser irradiation on Ti, the increase in power cannot increase melting depth significantly, for the material cannot sustain such high heat flux. But gold does not have this problem due to its higher thermal conductivity.
- With moderate energy flux and proper duration of multiple-pulse laser irradiation on titanium, surface damage was minimized and depth of penetration of laser beam was significantly improved.

Tsongi Chai et al (1998) evaluated the mechanical properties of laser-welded cast commercially pure titanium under different laser welding conditions. Fifty-seven cast pure titanium specimens were divided into nine experimental groups and one control group. The sectioned titanium bars were laser-welded under different duration (8, 10 and 12 ms) and energy (290, 300, and 310 V) levels and evaluated for ranges of ultimate tensile strength (374 to 562 MPa) and percentage elongation (2.49% to 10.58%). The optimal duration and voltage (energy level) used in laser welding for cast commercially pure grade I titanium bar was superior or comparable with the un-sectioned control specimens.

Darunee P. Nanbadalung et al (1998) compared the tensile strength of electric-brazed and laser welded joints for a Co-Cr removable partial denture alloy. 24 Co-Cr standard tensile testing rods were prepared and divided into three groups of eight. All the samples in the control group were left as in cast condition. Group 2 and 3 were test specimens, which were sectioned at the center of the rod. Eight specimens joined by using electric brazing and remaining laser welding. After welding each joint was ground to a uniform diameter, then tested to tensile failure with an Instron Universal Testing Machine. The tensile strengths of the as-cast joints were higher than those for laser-welded joints, and both were higher than the electric-brazed joint strengths.

Torsten Jemt et al (1998) studied the clinical and radiographic performance of patients who received implants and fixed prostheses with laser-welded titanium frame works. Fifty-eight consecutive patients were treated with 349-osseointegrated implants and modum Branemark in the edentulous maxilla at 6 implant centers. The patients were arranged into 2 groups. Twenty-eight received laser-welded titanium frame-works and 30

patients received conventional cast frameworks. Clinical and radiographic analysis was done after 2 years. Patients treated with implant-supported prostheses fabricated with laser-welded titanium frameworks in the edentulous maxilla presented with no clinical or radiographic results to patients with conventional cast frameworks.

Shlomo Barak et al (1998) studied different types of implants that were placed in vitro in the mandible of pig and in vivo in mandibles of two dogs. In continuous mode, 4 and 6 watts, and in repeated pulse, 5 and 8 watts, for 2, 4 and 5 seconds, the Co_2 laser contacted several places around and on the implants. Temperature changes were measured at the implant bone junction. The results showed that the Co_2 laser produced minimal temperature changes in the continuous mode power setting at less than 4 watts and in the repeated pulse, 0.05 second-interval power setting at less than 8 watts.

Craig A. Wooten et al (1999) the aim of the study was to record the generation of heat in selected titanium implants while exposing them to super pulsed Co_2 laser mode and compared it with previous studies in which continuous and pulsed Co_2 laser modes were used. Titanium implants with cover screws were used in this study. The length of exposure ranged from 2 – 15 seconds, and wattage ranged from 3 – 15 watts. A thermo-coupler was used to record the temperature and it was directly related to the wattage and exposure time. Thus he concluded that super-pulsed Co_2 lasers generate significantly less heat with the 15 second, 15-watt trial as compared with continuous and pulsed laser modes.

Anders Ortorp et al (1999) compared the clinical performance of implant-supported prostheses with laser-welded titanium frameworks and prostheses with conventional cast frameworks. 824 edentulous patients were provided with fixed prostheses supported by implants in the edentulous mandible. In addition to conventional gold-alloy castings they were provided with 2 kinds of laser welded titanium frame works. All the patients were followed-up after 5 years. Cast frameworks had higher success rates, the overall titanium framework treatment was well in accordance with the result of cast frame works.

Kimuva V. et al (2000) reviewed the application of laser for the treatment of dentine hypersensitivity and their effect on pulp tissue. Four kinds of lasers were used for treatment of dentine hypersensitivity and their effectiveness ranged from 5.2 to 100%, which was dependent on the laser type and parameters used. The mechanism involved in the laser treatment of dentine hypersensitivity is not known. The efficiency for the treatment of dentine hypersensitivity using lasers is higher than other methods but it was less effective in severe cases.

Torsten Jemt et al (2000) compared the clinical performance of laser-welded titanium fixed partial implant-supported prostheses with conventional cast frameworks. Forty-two partially edentulous patients were provided with Branemark system implants and arranged into 2 groups. Group one was provided with a conventional cast framework with porcelain veneers on one side of the jaw and laser-welded titanium framework with low-fusing porcelain on the other side. Group two had an old implant prosthesis replaced by titanium framework prosthesis. The patient's were followed for 3 years. Clinical and radiographic analysis was done. The laser-welded titanium frame works presented similar clinical performance to conventional cast frameworks in partial implant situations after 3 years.

P. J. Coward et al (2000) studied if dimensional measurements of the ear could be determined with a laser scanning technique and whether or not the location of landmarks of the ear could be reliably measured with respect to those on the midline of the face. Computer-generated images were created from laser scans of 20 subjects. Dimensional measurements were made between landmarks on the ear and face. Differences between repeated dimensional measurements of the ear were very small as those dimensional measurements made between landmarks on the ear to the midline of the face. Differences between dimensions of the left and right ears of small amplitude were observed. Thus he suggested that the dimensions of the ear and its position with respect to landmarks in the midline of the face can be reliably measured on normal subjects and the laser scanning is a useful technique for planning and monitoring facial reconstruction of the ear.

John. G. Sulewski et al (2000) examined the effects of different wavelengths of laser energy on oral tissues. From soft tissue surgery to

restorative dentistry, from reshaping healthy gingiva to treating pathologic conditions, from routine procedures to experimental applications, he defined the limitation and the advantages of laser use in dentistry.

Donald. J. Coluzzi (2000) described the effects of dental lasers. He thought that it was important to be familiar with the principles, and then choose the lasers for the intended clinical application. He said that there was some overlap of the type of tissue interaction, and each wavelength had specific qualities that accomplish specific treatment objectives.

Janet Hatcher Rice (2000) described the use of lasers in reconstructive dental procedures (fixed, removable, or implant) and said that it provided more controlled environment at the operative site. Control is a prerequisite for successful prosthesis and this was accomplished by the unique ability of the laser to interact photo thermally with biologic tissues using the lightest touch or none at all. Hemostasis is the result of this interaction by coagulating and sealing small blood and lymph vessels and vaporizing soft tissue. This haemostasis allows for more exact soft tissue contours to replicate or improve the periodontium before reconstruction. He also mentioned biologic seal is a unique phenomenon that occurs in the jaws of peri-implant tissues of patients as a result of implant treatment and it is of paramount importance for longevity of the implant.

Charles. W. Wilcox et al (2001) measured the local heat effects created by use of unipolar surgical unit, a bipolar surgical unit, and a neodymium: yttrium- aluminum – garnet (Nd:YAG) laser. Temperature increase was measured during an in vitro implant uncovering surgical procedure performed with each unit. Variance for repeated measures was performed. Second, absolute temperature increase was compared with absolute clinical limit of a 10°C increase. Then he concluded that use of the unipolar surgical unit should be avoided and the judicious use of either bipolar unit or laser unit produce temperature profiles well within clinical limits.

C. Bertrand et al (2001) studied the accuracy, quality and reproducibility of a laser welding technique, which was applied to two Ni-Cr-Mo and Cr-Co-Mo alloys often used to make dental prosthesis. He used pulsed Nd:YAG laser equipment and various cast wires with different

diameters. The efficiency of joining was measured with tensile tests, with help of metallographic examinations and x-ray microprobe. He found a very slight change in the chemistry of the Ni-Cr-Mo alloys and tensile strength is decreased due to the micro-structural changes.

Herbert Deppe et al (2001) assessed the possible alterations in titanium implants in vitro and in vivo by use of Co_2 laser and determined whether new bone formation can occur on previously contaminated implants. In vitro, the temperature changes at the bone-titanium implant interface were recorded during use of Co_2 laser-scanning system. Additionally the effects of laser irradiation of various power settings on titanium implants were examined. In 6 beagle dogs, a total of 60 implants and bony defects resulting from plaque accumulation were treated by air-powder abrasive, laser irradiation, or both. Depending on the parameters chosen, melting and other surface alterations were seen in vitro, especially in the super-pulse mode. Otherwise, no alterations were found, even at high power settings in the continuous mode. In vivo, histologic examination of 4-month sections showed evidence of new direct bone to implant contact after laser-assisted therapy. The results supported the hypothesis that peri implant defects can be treated successfully by laser decontamination without damaging the surrounding tissues in the dog model.

L. Ceballos et al (2002) investigated the effect of Er:YAG laser irradiation on dentin shear bond strength and the ultra-structure of the resin dentin interface in superficial and deep dentin samples. The superficial and deep dentin from human molar teeth was acid-etched with 35% H_3Po_4, irradiated with an Er:YAG laser at 2 Hz and 180 mJ with water cooling and both. Single bond and Z-100 composite were bonded to the prepared surface. The specimens were tested in shear for failure; bonded interfaces were demineralized in EDTA and processed for transmission electron microscopy. Acid etching alone yielded shear bond strength values that were significantly higher than those achieved with laser ablation alone, or in combination with acid etching. The Er:YAG laser created a laser modified layer that adversely affects adhesion to dentin, so it does not constitute an alternative bonding strategy to conventional acid-etching.

Mathias Kreisler et al (2002) compared temperature elevations at the implant-bone interface during simulated implant surface decontaminated with a Co_2 and GaAIAs laser. Stepped cylinder implants with a titanium

plasma sprayed surface were inserted into bone blocks cut from pig femurs. An artificial peri-implant bone defect provided access for laser irradiation in the coronal third. Both lasers were operated at 1.0 – 2.5 W in the CW-mode. The bone block was placed into 37°C water bath in order to simulate in vivo thermal conductivity and diffusibility of heat. K-type thermocouples connected to a digital meter were used to register temperature changes. The critical threshold of 47°C was exceeded after 8 seconds at a power output of 2.5W, 13 seconds at 2.0W, 18 seconds at 1.5W, and 42 seconds at 1.0W with the GaAIAs laser and 15 seconds (2.5W), 23 seconds (2.0W), 35 seconds (1.5W), and 56 seconds (7.0W) with the CO_2 laser. Equal energy fluence, GaAIAs laser irradiation induced significantly higher temperature elevations. Surface decontamination with both laser types must be limited in time to allow the implant and bone to cool down.

Mathias Kreisler et al (2002) analyzed surface alterations in endosseous dental implants induced by irradiation with common dental lasers. Sandblasted and acid-etched, plasma sprayed hydroxyl apatite-coated, and smooth titanium discs were irradiated using Nd:YAG, HO:YAG, Er:YAG, Co_2 and GaAIAs lasers at various power settings. The samples were examined by scanning electron microscopy and energy dispersive spectroscopy. The pulsed YAG lasers induced partial melting, cracking and crater formation on all 4 surfaces, in the Co_2 laser caused surface alterations on the hydroxyapatite and plasma coatings as well as acid-etched surface. GaAIAs laser irradiation did not damage any of the surfaces. Nd:YAG and HO : YAG lasers are not suitable for use in decontamination of implant surfaces irrespective of the power output. With the Er:YAG and Co_2 laser the power output must be limited so as to avoid surface damage.

Herbert Deppe (2002) studied whether Co_2 laser – assisted decontamination of exposed implant surfaces is associated with an increase in titanium release. In 6 beagle dogs, a total of 60 implants were placed. After osteo-integration and second stage surgery, cotton floss ligatures induced peri-implantitis. Surgical treatment consisted removal of granulation tissue including decontamination of implant surface, by air abrasive powder (20 implants), laser treatment alone (20 implants), air-powder and then lased (20 implants). He analyzed titanium accumulation that could be detected especially in the spleen, liver, oral mucosa, regional lymph nodes, lung and kidney of the dog. But laser-assisted therapy of ailing implants did not result

in excessive titanium concentrations in tissue and thus Co_2 lasers appeared suitable and safe for peri-implant gingival surgery.

Orhum Dortbudak et al (2002) examined the effects of low-energy laser irradiation on osteocytes and bone resorption at bony implant sites. Five male baboons with a mean age of 6.5 years were used. Four holes for accommodating implants were drilled in each iliac crest. Sites on left side were irradiated with a 100 MW low-energy laser (1690nm) for 1 min (6 joule) immediately after drilling and insertion of four sand blasted etched implants and evaluated hestomorphometrically. The mean osteocyte count per unit area was 109.8 cells in the irradiated group Vs 94.8 cells in the control group. In the irradiated group, viable osteocytes were found in 41.7% of the lacuna Vs 34.4% in non-irradiated group. The osteocyte viability was significantly higher in samples that were subjected to laser irradiation immediately after implant site drilling and implant insertion.

Masatoshi Ishikawa (2002) described a new technique for the installation of magnetic keepers into abutment coping using laser welding. The magnetic stainless steel plate keepers were placed on the abutment copings, and interfaces between the plates and the abutment copings, are welded using laser-welder. The laser welding of keepers to over dentures offered a number of advantages like laser welding simplifies fabrication procedures, eliminate over contouring of the abutment coping and diminishes corrosion as laser-welding avoids extreme temperature changes. Thus the new technique for installing magnetic keeper is technically easy to accomplish and provides significant benefit to the patient.

T.J. Coward et al (2002) the aim of his study was to determine if laser-scanning techniques could be used to plan the construction of prosthetic ears as dimensional measurements between anthropometric points can be accurately measured on a screen image. Computer generated images were created from laser scans of 20 subjects. Frames of reference were constructed by locating a series of anthropometric points on the face from which three orthogonal planes were constructed. A central reference point was identified at the intersection of the three orthogonal planes. Dimensional measurements were made between anthropometric points on the ear and the references planes. The difference between anthropometric points and the reference planes on the left and right sides of the face were small. It was possible to describe the location of points three dimensionally

with respect to a central reference point. The development of frames of reference and a central reference point would appear to offer many advantages in the assessment and description of ear position for patients requiring reconstruction with prosthesis.

LASER PHYSICS

Lasers offer a lot of advantages to the clinician while working on it. Very precise control of laser output allows the tuning of time and wavelength to optimize the out comes of specific clinical procedures. Some types of lasers are useful for processing dental materials, some of them are useful for measuring blood flow and some are useful for many operative procedures etc.

Lasers are unique and versatile instruments by virtue of their physical characteristics. All the lasers have certain same characteristics like collimation, Coherence and monochromation. The laser beam that is projected onto the patient's tissue retains their characteristics. Therefore, if one is to learn how to apply laser energy to obtain desired result, then one must understand the laser fundamentals.

This chapter provides an overview of the basic concepts and characteristics of the laser, which are currently used, and under investigation.

Fundamentals of laser

The word laser is a shortening of light amplification by stimulated emission of radiation. A short explanation of each of these five words begins to explain the unique qualities of a laser instruments and in turn becomes the basis for further use of lasers.

Light is a form of electro magnetic energy that travels in waves at a constant velocity. The basic unit of this energy is called a photon or a particle of light. So, photons can be defined as the basic unit of light. Quanta of electro magnetic energy is classified as cosmic rays, X rays. Light, gamma rays, microwave or radio waves. The light may be ultraviolet, visible (violet, blue, green, yellow, orange, red) or infrared. Now a wave of photon can be defined by two basic properties. The first is amplitude, which is

defined as the total height of the wave oscillation from the top of the peak to the bottom. This is a quantity of the sum of energy in the wave, the greater the amplitude the larger the amount of energy. A joule is a unit of energy; beneficial quantity for dentistry is a milijoule, which is 1/1000 of a joule. The second property of a wave is wavelength, which is the distance between two consistent points on the wave. This is a measurement of physical size, which is significant with respect to how the laser light is distributed to the surgical site and how it responds to the tissue. Wavelength is measured in meters. Minor units of these measurements are microns (10^{-6} m) or nanometers (10^{-9} m). Additional property of waves is frequency, which is the measurement of the number of waves oscillation per second. So, frequency is inversely proportional to wavelength. The shorter the wavelength, the higher the frequency and vice versa.

The cosmic rays have extremely short wavelengths whereas radio waves (10-12m) have very long wavelengths (103 m). With current technology laser light covers the range from about 0.1 to 10μm. Most of the current types of clinical lasers plotted according to their wavelengths are shown in (Figure) notice that short wavelengths ultraviolet light is more energetic than long wavelength infrared. Ordinary light produced by a table lamp for example is usually a warm white glow. The white colour seen by human eye is really a sum of the many colour of the visible spectrum. The light is usually diffuse and not focused. Light produced by a laser has opposite properties. Laser has one specific colour called monochromatism and this finely focused precession of the monochromatic beam is due to 2 additional characteristics collimation and coherency.

Collimation: Refers to the beam having specific spatial boundaries. These boundaries ensure that there is a constant beam size and shape that is emitted from the laser unit. An X-Ray beam produce by an X-Ray machine used in dentistry is also collimated.

Coherency: Is property unique to lasers. The light waves produced by a laser are a specific form of electro magnetic energy. A laser produces light waves that are physically identical. They are all in phase with one another; that is they have identical amplitude and identical frequency. So a laser beam produces a monochromatic (although sometimes invisible) collimated and coherent beam of light energy.

An atom can absorb a photon (Figure) The photon then ceases to exist and an electron (e) within the atom jumps to higher energy level (e*). This atom is thus pumped up to an excited state from the resting ground state. In the excited state, the atom is unstable and will soon spontaneously decay back to the ground state releasing the stored energy in the form of an emitted photon. This process is called spontaneous emission. The interval between absorption and re-emission is usually very short. It has to be noticed that the spontaneously emitted photon has less energy (A longer wavelength) than the absorbed photon. The difference in energy is usually turned into heat. In any given atom only certain orbits (energy levels) are allowed. When a photon is absorbed, the atom jumps to one of the allowable energy levels. This means that each type of atom or molecule can absorb only photon of exactly the right energy (or wavelength). The result is that each species of atom or molecule has a unique absorption spectrum.

Light amplification by stimulated emission of radiation.

The Process of lasing occurs when an excited atom can be stimulated to emit a photon before the process occurs spontaneously. When a photon of exactly the right energy (or wavelength) enters the electro magnetic fields of an excited atom, the incident photon triggers the decay of the excited electron to the lower energy state. This is accompanied by the release of the stored energy in the form of a second photon. The first photon is not absorbed but continues to encounter another excited atom.

Stimulated emission can only occur when the incident photon has exactly the same energy as the released photon. Thus the result of stimulated emission is two photons of identical wavelength traveling in the same direction. If a collection of atoms includes more that are pumped up into the excited state than that remain in the resting stage, a population inversion exists.

This is a necessary condition for lasing. Now, the spontaneous emission of a photon by one atom will stimulate the release of second photon in a second atom and these two photons will trigger the release of

two more photons. These four will then yield eight, eight yields sixteen and so on. In a small space at the speed of light this photon chain reaction produces a brief intense flash of monochromatic and coherent light.

Laser components and beam generation.

The basic components of a laser are actually quite simple. They include a lasing medium placed with in the optical cavity, a pump energy source and a cooling system (Figure). To contain and amplify the photon chain reaction that results from stimulated emission in a population of excited atoms, it is necessary to place this reaction within the optical cavity. An optical cavity consists of 2 parallel mirrors placed on either side of the laser medium. In this configuration, photons bounce off the mirror and re-enter the medium to stimulate the release of more photons. If some form of energy is provided to continuously pump atoms to the excited state, the population inversion can be maintained and high intensity light circulation back and forth between 2 mirrors can be generated. The mirrors collimate the light that is; photon exactly perpendicular to the mirrors re-enters the active medium while those off axis leave the lasing process. Because the process is not 100% efficient and some energy is converted to heat, it is necessary to provide some form of cooling.

If one mirror is totally reflective and the other mirror partially transmissive the light that escapes through M1 becomes the laser beam, if our circulating power is 1000W and M1 is 10% transmissive then power returning from M1 is 900W and the exiting beam is 100W. A round trip through the lasing medium brings this power back up to 1000W.

The active medium contains the homogenous population of atoms or molecules that are pumped into the excited state and are stimulated to laser. The exact species of atom or molecules determines the wavelength of the output beam. The active medium is suspended in the optical cavity as a gas a liquid or distributed in solid state.

Thus stimulated emission within an optical cavity generates a collimated coherent and monochromatic beam of light. The laser is named for the contents of the active medium and their state of suspension. e.g. CO_2 gas laser or argon ion gas laser. The other types that are currently

available are solid state semiconductor made with metals, such as gallium aluminum and arsenide or solid rods of garnet crystal generally made from yittrium and aluminum to which are added the elements chromium, neodymium, holmium or erbium.

Beam profile and spot geometry

As shown in (Figure) there are more photons concentrated in the core of the beam and that the light intensity diminishes at the edges. Often in a well-tuned cavity the transverse cross section (Profile) is the normal gaussian curve. This is referred to as TEM00 (Transverse electro magnetic mode: 00) also called as fundamental mode. Other modes possible such as the donut mode (TEM10), which has a cold spot in center. The projection of the beam on target is called as spot. A Cross section of the beam is called the beam profile a common way of describing the spot geometry. The diameter of the spot is called as the spot size.

Power density

Power density is the concentration of photon in a unit area. Photon concentration is measured in watts and area is sq centimeters. Therefore

PD=W/Cm 2

Power density in the center of the spot is higher and that at the edge of the spot approaches zero. Power density can be increased significantly by placing a lens in the beam path. Because the light from the laser is collimated and monochromatic it is possible to force the power down to micrometer diameter spots. Lenses usually will not alter the beam profile, only change the power density.

The size and shape of the lens determines the focal length and the spot size at the focal point. Beyond the focal point the beam diverges and the power density decreases. The terms focused or defocused when working with lasers refers to the position of the focal point in relation to the tissue plane. When working on tissue, the laser should always be used either with the focal point positioned at the tissue surface or positioned above the tissue surface. The beam should never to be positioned with the focal spot deep or within the tissue as this can lead to deeper thermal damages and undesirable tissue defects (Figure).

Gating and pulsing

Surgical Lasers have a mechanical shutter positioned in the beam path (like a camera). Timing circuits control the opening and closing of the Shutter. Timing values are set by controls on the front panel control. The time sequence is activated when the user steps on the foot pedal, or in some units, presses the button on the hand piece. Single pulses can have durations such as 0.05, 0.1, 0.2, 0.5 and 1.0 sec, or the shutter can remain open as long as the pedal is depressed (continuous). Timing circuits vary in sophistication. Usually pulse duration can be set. And the time between pulses can be varied independently, changing the repetition rate. On some units, bursts of pulses can be delivered. (Figure)

Energy and energy density

For very short duration pulses, it often more practical to talk about the amount of energy per pulse in Joules (J), rather than the average output power in watts. Energy is actually the work that is done, or power applied for a period of time. A unit of energy, 1J, is equal to one unit of power (1 W) times one unit of time (1 Sec). Thus 100 J equals 100W applied for 1 sec, or 10 W applied for 10 Sec, Etc:

$$1\ J = 1\ W \times 1\ sec.$$

most clinical pulsed lasers deliver less the 1 J per pulse. Here the unit milijoule is used:

$$1\ J = 1{,}000\ mJ$$

a similar concept to power density is energy density. This is simply the amount of energy per unit area. Or, stated another way, energy density is power density applied over time.

Solid – state lasers

In a CO_2 gas laser, the lasing medium (N_2 and CO_2) is dispersed in the optical cavity in the form of a gas. In solid-state lasers, the lasing medium is suspended in a transparent crystal. A garnet crystal made from yttrium and aluminum is commonly used in a variety of surgical lasers called YAG lasers.

In the past, YAG laser was used to refer to the neodymium: YAG (Nd:YAG). However, three types of YAG lasers are currently being used or are under investigation for their dental applications. Although each uses a YAG crystal to suspend the lasing medium, they differ in terms of the rare earth element, neodymium, holmium, and erbium that are doped into the crystal. Each element has a different arrangement of electron orbital, so that lasing occurs at different wavelengths for each. The energy transitions in YAG lasers are more energetic than those in the CO_2 so that wavelengths are shorter in the near infrared.

The 10.6μm wavelength of the CO_2 laser must be delivered to tissue through a system of mirror and lenses. One advantage of visible light (e.g. argon) and near infrared (Nd:YAG and Ho:YAG) lasers is that they can be delivered through an optical fiber, therefore access within the oral cavity is improved. The fiber can be used either in contact with the tissue or withdrawn (defocused) and used in the non-contact mode. The Er:YAG wavelength is beyond the transmission window of conventional optical fiber technology.

Flash-lamp pulsing

A popular system in dentistry is the pulsed YAG (Neodymium, erbium, and holmium). In these systems, a flash-lamp is used to pump the lasing medium. As with the pulsed CO_2, peak Powers are higher since the energy is confined to short duration Pulses. The duration of the flash-lamp, typically 0.1 to 0.8m sec (100 to 800-psec), determines the duration of the output of the pulse.

Q-Switching

Even shorter duration pulses are achieved with Q-switching. A simple Q-switch uses a rotation mirror as part of the optical cavity (Figure). Only when the rotating mirror is precisely aligned with the output mirror is lasing possible, so lasing is restricted to a very short time interval (1 to 10n sec). Between alignments, energy is stored in the excited population. Thus, several hundred millijoules of energy can be squeeze into nanosecond pulses.

LASER INTERACTIONS WITH BIOLOGIC TISSUES, HARD TISSUE AND DENTAL PULP

Laser interactions with biologic tissues

The effects of laser emissions on biologic structures can, to some extent, be evaluated in terms of what occurs when radiant light energy reacts with matter. Other reactions of tissue to laser light involve biologic and physiological processes of tissue, which are more complex in nature and reflect a more intricate interrelationship. Also the biologic factors that influence laser tissue interactions are very extensive. Included among these are the optical properties of various tissue elements that govern how specific molecular and chemical components in tissue react with light energy.

The optical properties of tissue elements determine the nature and extent of the tissue response through the processes of absorption, transmission, reflection, and scattering of the laser beam, other factors involved are the various types of physiologic and mechanical processes that occur as a result of energy transformations within tissue. These include heat conduction and dissipation within the tissue mass, the inflammatory response of tissue to noxious stimuli, tissue vascularity, and repair mechanisms.

The amount of the interaction of laser light as a form of radiant energy with tissue will commonly be determined by two dependent variable: the optical characteristics of the particular target tissues and specific wavelength of the laser emission; and Independent factors to be considered, which are under the control of the clinician, include the level of applied power (power density), the total energy delivered over a given surface area (energy density or fluence); the rate and duration of the exposure (pulse repetition rate, and pulse duration), and the mode of delivery of the energy to the target tissue (i.e., continuous vs. pulsed; contact vs. non contact). Manipulation of these four variables (power output, spot size, fluence or total light dose, and mode of operation) will enable the operator to have precise control over the laser in the clinical setting to achieve the desired tissue effect when coupled with the ability to select the appropriate wavelength for the particular tissue target.

Optical properties of tissue and wavelength specificity

Radiant energy will interact with tissue in four ways (Figure) first; a portion of the incident beam may be reflected off the surface without penetration or interaction of light energy with the tissue. Second, portion of the light may be transmitted through the tissue unattenuated as if transparent to the laser beam, Third, some light may be absorbed into a component of the tissue, in which case there will be transference of energy to the tissue. Fourth, the remaining light may penetrate tissue and be scattered without producing a noticeable effect on the tissue.

In complex biologic systems which composed of a great variety of cellular elements and tissue fluids, each with differing optical absorption characteristics, predicting the effect of specific laser emissions may at first appear to be problematic. Fortunately, oral soft tissue is largely composed of water, which predominantly controls the infrared spectrum such as CO_2. This means that CO_2 laser energy at a wavelength of 10.6μm is absorbed very efficiently by tissue fluids and has little penetration beyond the surface. On the other hand, water is relatively transparent to the emission of the Nd:YAG Laser, which accounts for its predisposition to penetrate deeper into tissue.

Tissue elements that exhibit a high coefficient of absorption for particular wavelength of spectra of light energy are called chromophores. In fact, all matter has this property of absorption specificity, which controls how it will react to incident radiation. Other chromophores within tissue such as hemoglobin and melanin pigments also exert a significant influence over the interaction of radiant energy and tissue. Hemoglobin readily interacts with 488 and 514-nm wavelength, thus accounting for the greater ability of the argon laser for coagulation and hemostasis.

Hydroxyapatite is a natural component of enamel, dentin, and bone, comparisons of the absorption. Transmission, and scattering spectrographs of the four materials reveal marked dissimilarities between the pure synthetic and biologic materials. These differences may in part be attributed to variations in the percent composition of hydroxyapatite among the biologic materials or due to other more dominant soft tissue components affecting their optical behavior. In soft tissue, the effects of specific laser wavelengths are quite predictable due to the high absorption of energy of specific

wavelengths by tissue chromophores of differing optical properties. Preferential absorption by chromophores of particular laser wavelengths provides for a phenomenon of laser tissue interaction known as wavelength or target specificity. Laser hard tissue interactions on the other hand are more unpredictable due to the limited amount of information presently available related to these types of interactions.

Tissue effects of laser irradiation

When radiant energy is absorbed by tissue four basis types of interaction can occur: 1) Photochemical interactions 2) Photothermal interactions 3). Photo mechanical interactions; and 4) Photoelectrical interactions. Because of great number of clinical effects observed with these four types of interactions, they may be further subdivided according to how they manifest in clinical application as follows. Photochemical interactions include biostimulation, which describes the stimulatory effects of laser on biochemical and molecular processes that normally occur in tissues such as healing and repair; photodynamic therapy (PDT), which is the therapeutic use of laser to induce reactions in tissues for the treatment of pathologic conditions; and phosphorescent re-emission or tissue fluorescence, which may be used as diagnostic method to detect light-reactive substances in tissue. Photothermal interactions manifest clinically as photoablation, or the removal of tissue by vaporization and superheating of tissue fluids; coagulation and hemostasis; and photopyrolysis, or the burning away of tissue. Photomechanical interactions include photodisruption or photodisassociation, which is the breaking apart of structures by laser light; and photoacoustic interactions, which involve the removal of tissue with shock-wave generation. Photoelectrical interactions include photoplasmolysis, which describes how tissue is removed through the formation of electrically charged ions and particles that exist in a semi-gaseous, high-energy state.

Various types of tissue responses that result from exposure to laser energy, irrespective of wavelength, can be categorized over a theoretical range of exposure times and power densities (Figure). Generally, laser light emissions of relatively low intensity and long duration are less destructive and induce their effects at the cellular or molecular level, producing

photochemical effects. One may summarize from this relationship between power density and exposure duration that potentially there could be a minimal level or threshold of energy required for specific types of interactions to occur.

Photochemical interaction

The basic principle of the photochemical process is that specific wavelengths of laser light that are absorbed by naturally occurring chromophores or wavelength-specific, light-absorbing substances that are able to induce certain biochemical reactions at the cellular level in both plants and animals, research has also shown that derivatives of naturally occurring chromophores or dyes can be used as photosensitizers to induce biologic reactions within tissue for both diagnostic and therapeutic applications.

A common example of a naturally occurring photochemical reaction is photosynthesis, where photons are absorbed by the chromophore, chlorophyll, to convert light energy into adenosine triphosphate (ATP). The process may be simplified by the chemical formula:

$$6C0_2 + 6\ H_20 \xrightarrow[\text{Light energy}]{\text{Chlorophyll}} C_6H_{12}0_6 + 6\ 0_2$$

When carbon dioxide and water through a series of reactions are converted to glucose and oxygen. In the process, one electron of the chromophore, chlorophyll, absorbs light energy and becomes elevated to a higher energy level. The absorbed light energy becomes transformed into chemical energy by a process of photophorylation, which converts adenosine diphosphate (ADP) into ATP. The stored chemical energy is then used for the reduction of carbon dioxide and synthesis of glucose. The same principle is the basis for the type of photochemical reactions that occur in PDT and biostimulation. In PDT, the chromophore or photosensitizer, HpD absorbs photons it – becomes excited to a higher energy wavelength, HpD promotes destruction of the tumor cells by release of singlet oxygen.

PDT has recently been applied for treatment of port wine stain. Here a photosensitizer and red light are used to induce photochemical destruction of subsurface blood vessels in the skin with a high degree of specificity.

Another example of PDT is laser angioplasty for the treatment of atherosclerosis. In this application, the removal of arterial plaque is facilitated by laser irradiation delivered through an optical fiber. While still under development, the potential use of photosensitizers to induce selective absorption of the beam may reduce the risk of vessel perforation.

Laser-induced photochemical reactions such as tissue fluorescence of phosphorescent re-emission may also be used for diagnostic purpose. Fluorescent tissue interaction or phosphorescent re-emission occurs when light energy is absorbed by specific molecules or tissue components that momentarily store and subsequently release the energy again as light. The absorbing tissue component acts as a biologic capacitor without undergoing any permanent transformation. The process of tissue fluorescence or phosphorescent re-emission is called photochemical decomposition. Certain oral tissues exhibit auto fluorescence when stimulated by specific wavelengths. Generally, some energy is lost in the process during decomposition and therefore the re-emitted photon has a somewhat lower energy level than that of the incident radiation. This can be observed by the slightly longer wavelength of the fluorescent radiation. The entire process of phosphorescent re-emission occurs in less then 10^{-6} seconds. Recent research has demonstrated that laser-stimulated tissue fluorescence may be a viable method for the detection of caries. Other potential applications of tissue fluorescence include the use of photosensitizing dyes for the enhancement of absorption of particular wavelengths to induce destruction of microorganisms and for other tissue interactions.

Photothermal interactions

At somewhat higher fluencies (1 to 10000J/CM^2) and shorter exposure times (1 to 10^{-6} Sec), photothermal interaction with tissue occurs. This class of interaction is the basis for most types of surgical laser applications. Because of its importance, extensive research has been performed to identify the biologic response of tissue attributed to the effects of heat generation from laser irradiation.

In photothermal interaction, radiant light energy absorbed by tissue substances and molecules becomes transformed into heat energy, which produces the tissue effect. The amount of laser light energy absorbed into

tissue depends on a number of factors that include: the wavelength of the radiant energy from the laser; the laser parameters such as spot size, power density, pulse duration and frequency; and the optical properties and composition of the target tissue. It is important to recognize that each parameter of the laser beam significantly affects the nature and extent of the interaction with tissue. Thermal interactions are largely wavelength-dependent because the amount of heat generation in tissue is determined by the extent of preferential absorption of the beam attributable to wavelength and target specificity. Tissue pigments and other chromophores are selective absorbands for some specific wavelength of laser emission, while other primary absorption regions for biologic molecules fall within the range of short wavelengths below 300 nm. Many biologic molecules have specific vibrational and rotational absorption bands for wavelengths within the infrared region (wavelengths >1 μm), and in the visible spectrum. Additionally, the high water content of most oral soft tissues contributes to extensive absorption of radiant energy in the infrared region.

The CO_2 laser beam is highly attenuated by intracellular water within oral soft tissue. Because of this 90% of the incident energy of the CO_2 laser is absorbed within the first 100 μm of penetration of the tissue surface (Carruth and McKenizie, 1986). The high absorption of the 10.6μm wavelengths by tissue fluids leads to rapid vaporization (boiling) of the water component and pyrolysis (charring and burning) of the organic matter within the target tissue. These types of thermal interactions are observed with the CO_2 laser even at moderately low power densities (>100 W/Cm²) when using a focused beam. The erbium laser has an even greater coefficient of absorption in water (8,000/cm) vs that of the CO_2 laser (770/cm) for comparison. Based on difference in water absorption alone, wavelengths such as Nd:YAG, with a coefficient of absorption in water of 1.8/Cm, would have a calculated minimum boiling threshold of 42,800 W/CM² power density to achieve the equivalent clinical effect (Fisher, 1993). Other wavelengths such as Nd:YAG and argon however are more strongly absorbed by blood hemoglobin, melanin pigments, and other tissue components, which contribute to their thermal effects. With some wavelengths, exogenous dyes can be used to enhance absorption in tissue to induce interaction that otherwise might not occur. The mechanisms involved are not unlike those observed with endogenous pigments or other tissue chromophores.

Thermal interactions in tissue generally appear to take place almost instantaneously, however, a description of the temporal evolution of the thermodynamic processes occurring will provide additional insights into the mechanisms involved. Initially, absorbed laser light (Photon energy) induces electronic or molecular excitation of structures in the tissue. An important condition of this to occur is that the absorbing molecules of the target tissue have an energy level structure similar to the wavelength of the incident laser beam. In later stages, heat energy within the tissue mass is dissipated to surrounding structures by processes of thermal diffusion and conduction. Heat dissipation or diffusion from the site is a function of the thermal conductivity of the tissue and will ultimately determine the extent of collateral damage observed adjacent to the wound. The time required for diffusion of heat or thermal relaxation time (TRT) for a given type of tissue is also related to its composition and vascularity and another characteristic property of the type of tissue. Thermal relaxation time is defined as the time required for the accumulated heat energy within the tissue mass to cool to 37% of its original value (Harris and Werkhaven, 1989). The Degree of heat conduction to adjacent tissue and rate of tissue cooling are two important factors in determining the extent of the thermally affected area and collateral tissue damage. This area is sometimes referred to as the thermal damage envelope for a given wavelength and tissue type.

The Degree of collateral damage depends to a great extent on properties of the tissue that are related to its structure, composition, and water content. Other tissue factors that influence the extent of thermal damage are tissue vascularity, the volume of the irradiated tissue, and its surface area. These factors will have a direct influence on the rate at which heat is dissipated from the affected area by both passive and active mechanisms. For long laser exposures in particular, convection cooling by blood flow through regions adjacent to the target area plays an important role (Barms, 1975). For shorter exposures on tissue surfaces, excess heat energy generated during the exposure is more easily released to the overlying air and surrounding tissue by passive conduction mechanisms.

Another important tissue factor influencing the extent of the thermal damage zone is the relative degree of absorption and scattering of the beam once it enters tissue. While much information has been gathered about the

absorptive properties of the various types of tissue, little is known about scattering of the beam within tissue. Scattering can directly increase the extent of collateral tissue damage by spatial redistribution of the beam into a larger volume of surrounding tissue that would be affected by a more localized absorption. Much of the scattered energy from the beam is transformed into heat energy within the tissue since it has insufficient power density to induce vaporization. While the scattered component of the beam retains the same wavelength as the incident beam, the intensity or power density of the scattered radiation decreases with distance exponentially.

Tissue dehydration also plays a significant role in the thermal interaction of laser with tissue. Laser-induced dehydration of tissue is a natural sequelae of the heat generated within the thermally affected area. Laser-induced changes in the composition and other optical properties of tissue, such as charring, coagulation of blood elements, and protein denaturation, can thereby alter the nature of subsequent interactions that might occur. Carbon arcing is one example of a laser-induced modification of target tissue that interferes with further tissue ablation and contributes to excessive heat generation. Carbon arcing can occur as a result of photopyrolysis of organic matter. Carbon, which is the end product of the burning of tissue and a high absorber of all wavelengths, readily forms on the surface during the initial phase of laser tissue ablation. If lasing is continued, the carbonized layer that is formed will preferentially absorb the incident beam, preventing further tissue ablation. Instead the carbonized material, which burns at approximately 3,200°C, acts as a heat sink transferring thermal energy to surrounding tissue and thereby increasing the zone of collateral damage.

In most clinical situations it is desirable to minimize or control the extent of collateral damage to surrounding tissue. Extensive research has been performed to establish practical and effective methods to minimize and control the undesirable effects attributed to the thermal interaction of tissue. The size of the thermal damage envelope created by a laser in a particular tissue to some extent may be controlled by the laser operating parameters such as spot size, exposure duration, pulse repetition rate, and the duration of the pulse. If the thermal effects to tissue are controlled by spot size, then power density is the modified parameter. The focused laser

beam in this case can be used to produce a well-localized hot spot, which may be essential for some applications such as incision and excision.

The temporal emission mode of lasers describes those parameters that control the time and rate of delivery of energy to the target such as exposure duration; pulse rate, pulse frequency, or pulse repetition rate; and pulse width or duration. For continuous wave laser emissions, the energy is deposited without any thermal relaxation time and therefore has a linear relationship directly proportional to the total time of the exposure (Miserendino et al 1989). A pulsed beam is delivered in bursts or intervals, which provides brief moments for heat dissipation or cooling between pulses. Pulsing may be controlled over a wide variety of frequencies and duration to limit the extent of heat dispersion to surrounding tissues or to induce other types of tissue effects. Ultrashort pulses within the picosecond and nanosecond range compress the output of the laser beam to achieve very high peak powers that are capable of inducing other non-thermal types of interactions such as photoplasmolysis and photodisruption. Superpulsing, Q-switching, and mode locking are some example of the variety of lasers with the temporal emission modes necessary for inducting these types of non-thermal interactions.

The relationship between the various temporal emission modes (continuous, pulsed, superpulsed) and the level of heat dispersion to surrounding tissue can be illustrated by a theoretical graph of the expected temperature rise resulting from a 1-sec exposure for three modes of delivery of the same total energy. In general, it can be assumed that continuous wave exposures and longer pulse widths will result in a greater heat transfer to surrounding structures than that for shorter pulses. Conversely, longer intervals between pulses (lower pulse repetition rate) will produce less heat generation in adjacent tissue. While these generalities may hold true for laser interactions with oral soft tissue, the relationship with dental hard tissue such as enamel and dentin may differ substantially most likely due to the differing properties of heat conduction and diffusion between the two tissue types. The effects of pulse width on heat transmission within soft tissue are described in an interesting study by (Armon and Laufer, 1985). They observed that longer pulse durations (> 1 sec) produced a larger damage envelope adjacent to the crater than that produced by shorter pulses (1 Millisecond) for the same energy of exposure (1 J).

Other methods used to limit or control the extent of collateral damage to hard tissue have been explored, Such as cooling and pre-cooling of the target area. According to theoretical models of thermal interactions with teeth (Boehm et al, 1977). Once laser parameters have been fixed and the optical properties of the tissue are known, thermal distribution within tissue can be minimized by cooling or pre-cooling of the irradiated area; but no clinical applications have been proposed. Wakaki studied the possibility of using nitrogen to cool and pre-cool feline skin tissue that was irradiated with a Co^2 laser. When the thickness of the scars was measured, the results demonstrated an improvement in quality and period of healing for areas lased and cooled. However, this method has not been used.

In 1988 Levy (US patent no. 5,020,995) proposed another concept for hard and soft tissue applications by using an Nd:YAG (1,064 nm) pulsed laser beam in combination with an air-and-water spray as a transparent medium for the beam. This concept was applied in studies performed on soft and hard tissues (Levy, 1991). Rizoiu and Levy (1993) showed the benefits of using an air-and-water spray to cool the tooth structure during exposure with an ND:YAG pulsed laser beam, They demonstrated that a spray of air and water as a coolant is more effective than only water or only air.

Thermal effects of laser irradiation range in intensity depending on the level of temperature rise within the target tissue. Tissue changes may be either transient or more enduring. Temperatures below 60°C generally will manifest as tissue hyperthermia, which for short durations of exposure will not produce lasting or irreversible tissue effects. Between 45^0C and 50^0C, enzymatic changes occur and edema develops. Above 65^0C, protein denaturation occurs accompanied by coagulation of blood elements with exposures of a few seconds duration or longer. Below 100^0 C, tissue dehydration or desiccation is observed, which clinically appears as a whitening or blanching of tissue. At temperatures above 100^0 C, Superheating occurs producing rapid vaporization of tissue fluids resulting in tissue ablation and shrinkage or contracture of the adjacent area. Continued lasing of the area results in temperature elevation to several hundred degrees where upon tissue vaporizes, carbonizes, and burns (Frank, 1989).

The thermal response of tissue to a surgical laser exposure is best described with the CO_2 surgical laser wound as an example. When a single pulse of 15,000 W/cm² or greater is applied to oral mucosa. Vaporization of water at the tissue surface occurs. Rapid expansion at the exposure site causes elevation of the superficial epithelium, which subsequently ruptures, releasing both vapor and tissue particles. The net effect is ablation of tissue resulting in the formation of a craterlike defect on the tissue surface. Superficially, the laser crater appears as a circular hole. In cross section, the crater appears as an inversion of the gaussian beam profile (Figure). The greatest depth of penetration of the crater into tissue is represented by the center of the focal spot of the beam or point of greatest power density. Surrounding the defect are relative zones of tissue damage, which decrease in intensity toward the periphery. A diagrammatic section through the crater reveals the various zones of tissue interaction as they extend outward from the wall of the crater towards the unaffected tissues.

Lining the crater wall is a layer of carbonized tissue residue. Immediately adjacent to this carbonized zone is a layer of coagulation and thermal necrosis of approximately 0.5 mm thickness, adjacent to this zone of thermal necrosis and extending outward is a zone of edema and hyperthermia, which will vary in thickness depending on the duration of the exposure or total light dose delivered to the tissue.

The depth of penetration of the beam will be a function of the physical properties of the particular target tissue, the wavelength, and the power density of the emitted beam. The degree or rate at which power density is diminished as the beam is projected deeper into tissue is determined by the attenuation coefficient (A) of the specific type of tissue. In most media, attenuation is an exponential function that is the laser beam loses a constant fraction of its intensity as it travels through the medium. The attenuation coefficient for a particular medium can be derived from a mathematical formula known as Lambert's or Beer's Law, which states that the absorption of a medium is directly proportional to the concentration of the absorbing element. Theoretically, penetration of the beam into medium continues indefinitely; however, in practical terms there is a specific distance at which the power density of the beam becomes reduced to a level where it no longer is capable of inducing interaction. This distance has been arbitrarily defined as the extinction depth of the laser beam. Extinction

depths for various wavelengths and media are generally calculated at the distance where the intensity of the beam is reduced to 1 % of its power density at the surface.

Therefore the optimal parameters for exposure of a given tissue required for ablation will be determined by: 1) The specific wavelength of absorption for that tissue; 2) The threshold power density required for ablation; and 3) Exposure parameters that take into consideration the absorption characteristics and thermal relaxation time of the specific tissue.

Photomechanical and photoelectrical interactions

Photodisruption, Photodisassociation, Photoplasmolysis, and photoacoustic interactions are terms used to describe specific types of essentially non-thermal processes of laser-tissue interactions characterized by ultrashort pulse ($<10^{-6}$ sec) of very high energy density. The high energy levels and rapid absorption that occur during photoablation by these processes result in rapid expansion or generation of shock waves that are capable of rupturing intermolecular and atomic bonds. Mechanical disruption or the breaking apart of matter by acoustic shock waves is accomplished by conversion of high intensity light (photon) energy to Vibrational (kinetic) energy. Very high peak energy and ultrashort pulses are required to generate non-thermal photoablative interactions, therefore only pulsed lasers with very high photon energy and short wavelengths (< 319 nm) have this capability. Photodisruption occurs whenever the photon energy of the incident beam exceeds either the atomic or intermolecular bond energies of the target tissue.

The process involved for photodisruption to occur can be divided into three interrelated mechanisms or phases: ionization, plasma formation, and shock wave generation. Ionization can occur in tissue at very high-energy densities-when the electric field strength of the beam becomes high enough to ionize atoms. The level for the field strength, which binds the outer shell electron of an atom to its nucleus, determines the threshold value for the field strength necessary for ionization. Once ionization occurs, a hot electrically charged gas of free electrons and positive ions, or plasma, is formed. The plasma itself is maintained by absorption of energy from the incident beam reaching temperatures in excess of 15,000^{0}C. As the

temperature fluctuates within the electric field from the laser, electrons within the plasma begin to vibrate, creating a rapid expansion and contraction that leads to generation of shock waves that can be heard as a sharp popping sound. The pressures exerted by the acoustic shock wave on the target are responsible for the mechanical breaking apart or shattering of the target material observed during photoplasmolysis. Since it is a strong absorber of all wavelengths, the plasma acts as shield preventing further penetration of the beam to the target tissue.

Only lasers that have high absorption in tissue and create extremely high power densities are able to produce the energy levels necessary to induce photoplasmolysis. Most biologic tissues readily absorb radiant energy within the ultraviolet spectrum. Laser of this variety such as excimer has been shown to interact with dental hard tissue in a manner that results in minimal thermal effects (Stabholz et al, 1992; Neev et al, 1992). Other lasers with high peak energies and ultrashort pulse widths such as the Q-switched YAG laser are also capable of inducing non-thermal photoablative interactions they may have potential application to dental hard structures.

LASER EFFECTS ON DENTAL HARD TISSUE

Only a few years after the discovery of the first ruby laser, investigations were performed to introduce laser technology into dentistry for "optical drilling" of teeth. Goldman and Stem carried out basic investigations on the effects of laser impacts on teeth in the 1906s. Basic studies with Nd:YAG and CO_2 lasers followed in the 1970s. As a result of these investigations unavoidable disadvantages such as damage to the dental pulp, carbonization of dentin, and crack formation in enamel were discussed as limitations in cavity preparation. Reviewing the early papers, Stern concluded in 1974 that laser technology may not replace the conventional drill unless heat-related structural changes and damage to the surrounding dental tissues could be reduced dramatically by new laser systems. Since then, further developments in laser technology have steadily been made. Today more than ten different laser types are used in dental research. A basic knowledge of laser effects is essential to decide whether laser applications really do offer new possibilities for advancement.

Models of laser-tissue interaction

The interaction of laser light with living tissues is the interaction of photons with the atoms or molecules of the target. These interactions are followed by very complex reactions, and the involved mechanisms are not yet completely understood. In the field of mineralized tissue, the most thoroughly investigated interactions are the photothermal and thermo-mechanical interactions and the ablative photodecomposition.

Optical properties of hard tissues

In terms of the optical properties, enamel and dentin are thought to be optical systems with wave guiding, scattering, and absorbing elements. Many effects caused by these optical elements are grossly unknown. The absorption and transmission of laser light in human teeth is mainly dependent on the wavelength of the laser light. Ultraviolet (UV) laser light is well absorbed. However in the mid-infrared spectrum, the absorption in

water and in hydroxyapatite (HA) changes tremendously depending on the wavelength of the laser light. In water and in HA, there is a very low absorption at a wavelength of 2µm in comparison to the high absorption of laser energy at 3µm and 10µm. At 1µm, the absorption in water and in HA becomes about 10,000 times less than that at 3µm (Hale and Query, 1973; Nagasawa, 1983; LeGeros, 1991).

Thermal effects

The best-known laser effect in dentistry is the thermal vaporization of tissue by absorbing infrared laser light. The laser energy is converted into thermal energy or heat that destroys the tissue. The laser beam couples to the tissue surface, and this absorption leads to a heating with denaturation at about 45°C to 60°C. Above 60°C Coagulation and necrosis can be observed, accompanied by a desiccation of the tissue. At 100°C the water inside the tissue vaporizes. The absorption of the laser energy increases rapidly. Carbonization and later pyrolysis (>300°C) with vaporization of the bulky tissue terminate the thermal laser-tissue interaction (Muller etal, 1990).

Thermally induced ablation of dental tissues.

Volume effects can be observed as a result of heating tissues. The local extensive heating of the water in mineralized tissues leads to micro-explosions in the liquid phase. The resulting micro-fragments are removed by the high pressure caused by the steam. The thermal injury of the adjacent tissue could possibly be reduced, at least in hydrogenous tissues (Walsh and Deutsch, 1989; Walsh et al, 1989). The reduction of side effects in dental hard tissues may be achieved by a using the Er:YAG laser at 2.94µm : due to a high absorption in water and a good coupling to mineralized structures, only small zones of debris, necrosis, and carbonization can be found in dentin after laser irradiation with additional water cooling.

Ablation of hydroxyapatite with lasers.

In the ablation of mineralized tissue with laser light, the characteristics of the inorganic matrix are of great importance. Ablation of

Hydroxy Apatite Ceramic (HAC) is not possible with wavelengths in the infrared and visible spectral range (0.48μm to 10.06μm). Depending on the adjusted parameters, the materials were destroyed after a shorter or longer time without signs of ablation. In contrast, ablation of the HAC surface without damage to the ceramic is only observed with use of laser in the UV spectral range. With decreasing wavelengths (308 nm > 248 nm > 193 nm), the thermal side effects decreased while the ablation effects increased (Koort. 1991).

Efficiency of laser ablation

The mechanical drilling with burs is a well-known and accepted method for hard dental tissue preparation. Therefore any laser system has to be compared to this standard drilling method with respect to efficiency, side effects, and technical effort. A comparison of possible advantages and disadvantages of some laser systems that might be of interest for hard dental tissue treatment are shown in the table below.

Characteristics	Arf (193 nm)	XeCl (308 nm)	Nd:YAG (1.06μm)	Er:YAG (2.94μm)	CO_2 (10.6 μm cw / pulsed)	TEA CO_2 (10.6μm)
Fiber transmission	-	+	++	-	- / -	-
Ablation effectivity	+	-	- -	++	- / +	+
Thermal damage	++	+	-	(+)	- - / -	+
Pressure effects	+	nd	++	-	++ / +	nd
Optical properties dependence	++	+	- -	nd	- - / - -	nd
Operating expenses	- -	-	+	+	++ / +	-

\+ = Advantage
\- = Disadvantage
nd = Not determined

To determine the advantages of lasers in dental hard tissue treatment, efficiency is an important factor to introduce this technology into therapy. Side effects, however, could be a limiting factor. Thus efficiency and side effects must be well balanced.

LASER EFFECTS ON THE DENTAL PULP AND SOFT TISSUE

The pulpal effects of existing laser wavelengths used in dentistry (10,600 nm, 9,320 nm, 2,900 nm; 1,064 nm. 693 nm; 514.5 nm; 488 nm; 308 nm; and 193 nm) have been well documented in the scientific literature. In particular, effects on the odontoblasts and the erythorcytic matrix have received special attention. Most studies have focused on the interaction between the specific wavelength and tissue in addition to the resultant heat response. Because the vast majority of these wavelengths have the capacity to convert light energy to thermal energy, it is important to understand that pulpal heat convection has been a significant problem. When examining dental pulp in a histologic manner after laser ablation, the presence of odontoblastic nuclei is extremely important. Recent histologic evidence suggests that a normal odontoblastic layer, stroma, and viable epithelial root sheath can be retained (Figure) following laser radiation provided damage threshold energy densities are not exceeded (Abt et al, 1992). If pulp temperatures are raised beyond the 5°C level, research has shown that the odontoblastic alignment may also be present Moreover; odontoblastic alignment may also be acutely disrupted, displaying a vertical or layering type of structure. Characteristics of the dentinogenesis process related to root development, predentin and reparative dentin formation, dentinal bridge presence, and remaining dentin thickness typically reflect the overall trauma that has been induced in the odontoblasts via either the response to heat production or from the inter-action between light energy and the cellular substance. Although the latter mechanism is poorly understood, it may account for the possibility of cell damage in pulp specimens that have not exhibited a significant rise in temperature.

The interaction of any laser-induced trauma can theoretically stimulate the dentinogenesis process. The consistency and composition of the intracellular tissue is another factor influencing cell viability. If heat is intensive and exists for an extended time, the consistency of the intracellular ground substance may not be preserved. This is a function of the interaction both at the surface where first contact of the beam is evident and also very deep, where a specific wavelength can penetrate profoundly into the tissue.

Accordingly, the application of excessive energy densities has been shown to result in significant damage to pulp tissue and, in particular to odontoblasts. The threshold response for pulp reaction appears to lie at energy densities somewhat less than 60 J/cm². It is apparent that there is a window of survivability with any dental laser system irrespective of wavelength. This is dependent on the parameters within the system, specifically power, pulsing nature, beam duration, pulse width, and spot size. Unfortunately, from a clinical perspective, this window of tissue viability is extremely narrow and may not produce a desirable clinical response on bone, enamel, dentin, or caries.

Laser-tissue interactions of pulp

Although the destructive effects of laser beams on pulpal tissue have been delineated for several years, safe windows regarding hard-tissue use are slowly achieving acceptance. Historically, the use of a continuous wave apparatus had been shown to generate significant thermal tissue damage in the oral cavity extensively disseminating into surrounding tissue (Miserendino et al, 1989; Jeffrey et al, 1990).

With the advent of superpulsed laser systems, a potential decrease in soft tissue necrosis became possible because heat was given sufficient time to dissipate from the site of irradiation as a result of the rapid interruption of the beam (Fanquin and Salomon, 1986). Although the use of a discontinuous beam has produced a more workable tissue-management system, the thermal effects have not completely abated in excess of 60 j/cm² (Taylor et al, 1965; Lobene et al, 1968; Brune, 1980). As a result, infrared and/or visible light mediums utilizing a pulsed mode have also exhibited pulpal damage indigenous to a wavelength with a measurement larger than 390 nm (Adrian, 1977). The use of a combination of air-and-water spray before, during or immediately after laser irradiation to enamel and dentin may be a more effective method for temperature control and reduction of heat transfer to the pulp and other vital structures surrounding the teeth. Pre-cooling by air-and-water spray prior to lasing may be used with laser systems with wavelengths such as carbon dioxide, holmium, and erbium, which are more readily absorbed by water. Nd:YAG, which has little

absorption in water, may be effectively cooled with simultaneous air-and-water spray. Lasers with limited transmission through enamel and dentin may also be effectively cooled with application of an air and-water spray immediately after lasing. The application of an air-and-water spray has been found to provide adequate heat protection to the pulp equivalent to that of the common dental drill (Miserendino et al, 1993; Abt et al, 1992). The use of other methods of delivery, pulse configuration, or wavelengths such as Excimer, which exhibit less thermal interaction with enamel and dentin, are other possible mechanisms for preserving pulp vitality during laser treatment of teeth.

Clinical Manifestations Of Laser-Tissue Interactions

Ablation and incision

Removal of oral lesions by application of laser energy may easily be performed for surface, exophytic, and invasive lesions. The ablation of surface lesions by use of an unfocused beam of relatively large diameter (1 cm or greater) is easily accomplished through the effects of vaporization. Excision of exophytic or invasive lesions may also be performed with a focused beam of 1 mm or less to cut or incise tissue in a manner similar to that when a scalpel is used. The results of a histologic study conducted at Northwestern university Dental school indicate that laser wounds heal in a similar manner to that observed with more conventional surgical methods The depth of penetration of the incision made by a focused laser beam or control probe will vary with the power density used and the speed of movement of the beam across the tissue surface.

Time-dependent tissue effects

The amount of transfer of radiant light energy into thermal energy that occurs during absorption will necessarily be related to the power density of the incident radiation and the duration of the exposure. The extent of tissue damage therefore will be both power- and time-dependent. Additionally the rate at which heat energy is dissipated within a given tissue type will also have an influence on the extent of thermal damage to

surrounding tissue. This concept of thermal diffusion within tissue is fundamental to understanding the nature of the laser-tissue interaction that occurs within the various tissue types of the oral cavity. Recognizing the differences in the TRT (Thermal Relaxation Time) among tissue types is also essential to establish suitable exposure parameters for the various types of tissue encountered in the oral cavity. Values for TRT are tissue specific and are related to the water content and vascularity of a particular tissue type. Variations in water content between fibrous non-inflamed tissue and inflamed edematous tissue will require consideration when selecting laser parameters to avoid excessive heating and charring of tissue during surgical procedures. The significance of the TRT of tissue is that if tissues are allowed a period of cooling of approximately three times their TRT, accumulation of heat energy will be avoided and thermal diffusion from the exposure site can be minimized. Therefore, by controlling the diffusion of heat energy to surrounding tissue, the extent of collateral tissue damage can be managed effectively with the proper combination of power density and pulse duration for the desired procedure (Fisher, 1993; Miserendino et al. 993).

Hemostasis, Sterilization, and Tissue Welding

In addition to the basic techniques used for incision and ablation, lasers are capable of inducing other desirable effects that can be applied in soft tissue surgery. These include application of the coagulation effect afforded through protein denaturation and the sealing of small blood vessels and lymphatic for improved hemostasis; sterilization of wounds; and welding of tissue, all of which result from the thermal interaction of lasers with biologic tissues.

LASER SAFETY, REGULATION AND STANDARDS FOR LASER IN DENTISTRY

Laser safety in dental practice

Laser safety is an issue limited not only to the performance of treatment within the dental operatory, but one that also encompasses the interrelationship among healthcare providers, educational institutions, government, and the commercial sector. The safe and appropriate use of lasers in the field of dentistry requires the conscious and cooperative efforts of all of the abovementioned groups to be effective. The responsibility for the safe application of lasers in dentistry therefore is one that is shared by all those concerned: dentist, educator, manufacturer, and scientist. Each has a role, from design and development to practical application. Laser safety training should be considered an essential component of basic laser instruction and a prerequisite to any application within the dental clinic or research facility. The importance of this premise cannot be overemphasized. Given the Proper training and with appropriate precautions, lasers may be used safely for the mutual benefit of both the patient and the dental health-care practitioner.

The subject of dental laser safety is broad in scope, including not only an awareness of the potential risks and hazards related to how lasers are used, but also recognition of existing standards of care and a thorough understanding of safety control measures. This chapter reviews several of the safety standards and regulatory agencies that pertain to the dental use of laser; specific educational requirements related to laser safety in the dental office setting; identification of biologic hazards that may be encountered; and proposed laser safety control measures that may be applied by the dental practitioner.

Regulations, Safety Standards, and Guidelines

In many countries, voluntary standards have been established to guide the laser user and manufacturer based on the standard developed by the Technical Committee no.76 (TC-76) of the international Electro-technical Commission (IEC) initially released as IEC publication 825 in 1984 and revised in 1990. One such version has been adopted by the European Organization for Electro-technical Standardization and serves as the European Norm (EN 60825). Within the United States, the Center for Devices and Radiological Health (CDRH) of the Food and Drug Administration (FDA) is the regulatory agency that governs the manufacture and sale of all laser devices used in the United States. The CDRH sets forth the Standards governing the manufacture of lasers in the code of Federal

Regulations (CFR). This standard categorizes all laser devices into one of four classes based on their total energy output and wavelength (Table). The Surgical lasers currently used in dentistry generally fall into the class IV category, which is considered the most hazardous group of lasers. Additionally it mandates that manufacturers of lasers fix warning labels, sets limits on collateral radiation emitted, and generally imposes specific performance requirements for lasers such as protective enclosures, safety interlocking mechanisms, and emission indicators.

Laser Hazard classification according to ANSI and OHSA standards

CLASS	DESCRIPTION
I	Low powered lasers that are safe to view
IIa	Low powered visible lasers that are hazardous only when viewed directly for longer than 1,000 sec
II	Low powered visible lasers that are hazardous when viewed for longer than 0.25 sec
IIIa	Medium powered lasers or systems that are normally not hazardous if viewed for less than 0.25 sec. without magnifying optics
IIIb	Medium powered lasers (0.5 W maximum) that can be hazardous if viewed directly.
IV	High powered lasers (>0.5 W) that produce ocular, skin and fire hazard.

Hazard classification and identification

According to the Center for Devices and Radiological Health (CDRH) and American National Standards Institute (ANSI) system of classification, Class IV lasers are defined as those devices that pose a biologic hazard from either direct or diffuse reflection. Generally any laser capable of emitting power greater than 500-mW continuous wave output belongs in this class. The types of hazards that may be encountered within the clinical practice of dentistry may be grouped as follows: (1) ocular injury; (2) tissue damage; (3) respiratory hazards; (4) fire and explosion; and (5) electrical shock.

Ocular Hazards

Potential injury to the eye can occur either by direct emission from the laser or by reflection from a specular (mirror like) surface. Dental instruments have been capable of producing reflections that may result in tissue damage to both operator and patient. The use of carbonized or non-reflective instruments has been recommended during laser treatment by some authorities (Sosis, 1990). Several structures of the eye may be injured as a result of laser emissions. The site of injury is directly dependent on the preferential absorption of various wavelengths by specific structures of the

eye (Figure). The primary ocular injury that may result from a laser accident is a retinal or corneal burn. Retinal injury is possible with emissions in the visible (VIS, 400 to 780 nm) and near-infrared (NIR 780 to 1,400 nm) spectral regions. Direct (intrabeam) and specular reflections of relatively low intensity are capable of causing retinal damage because of the focusing effect of the lens and cornea.

Damage to the sclera or corneal surfaces can occur from exposure to radiant energy within the far ultraviolet (FUV < 300 nm) and far infrared (FIR > 7,000 nm) spectral ranges. Cataracts are most likely to result from radiant exposure from wavelengths within the 300 to 400 nm (near ultraviolet) region by absorption of the lens and cornea as well as potential injury to the sclera or aqueous humor.

Tissue Hazards

Laser-induced damage to skin and other non-target tissue can result from the thermal interaction of radiant energy with tissue proteins. Temperature elevations of 21°C above normal body temperature (37°C) can produce cell destruction by denaturation of cellular enzymes and structural proteins, which interrupts basic metabolic processes. Additionally, exposures of 1 sec or greater duration can interfere with vascular perfusion and thus compound the problems associated with thermal diffusion of heat energy within tissue. Histologically, the thermal effects of absorbed radiant energy are manifested as thermal coagulation necrosis for wavelengths above 400 nm. Short exposures producing temperature elevations less than 30°C, however, may be within physiologic limits of recovery.

Environmental Hazards

Another class of hazards involves the potential inhalation of air borne biohazardous materials that may be released as a result of the surgical application of lasers. These secondary hazards belong to a group of potential laser hazards sometimes referred to as non-beam hazards since they do not pertain to injuries resulting from direct exposure to the laser beam. Inhaled air borne contaminants can be emitted in the form of smoke or pulme generated through the thermal interaction of surgical lasers with tissue or through the accidental escape of toxic chemicals and gases from the laser itself. While most surgical lasers used in dentistry are capable of smoke

generation to some extent, toxic gases and chemicals are a more common hazard in dental research facilities and laboratories. Excimer lasers, for example, contain inert gases (argon, krypton, or xenon) mixed with toxic gases such as fluorine or hydrogen chloride as the active medium. Toxic dyes and solvents are used in other types of laser systems for photodynamic therapy. The generation of smoke or laser flume during surgery can be a hazard to operating personnel and patients. Inhalation of toxic or infectious matter in the form of aerosols and particles has been found to be potentially damaging to the respiratory system.

Combustion Hazards

In the presence of flammable materials, the laser may pose other significant hazards. Flammable solids, liquids, and gases used within the surgical setting can be easily ignited if exposed to the laser beam. Of particular concern is the potential combustion of flammable gases and endotracheal tubes used during general anesthesia due to their proximity during head and neck procedures. Toxic fumes released as a result of the combustion of flammable materials present an additional hazard. The use of flame-resistant materials and other precautions therefore is commended.

Electrical Hazards

Because class IV surgical lasers often use very high currents and high voltage power supplies, there are several associated hazards that may be potentially lethal. Electrical hazards of lasers can be grouped as electrical shock hazards, electric fire hazards, or explosion hazards. Safe manufacturing practices for the most part offer adequate protection from these hazards in dental laser systems. Considerable effort has been made by biomedical and electrical engineers in the design and manufacture of safe laser system. Insulated circuitory, shielding, grounding, and housing of high-voltage electrical provide adequate protection under most circumstance from electrical injury.

Laser Hazard control measures

According to the OSHA Guidelines for laser safety and hazard assessment and the ANSI Standard for the safe use of lasers in health-care facilities, control measures are required to reduce the possibility of unwanted exposure of patients and personnel to later radiation within the

dental and medical clinical setting. Four categories of control measures have been identified in the standards that have relevance within the dental laser Environment (Table). These include: (1) Engineering controls; (2) personal protective equipments; (3) administrative and procedural controls; (4) environmental controls.

Laser Safety control measures recommended by ANSI Z

Engineering controls	Administrative controls	Personal protective equipment	Special controls
• Protecting housing interlocks. • Beam enclosures • Shutters. • Service panels • Equipment labels • Warning systems • Key switch	• Laser safety officer (LSO) • Standard operating procedures. • Output limitations • Training and education • Maintainence and alignments • Warning signs • Protective devices • Medical surveillance. • Incident reporting	• Eye wear 1. Optical density 2. Transmission 3. Identification 4. Visibility 5. Comfort and fit clothing 6. Screens and curtains	• Fire and explosion • Repair and maintenance • Fiberoptic delivery systems

Role of the laser safety officer

The LSO has been identified as the individual having administrative control over all measures that are to be implemented for the safe operation of laser within industry and health-care facilities. The responsibilities of the LSO include: hazard identification and assessment within the operative setting; determination of the potential hazard zone otherwise termed the nominal hazard zone (NHZ); establishing- the standard operating procedure (SOP) for operation of the laser within the facility; ensuring proper laser safety training for all persons working within the environment; approving use of protective equipment; specifying use of warning signs and labels; and implementing medical surveillance and accident report programs.

Specific recommendations

All dental lasers that are classified, as class IV lasers should be considered potentially hazardous to anyone present during the time of their operation. It is strongly advised that any safety precautions delineated by the manufacturer in the operator's manual be strictly followed as well as all

general laser safety precautions listed within the ANSI and OSHA standards. When used properly, lasers are very safe and effective dental tool, provided that adequate safety measures also are followed.

Training requirements

Prior to any clinical or research application of a laser, the intended operator of any laser system must have a thorough knowledge of the operation and safety requirements of the specific laser system and should have received hands-on instruction related to its practical application. A variety of laser safety training courses have been developed by the Laser Institute of America and other laser centers to suit the needs of the laser clinician, scientist, engineer, LSO, Service technician, and industrial worker.

Fire and electrical control measures

To avoid an electrical hazard during the operation of the laser unit, the floor of the theatre must be kept dry to avoid having the operator standing in a pooled liquid. Additionally, the control panel and its electrical power unit should be protected from splashing that can sometimes emanate from working in a wet field environment. Because laser energy generates heat, care must be taken to avoid the use of flammable or explosive liquids or gases in the operating room. In addition to heat, combustible materials may also be ignited by exposure to the focused laser beam. As a result the presence of combustible material, either in the field of operation or the operating theatre, is discouraged. Flammable materials such as surgical drapes and gauze sponges may be soaked in sterile saline to reduce the potential of burning by accidental exposure to the laser beam.

Personal protective equipment

Eye Protection

Light produced by all class IV lasers by definition presents a potential hazard for ocular damage by either direct viewing or reflection of the beam. Therefore, all people within the NHZ must wear adequate eye protection,

including the patient (Figure). This can be provided by either safety goggles or screening devices; however, the means selected must be designed specifically for use with the particular wavelength of laser radiation.

When selecting appropriate protective eyewear several factors should be considered:

1. Wavelength of laser emission
2. Maximum permissible Exposure limits
3. Degradation of the absorbing media or filter
4. Optical density of the eyewear
5. Radiant exposure limits
6. Need for corrective lenses
7. Comfort and fit.

Control of airborne contaminants

The laser plume, which is the smoke or vapor emitted from the site of surgery during exposure to laser energy, is a special concern. This plume should be regarded as potentially hazardous both in terms of particulate matter and infectivity. Airborne, contaminants may be controlled by ventilation, evacuation, or other methods of respiratory protection. Laser surgery within the oral cavity or near respiratory passages requires sufficient evacuation of plume for patient protection. Airborne contaminants should be removed as near as possible from the point of origin by evacuation and ventilation to the outside if possible or by re-circulating air filtration systems. Adequate suction must be maintained at all times, especially when treating pathologic conditions that are suspected of being viral in origin to limit the possibility of spreading that virus via the laser plume.

Regulation, standards and education for lasers in dentistry

OSHA Guidelines and ANSI standards

There are two agencies that have an interest in the safe and effective use of lasers on the American public: the American National Standards Institute (ANSI) and the Occupational Safety and Health Administration (OSHA) of the United States Department of Labor. The OSHA guidelines and ANSI Standards serve as the primary documents that regulate the use of

lasers in both industry and health care. The OSHA Guidelines for laser safety and hazard assessment are mandatory and enforceable under strict penalty by federal and state agencies throughout the United States. The ANSI standards are strictly voluntary in nature serving only as guidelines. The ANSI is not a part of the federal government, as one might expect, but is an independent organization that serves to develop national standards for various industries (including health care) in the United States.

Laser equipments and training programs

Essential elements of laser training programs

Elements of laser training program include (1) Course Content (2) hands-on Experience (3) evaluation of competency or clinical proficiency (Certification of credentialing) (4) instructor competency (5) advanced training and education needs (Updating). Specific educational and training requirements for laser users, (Dental practitioners) will also vary from that needed for proper training of dental auxiliaries and other support staff.

Curriculum guidelines for dental laser education

On July 25 and 26, 1992 curriculum guidelines for dental laser education were drafted at a workshop held at the University of California, San Francisco, for the development of Standards for dental laser education and laser instructor certification. Within these guidelines, four levels of education are defined for dental practitioners. Outlined for each level of training are the recommended Course contents. Which range from the introductory course level to instructor level training courses. To date, a number of national and International dental laser associations Including the Academy of Laser-Dentistry, International Society of Laser Dentistry and number of dental schools have adopted these guidelines as a basis for their laser training.

Course content

A typical laser course intended to provide education that is sufficient to prepare an individual for laser use in clinical practice will necessarily be extensive. Similarly, courses designed to prepare dental auxiliaries and staff will also be quite involved. Both levels of training will necessitate each of the

essential components required for a clinical training program as described earlier. These components can be summarized briefly as didactic, practical experience, and testing.

WAVELENGTHS USED IN DENTISTRY

Argon

Argon lasers have an active medium of argon gas that is fiber-optically delivered in continuous-wave and gated-pulse modes. This laser has two emission wavelengths, and both are visible to the human eye; 488 nm, which is blue in colour, and 514 nm, which is blue-green.

The 488-nm emission is exactly the wavelength needed to activate camphoroquinone, the most commonly used photoinitiator that cause polymerization of the resin in light-cured composite restorative materials. Using the argon light for this purpose results in a much shorter curing time compared with conventional dental lights, with the advantage of having an excessive number of photons to ensure proper cure of the materials. Some studies show some increase in the strength of the laser-cured resin when compared with visible light-cured resins. The argon laser also can be used with other dental materials, such as light-activated impression paste and light-activated bleaching gels.

The 514-nm wavelength has its peak absorption in red pigment. Tissues containing hemoglobin, hemosiderin, and melanin readily interact with this laser; it is a useful surgical laser with excellent haemostatic capabilities. Used in contact with the tissue, treatment of acute inflammatory periodontal disease and highly vascularized lesions, such as a hemangioma, would be ideally suited to the argon laser.

Both wavelengths are not well absorbed in dental hard tissues and are poorly absorbed in water,. The poor absorption into enamel and dentin is advantageous when using this laser for cutting and sculpting gingival tissues because there is no interaction and no damage to the tooth surface during those procedures. Both wavelengths also can be used as an aid in caries detection. When the argon laser light illuminates the tooth, the diseased, carious area appears a dark orange-red colour and is easily discernible from the surrounding healthy structures.

Diode

Diode lasers (Figure) have a solid active medium; it is a solid-state semiconductor laser that uses some combination of aluminum, Gallium, and arsenide to change electric energy into light energy. The available wavelengths for dental use range from about 800 to 980 nm, placing them at the beginning of the near-infrared invisible non-ionizing part of the spectrum Each machine delivers laser energy fiber-optically in continuous-wave and gated-pulse modes, used ordinarily in contact with the tissue, the optic fiber needs to be cleaved and prepared before initial use and occasionally during long procedures to ensure the efficient operation of the laser. Glasslike tips are available that can be placed on the end of the fiber for certain applications. The wavelength range puts this laser into the invisible non-ionizing infrared radiation portion of the electromagnetic spectrum. All of the diode wavelengths are, similar to argon, very well absorbed by pigmented tissue, although hemostasis is not quite as rapid as with the argon laser. These lasers are relatively poorly absorbed by tooth structure so that soft tissue surgery can be performed safely in close proximity to enamel, dentin, and cementum. The diode is an excellent soft tissue surgical laser indicated for cutting and coagulating- gingiva and mucosa and for soft tissue curettage, or sulcular debridement. Care must be taken when using the continuous emission mode because of the rapid

thermal increase in the target tissue. The chief advantage of the diode lasers is use of a smaller size instrument. The units are portable and compact, are easily moved with minimum setup time, and are the lowest-priced lasers currently available.

Nd:YAG

Nd:YAG has a solid active medium, a crystal of yttrium-aluminum-garnet doped with neodymium, and is fiber-optically delivered in a free-running pulsed mode, used most often in contact with the tissue. It was the first laser designed exclusively for dentistry, and it is the laser with the largest market share. It has extensive published scientific research for dental applications. The emission wavelength is 1364 nm, in the near-infrared invisible non-ionizing part of the spectrum. It is highly absorbed by pigmented tissue and is about 10,000 times more absorbed by water than an argon laser. Using the high peak powers of a free-running pulse emission with relatively long tissue cooling time, common clinical applications are for cutting and coagulation of dental soft tissue with good hemostatic ability. The free-running pulse mode allows the clinician to treat thin or fragile tissue with a reduction in heat buildup in the surrounding area. Nd:YAG laser energy is absorbed slightly by dental hard tissue, but there is little interaction with sound tooth structure, allowing tissue surgery, adjacent to the tooth to be safe and precise. There are numerous published clinical case studies showing effective periodontal disease control using this laser for sulcular debridement. There is also a useful clinical application in vaporizing pigmented surface carious lesions without removing the healthy surrounding enamel. The fiber usually is used bare-ended, in contact with the tissue. During use, the fiber end needs to be cleaved and cleaned; otherwise the laser light rapidly loses its effectiveness. When used in a non-contact, defocused mode, this wavelength can penetrate several millimeters into soft tissue, which can be used advantageously for delivering the laser energy to the inner surface, for example, an ulcerated lesion (Figure)

Ho:YAG

Ho:YAG has a solid active medium, a crystal of yttrium-aluminum-garnet doped with holmium, and is fiber-optically delivered in contact with

the tissue in free-running pulsed mode. The wavelength produced by this laser is 2120 nm, also in the near-infrared invisible non-ionizing part of the spectrum. Its absorption by water is 100 times greater than Nd:YAG, and it has many soft tissue surgical uses. Because soft tissue contains a large amount of water this laser can remove that tissue rapidly, and the optic fiber affords good access, precision and tactile feedback. Because this laser has good absorption by water and it is produced in a pulsed mode, the tissue ablation at the surgical site can proceed at an efficient rate, and collateral thermal damage can be avoided. The Pulse rate, or the amount of pulses of laser energy per second, is rather low compared with a Nd:YAG laser, and the resulting incisions can be somewhat jagged edged. Clinically, this rough surface may manifest itself only on tissue that is more fibrous, but the healing result would still be acceptable. The optical fiber, which is similar to the diode and Nd:YAG lasers, needs to be cleaned and cleaved periodically during surgery. A Ho:YAG laser has little affinity for pigmented tissue; its hemostatic ability is decreased because of its lower absorbency into hemoglobin and other similar pigments. The laser's absorbency by tooth structure is low, which allows soft tissue surgery in close proximity to enamel, dentin, or cementum to proceed safely. The Ho:YAG laser frequently is used for arthroscopic surgery on the temperomandibular joint.

Er, Cr:YSGG and Er;YAG

Er,Cr:YSGG (2790 nm) has an active medium of a solid crystal of yttrium scandium-gallium-garnet that is doped with erbium and chromium. Er:YAG (2940 nm) has an active medium of a solid crystal of yttrium-aluminum-garnet that is doped with erbium. Both of these wavelengths are near that boundary of the near-infrared and mid-infrared, invisible, and non-ionizing portion of the spectrum. These two lasers are discussed together because of their similar properties. Both of these lasers are delivered fiber-optically in the free running pulsed mode. The fibers are air-cooled and have a larger diameter than the other lasers mentioned, making the delivery system somewhat less flexible. At the end of the fiber, a handpiece and small-diameter glass tips concentrate the laser energy down to a convenient surgical size, approximately 0.5mm. The technical challenge in building an optic fiber system stems from the fact that the wavelength's size cannot be transmitted easily-along, the glass molecules so that the fiber-optic bundle is costly and can be fragile.

These two wavelengths have the highest absorption in water of any dental wavelength and have a high affinity for hydroxyapatite, although Er is approximately 20% higher than ErCr in that regard. A portion of the laser energy couples into the hydroxy radical in the apatite crystal. The water that is bound to the crystalline structures of the tooth absorbs the laser light readily and easily. The vaporization of the water within the mineral substrate causes a massive volume expansion, and this expansion cause the surrounding material literally to explode away. The free-running pulse mode provides the peak power to facilitate the explosive expansion, and laboratory studies indicate that the pulpal temperature of the treated tooth may actually decrease by 5°C during laser treatment. These lasers are ideal for caries removal and tooth preparation when used with water spray. The sound tooth structure can be preserved better when the carious material is being ablated; the increased water content of dental caries allows the laser to interact preferentially with that diseased tissue. The healthy enamel surface can be modified for increased adhesion of restorative material by exposing it to the laser energy. The current indication for use of these lasers dictates that they not be used for removal of amalgam.

Both lasers can ablate soft tissue readily because of its water content, but the hemostatic ability is limited. In this modality, the water spray normally used in hard tissue interactions is turned off. The advantage of these lasers for restorative dentistry is that a carious lesion in close proximity to the gingiva can be treated, and the soft tissue recontoured with the same instrumentation.

CO_2

The CO_2 laser is a gas-active medium laser that must be delivered through a hollow tube-like wave-guide in continuous or gated pulse mode. The wavelength of 10,600 nm or 10.6 µm, places it at the end of the mid-infrared invisible non-ionizing portion of the spectrum. It is well absorbed by water; second only to the Er series of lasers. It is a rapid soft tissue remover and has a shallow depth of penetration into tissue, which is important when treating mucosal lesions, for example. It is especially useful in cutting dense fibrous tissue It has the highest absorption in hydroxyapatite of any dental laser, about 1000 times greater than the Er series of lasers.

The CO_2 laser cannot be delivered in an optic fiber. Instead, a hollow waveguide with a handpiece is used. The laser energy is conducted through the wave-guide and is focused onto the surgical site in a non-contact fashion. The loss of tactile sensation is a disadvantage for the surgeon, but the tissue ablation can be precise with careful technique. Large lesions can be treated easily using a simple back-and-forth motion; the procedure proceeds quickly because there is no need to touch the tissue. The current delivery system technology somewhat limits its hard tissue applications, but ongoing research shows favourable results for surface modification and strengthening of tooth enamel for increased caries resistance (Figure).

Excimer

Various studies have demonstrated that it is possible to remove dental hard and soft tissues in a controlled fashion with the excimer laser. This has also been the result of former investigations on excimer laser in dentistry (Liesenhoff et all, 1989). As reported by other research groups, the alteration of surrounding tissue due to 308-nm excimer laser irradiation is minimal (Frentzen and Koort, 1990). Compared to all other existing laser systems that have application (Nd:YAG, Ho:YAG, Er:YAG & CO_2) – the 308-nm excimer laser is the only system that offers precise ablation of tissue, fiber delivery, bactericidal effects good transmission through water, and enamel surface conditioning. The temperature elevations that were produced by the 308-nm excimer laser within the pulp chamber were 180^0C maximum. This temperature rise should be tolerable for the living tooth (Serebro et al, 1987) and remains far below the temperature raised by other laser systems (Serebro et al, 1987). The described temperature rises were measured without any cooling system. Since the 308-nm excimer laser has good transmission through water, a continuous saline rinsing could prevent a rise in temperature.

The SEM and TEM investigations of the irradiated tissues demonstrated that it is possible to ablate dental hard and soft tissue without alteration in the surrounding tissue. The amount of ablation is dependent on the applied energy density and the beam size and quality. By using energy densities of more than 4 L/cm^2, maximum ablation can be achieved while the thermal side effects can be minimized. Contrary to CO_2 and YAG lasers, the excimer laser causes fewer thermal side effects when the energy density

is raised. The maximal rate of ablation of about 1 mm/pulse for enamel and about 3.2 mm/pulse for dentin assure a high degree of precision.

The bactericidal effects of the 308-nm excimer laser have also been shown to be present at different energy densities. Since it is possible to achieve bactericidal effects even by applying the 308-nm excimer laser with energy densities far below the threshold of ablation, it is possible to influence bacterial growth in areas where the laser beam is out of focus (spot of maximum energy density). The disinfection of the apical delta and the periapical region seems to be one of the key roles for the good clinical results of the 308-nm excimer laser in root canal preparation.

The domain of the 308-nm excimer laser is the precise removal of tissue. All treatments that can be performed with conventional instruments, such as drills and roots canal instruments, are not going to be replaced but rather significantly improved by the 308-nm excimer laser. The primary indications for the 308-nm excimer laser in dentistry are root canal treatment, periodontal treatments, and surface conditioning of dental hard tissues.

LASER USE IN PROSTHODONTICS

The scientific methods and artistic details prescribed for reconstructive dentistry are well documented. The addition of laser surgery to the reconstructive process can heighten the art and the science of this multidisciplinary field. The current use of lasers in reconstructive dentistry

encompasses a wide variety of soft tissue procedures. The future may hold promise for hard tissue laser use in crown preparation, bone recontouring, and implant Placement. Laser use during soft tissue procedures for fixed, removable, and implant dentistry can enhance esthetics, improve impression outcomes, and provide a foundation for the restorative appliance nearer to ideal in fit, form, and function. This objective can be accomplished through precise control of soft tissue removal, improved visualization (by hemostasis), and more predictable healing.

Underlying structures, such as the attached gingiva, gingival sulcus, epithelial attachment, periodontal ligament, and alveolar crest, are important and must be evaluated carefully. Before laser surgery, basic surgical prerequisites should be met. The zone of attached gingiva must be wide enough, and the alveolar crest should be near normal; horizontal bone loss may be present, but there can be no infrabony defects. These prerequisites apply to laser surgery whether it is sulcular gingivo-plasty for crown and bridge, implant uncovering, or tuberosity reduction. When sound principles are followed, the outcome of laser surgery provides a more predictable, improved foundation for fixed, removable, and implant dentistry.

Laser use in fixed prosthetics

Complete control of the oral environment at the operative site is essential during restorative dental procedures. This control extends beyond suppressing saliva and blood to managing the gingiva surrounding the teeth. Frequently, cases are encountered in which the gingival tissues need to be altered because of areas of inflammation, previous sub-gingival restorations, or sub-gingival caries. The finish line may need to be placed near the epithelial attachment, making it impossible to retract the gingiva without stripping the attachment, bruising the periodontal ligament, and creating uncontrolled bleeding. Resulting hemorrhage in the gingival sulcus can make impression making impossible as well as healing unpredictable. In these cases, laser sulcular gingivoplasty can be used to develop a new, healthier gingival sulcus; to control hemorrhage; and to remove just enough epithelial attachment and periodontal ligament to facilitate the placement

(not packing) of retraction cord. Laser sulcular gingivo-plasty improves impression techniques and minimizes gingival recession.

Technique for laser sulcular gingivoplasty

Before any tissue is removed, it is important to assess the width of the band of attached gingiva. If there is unattached alveolar mucosa too near the gingival crest, periodontal surgery in the form of a gingival graft should be performed. If the margins need to be carried to close to the alveolar process, periodontal surgery in the form of a crown lengthening needs to be completed first. When sub-gingival margins are encountered that meet these requirements, for success, laser sulcular gingivo-plasty can be used.

A dental laser that has good absorption characteristics for hemoglobin or water and that has a variety of power settings is most advantageous. A laser that uses fiber-optic delivery and contact tip mode is highly recommended but is not required. Laser tips or fibers 400 to 600 μm diameter are ideal. A quartz glass fiber must be cleaved properly to permit complete transmittance of laser energy through the fiber. Energy settings are according to the manufacture's recommendation and the operator's experience. The least amount of energy should be used to accomplish the therapeutic objective. The hand piece should be lightweight and comfortable to grasp and should be completely sterilizable.

Some hand pieces use disposable tips that can be modified and discarded. A feather-light stroke should be used that resembles the pressure equal to drawing a line with an ink-dipped brush without bending the bristles but with quick, deft strokes. The laser hand piece should be kept moving to prevent unwanted thermal damage to underlying tissues. The operator must feel the tissue being removed and adjust the speed of the stroke to allow the laser to remove tissue at the desired rate.

The operator should not attempt to remove the tissue by dragging the glass fiber through the tissue because this creates more bleeding and subsequent overuse of laser energy to coagulate damaged tissue. The fiber should be held parallel to the long axis of the tooth as much as possible. Along with the attached gingiva approximately 1 mm of epithelial attachment should be removed and coagulated to achieve hemostasis and to

expose the crown margins. Hemostasis occurs because of the capacity of the laser to seal or weld small blood vessels as a result of the photochemical interaction with the biologic tissue. The laser can be used on the walls of the created sulcus depending on the amount of tissue needed to be removed to create a 2 to 3mm sulcus in depth.

More laser energy can be applied from the base to the top of the walls of the unhealthy sulcus to create additional gingival shrinkage. For healthy gingival tissue, only a sweep around the base of the crown preparation to coagulate and seal the attached gingiva and the epithelial attachment may be required. Overuse of laser energy causes shrinkage of the tissue and unwanted exposure of crown margins. Gentle placement (not packing) of retraction cord accomplishes complete hemostasis and retraction.

Postoperative instructions

1. Warm salt water rinses morning and night for 5 to 7 days
2. Use of an ultra-soft toothbrush to the affected area, using the modified bass technique for sulcular brushing.
3. Use of over the counter pain medications, such as non-steroidal anti-inflammatory drugs.

Proper technique for laser sulcular gingivo-plasty includes the following points.

1. Proper power settings per manufacturer's recommendation and operator's experience
2. Light touch, deliberate strokes
3. 1 mm removal of epithelial attachment to expose margin
4. Development of a 2- to 3 –mm gingival sulcus
5. Adherence to all laser safety guidelines
6. Appropriate postoperative instructions

Techniques for laser sculpting of edentulous areas

It often is advantageous to sculpt and contour the edentulous ridge to enhance the esthetics of the final restoration. Remembering that the laser is just another tool, the practitioner may wish to use conventional gingitage burs (diamond burs used in the gingival sulcus) for bulk removal of tissue during crown preparation, then use the laser to coagulate this area at the same time as sulcular gingivo-plasty. This approach saves time and reduces unnecessary laser energy to the site. For example, to create an oval pontic site, a football diamond bur can be used. To remove the remnants of the inter dental papilla adjacent to an edentulous space to promote desirable embrasures, diamond points can be used. The laser then is used to coagulate and seal the tissue to provide a better impression, to improve visualization of the surgical site, and to provide more predictable healing. The technique is to use a low to medium energy level with light quick strokes back and forth over the affected area until hemostasis is achieved over the area.

Laser use in soft tissue pre-prosthetic surgery

The key to positive removable prosthetics is the preoperative planning of the surrounding oral structures. The prognosis for success often is in direct proportion to the appropriate preparation of these supporting structures. Dentistry has come a long way from just replacing missing teeth to replacing lost alveolus, supporting facial structures, recreating esthetics, reestablishing phonetics, and, most important, providing retention of the appliance. For a removable appliance to accomplish this task, hard and soft tissues must be evaluated for pre-prosthetic surgery. The resultant surgery should provide the patient with ridges and mucosal coverings free of disease and of a quality and quantity sufficient to provide stability and retention so that the appliance may function as close to ideal as possible.

Advantages

1. Laser surgery is precise and self-sterilizing because the tissues are vaporized.
2. It is relatively blood –less, because any blood vessel with a diameter less than the width of the laser beam will be vaporized and heat sealed.
3. It is relatively pain-free because nerves that are transected are also heat sealed by the laser beam

4. Postoperative edema and swelling appear to be minimal presumably because lymphatics are also sealed.
5. Laser wounds contract less than other types of wounds, possibly because fewer myofibroblasts are seen in the wounds and these cells are believed to be the etiologic agents in wound contraction.

Disadvantages

1. Laser wounds have less tensile strength than scalpel wounds, although after 3 weeks the strengths are similar.
2. Although the laser beam is focused, it can potentially injure tissues that might be inadvertently contacted by the laser beam if the arm is bumped or slips.

The pre-prosthetic surgeries that can be performed most favorably with a dental laser are the following:

1. Soft tissue tuberosity reduction
2. Removal of labial, buccal, and lingual frena
3. Treatment of hyper plasia of the oral mucosa
4. Removal of fibromas, papillomas, or soft tissue cysts

Soft tissue tuberosity reduction

Commonly the maxillary tuberosity area approaches the retromolar pad and is composed mainly of fibrous connective tissue. Though the maxillary tuberosity may not approximate the retromolar pad, it can be pendulous and not offer a stable base for a removable appliance. In both of these conditions, the fibrous or pendulous tissue should be detached. The laser of choice is one that can remove a large amount of tissue fairly fast. The CO_2 laser is recommended for larger pre-prosthetic surgeries because of its speed and effectiveness in vaporization. With the new 600-μ and 1000-μ fibers and sculpted tips, numerous wavelengths can be used. The same paint-brush-like stroke permits the operator to vaporize or cut away tissue sensibly and only as needed until the anticipated end result is achieved. The practitioner needs to have experience and knowledge in identifying anatomic structures that could pose problems, such as the palatine arteries and nerves.

Removal of frenum

The maxillary and mandibular labial and buccal frenum can present uninvited situations, if they are too near to crest of the residual alveolar ridge. A frenectomy accomplishes two important results: (1) The technique allows border extensions, and (2) it releases a mobile band of tissue that is in contact with the denture. The lingual frenum also should be assessed carefully for presence of ankyloglossia and attachment in an undesirable position on the alveolar ridge.

There is no better use for the CO_2 laser than for maxillary midline or lingual frenectomies. In maxillary midline frenectomy, the frenum is simply vaporized with the CO_2 laser. In lingual frenectomy, the tip of the tongue is grasped tension is placed, and from the greatest concavity of the frenum moving posteriorly, the frenum is simply vaporized until the desired effect is achieved. Indicated power settings for both frenectomies are usually 4 to 5 W and in the slightly defocused mode. When the CO_2 laser is used for these procedures, operative time is reduced, requiring 35 seconds to 2 or 3 minutes. With these procedures, patients can almost be guaranteed a pain free postoperative course. For both maxillary and lingual frenectomies, there is a tremendous advantage with this method since sutures do not have to be removed from the non-keratinized movable oral mucosa at 1 week, which can be difficult and irritating to the patient.

Use of laser for welding

Lasers have been investigated for potential use in working with dental materials since the mid 1960's. The results of industrial applications of lasers for machining and processing materials have had stimulating effects on dentistry. Previous investigations into the laser treatment of dental materials addressed attempts to fuse dental materials on or into the tooth's surface (Beyer et al, 1986) and attempts to fuse or repair dental alloys (Beyer et al, 1984). These investigations sought to examine the possibility of treating dental ceramics with lasers and to test the laser's ability to weld dental precious and non-precious metal alloys.

Welding of ceramic material

Processes for laser-induced modification of ceramic materials are currently being investigated under laboratory conditions (Zscherpe et al, 1984). The Strength of ceramic materials in the presence of temperature changes is low. This is evidenced by high elasticity, low tensile strength and low plastic workability, which normally are displayed only with high temperatures. During laser treatment, steep local temperature changes in the heating and cooling phases create internal tensions that can damage the materials. It is necessary therefore to use appropriate laser operating parameters (Reisse et al, 1984).

The CO_2 laser is well suited for the treatment of ceramic materials because its emission wavelength is almost totally absorbed by ceramic. The use of a defocused CO_2 laser beam produces a local gloss firing on the surface of the dental ceramic, which when compared to the main vacuum firing and the furnace gloss firing makes an impression due to its macroscopic homogeneous surface. After the main vacuum gloss firing, irregular wavelike structures with dendritic crystal features are found on dental ceramics. After the furnace gloss firing, these structures are leveled off, but the crystal features are not removed. However, with the laser gloss firing a full leveling of the surface is achieved.

Double-beam laser modification

One possible solution for problem-free laser treatment of dental ceramics, in contrast to the prevailing laser treatment methods, is the preheating of relatively large areas of the ceramic surface prior to high temperature treatment. After laser-induced modification of ceramic surfaces, a laser double-beam process has been developed for the laser-induced joining of dental ceramic materials. In this process (Figure) a pulsating, 200-W, defocused CO_2 laser beam (L_1) with a gaussian-shaped beam profile distribution, is used for preheating, which when used at an angle of 45 degrees warms a fundamentally larger area than the weld site.

The other continuous-wave, 100-W CO_2 laser beam (L_2), which falls vertically onto the target, actually performs the laser welding. The first laser maintains a temperature below the fusion temperature, and the second produces a higher temperature, which softens the dental ceramic. The area of influence of the second laser beam lies temporally and locally within the sphere of influence of the first laser beam. The maximum intensity of the

second laser is found within the range of the first laser beam. So that the necessary depth in the materials for the laser welding is reached.

With laser surface homogenization of the dental ceramics, it is possible to remove local surface defects and polishing marks without the need to reconstruct a complete correction firing. It is also possible that by using the laser double-beam process, one could expand the use of ceramics to a number of intraoral applications.

Welding of dental alloys

Laser welding can help solve the technical problems encountered in the repair of various dental alloys. Laser welding belongs to the field of melt-weld processing. The efficiency of laser beam treatment is determined by the absorbed optical energy and the degree of absorption of the materials. Metals with a high reflection have a small degree of absorption in the visible and infrared spectral areas. These metals include the dental alloys, as indicated by the reflection curves of some of the main constituents of these alloys (Landoldt-Biornstein 1982).

With the Nd:YAG laser, the degree of absorption of non-precious metal alloys and titanium is slightly better than that of the precious metal alloys. If, however, a laser beam with a performance concentration of $10^6 W/Cm^2$ is used, an increase in absorption can usually be seen (Beyer et al, 1984; Dorn et al, 1980).

Nd:YAG laser welding

The interaction between the laser and materials is determined by the characteristics of the materials being used. i.e. degree of absorption, thermal conductivity and capacity, and the composition of the surface. The choice of laser parameters and thus the energy density of the beam greatly influence the quality of the weld (Beyer et al, 1986; Dorn et al, 1980; Herziger, 1983).

Evaluation of corrosion resistance

By coordinating the type of laser and its parameters with the material that is to be used, a high efficiency can be achieved. Pure titanium is a very good material for use with laser treatment. Apart from the strength factors, the corrosion reaction of a point of joining is another important criterion for its quality and use. Soldered points of joining (solder joints) in partial dentures have been weak with regard to strength and corrosion resistance. The following effects could be expected due to insufficient oral durability: galvanic currents, toxicity, allergic reactions, and risk of cancer. With regard to biocompatibility, laser welding could also be an interesting alternative to the conventional fusing processes in laboratory technology.

Welding of titanium with the Nd: YAG laser.

Laser beam welding of titanium for prosthodontics has begun to be investigated by a number of researchers. Titanium is a metal that displays minimal corrosion and therefore is highly safe in vivo. Because of its excellent biocompatibility, the use of titanium as an implant material has become widespread in dentistry.

With the recent advances in high-temperature, vacuum casting technology. It is now possible to use titanium as a prosthetic material (e.g. Partial dentures, crowns, and bridges). Clinical applications of titanium are expanding. Although titanium has a high relative strength and excellent corrosion resistance, the use of titanium for prostheses has been hampered by difficulties in processing because of its high melting point (about 1,700 C) and susceptibility to oxidation. Within the dental field, soldering has generally been used to join metallic materials. Titanium, however, is very difficult to solder because of its high melting point. As an alternative method, laser welding of titanium is more practical and may offer some distinct advantages.

Laser welding can be characterized by:

1. High bond strength and corrosion resistance, since laser welding is a form of sweating that does not use solders of different metals
2. Reduces oxidation when argon gas is applied during welding; and

3. Decreased thermal influence and greater precision in processing than with soldering or other techniques.

When precision welding is required or when alteration of the metal properties from heat must be avoided, high-energy-density welding techniques are used. These include electron beam welding, plasma arc welding, and laser beam welding. Unlike soldering, laser welding does not involve contamination with different metals; therefore, the joint is more uniform and resistant to corrosion.

By this we can conclude that apart from the dental alloys, pure titanium is a material that can be manipulated very well with a laser; the advantages of this technology are:

1. The laser treatment is contact-free
2. The good focusing ability makes an extremely high-performance concentration possible, which assures low thermal stress on the material
3. Many varieties of dental materials can be treated with the laser
4. The ability to reproduce the laser beam assures a consistent quality in the result of the treatment
5. The laser is an excellent tool for treating micro-materials because of the small focus diameter.
6. Lasers save time.

Laser use in implant dentistry

Implantology has been an area of considerable interest for dental application of laser technology. This chapter provides an overview of the use of lasers in laboratory and clinical techniques used in implantology, and outlines principles for the safe use of lasers for particular application. An emphasis is placed on lasers which are available commercially in dentistry at the present time, carbon dioxide, neodymium-yttrium-aluminum-garnet (Nd:YAG), argon, and erbium:YAG.

Interactions of laser energy with implant materials

Metals

Near-infrared laser radiation of the 1064-nm wavelength (from Nd:YAGlasers) is absorbed strongly by many metals. This has led to the development of commercial metal welding services based on Nd:YAG lasers. In dentistry, Unalloyed titanium is also suitable for welding with Nd:YAG lasers (Sjogren et al.. 1988). Welding of titanium castings with Nd:YAG lasers results in a greater ultimate tensile strength than plasma-welding soldering (Geis Gerstorfer et al. 1990). This ability of Nd:YAG laser radiation to induce melting of titanium is used occasionally for the metallic super structure placed upon implant fixtures, as well as for crowns and bridges of the conventional type.

The marked absorption of metallic implant materials for Nd:YAG laser radiation (Dobberstein et 19889; Chu et al., 1992) indicates that indiscriminate use of these lasers for peri-implant soft-tissue procedures poses considerable risks. Preliminary studies have described melting and surface alterations of titanium implants following exposure radiation from an Nd:YAG dental laser (Block et 1991). Similar types of surface alterations can recognize upon close examination of titanium implants exposed to Nd:YAG lasers (Myers, 1991a), in the form of pits and melted areas on the lased implant surfaces. Moreover, since the potential exists for Nd:YAG laser irradiation to remove the surface layer from plasma coated titanium implants, use of such lasers for decontamination or sterilization prior to placement is contra-indicated

Extensive heating of peri-implant tissues and thermal injury to bone are other potential compilations of indiscriminate laser use. Temperature elevations in metal implants irradiated with Nd:YAG lasers have been reported (Chu et al., 1992); however, these were less than those which occurred following use of electro-surgery equipment (5-122°C), respectively.

Carbon dioxide laser energy is not absorbed to any significant extent by metallic surfaces, a feature which has allowed the widespread use of polished metal mirrors for reflection of the laser beam within articulated arm delivery systems. Provides a major advantage for laser soft-tissue

procedures involving metallic implants. The preferential reflection of carbon dioxide laser energy greatly reduces the potential for damage to the metallic implant surface and for thermal injury (via conduction) to underlying tissue. Considering this carbon dioxide lasers are, in general **"safe for metallic implants"** and suitable for implant-uncovering procedures and peri-implant gingival surgery. In contrast, because of their potential to damage implant materials, Nd:YAG lasers should be considered inherently "unsafe" for such procedures.

Ceramics

Ceramics have attracted considerable interest as implant materials in their own right (Denissen et al., 1985), or as coatings for metallic implants. Lasers have been used in the fabrication of a variety of ceramic implants, particularly as an alternative for ultrasonics or diamond drills for drilling channels (Longfellow, 1971: Minamizato, 1990; Piddock, 1991). Use of carbon dioxide lasers for drilling alumina (Longfellow, 1971) and Nd:YAG lasers for drilling zirconia (Minamizato, 1990). Sintering of ceramic materials, including hydroxyapatite, with carbon dioxide lasers has been reported (Stewart et al., 1985). Given the similarity of hard-tissue interactions between carbon dioxide and erbium:YAG lasers, latter may prove useful for drilling and sintering application.

For drilling procedures, the use of black dyes enhances absorption of Nd:YAG energy and is important for maximizing drilling efficiency. Use of such dyes is required for etching of enamel with Nd:YAG lasers (Hess, 1990). Because of strong absorption in ceramic materials and hydroxyapatite (Stewart et al., 1985), such dyes are not needed for drilling with carbon dioxide lasers. In ceramic materials, laser impact areas appear as bullet shaped craters and show a dose response for irradiance (Minamizato, 1990) similar to that reported for human enamel (Walsh, 1990; Walsh and Perham, 1991). Heat conductivity in ceramic materials is less than in metals, and evidence of local heat- related stress following lasing can be identified in the form of small cracks, particularly with the short pulse widths of Nd:YAG lasers(Minamizato, 1990).

Clinical standpoint, deliberate exposure of ceramic implants to infrared laser energy (carbon dioxide, Nd:YAG, or erbium:YAG) should be

avoided. Logically, similar comments apply to ceramic-coated metallic implants, such as hydroxyapatite coated titanium products. In which the metallic core can become exposed following lasing of the surface (Block et al., 1991). Thus, if minor tissue recontouring around implants is planned, a suitable instrument (e.g., flat plastic) should be placed between the implant and the soft tissues to provide protection during lasing. Similar protective techniques are used routinely in periodontal surgery for protection of enamel (Pick et al. 1985; Walsh, 1992).

Ablation of bone

Lasers (of any type) are not preferred over mechanical instruments for removal or recontouring of bone; thus their use in implant placement procedures is not advocated. For Nd:YAG lasers, heat generation with laser ablation is greater than that from burs (Latif et al., 1991); consequently, inflammation is more marked and bone necrosis more extensive. Alveolar bone necrosis following exposure to Nd:YAG laser radiation has also been reported (Bahcall et al., 1992). For carbon dioxide lasers, the low water content of bone results in poor absorption such that is more difficult to ablate than soft tissues. Carbonized residues of ablated bone may also serve as irritants and delay healing (Clayman et al., 1978; Small et al., 1979).

Soft-tissue procedures

Established benefits of infrared laser surgery include:

1. A virtually bloodless field
2. A lack of mechanical trauma to tissues
3. Enhanced infection control
4. Reduced swelling and pain
5. Reduced scarring
6. Elimination of bacteraemias, and
7. Microsurgical capabilities

(Pick and Pecaro, 1987; Kaminer et al., 1990).

Carbon dioxide lasers:

The suitability of various laser wavelengths for surgical procedures depends largely on the degree to which the energy is absorbed in oral

tissues. Carbon dioxide laser energy, which falls in the far-infrared region of the spectrum (10, 600-nm wavelength), is absorbed efficiently by water. Because soft tissue is 70-90% water in composition, interaction of carbon dioxide laser radiation with tissues is exclusively a surface effect. The extinction length for carbon dioxide laser radiation in soft tissue (defined as the distance within which 98% of the incident energy is absorbed) is approximately 0.2 mm (Fuller, 1987). Accordingly, the potential for damage to underlying tissue following a laser surgical incision is limited, Pigmentation and vascularity of tissues do not influence absorption of carbon dioxide laser radiation; thus, predictable incision and vaporization of soft tissues are obtained within the oral cavity.

Nd:YAG lasers :

Nd:YAG laser energy. Which falls in the near-infrared region of the spectrum (1064-nm wavelength), is poorly absorbed by water, and thus penetrates tissue quite deeply. The extinction length in normal soft tissue is approximately 3mm. Because of the absorption characteristics of soft tissue, incision and vaporization of tissue are slower with Nd:YAG than with carbon-dioxide lasers. Despite the fact that the peak energy values which may be obtained with current Nd:YAG lasers far exceed those of carbon dioxide lasers (typically 1000 watts us. 20 watts, respectively).

The presence of a sizable zone of coagulation at the laser impact site is particularly problematic. This tissue will subsequently undergo sloughing and remodeling, such that judgments at the time of surgery regarding final tissue contours cannot be made reliably. Because pigmentation enhances absorption of Nd:YAG laser energy, outlining of incisions with pigments prior to lasing is commonly used to improve the ability to create incisions in tissues (Midda and Renton-Harper, 1991). However, as tissue fragments are ablated during incisions the accumulation of debris on the fiber termination (the 'bar-tip") results in localized absorption. This reduces the energy reaching the tissues, and causes deterioration of the fiber termination, which must be trimmed periodically to maintain efficiency.

Argon and erbium:YAG lasers

Argon lasers (wavelength, 488nm) and erbium:YAG lasers (wavelength, 2930 nm) have been used in general surgery for incising and vaporizing tissue. Argon laser energy is poorly absorbed by tissues, which

are not highly vascular (Fuller, 1987). This fact, together with their relatively poor hemostatic properties in most soft tissues, makes argon lasers less suitable for intra-oral surgical procedures than other lasers. In contrast, erbium:YAG laser energy is absorbed strongly by dental hard and soft tissues.

Low-level laser therapy

There are no data available at present regarding potential applications of low-level laser therapy in implantology. Recently, low-power gallium-aluminum-arsenide (Ga-Al-As) diode lasers have been promoted for dental applications. These instruments typically emit radiation with a wavelength of 940 nm, which capable of deep tissue penetration (approximately 10 nm) without significant thermal effects. Irradiation with these lasers has been reported to accelerate wound healing (fibroblast proliferation and osteoid deposition) in extraction sockets (Takeda, 1988). Whether these same laser wavelengths are able to promote Osseo integration or accelerate bony healing about implants placed into extraction sockets remains to be determined.

Implant maintenance

There is no evidence at the present time supporting the use of lasers for removing plaque or calculus from dental implants. While lasers may exert antibacterial effects by vaporizing microorganisms (Dederich et al., 1990), the likelihood of damage to the implant surfaces of metal and ceramic implants must be weighed against the possible benefits gained. In addition, the possibility that lasing implant surfaces may result in accelerated accumulation of dental plaque because of surface changes should also be considered. At present, prevailing opinion does not support the use of debridement techniques, which alter implant surfaces (Fox et al., 1990). Similar comments apply to the use of lasers for sterilizing implant surfaces, either prior to insertion or post-insertion. Use of lasers within presumptive periodontal pockets associated with implants possess the additional difficulty that probing depth ranges for implants are not clearly defined (Listgarten et al., 1991); thus, the potential for iatrogenic damage to soft tissues as well as to implant surfaces within such "pockets" is high.

Exposure of implants (Stage II Surgery)

Lasers can be used to uncover implants whether they be single or multiple and work exceptionally well for this application. Before any laser surgery is attempted however initial surgery and healing process should be evaluated. The rigidly fixated implant with no crestal bone loss and adequate zones of attached gingiva should be present. Soft tissue thickness of 1 to 3mm and no tenderness or discomfort under vertical or lateral forces is needed.

Carbon dioxide laser can be used for second-stage uncovering procedures in endosseous implants. Sculpting tissue around existing implants, control of mucosal abnormalities, and the treatment of implants soft tissue complications. The carbon dioxide laser is ideal for surgical manipulations around implants because carbon dioxide radiant energy is rapidly absorbed by the high water content of the mucosa so that the depth of tissue necrosis or vaporized tissue is minute (only 100 to 200 microns). The potentially harmful thermal energy is dissipated rapidly and does not reach the metal surface of the implant. The specular reflection of the carbon dioxide wavelength is so rapid that if laser beam contact is made. There is not enough time for the energy to be transferred to the implant and to increase its temperature to a critical degree that causes damage.

This unique interaction of particular laser wavelengths with tissues and restorative materials, determines that there is no one laser, which is suitable for use in all laboratory and clinical procedures in the field of implantology. Analysis of current information suggests that certain laser applications in implantology can be considered safe and efficacious at the present time (see Table). With all lasers capable of generating thermal effects, appropriate consideration should be given to the extent to which energy will be absorbed or reflected by the target material. Thermal injury to implants as well as to bone and soft tissues can occur with injudicious use of lasers (Figure).

PROCEDURE	LASER
Laboratory Procedure	
1. Welding of metallic implants	Nd:YAG
2. Welding of ceramic implants	Nd:YAG or CO_2
3. Drilling of ceramic implants	Nd:YAG or CO_2

4. Sterilization of implants	Not recommended prior to insertion
Clinical Procedure	
1. Preparation of bone	Not recommended
2. Implant exposure (Stage II)	CO_2 or Erbium:YAG
3. Gingival surgery	CO_2 or Erbium:YAG
4. Scaling and plaque removal	Not recommended

Laser holography

The purpose of this chapter is to illustrate some of the dental applications of non-destructive laser imaging or holography. A laser is a device that generates and amplifies coherent electromagnetic energy at optical frequencies. One important application of the laser has been in the field of optical image storage and image reconstruction known as holography. The principle of holography was discovered by Gabor in 1948. when the laser light source was applied to holography in 1963 by Leith and Upatnieks, the practical application of holography became possible for three-dimensional recording of objects.

Science of holography

A hologram is a photographic film, slide, or plate upon which is recorded the interference pattern produced by the reinforcement or cancellation of two different intersection light wave fronts. Holography is the science of recording the reflected light waves from an object onto a hologram and subsequently reconstructing the stored image of the object in the space where the original object had been. The terms holo, meaning complete, and gram, meaning message, give rise to the hologram or complete message.

The three-dimensional aspect of the hologram image is unique. Unlike 3-Dimensional stereoscopic slides the hologram, as a single slide, recreates the object's natural parallax effect in the image. Thus the viewer of the hologram, by changing his position, can see objects blocked by foreground objects-an important factor when recording images in an area as severely restricted as the oral cavity.

Holography is advancement over light photography as means to record and store information. The photography records only the intensity

of light reflected from an opaque object. The hologram however, records phase as well as intensity and in so doing overcomes many of the limitations of the ordinary photograph.

As in photography a shutter is used to determine the holographic exposure. A beam splitter divides the laser beam into two components. The holographic film plate simultaneously records the reflected light from the object and an additional reference light coming directly from the reflected light from the object and an additional reference light coming directly from laser. Beam-expander lenses allow use of the entire hologram plate. The reference beam and object beam light waves intersect and reinforce or cancel one another, producing a series of light and dark bands which constitute the interference pattern on the exposed hologram. The hologram is thus a recording of the interference of the wave pattern of the reference beam with the wave pattern of the object beam.

As an example of the principle involved imagine a rectangular pool of water into one end of which a rod is thrown parallel to the pool's shortest side. The rod produces a wave pattern of parallel lines (the reference beam), which travel the length on the pool. A stone is thrown into the other end of the pool at the same time and produces a different wave pattern (which represents the waves reflected from the object). In about the middle of the pool the two wave fronts will meet and will either mutually reinforce or cancel each other partially or completely at different points. The hologram plate is in the middle; recording this event at the instant the camera shutter opens. Every object will have a different hologram interference pattern (Figure).

Recording the hologram

The recording of the hologram must be made with no change in the object or reference beams during the moment of exposure. Any relative motion of the object, optics, or the laser beams will prevent the recording of a hologram.

The hologram records minute movements, ranging into fractions of the wavelength of light. If the object is moved very slightly between exposures during a double exposure of the film plate, a secondary interference pattern will be produced. This secondary interference pattern

creates dark bands superimposed on the holographic reconstructed image of the original object. The bands indicate a displacement of the object between exposures and may demonstrate the direction and degree of change that occur. The interferometric bands can be used to measure dimensional changes during temperature variations, distortive effects of stress and strain, and relative positional variances due to vibration of physical movement.

Viewing the hologram

Viewing the hologram can be accomplished using any inexpensive, low-powered laser as a light source. For the hologram to be viewed, a single laser light beam is directed to plate. The hologram divides the single beam back into its original object and reference beams. The object beam forms or "reconstructs" in space a phantom object- composed of light but having no mass (a hand can pass through the image with no effect) – which appears at the same distance from the hologram plate as the original object. The reconstructed image appears in the monochromatic color of the laser light.

Certain unique features differentiate the hologram from ordinary photographic, slides. Because the hologram records the wave patterns along its entire surface, the holographic plate may be divided into several pieces without fragmenting the image since each individual segment has the capability to reconstruct the entire image. In addition, the angles between the laser plate, and viewer are fairly critical. A number of holograms of different objects may be made by rotating the same hologram plate by several degrees after each exposure. When the plate is developed, each hologram may be viewed in turn by rotating the plate the same number of degrees. Thus a single hologram plate can contain multiple images and can be segmented to provide more than one record (Figure).

Advantages

- Holographic stress analysis
- Computer – generated reproduction of complex objects.

It may someday be possible to construct objects such as a complete crown or inlay by exposing holograms of the natural tooth or wax-up prior to and immediately after preparation for the restoration. The computer is

capable of determining the exact dimensions of the material removed, and the numerically controlled milling device is capable of constructing an object to match that material.

CONCLUSION

The dental community wants to find a way to eliminate diseased dental hard tissues that is less noxious than today's rotary hand pieces. Much interest has been aroused in lasers as replacements.

Although there has been research done in laser dentistry since the development of the ruby laser in the early 1960s, only recently has clinical use grown. But with this growth, there hasn't been an equal flurry of research to substantiate the claim that the laser is a more efficient and better method of treatment for dental disease.

Dental use of lasers can be divided into two areas: soft-and hard tissue applications. Researches have examined both areas using all existing lasers. These include the carbon dioxide, neodymium:yttrium-aluminium-gamet, argon, holmium:YAG, erbium:YAG and excimer lasers.

There is a quest to find a method to remove diseased and healthy dental hard tissues without the negative stimuli associated with dental handpieces. Today, lasers are being considered as a potential replacement. Various reports evaluate thermal effects of three lasers.

FDA approval for soft tissue removal has now been granted and thus procedures such as laser gingivoplasty, operculeutomy and frenectomy can be carried out without the use of local anaesthesia in a bloodless field.

The combination of the laser's ability to sterilize, and in the case of Nd:YAG (and some other laser), to be transmitted along a fibre-optic cable opens up further areas of application.

The surgical carbon dioxide laser appears to have a number of potential advantages in soft tissue pre-prosthetic surgery that merit further exploration. It enables a number of procedures to be performed in the dental office quickly. The surgical carbon-dioxide laser has a number of claimed advantages over other modalities for soft tissue surgery. Many of these advantages appear to be particularly applicable for soft tissue pre-prothetic surgery. Because of this unique interaction of particular laser wavelengths with tissues and restorative materials. There is no one laser, which is suitable for use in all laboratory and clinical procedures in the field of implantology. Lasers are further being used for welding of prosthesis with better results.

Caution is required in interpreting the results of experimental or clinical reports. It is important not to prematurely assume the applicability of a particular treatment before sufficient evidence, substantiates both its safety and efficacy. It is also important to recognize the limitation of our current understanding of the long-term effects of laser energy on oral tissues and the mechanisms by which lasers affect biologic systems.

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TYPE I DIABETES AS A PREDISPOSING FACTOR FOR ORAL DISEASES IN CHILDREN AND ADOLESCENTS

INTRODUCTION

Diabetes mellitus is a group of disorders characterized by increased blood glucose levels. This elevation is the result of a deficiency in insulin secretion or increased cellular resistance to the action of insulin leading to a number of metabolic abnormalities related to carbohydrates, fats and proteins. [1] Diabetes affects approximately 2-10 % of the population and more than 10million people around the world.[2-3] Type1 diabetes is categorized as a systemic autoimmune disease, marked by an impaired insulin secretion from the pancreatic beta cells.It is involved in the abnormal regulation of glucose and lipid metabolism causing hyperlipidemia and hyperglycemia[4] This form of diabetes accounts for up to 5-10% of diabetes cases and usually predominant in adolescents and children. The lack of insulin production in these patients makes the use of exogenous insulin necessary to sustain life; hence it was previously called Insulin-dependent diabetes mellitus. [5-6] Diabetes usually affects capillary-rich organs such as the kidneys, retina, and nerves, complications that are associated with microangiopathy.[7] Oral health complications commonly related to diabetes include xerostomia (dry mouth),dental caries, tooth loss, gingivitis, periodontitis, odontogenic abscesses, oral lesions like candidiasis and oral lichen planus, burning sensation and soft tissue lesions of the mucosa and tongue. [8-9]

AIM OF THE REVIEW

The objective of this narrative review was to assess the effects of type 1 diabetes and its influencing factors on the oral health of children and adolescents.

MATERIALS AND METHODS

The study was conducted using the following scientific databases: PubMed, Google scholar, Embase and Scopus. Search terms used included type 1 Diabetes mellitus, children, dental caries, oral health, periodontal health, tooth eruption. Thirty-five articles were selected from the digital search and references of the selected articles, which concerned the association between type 1 diabetes mellitus and oral health in young patients.

DISCUSSION

The impact of type 1 diabetes on the oral cavity is manifold. A series of studies explore the link between type 1 diabetes and oral health in children and adolescents. Several studies have demonstrated a correlation between type 1 diabetes and higher rates of tooth decay, alterations in teething, decreased salivary flow, xerostomia, gum and periodontal disease, and lesions. soft tissue and impaired wound healing. All of these aspects of oral health and their relationship to type 1 diabetes as an underlying disease were then discussed in this article.

TOOTH ERUPTION

Teeth development in children with diabetes was found to increase rapidly until the age of 10, after which it gradually decreased. In addition, the edentulous period in the group of patients with type 1 diabetes lasted longer. It has also been determined that individuals with poor metabolic control had gingival inflammation associated with a higher rate of eruption [7]. Older children have delayed eruptions [10] One study demonstrated that children with diabetes under the age of 11.5 years had no significant changes in tooth development, but older children exhibited a delay in development. [11] Another study observed that children with type 1 diabetes, below the age of 11.5 years, had a faster rate of eruption while children above 11.5 years of age had a delayed eruption process [12].

DENTAL CARIES

Numerous studies have documented the prevalence of tooth decay in children with type 1 diabetes; however, there is some degree of inconsistency in the results. A meta-analysis found that almost 67% of children and adolescents with type 1 diabetes had dental caries with a mean DMFT value of 5.7 [13]. It was found that people without diabetes had a lower rate of tooth decay than people with type 1 diabetes, and the number of cavities increased with age for both diabetics and healthy individuals. [7] This is consistent with the findings of [14], who stated that the DMFT index of children with type 1 diabetes was higher than that of children without diabetes.According to this study [14], the prevalence of component D (Decayed) was higher in diabetic patients compared with controls, while component F (Filled) was higher in non-diabetic group. type 1 diabetes. Dental caries is a multifactorial disease, and its predisposing factors include oral pathogenic bacteria, consumption of fermentable carbohydrates as substrates for caries-causing bacteria, and ample time permitted for caries to form. . Levels of pathogenic bacteria, especially Streptococcus mutans, were higher in diabetics, and a higher proportion of individuals had greater levels of pathogenic bacteria, especially Streptococcus mutans, in the diabetic population . [16] Additionally, it has been reported that insulin deficiency can lead to deteriorating alterations in the salivary glands, leading to reduction in the rate of salivary flow as well as salivary buffering capacity. [13] In another study, the author stated that decreased salivary flow due to hyperglycemia was a predominant feature of poor metabolic control in diabetic patients. [16] Leakage of glucose into the oral cavity during this period, can facilitates the growth of aciduric and acidogenic bacteria and the formation of carious lesions. Multiple studies have shown that children and adolescents with type 1 diabetes have a high uptake of saturated fat. Furthermore, consumption of these high saturated fat, which are energy dense and low in nutrition is linked with weight gain and obesity, which can lead to tooth decay in children. [29][18]. A higher rate of caries has been observed, especially in the root region of type 1 diabetics. However, some studies have shown a lower caries prevelance in diabetics as opposed to their healthy counterparts. In one study, diabetics had lower caries prevelance than non-diabetic controls, who also had higher oral debris scores. [20] Even though earlier studies have attributed lower caries prevelance to lower carbohydrate intake and insulin treatment regimens, this study confirmed that modern diabetes management including less rigid meal plans and a flexible use of insulin, diminishes influence of diet on caries development. Whereas, the role of good metabolic control in these diabetic patients is also a matter of significance [20] In another study, the key finding was that diabetic children and adolescents with poor metabolic control had thrice more lesions during the study period than those with an improved metabolic control. [21] The authors conclude that children and adolescents with poorly controlled type 1 diabetes may develop uncontrolled dental caries despite comprehensive preventive care, the main risk factors being lack of good oral hygiene, previous experience with caries and higher levels of lactobacilli in saliva.

SALIVARY STATUS

Many studies have reported qualitative and quantitative changes in the diabetic saliva. Diabetic individuals often show a decreased salivary flow. One study mentioned that significantly low levels of saliva was found in diabetic children. [14] A diminished salivary flow rate has also been recorded in diabetic children in some studies. [22][23] Type 1 DM is related to a higher incidence of xerostomia (53%) in adolescents [22] and mean salivary flow rates are reported to be low and hyposalivation more prevalent among diabetic patients. [8] As per another study [20], the mean flow rate of unstimulated saliva was 0.26 in diabetics and 0.34 in healthy controls, while mean flow rate of stimulated saliva was 1.17 in diabetic patients and 1.49 in non-diabetic patients. The salivary pH and buffering capacity are also found to be lower in diabetics. In one study, the pH of saliva in the non diabetic group displayed a mean of 7,071 and for the diabetic group, it was 6,406, which was significant statistically[24]. Glycosuria, caused by hyperglycemia resulting in dehydration and fluid loss as well as salivary gland pathologies might be the reasons behind impaired saliva production. [14] Diabetics with poor glycaemic control have lesser rates of salivary flow than patients with well-controlled diabetes. [25] However, several studies have not recorded significant differences in salivary flow, pH, or buffering capacity between diabetics and non-diabetics. [26] Increased levels of S. Mutans and lactobacilli have been reported in patients with diabetes, and lactobacilli as well as S. Mutans are known indicators of the cariogenic environment. [21] Glucose, total sugars, total proteins and amylase were found to be more abundant in the saliva of diabetic patients. [23] This is similar to the finding of [14] that due to decreased salivary flow, patients with diabetes may have increased concentrations of glucose and mucin and proliferation of pathogenic microorganisms. The results are inconsistent when it comes to calcium levels. A higher calcium level [27] as well as lower calcium level [23] have been reported in the saliva of diabetic patients, as per different studies.

PERIODONTAL HEALTH

It is a well known fact that there is a two-way relationship between periodontal health and diabetes. Several mechanisms have been proposed to illustrate the relationship between diabetes and periodontal status, which can be considered as changes in repair processes, vasculature, and cellular processes of the host. The two main risk factors for the occurance of chronic complications of diabetes are the duration and severity of the hyperglycemia. [28] Type 1 diabetics reported higher gingival and periodontal index values than controls. [7] A positive relationship was found between duration of diabetes and clinical disassociation (CAL), wherein it wasobserved that longer the duration of diabetes, greater was the prevalence and severity of periodontal disease[2]. This finding has been supported by other studies. [29]. [19] reported significantly higher mean periodontal exploration depth and clinical disintegration values in children with diabetes compared with non-diabetic controls [2]. In another case-control study, children with type 1 diabetes had significantly higher plaque and gingival indices and more bleeding on exploration compared with control subjects; They also showed an association between periodontitis and prolonged duration of diabetes [30]. In a 5-year study [19], the rate of clinical disconnection (CAL) was remarkably higher in diabetic subjects, with a similar association between duration of diabetes and CAL. . However, in another 3-year longitudinal study [31], no differences in measured clinical parameters and subgingival microbiota were found between diabetic and non-diabetic subjects, although there was a decrease in gingivitis in the non-diabetic group with an improvement in SBI (Sulcus Bleeding Index). One study [25] observed an increased incidence of gingivitis and plaque accumulation in diabetics and attributed these to an elevated inflammatory response to periodontal pathogens, diminished tissue repair and regeneration as well as the effects of advanced glycation end products. They emphasized on the role of personal oral hygiene practices as well as professional oral health care in the prevention of periodontal disease; An improvement in API and OHI were indeed observed in patients who underwent oral hygiene tution. [32]

TREATMENT CONSIDERATIONS

Type 1 diabetes can be managed with insulin, together with changes in diet and exercise. [33] Working alongside physician and nutritionist, the dentist can help in maintaining the oral health of the patient and also boost their metabolic control. A dentist can use a glucometer to check the patient's blood sugar levels; if the levels are congruous with hyperglycaemia, then a prompt follow up with the physician is advised; the dentist therefore plays an important role in referring diabetic patients to physicians for evaluation. Diabetic patients should be preferably given short morning appointments, to lower the stress. Type 1 diabetic patients are known to exhibit a higher incidence of dental caries and they require daily oral care with regular dental visits ; at the same time, the efficacy of the preventive programs should be reviewed. Before any surgical/invasive procedure, the patient's blood sugar should be tested to avoid any emergencies including insulin shock or ketoacidosis with severe hyperglycaemia that can occur before, during or after the procedure. The treatment approach for xerostomia typically includes the use of salivary substitutes and stimulants. Salivary stimulation or replacement therapy can be done to retain moistur mouth which aids in prevention of dental decay. The prevention of periodontal disease involves education of the patient about the importance of oral health along with removal of plaque and calculus through self care as well as professional help. [7] Periodontal surgical procedures n be performed, taking into account the patient's history of complications and glycaemic control and supportive periodontal therapy should be provided at regular intervals. [34] Diabetic patients undergoing extensive periodontal and surgical procedures should also be given dietary instructions. The dental team should focus maintaining optimum oral health for diabetic patients, thereby improving their metabolic control. The dentist can also discuss with the physician, the indications and contraindications of medications to treat the oral complications resulting from diabetes and strive to provide an overall better oral care for such patients. [34]

CONCLUSION

Type 1 Diabetes is identified as an endocrine metabolic disorder of childhood and adolescence, the incidence of which has reportedly been increasing worldwide and which has significant consequences on physical and emotional development. [20] It is characterized by hypergl mia and dysregulation of protein and lipid metabolism, resulting in one or multiple complications in the eyes, blood vessels, heart, kidneys and nervous system. [38] T1DM exhibits a range of oral symptoms including tooth decay, reduced flow of saliva, periodontal diseases and oral soft tissue lesions such as candidiasis, lichen planus, geographic tongue etc., which has been documented in several studies. Metabolic control and duration of diabetes also pl a role in manifestation of these symptoms. The dentist therefore has a vital contribution in aiding the patient maintain glycaemic control by treating the oral diseases and guiding them to maintain proper oral hygiene as we diet. [34] There are some contradictory studies which reports no sign ant changes in oral health of patients with diabetes as compared to their non diabetic counterparts. Further studies are needed to justify the effects of type 1 diabetes on the oral health of children and adolescents.

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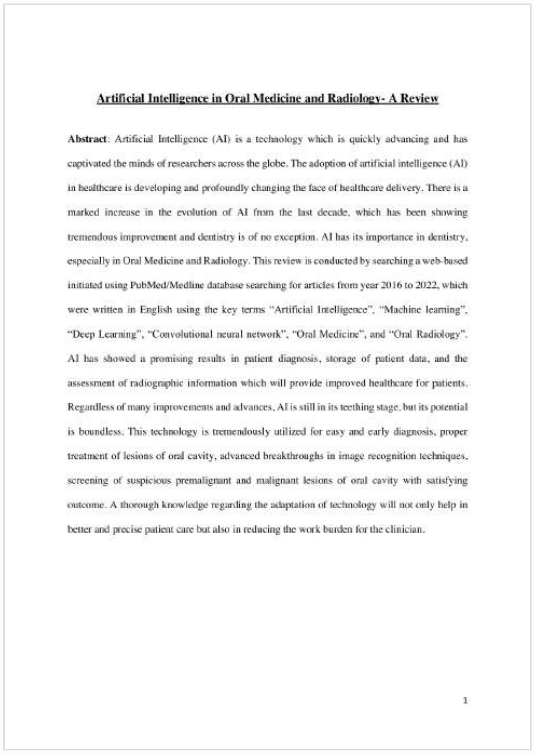

Artificial Intelligence in Oral Medicine and Radiology- A Review

Abstract: Artificial Intelligence (AI) is a technology which is quickly advancing and has captivated the minds of researchers across the globe. The adoption of artificial intelligence (AI) in healthcare is developing and profoundly changing the face of healthcare delivery. There is a marked increase in the evolution of AI from the last decade, which has been showing tremendous improvement and dentistry is of no exception. AI has its importance in dentistry, especially in Oral Medicine and Radiology. This review is conducted by searching a web-based initiated using PubMed/Medline database searching for articles from year 2016 to 2022, which were written in English using the key terms "Artificial Intelligence", "Machine learning", "Deep Learning", "Convolutional neural network", "Oral Medicine", and "Oral Radiology". AI has showed a promising results in patient diagnosis, storage of patient data, and the assessment of radiographic information which will provide improved healthcare for patients. Regardless of many improvements and advances, AI is still in its teething stage, but its potential is boundless. This technology is tremendously utilized for easy and early diagnosis, proper treatment of lesions of oral cavity, advanced breakthroughs in image recognition techniques, screening of suspicious premalignant and malignant lesions of oral cavity with satisfying outcome. A thorough knowledge regarding the adaptation of technology will not only help in better and precise patient care but also in reducing the work burden for the clinician.

1

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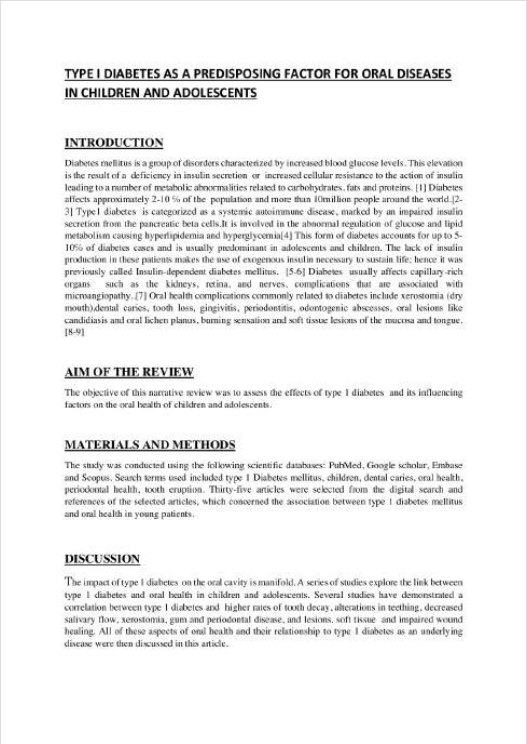

TYPE I DIABETES AS A PREDISPOSING FACTOR FOR ORAL DISEASES IN CHILDREN AND ADOLESCENTS

INTRODUCTION

Diabetes mellitus is a group of disorders characterized by increased blood glucose levels. This elevation is the result of a deficiency in insulin secretion or increased cellular resistance to the action of insulin leading to a number of metabolic abnormalities related to carbohydrates, fats and proteins. [1] Diabetes affects approximately 2-10 % of the population and more than 10million people around the world.[2-3] Type1 diabetes is categorized as a systemic autoimmune disease, marked by an impaired insulin secretion from the pancreatic beta cells.It is involved in the abnormal regulation of glucose and lipid metabolism causing hyperlipidemia and hyperglycemia[4] This form of diabetes accounts for up to 5-10% of diabetes cases and is usually predominant in adolescents and children. The lack of insulin production in these patients makes the use of exogenous insulin necessary to sustain life; hence it was previously called Insulin-dependent diabetes mellitus. [5-6] Diabetes usually affects capillary-rich organs such as the kidneys, retina, and nerves, complications that are associated with microangiopathy..[7] Oral health complications commonly related to diabetes include xerostomia (dry mouth),dental caries, tooth loss, gingivitis, periodontitis, odontogenic abscesses, oral lesions like candidiasis and oral lichen planus, burning sensation and soft tissue lesions of the mucosa and tongue. [8-9]

AIM OF THE REVIEW

The objective of this narrative review was to assess the effects of type 1 diabetes and its influencing factors on the oral health of children and adolescents.

MATERIALS AND METHODS

The study was conducted using the following scientific databases: PubMed, Google scholar, Embase and Scopus. Search terms used included type 1 Diabetes mellitus, children, dental caries, oral health, periodontal health, tooth eruption. Thirty-five articles were selected from the digital search and references of the selected articles, which concerned the association between type 1 diabetes mellitus and oral health in young patients.

DISCUSSION

The impact of type 1 diabetes on the oral cavity is manifold. A series of studies explore the link between type 1 diabetes and oral health in children and adolescents. Several studies have demonstrated a correlation between type 1 diabetes and higher rates of tooth decay, alterations in teething, decreased salivary flow, xerostomia, gum and periodontal disease, and lesions, soft tissue and impaired wound healing. All of these aspects of oral health and their relationship to type 1 diabetes as an underlying disease were then discussed in this article.

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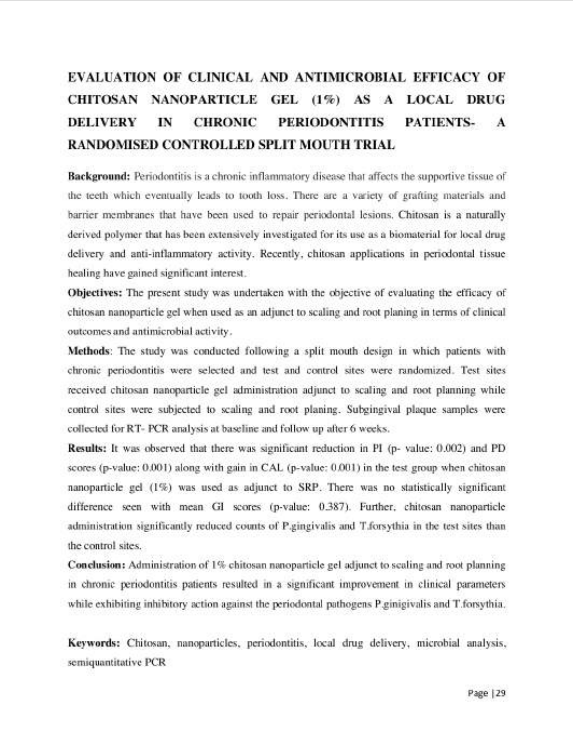

EVALUATION OF CLINICAL AND ANTIMICROBIAL EFFICACY OF CHITOSAN NANOPARTICLE GEL (1%) AS A LOCAL DRUG DELIVERY IN CHRONIC PERIODONTITIS PATIENTS- A RANDOMISED CONTROLLED SPLIT MOUTH TRIAL

Background: Periodontitis is a chronic inflammatory disease that affects the supportive tissue of the teeth which eventually leads to tooth loss. There are a variety of grafting materials and barrier membranes that have been used to repair periodontal lesions. Chitosan is a naturally derived polymer that has been extensively investigated for its use as a biomaterial for local drug delivery and anti-inflammatory activity. Recently, chitosan applications in periodontal tissue healing have gained significant interest.

Objectives: The present study was undertaken with the objective of evaluating the efficacy of chitosan nanoparticle gel when used as an adjunct to scaling and root planing in terms of clinical outcomes and antimicrobial activity.

Methods: The study was conducted following a split mouth design in which patients with chronic periodontitis were selected and test and control sites were randomized. Test sites received chitosan nanoparticle gel administration adjunct to scaling and root planning while control sites were subjected to scaling and root planing. Subgingival plaque samples were collected for RT- PCR analysis at baseline and follow up after 6 weeks.

Results: It was observed that there was significant reduction in PI (p- value: 0.002) and PD scores (p-value: 0.001) along with gain in CAL (p-value: 0.001) in the test group when chitosan nanoparticle gel (1%) was used as adjunct to SRP. There was no statistically significant difference seen with mean GI scores (p-value: 0.387). Further, chitosan nanoparticle administration significantly reduced counts of P.gingivalis and T.forsythia in the test sites than the control sites.

Conclusion: Administration of 1% chitosan nanoparticle gel adjunct to scaling and root planning in chronic periodontitis patients resulted in a significant improvement in clinical parameters while exhibiting inhibitory action against the periodontal pathogens P.ginigivalis and T.forsythia.

Keywords: Chitosan, nanoparticles, periodontitis, local drug delivery, microbial analysis, semiquantitative PCR

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ABSTRACT

Title- Assessment of different irrigation techniques on the penetration depth of different sealers into dentinal tubules by confocal laser scanning microscopy -an in-vitro comparative study

Background: This study intended to assess and compare the efficacy of three final irrigation techniques on the depth of penetration of two root canal sealers into dentinal tubules using Confocal Laser Scanning Microscopy (CLSM).

Methods and Materials: 48 single-rooted mandibular premolars were selected and de-coronated to a length of 12mm. All the samples were prepared using ProTaper gold rotary files and divided into three groups-Group 1-Conventional syringe irrigation (CSI), Group 2- Passive Ultrasonic Irrigation (PUI), and Group 3-Pro-agitator tips system (PATS). Each group was divided into 2 sub-groups- Sub-Group A-AH Plus and Sub-Group B- GuttaFlow Bioseal. Then, sealers were mixed with 0.1% Rhodamine B dye and the samples were obturated. All the samples were sectioned at 2mm and 5mm from the apex and visualized under Confocal Laser Scanning Microscopy (CLSM) (10X) for maximum mean penetration depth and percentage of sealer penetration. Statistical analysis was done using the Independent t-test, and One-way ANOVA test followed by Tukey's Post hoc analysis.

Results: PUI performed better in the apical third whereas, PUI and PATS showed comparable results in the middle third for both depth and percentage of sealer penetration. Amongst the two sealers, GuttaFlow bioseal performed better than AH Plus in both the apical and middle third. These values were statistically significant. ($p<0.05$)

Conclusion: Final irrigation activation with Passive ultrasonic irrigation or Pro Agitator Tips System can significantly improve sealer penetration. The average depth of penetration of GuttaFlow bioseal both at the middle and apical third of the root was significantly superior to AH Plus.

Keywords: AH Plus, GuttaFlow Bioseal, Passive ultrasonic irrigation, Pro-Agitator system, PATS.

Introduction

The successful outcome of the endodontic treatment relies on the complete removal of the infected pulp, efficient disinfection of the root canal with adequate biomechanical preparation, and obtaining a fluid-tight apical seal with obturating materials.[1]The challenges faced during

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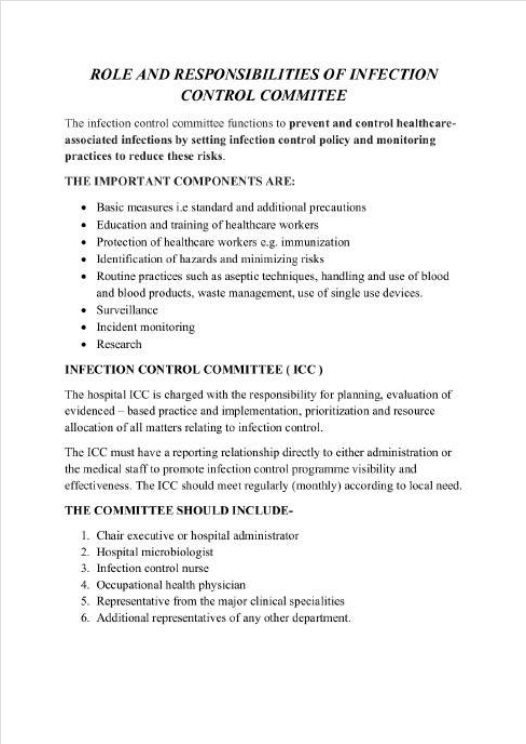

ROLE AND RESPONSIBILITIES OF INFECTION CONTROL COMMITEE

The infection control committee functions to **prevent and control healthcare-associated infections by setting infection control policy and monitoring practices to reduce these risks.**

THE IMPORTANT COMPONENTS ARE:

- Basic measures i.e standard and additional precautions
- Education and training of healthcare workers
- Protection of healthcare workers e.g. immunization
- Identification of hazards and minimizing risks
- Routine practices such as aseptic techniques, handling and use of blood and blood products, waste management, use of single use devices.
- Surveillance
- Incident monitoring
- Research

INFECTION CONTROL COMMITTEE (ICC)

The hospital ICC is charged with the responsibility for planning, evaluation of evidenced – based practice and implementation, prioritization and resource allocation of all matters relating to infection control.

The ICC must have a reporting relationship directly to either administration or the medical staff to promote infection control programme visibility and effectiveness. The ICC should meet regularly (monthly) according to local need.

THE COMMITTEE SHOULD INCLUDE-

1. Chair executive or hospital administrator
2. Hospital microbiologist
3. Infection control nurse
4. Occupational health physician
5. Representative from the major clinical specialities
6. Additional representatives of any other department.

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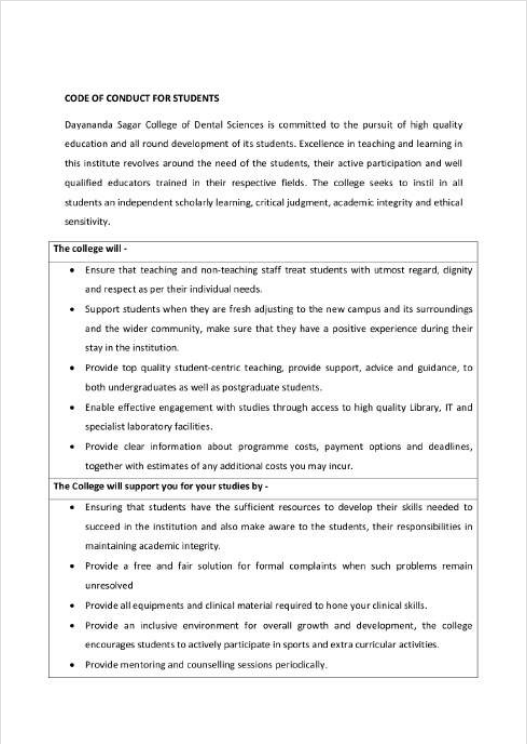

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Dayananda Sagar College of Dental Sciences is committed to the pursuit of high quality education and all round development of its students. Excellence in teaching and learning in this institute revolves around the need of the students, their active participation and well qualified educators trained in their respective fields. The college seeks to instil in all students an independent scholarly learning, critical judgment, academic integrity and ethical sensitivity.

The college will -

- Ensure that teaching and non-teaching staff treat students with utmost regard, dignity and respect as per their individual needs.
- Support students when they are fresh adjusting to the new campus and its surroundings and the wider community, make sure that they have a positive experience during their stay in the institution.
- Provide top quality student-centric teaching, provide support, advice and guidance, to both undergraduates as well as postgraduate students.
- Enable effective engagement with studies through access to high quality Library, IT and specialist laboratory facilities.
- Provide clear information about programme costs, payment options and deadlines, together with estimates of any additional costs you may incur.

The College will support you for your studies by -

- Ensuring that students have the sufficient resources to develop their skills needed to succeed in the institution and also make aware to the students, their responsibilities in maintaining academic integrity.
- Provide a free and fair solution for formal complaints when such problems remain unresolved
- Provide all equipments and clinical material required to hone your clinical skills.
- Provide an inclusive environment for overall growth and development, the college encourages students to actively participate in sports and extra curricular activities.
- Provide mentoring and counselling sessions periodically.

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Submission ID:	1987021486

To Evaluate Knowledge Awareness and Attitude Regarding Teledentistry Among Dentists in Bangalore- A Cross Sectional Study

Abstract

A rapidly developing country like India, still has to face the problems of lack of availability of access to medical and dental care even today. With rapid digitalization happening all across the globe, the idea of using it for clearing the gap between the patient and the dentist is a new revolution in the field of telemedicine. This article evaluates the awareness and attitude of dentists in south Bangalore towards teledentistry. It also includes a discussion based on different questions and how dentists from different specialties and age groups answered them. We can conclude with this article, that, teledentistry is a very viable option for oral health care for those who have difficult in accessing it and that dentists are very open to accept it and adopt it.

Keywords: Teledentistry, telemedicine, teleconsultation, COVID-19, awareness, attitude

Report- Dr.Shobha- Paper-2

by Dr. Shobha

Submission date: 12-Nov-2022 01:15PM (UTC+0530)
Submission ID: 1951775237
File name: Nasal_Floor_Augmentation_for_Dental_Implants_-_MANUSCRIPT.pdf (197.92K)
Word count: 4632
Character count: 25734

Title: Efficacy of nasal floor augmentation on the survival rate of dental Implants: A Systematic review

Abstract

Background: Despite the fact that Nasal floor augmentation was first described more than three decades ago, the information on the literature regarding this procedure and technique and the predictability of dental implants placed in conjugation with augmented nasal floor is rather scarce.

Aim: To systematically review the existing scientific literature, to summarize and assess the efficacy of the nasal floor augmentation on the survival rate of dental implants by systematically reviewing the available literature.

Methods: Review was performed in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. Electronic databases like PubMed, google scholar and Ebsco Host were searched from 2000 to December 2021 for studies reporting efficacy of nasal floor augmentation and reporting outcomes in terms of survival rates of dental implants. Quality assessment of included comparative follow up studies was done using the critical checklist put forward by the Joanna Briggs Institute (JBI) was used.

Results: Only nine studies fulfilled the eligibility criteria and were included in the qualitative synthesis. Of those nine studies, five were case reports and four comparative follow up studies. A total of 14 implants were placed in five patients with a survival rate of 100% in included case reports while a total of 408 implants were placed in 130 patients with survival rates ranging from 89% to 100% in included comparative follow up studies. No complications were observed during follow ups and the patients were satisfied with the functional and aesthetic results of the treatment. Quality assessment of included studies showed moderate to low risk of bias with overall high quality of studies.

Conclusion: The results of this systematic review indicate that implant placement by nasal floor augmentation techniques can be considered as a predictable treatment modality. However, due to the scarcity of literature, more studies should be carried out on proving the efficacy of nasal floor augmentation on survival rate or success of dental Implants.

Keywords: Dental implant, nasal floor augmentation, implant success, implant survival

Introduction

It was strongly suggested that a lost tooth must be replaced by the restorative procedures in order for the patients to benefit from their dentition masticatory function and aesthetics.[1] Over the years, various treatment methods have been used by the clinicians to replace lost teeth such as: removable partial dentures, resin bonded or cemented fixed partial prosthesis. These treatment methods could not fulfill the patients and clinicians demand as long as preparation of adjacent intact teeth was a main part of their procedures. Especially, in anterior region of maxilla, reestablishment of aesthetic is a crucial task which cannot be accomplished by these treatment modalities properly.[2]

The loss of teeth affects the aesthetics and function of the orofacial region and consequently compromises the patient's quality of life.[3] The goal of modern dentistry is to restore oral function, appearance, and aesthetics and to improve patient's health. Implant placement in the maxilla is often limited by insufficient bone width and height after teeth loss and by the proximity of the anatomical structures, nasal cavity, and maxillary sinus.[4] In the anterior maxilla, the alveolar ridge dimensions influence implant location, position of the lip, and the architecture of the free gingival margin.[5] Bone resorption after tooth loss is usually dramatic and irreversible, and more prominent in the first year. Resorption can be vertical or horizontal, leaving the area without sufficient bone to place implants. In the anterior maxillary region, nasal floor elevation could serve as an option for bone augmentation to enable dental implant placement.[6] Despite the anatomical proximity, rehabilitation of the anterior part of the maxilla is even more challenging. The pattern of remodelling after tooth loss leads to vertical and horizontal bone resorption, leaving an inadequate alveolar ridge for dental implantation.[7] Additionally, the high aesthetic and functional demands of the patient makes the necessity of immediate provisionalization an obstacle for large reconstructions. As the nasal cavity is usually the height limit for implant placement in the anterior area, nasal floor augmentation emerges as a possibility for rehabilitation of the anterior-superior region.[8]

Nasal floor augmentation techniques was first described by Adell et al[9] and Jensen et al[10] reported on reconstruction of the severely resorbed maxilla using nasal floor elevation with autogenous bone grafts. Lundgren et al[11] reported on a two-stage technique using autogenous bone grafts to the nasal floor for implant placement. Misch et al[12] discussed a subnasal elevation techniques for implant placement using bone substitutes but scientific production regrading this procedure and the predictability of dental implants inserted in association with this

technique are still limited. Garg et al in 1997 described nasal floor augmentation as a technique for implant placement in severely resorbed maxilla with less than 10 mm of residual ridge height. He advocated the use of intraoral donor sites for autogenous bone harvest to predictably elevate the nasal mucosa by 3 to 5 mm. He further recommended that implants be placed after consolidation of the graft.[13] A modification of this technique was reported by Hising et al, in which a mixture of autogenous bone harvested from the chin, bovine bone mineral and biologic adhesive was used for the augmentation of three nasal cavities.[14]

El-Ghareeb and colleagues recently described a study aimed to evaluate the survival and success of dental implants placed in nasally grafted maxillae and inadequate height in the anterior arch to support implants underwent nasal floor augmentation. The nasal floor was exposed through an intraoral approach and grafted with osteoconductive substitutes. Twenty-four dental implants in six patients in six patients were placed, restored with bar-retained implant- supported overdentures after a traditional healing period and followed after prosthetic loading. Three patients received nasal floor augmentation and simultaneous implant placement, whereas the other three had a mean healing period of 6. Months before implant placement. The implant survival rate was 100% with no complications.[15]

The tougher and thicker nasal mucosa is difficult to pierce and relatively easy to repair. Another advantage of nasal floor augmentation is that in nasal sites, the membrane is consistently intact, while in antral sites, this is not so. The residual bone of the nasal floor often provides adequate initial implant stability, while in posterior maxilla often presents major bone deficits, resulting in a thin, low-density antral floor (residual ridge) in which low implant stability can be expected.[16]

Despite the fact that Nasal floor augmentation was first described more than three decades ago, the information on the literature regarding this procedure and technique and the predictability of dental implants placed in conjugation with augmented nasal floor is rather scarce. Going through evidences, till date no study has provided a comprehensive, qualitative analysis on the efficacy of nasal floor augmentation on the survival rate of dental implants. Therefore, we updated our research for related articles and conducted a systematic review with the aim to summarize and assess the efficacy of the nasal floor augmentation on the survival rate of dental implants by systematically reviewing the available literature.

Methodology

Protocol development

This review was conducted and performed in according to the preferred reporting items for systematic review and meta-analysis (PRISMA) statement[17].

Study design

The review question was to evaluate the outcome in terms of dental implant survival from nasal floor augmentation. The following focused research question in the Participants (P), Intervention (I), Comparison and Outcome (O) format was proposed "In patients requiring dental implant placement, what is the effect on implant survival of nasal floor augmentation?

The PICO criteria for this review were as follows:

P (Participants) – Patients requiring dental implant placement

I (Intervention) – Patients with dental implant placement in augmented nasal floor

C (Comparison) – "optional"

O (Outcome) – success or survival of dental implants placed in maxillary anterior tooth region

Eligibility Criteria

a) **Inclusion Criteria:** following were the inclusion criteria

1) Studies involving placement of dental implant in augmented maxillary nasal floor
2) Studies involving outcome measures as success or survival of dental implants in augmented nasal floor
3) Articles from open access journals
4) Articles published in English language
5) Articles published from 2000 – 2021
6) Study design: Comparative studies, prospective studies, follow up studies, retrospective studies, case report, case series

b) **Exclusion Criteria:** following were the exclusion criteria

1) Studies that do not involve placement of dental implant in augmented maxillary nasal floor
2) Studies not reporting study outcome measures as success or survival of dental implants in augmented nasal floor
3) Articles not from open access journals
4) Articles published in other than English language
5) Articles not published from 2000 – 2021
6) Animal studies, in vitro studies were excluded
7) Articles on dental implants placed in maxillary posterior region

Data extraction

For all included studies, following descriptive study details were extracted by two independent reviewing authors and using pilot-tested customized data extraction forms in Microsoft excel sheet with the following headings included in the final analysis: author(s), country of study, year of study, mean age of the participants, study design, sample size, follow up period, survival rate and conclusion

Search Strategy

A comprehensive electronic search was performed till December 2021 for the studies published within the last 21 years (from 2000 to 2021) using the following databases: PubMed, google scholar and EBSCOhost to retrieve articles in the English language. The searches in the clinical trials database, cross-referencing and grey literature were conducted using Google Scholar, Greylist, and OpenGrey.

A manual search of oral and maxillofacial surgery journals, including the International Journal of Oral and Maxillofacial Surgery, British Journal of Oral and Maxillofacial Surgery, Journal of Oral and Maxillofacial Surgery, international journal of oral and maxillofacial surgery, Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology, Journal of Cranio-Maxillofacial Surgery, Journal of Craniofacial Surgery, Journal of Maxillofacial and Oral Surgery and the journal of American Dental Association was also performed.

Appropriate key words and Medical Subject Heading (MeSH) terms were selected and combined with Boolean operators like AND. The relevant data was searched using the following keywords and their combinations: "nasal floor" (MeSH term) AND "dental implant" (MeSH term); "implant survival" (MeSH term) AND "maxillary anterior teeth" (MeSH term); "augmentation" (MeSH term) AND "nasal floor"" (MeSH term) AND survival (MeSH term); "dental implant with survival rates" (MeSH term) AND "augmented (MeSH term) AND "nasal floor elevation" (MeSH term); "dental implant" AND "survival rates" (MeSH term).

In addition to the electronic search, a hand search was also made, and reference lists of the selected articles were screened. The reference lists of identified studies and relevant reviews on the subject were also scanned for possible additional studies.

Screening Process

The search and screening, according to previously established protocol were conducted by two authors. A two-phase selection of articles was conducted. In phase one, two reviewers reviewed titles and abstracts of all articles. Articles that did meet inclusion criteria were excluded. In phase-two, selected full articles were independently reviewed and screened by same reviewers. Any disagreement was resolved by discussion. When mutual agreement between two reviewers was not reached, a third reviewer was involved to make final decision. The final selection was based on consensus among all three authors. The corresponding authors of study were contacted via email where further information was required.

Assessment of methodological quality

The quality of included studies for comparative and prospective studies was evaluated based on Newcastle Ottawa Scale and accordingly a numeric score (NOS Score) was assigned[18]. It was designed to evaluate bias based on participant selection, study group comparability in cross-sectional study, attainment of exposure in case-control studies and outcome of interest in cohort study. It is a valid and reliable tool for assessing the quality of non-randomized studies, supported by the Cochrane Collaboration for the quality appraisal of non-randomized trials. The NOS uses a nine-star rating system with a maximum of four points available for selection, two for comparability and three for the assessment of the outcome or exposure. The tool was deemed acceptable for the appraisal of cross-sectional studies as the effectiveness of an

intervention was not being measured. Quality appraisal of the included studies was undertaken by the two authors and a third author was consulted in the event of any discrepancy. A study with a score from 7 to 9 will be considered as high quality, 4 to 6 will be considered as moderate quality and 0 to 3 will be considered as low quality or very high risk of bias.

Quality assessment for the included case reports and case series, the critical checklist put forward by the Joanna Briggs Institute (JBI) was used in order to assess the quality of studies[19].

Results

Study Selection

After duplicates removal, reference list of included studies (n=25) was screened. Of which five studies were excluded. After this full text articles (n=20) were assessed for eligibility and articles that did not meet inclusion criteria were excluded. Only nine studies fulfilled eligibility criteria and were included in qualitative synthesis. A flowchart of identification, inclusion and exclusion of studies is shown in **Figure 1** below.

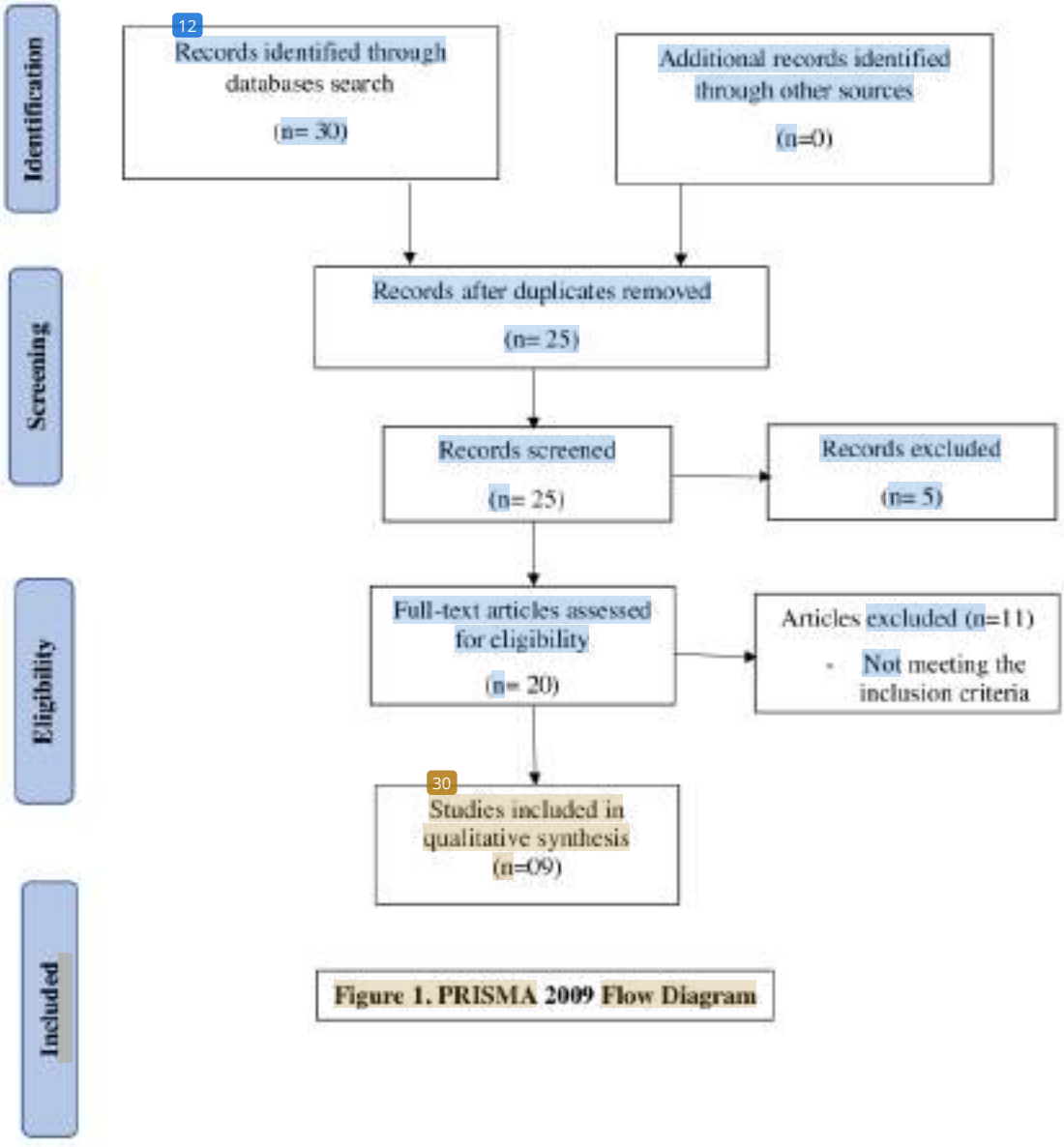

Figure 1. PRISMA 2009 Flow Diagram

Study Characteristics

A summary of descriptive characteristics all included studies is shown in **Table 1.** Five case reports[20-24] and four comparative studies[25-28] describing nasal floor augmentation and implant survival or success were included. For involved case reports, data was evaluated from an aggregate of five patients with a mean age of 63.6 years with placement of 14 implants. For included comparative follow up studies, data was evaluated from an aggregate of 130 patients with a mean age of 55.25 years and with placement of 408 implants. All the case reports concluded that nasal floor augmentation proved to be a reliable method of dental implant insertion. No complications were observed during follow ups and the patients were satisfied with the functional and aesthetic results of the treatment and all studies had survival rate of 100%. For comparative follow up studies, two studies[25,27] showed 100% implant survival through the follow ups, one study[26] had 89.2% implant survival through the follow ups and one study[28] showed 96.3% implant survival. All studies concluded that nasal floor augmentation might serve as a predictable procedure and is an effective and safe procedure, which allows implant placement in areas with significant atrophy together with increased implant stability due to the bio-cortical support and nasal floor augmentation can be used for implant placement in atrophic maxillary regions with success rates that are comparable to those of implants placed in the maxillary sinus.

S.no	Author (Year)	Country	Sample Size (n)	Mean Age of Volunteers	No. of implant placed	Follow up period	Survival rate	Conclusion
1.	Kucukkurt et al, 2015[20]	Turkey	1	63 years	4	12 months	100%	Nasal floor augmentationn may be a treatment modality and could serve as a feasible option for treatment of edentulous maxilla
2.	Rafael et al, 2016[21]	Brazil	1	48 years	3	Six months	100%	Nasal floor augmentation proved to be a reliable

								method for dental implant
3.	Sentineri et al, 2016[22]	Italy	3	67 years	3	Eighteen months	100%	Nasal floor augmentation could be a minimally invasive, alternative method for vertical bone augmentation
4.	Anitua et al,2021[23]	Spain	1	65 years	2	10 years	100%	Nasal floor augmentation might serve as a reliable method for Implant placement
5.	Jordan et al, 2022[24]	Croatia	1	75 years	2	Not mentioned	100%	Nasal floor augmentation can be considered as a predictable technique for rehabilitation in the atrophic anterior maxilla.
6.	Mazor et al, 2010[25]	Israel	32	56.5 years	100	28 months	100%	Nasal floor augmentation might serve as a predictable procedure
7.	Garcia-Denche et al, 2014[26]	Canada	14	65.9 years	78	12 months	89.2%	Nasal floor augmentation is an effective and safe procedure that can be used for implant placement with high success rates
8.	Lorean et al, 2014[27]	Israel	67	58.7 years	203	86 months	100%	Nasal floor augmentation might serve as a reliable

								method for reconstruction of the anterior atrophic maxilla when residual height is insufficient
9.	Parhiz et al, 2017[28]	Iran	14	40 years	27	6 months	96.3%	Implant placement by nasal floor augmentation techniques can be considered as a predictable treatment modality

Table 1: showing descriptive study characteristics of included studies

Assessment of Methodological Quality

Among the included case repots, overall quality appraisal of the included studies were high as all the questions under the checklist were answered by all the studies as **shown below in Figure 2**

Questions	Yes	No	Unclear	Not applicable
1. Were patient's demographic characteristics clearly described?	Present	-	-	-
2. Was the patient's history clearly described and presented as a timeline?	Present	-	-	-
3. Was the current clinical condition of the patient on presentation clearly described?	Present	-	-	-
4. Were the diagnostic tests or assessments methods and the results clearly described?	Present	-	-	-
5. Was the intervention(s) or treatment procedure(s) clearly described?	Present	-	-	-
6. Was the post intervention clinical condition clearly described?	-	-	-	-
7. Were adverse events identified and described?	Present	-	-	-
8. Does the case report provide takeaway lessons?	Present	-	-	-

Figure 2: shows quality appraisal of included case reports using Joanna Brigga Checklist

Among the included cohort studies, none of the study reached the maximum score of the Newcastle Ottawa scale. The highest overall quality score was gained only by one study[25] . Only one study[25] gained the maximum score in the selection criteria and was considered to have the highest level of quality with an estimated low risk of bias; only one study[26] had high risk of bias for comparability outcome while for outcome, all the studies had moderate to low risk of bias. Risk of bias of included cohort studies through Newcastle Ottawa scale is depicted in **Figure 3** below.

Author, year	Selection (Max = 4)	Comparability (Max = 2)	Outcome (Max = 3)	Overall quality score (Max = 9)
Mazor et al, 2010[25]	****	**	**	8
Garcia-Denche et al, 2014[26]	***	*	***	7
Lorean et al, 2014[27]	**	**	***	7
Parhiz et al, 2017[28]	**	**	**	6

Figure 3: shows Risk of bias of included cohort studies through Newcastle Ottawa scale

Discussion

The aim of this systematic review was to summarize and assess the efficacy of the nasal floor augmentation on the survival rate of dental implants by systematically reviewing the available literature. Despite the fact that Nasal floor augmentation was first described more than three decades ago, the information on the literature regarding this procedure and technique and the predictability of dental implants placed in conjugation with augmented nasal floor is rather scarce.

Going through evidences, till date no study has provided a comprehensive, qualitative analysis on the efficacy of nasal floor augmentation on the survival rate of dental implants. Therefore, we updated our research for related articles and to our knowledge conducted a first systematic review with the aim to summarize and assess the efficacy of the nasal floor augmentation on the survival rate of dental implants by systematically reviewing the available literature.

The present systematic review summarizes evidence from case reports and comparative follow up studies on human participants receiving dental implants on nasal floor augmentation with mean follow up of 24 months. The results from the identified case reports with 5 patients with placement of 14 implants had an excellent survival rate of 100% with no evidence of delayed healing or complications and all studies suggested that Nasal floor augmentation might serve as a reliable method for Implant placement while results from the comparative follow up studies with 130 patients with placement of 408 implants also had an excellent survival rate from 89% to 100%. The highest survival rate was shown by two studies[25,27] while the lowest survival rate was shown by one study[26]. All studies concluded that nasal floor augmentation might serve as a predictable procedure and is an effective and safe procedure, which allows implant placement in areas with significant atrophy together with increased implant stability due to the bio-cortical support and nasal floor augmentation can be used for implant placement in atrophic maxillary regions with success rates that are comparable to those of implants placed in the maxillary sinus.

The strengths of this systematic review include the following of strict PRISMA guidelines, the extensive unrestricted literature search, the use of robust methodology pertaining to the qualitative synthesis of data, the assessment of the quality of evidence with the Newcastle Ottawa Scale (NOS) and the critical checklist put forward by the Joanna Briggs Institute (JBI) was used. For the quality assessment all the included studies, had moderate to low risk of bias

and overall quality of included studies were high indicating absence of potential and unavoidable sources of bias with less reporting deficiencies and variability.

However, few limitations were also present. Going through the evidences, there is a scarcity and paucity of literature on efficacy of nasal floor augmentation on the survival rate of dental implants. Even after going through an unrestricted search and eligibility criteria, the number of included studies for qualitative synthesis was very less. Only nine studies were included in our systematic review. There is a need to conduct more follow up studies on the efficacy of nasal floor augmentation on the survival rate or success of dental implants. Furthermore, there should a trial of conducting a systematic review and meta-analysis, for getting an overall pooled estimate of the success rate of dental implants placed on augmented nasal floor.

Conclusion

The results of this systematic review indicate that implant placement by nasal floor augmentation techniques can be considered as a predictable treatment modality. However, due to the scarcity of literature, more studies should be carried out on proving the efficacy of nasal floor augmentation on survival rate or success of dental Implants.

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Report- Dr.Shobha- Paper-2

ORIGINALITY REPORT

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Report- Dr.Shobha- Paper-3

by Dr. Shobha

Submission date: 12-Nov-2022 01:16PM (UTC+0530)
Submission ID: 1951775639
File name: ORIF_vs_CR_for_Condylar_Fracture_Management_-_Manuscript.pdf (677.65K)
Word count: 6472
Character count: 36191

Title: Comparative evaluation of open reduction with internal fixation against closed reduction methods for condylar fracture management– A Systematic review and meta- analysis

Abstract

Background: Mandibular fractures are frequent in facial trauma. Management of mandibular condylar fractures (MCF) remains an ongoing matter of controversy in maxillofacial injury. A number of techniques, from closed reduction (CR) to open reduction and internal fixation (ORIF) can be effectively used to manage these fractures. The best treatment strategy, that is, closed reduction or open reduction with internal fixation, remains controversial.

Aim: To systematically review the existing scientific literature to determine whether open reduction with internal fixation or closed reduction is a better treatment alternative for the patients with condylar fractures through a meta-analysis.

Methods: Review was performed in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. Electronic databases like PubMed, google scholar and Ebsco Host were searched from 2000 to December 2021 for studies reporting management of condylar fractures through open reduction with internal fixation against closed reduction and reporting the outcome in terms of mean and standard deviation (SD). Quality assessment of included case control and cohort studies was done using Newcastle Ottawa Scale and randomized studies was evaluated using Cochrane risk of bias (ROB) -2 tool through its domains. The risk of bias summary graph and risk of bias summary applicability concern was plotted using RevMan software version 5.3. The standardized mean difference (SDM) was used as summary statistic measure with random effect model and p value <0.05 as statistically significant.

Results: Seventeen studies fulfilled the eligibility criteria and were included in qualitative synthesis, of which only nine studies were suitable for meta -analysis. The pooled estimate through the Standardized Mean Difference (SMD) of 0.80, 0.36 and 0.42 for maximum inter incisal opening, laterotrusion and protrusion favours CR compared to ORIF for condylar fracture management. Also, most results of heterogeneity tests were poor and most of the funnel plots showed asymmetry, indicating presence of possible publication bias.

Conclusion: The results of our meta-analysis suggests that CR provides superior outcomes in terms of maximum inter incisal opening, laterotrusion and protrusion compared to ORIF in condylar fractures management. It is necessary to conduct more prospective randomized studies and properly control confounding factors to achieve effective results and gradually unify clinical guidelines.

Keywords: Closed reduction, condyle, fracture, laterotrusion, mouth opening, protrusion, open reduction

Introduction

Mandibular fractures are frequent in facial trauma. Condylar process fractures are highly frequent and prevalent in maxillofacial injuries and represent about 25 – 40% of all mandibular fractures[1]. Management of mandibular condylar fractures (MCF) remains an ongoing matter of controversy in maxillofacial injury. This controversy is reflected in the wide variety of opinions and proposed treatment modalities offered in the literature[2]. The best treatment strategy, that is, closed reduction or open reduction with internal fixation, remains controversial[3].

For decades, closed reduction (CR) has been the preferred treatment because the treatment is easier and less invasive and the results are comparable with no surgical complications. However, CR may employ varying periods of intermaxillary fixation (IMF) from 0 to 6 weeks followed by aggressive physiotherapy[4]. Nevertheless, CR appears to be associated with a high risk of long -term complications like temporomandibular joint (TMJ) pain, open bite, arthritis, malocclusion, deviation of mandible on opening and closing movements, TMJ dysfunction, facial asymmetry, inadequate restoration of vertical height of ramus and ankylosis may occur in condylar injuries treated closed[5].

A better understanding of the sequelae associated with closed treatment has resulted in a trend towards open treatment, allowing anatomic repositioning and internal fixation and enabling functional aftercare[6]. With the development of surgical techniques and improvement of internal fixation materials, open reduction and internal fixation (ORIF), which could be used to anatomically restore fractured condyle, has been gradually accepted and widely applied[7]. Open reduction and internal fixation (ORIF) allow anatomic repositioning and immediate functional movements of the jaw but has the potential complications of damaging the facial nerve and forming visible scars[8].

With the implementation of rigid internal fixation (IF) over the past 30 years, indications for surgical treatment of MCFs have broadened. A review of the literature revealed several studies comparing open reduction with internal fixation (ORIF) against closed Reduction (CR) in the treatment of MCFs, but there is still a continuing debate over how to best manage this type of fracture.

Going through evidences, till date no study has provided a comprehensive, quantitative analysis of comparison of open reduction with internal fixation (ORIF) against closed reduction on which best treatment option for condylar fractures could be established. Therefore, we updated

our research for related articles and conducted a systematic review with the aim to compare the open reduction with internal fixation (ORIF) against closed reduction according to the effect on maximum interincisal opening, laterotrusion and protrusion in adults with condylar fractures through a novel meta-analysis.

Methodology

Protocol development

This review was conducted and performed in according to the preferred reporting items for systematic review and meta-analysis (PRISMA) statement[9].

Study design

The review question was to evaluate the outcome in terms of maximum interincisal opening, laterotrusion and protrusion by comparing open reduction with internal fixation (ORIF) against closed reduction in management of condylar fractures. The following focused research question in the Participants (P), Intervention (I), Comparison and Outcome (O) format was proposed "What is the efficiency of open reduction with internal fixation (ORIF) against closed reduction in management of condylar fractures?

The PICO criteria for this review were as follows:

P (Participants) – Patients with condylar fractures

I (Intervention) – open reduction with internal fixation

C (Comparison) – Comparison of open reduction with internal fixation (ORIF) against closed reduction in management of condylar fractures

O (Outcome) – correction of condylar fractures in terms of maximum interincisal opening, laterotrusion and protrusion

Eligibility Criteria

a) **Inclusion Criteria:** following were the inclusion criteria

1) Articles published in English language
2) Articles having sufficient data on open reduction with internal fixation (ORIF) against closed reduction in management of condylar fractures
3) Studies published between 2000 – 2021 and having relevant data on open reduction with internal fixation (ORIF) against closed reduction in management of condylar fractures

4) Clinical studies, case control studies, cohort studies, comparative studies
5) Articles from open access journals
6) Articles reporting the study outcomes in terms of mean and standard deviation

b) **Exclusion Criteria:** following were the exclusion criteria

1) Any studies conducted before 2000
2) Articles in other than English language
3) Reviews, abstracts, letter to the editor, editorials, animal studies and in vitro studies were excluded
4) Articles not from open access journals
5) Articles not reporting the study outcomes in terms of mean and standard deviation

Data extraction

For all included studies, following descriptive study details were extracted by two independent reviewing authors and using pilot-tested customized data extraction forms in Microsoft excel sheet with the following headings included in the final analysis: author(s), country of study, year of study, mean age of the participants, study design, sample size, type of condylar fracture, aetiology of fracture, treatment or fixation method.

Search Strategy

A comprehensive electronic search was performed till December 2021 for the studies published within the last 21 years (from 2000 to 2021) using the following databases: PubMed, google scholar and EBSCOhost to retrieve articles in the English language. The searches in the clinical trials database, cross-referencing and grey literature were conducted using Google Scholar, Greylist, and OpenGrey.

A manual search of oral and maxillofacial surgery journals, including the International Journal of Oral and Maxillofacial Surgery, British Journal of Oral and Maxillofacial Surgery, Journal of Oral and Maxillofacial Surgery, international journal of oral and maxillofacial surgery, Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology, Journal of

Cranio-Maxillofacial Surgery, Journal of Craniofacial Surgery, Journal of Maxillofacial and Oral Surgery and the journal of American Dental Association was also performed.

Appropriate key words and Medical Subject Heading (MeSH) terms were selected and combined with Boolean operators like AND. The relevant data was searched using the following keywords and their combinations: "open reduction" (MeSH term) AND "condylar fractures" (MeSH term); "closed reduction" (MeSH term) AND "condylar fractures" (MeSH term); "internal fixation" (MeSH term) AND "condylar fractures"" (MeSH term) AND protrusion (MeSH term); "open reduction with internal fixation" (MeSH term) AND "closed reduction (MeSH term) AND "laterotrusion" (MeSH term); "mouth opening" AND "mandibular fracture" (MeSH term).

In addition to the electronic search, a hand search was also made, and reference lists of the selected articles were screened. The reference lists of identified studies and relevant reviews on the subject were also scanned for possible additional studies.

Screening Process

The search and screening, according to previously established protocol were conducted by two authors. A two-phase selection of articles was conducted. In phase one, two reviewers reviewed titles and abstracts of all articles. Articles that did meet inclusion criteria were excluded. In phase-two, selected full articles were independently reviewed and screened by same reviewers. Any disagreement was resolved by discussion. When mutual agreement between two reviewers was not reached, a third reviewer was involved to make final decision. The final selection was based on consensus among all three authors. The corresponding authors of study were contacted via email where further information was required.

Quality assessment of included studies

The quality of included studies for observational studies was evaluated based on Newcastle Ottawa Scale and accordingly a numeric score (NOS Score) was assigned [9]. It was designed to evaluate bias based on participant selection, study group comparability in cross-sectional study, attainment of exposure in case-control studies and outcome of interest in cohort study. It is a valid and reliable tool for assessing the quality of non-randomized studies, supported by the

Cochrane Collaboration for the quality appraisal of non-randomized trials. The NOS uses a nine-star rating system with a maximum of four points available for selection, two for comparability and three for the assessment of the outcome or exposure. The tool was deemed acceptable for the appraisal of cross-sectional studies as the effectiveness of an intervention was not being measured. Quality appraisal of the included studies was undertaken by the two authors and a third author was consulted in the event of any discrepancy. A study with a score from 7 to 9 will be considered as high quality, 4 to 6 will be considered as moderate quality and 0 to 3 will be considered as low quality or very high risk of bias.

The methodological quality among included studies was executed by using Cochrane collaboration risk of bias (ROB) -2 tool[11]. The tool has various domains like random sequence generation (selection bias), allocation concealment (selection bias), blinding of personnel and equipments (performance bias), blinding of outcome assessment (detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias) and other biases through their signalling questions in Review Manager (RevMan) 5.3 software. The overall risk for individual studies was assessed as low, moderate or high risk based on domains and criteria. The study was assessed to have a low overall risk only if all domains were found to have low risk. High overall risk was assessed if one or more of the six domains were found to be at high risk. A moderate risk assessment was provided to studies when one or more domains were found to be uncertain, with none at high risk.

Statistical analysis

The standardized mean difference (SDM) with 95% CI was calculated for continuous outcomes. A fixed effects model (Mantel-Haenszel method) was used if there was no heterogeneity ($p > 0.05$ or I-squared $\leq 24\%$), otherwise a random effects model (Der Simonian-Laird method) was used[12]. All statistical analyses were performed using the RevMan 5.3 (Cochrane Collaboration, Software Update, Oxford, UK). The significance level was kept at $p<0.05$.

Assessment of heterogeneity

The significance of any discrepancies in the estimates of the treatment effects of the different trials was assessed by means of Cochran's test for heterogeneity and the I^2 statistics, which describes the percentage of the total variation across studies that is due to heterogeneity rather than chance. Heterogeneity was considered statistically significant if $P < 0.1$. A rough guide to the interpretation of I^2 given in the Cochrane handbook is as follows: (1) from 0 to 40%, the heterogeneity might not be important; (2) from 30% to 60%, it may represent moderate heterogeneity; (3) from 50% to 90%, it may represent substantial heterogeneity; (4) from 75% to 100%, there is considerable heterogeneity[13].

Investigation of publication bias

To test for the presence of publication bias, the relative symmetry of the individual study estimates was assessed around the overall estimates using Begg's funnel plot. A funnel plot (plot of the effect size versus standard error) was drawn. Asymmetry of the funnel plot may indicate publication bias and other biases related to sample size, although asymmetry may also represent a true relationship between trial size and effect size[14].

Results

Study Selection

After duplicates removal, reference list of included studies was screened. Of which 121 studies were excluded. After this full text articles were assessed for eligibility and articles that did not meet inclusion criteria were excluded. Only seventeen studies fulfilled eligibility criteria and were included in qualitative synthesis. Of which only nine studies were included in meta – analysis. A flowchart of identification, inclusion and exclusion of studies is shown in **Figure 1** below.

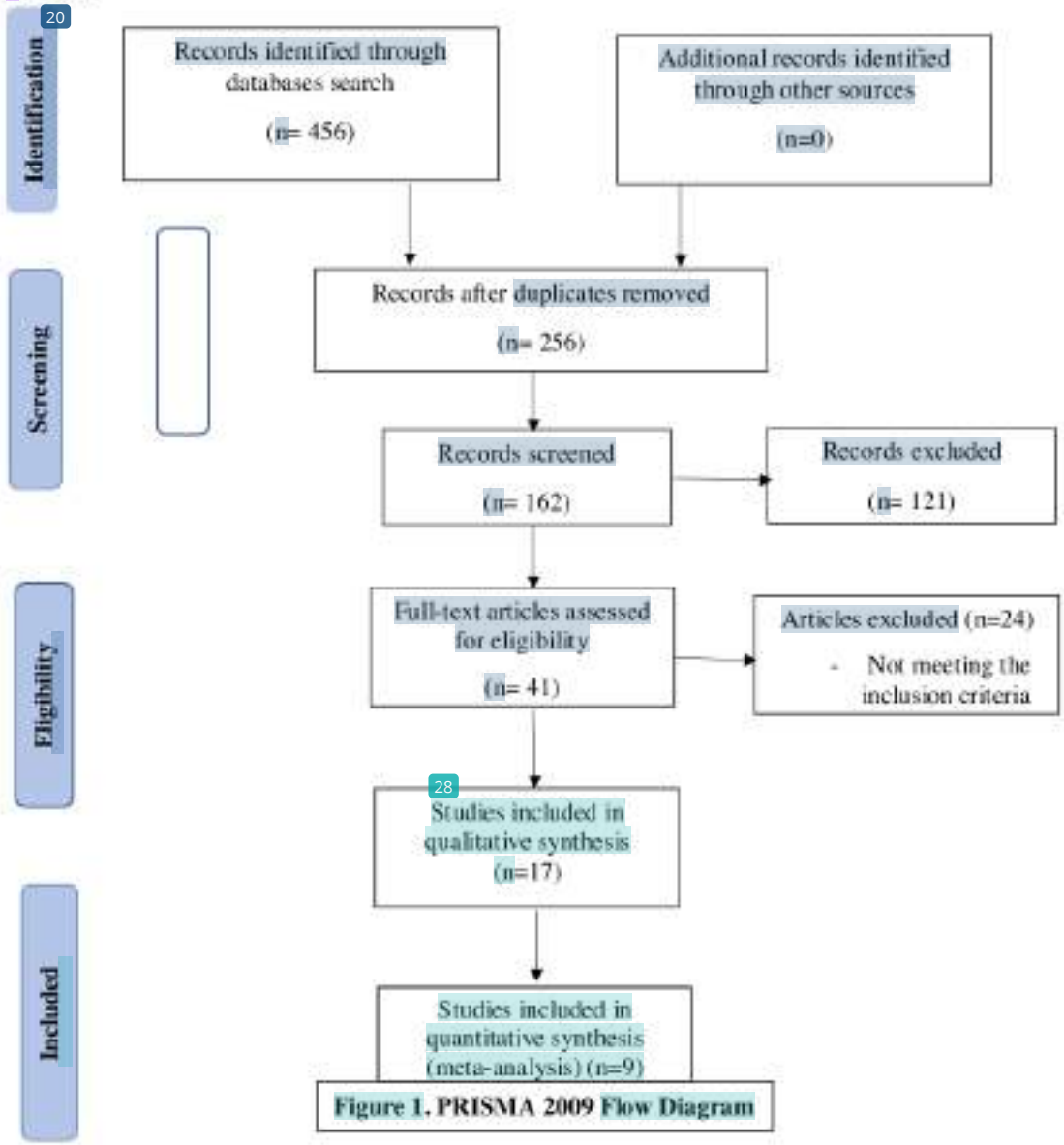

Figure 1. PRISMA 2009 Flow Diagram

Study Characteristics

A summary of descriptive characteristics all included studies is shown in **Table 1.** Data was evaluated from an aggregate of 907 (n) patients with a mean age of 35.01 years. Data of open reduction with internal fixation was evaluated from 440 (n) patients while data of closed reduction was evaluated from 467 (n) patients. Among the included studies, nine studies[17,22,23-27,29,30] studies were conducted in India, four studies[19-21,28] were conducted in Germany, one study[13] in Korea, one study[16] in Brazil, one study in USA[18] and one study in Slovenia[31]. Among the included studies, three studies[15-17] had case control design, seven studies[18-24] had cohort or prospective study design while seven studies[25-31] had randomized controlled study design. All the studies evaluated patients with closed reduction and open reduction with internal fixation.

Table 1: showing descriptive study characteristics of included studies

S. No.	Author (Year)	Country	Sample Size (ORIF / CR)	Mean Age of Volunteers	Study design	Type of condylar fracture	Closed reduction methods	Surgical approach
1.	Yong Kim et al, 2014[15]	Korea	33/15	42 years	Case control	Subcondylar	CR followed by IMF for 7 days	ORIF
2.	Stypulkowski et al, 2019[16]	Brazil	9/8	Not mentioned	Case control	Condylar process	CR followed by IMF for 2-3 weeks	OR by retromandibular approach
3.	Bansal et al, 2021[17]	India	23/ 54	Not mentioned	Case control	Condylar process	CR	ORIF
4.	Throckmorton et al, 2000[18]	USA	74/62	42	Cohort	Condylar process	CR	ORIF
5.	Landes et al, 2005[19]	Germany	27/31	36	Cohort	Subcondylar and condylar head	CT: IMF for 2 weeks	ORIF: preauricular approach
6.	Jensen et al, 2006[20]	Denmark	24/81	42	Cohort	Concomitant condylar fracture	Not mentioned	ORIF
7.	Kokemueller et al, 2012[21]	Germany	44/31	Not mentioned	Cohort	Condylar process	CR	ORIF
8.	Kotrashetti et al, 2013[22]	India	10/12	Not mentioned	Cohort	Subcondylar	CT: IMF+ elastics for 3 -4 weeks, ORIF:	ORIF: retromandibular approach

							titanium miniplates and 2x6 mm miniplate screws	
9.	Gareikpatii et al, 2021[23]	India	25/25	26	Cohort	Condylar process	CR	ORIF
10.	Prakash et al, 2022[24]	India	11/11	31.5	Cohort	Condylar process	CR	ORIF
11.	Karan et al, 2019[25]	India	10/10	Not mentioned	RCT	Condylar process and condylar neck	CR	ORIF
12.	Khiabani et al, 2015[26]	India	20/20	Not mentioned	RCT	Subcondylar	CR with arch bars	ORIF
13.	Rashid et al, 2020[27]	India	24/25	Not mentioned	RCT	Condylar process	CR	ORIF
14.	Schneider et al, 2008[28]	Germany	36/30	Not mentioned	RCT	Condylar process	CT: IMF for 10 days + elastic ORIF: ORIF using 1 or 2 Miniplate/lag screw	ORIF: preauricular, transoral and retromandibular approach
15.	Singh et al, 2010[29]	India	18/22	25	RCT	Subcondylar	CT: IMF+ elastic for 7 to 35 days ORIF: 2 mm titanium Miniplates+ IMF with elastic for 3-5 days	ORIF: retromandibular, anteroparotid approach
16.	Singh et al, 2016[30]	India	10/10	Not mentioned	RCT	Subcondylar	CR + MMF	ORIF: retromandibular approach + IMF with 2mm miniplates
17.	Vesnaver et al, 2011[31]	Slovenia	42/20	Not mentioned	RCT	Condylar process	CR	ORIF

RCT: randomized controlled trial; ORIF: open reduction internal fixation; CR: closed reduction; IMF: intermaxillary fixation

Assessment of methodological Quality of included studies

Among the included case control studies, none of studies reached the maximum score of the Newcastle Ottawa scale. Only one study[16] gained the maximum score in the selection criteria and was considered to have the highest level of quality with an estimated low risk of bias; two studies[15,17] had the maximum score in the comparability outcome and was considered to have the highest level of quality with an estimated low risk of bias; and all the studies had a partial score in the exposure outcome while only one study[17] had the highest score for exposure outcome having the lowest level of quality with an estimated low risk of bias. Risk of bias of included case control studies through Newcastle Ottawa scale is depicted in **Table 2** below.

Author, year	Selection (Max = 4)	Comparability (Max = 2)	Exposure (Max = 3)	Overall quality score (Max = 9)
Yong Kim et al. 2014[15]	**	**	**	6
Stypulkowski et al. 2019[16]	***	*	**	6
Bansal et al. 2021[17]	**	**	***	7

Among the included cohort studies, none of the study reached the maximum score of the Newcastle Ottawa scale. Only two studies[18,23] gained the maximum score in the selection criteria and was considered to have the highest level of quality with an estimated low risk of bias; only one study[19] had high risk of bias for comparability outcome while for outcome, all the studies had moderate to low risk of bias. Risk of bias of included cohort studies through Newcastle Ottawa scale is depicted in **Table 3** below.

Author, year	Selection (Max = 4)	Comparability (Max = 2)	Outcome (Max = 3)	Overall quality score (Max = 9)
Thockmorton et al, 2000[18]	****	**	**	8
Landes et al, 2005[19]	***	*	***	7
Jensen et al, 2006[20]	**	**	***	7
Kokemueller et al, 2012[21]	**	**	**	6
Kotrashetti et al, 2013[22]	***	**	**	7
Gareikpatii et al, 2021[23]	****	**	**	8
Prakash et al, 2022[24]	**	**	**	6

All fours RCTs were largely comparable in methodological quality. All the included studies had moderate to high risk of bias with all the respected domains. The highest risk of bias was seen for blinding of allocation concealment (selection bias). Among the included studies, three studies[26,28,31] had the high risk of bias compared to all other studies. Domains of random sequence generation (selection bias) and selective reporting (reporting bias) were given at the lowest risk of bias by included studies while allocation concealment (selection bias) was given highest risk of bias followed by blinding of outcome assessment (detection bias). Risk of bias for included randomized controlled trials through Cochrane risk of bias (ROB)-2 tool is depicted in **Figure 2 and 3** as shown below

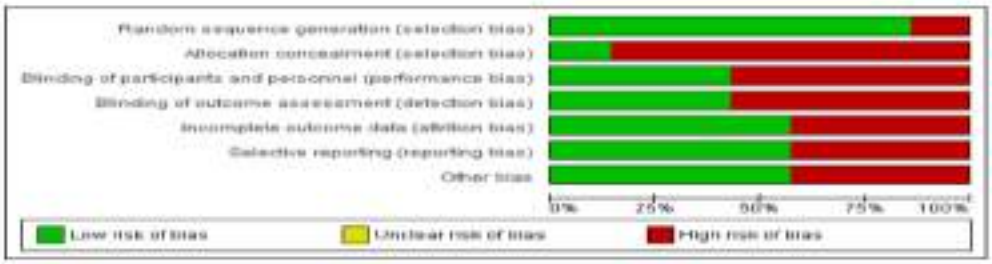

Figure 2: showing risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

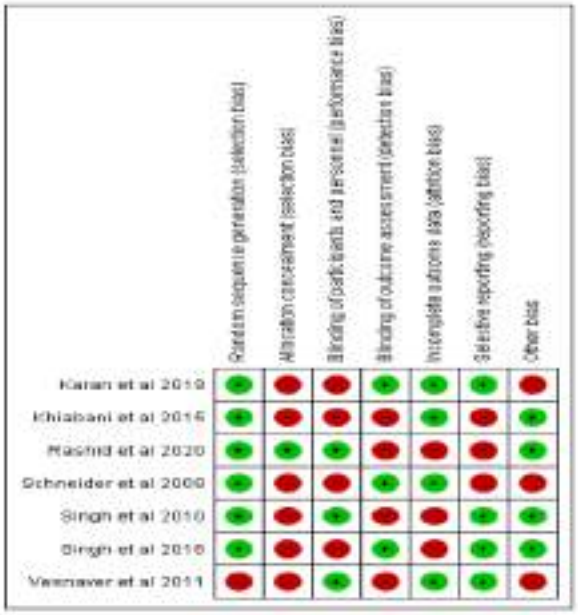

Figure 3: showing risk of bias summary: review authors' judgements about each risk of bias item for each included study

Synthesis of result

Nine studies[18,19,22-26,31] containing data on 384 (n=384) patients, of which (n=197) patients were evaluated by open reduction with internal fixation and (n=187) patients were evaluated by closed reduction for the evaluation of management of condylar fractures. The mean age of participants was 34.67 years. The standardized mean difference is used as a summary statistic in meta-analysis when the studies all assess the same outcome but measure it in different way. Therefore, it is necessary to standardized the results of the studies to a common scale before

they can be combined to an overall pooled estimate. The outcome was assessed in terms of maximum interincisal opening, laterotrusion and protrusion.

A) **Maximum inter incisal opening**: As shown in **Figure 4**, nine studies[18,19,21,26-31] containing data on 384 (n=384) patients, of which (n=197) patients were evaluated by open reduction with internal fixation and (n=187) patients were evaluated by closed reduction for the maximum inter incisal opening as an outcome. The Std. Mean Difference is 0.80 (0.21 – 1.39) and the pooled estimates favours closed reduction. This signifies that the management of condylar fractures in terms of maximum inter incisal opening as an outcome is on an average is 0.80 times more by closed reduction as compared to open reduction with internal fixation but it is not statistically significant (p=0.008). Both are more or less equally.

Among all the included studies, Throckmorton et al 2000 had highest weightage at the overall pooled estimate while the lowest weightage was observed for Singh et al 2016 at the pooled estimate. Weight of the study is directly proportional to the sample size (n) and inversely proportional to the variability. Box represents the weight of each study while the black horizontal line represents the 95% confidence limit. Bigger the size of box, more the weightage of study at the pooled estimate and wider the horizontal line, more the presence of variability and less weightage of that individual study at the overall pooled estimate

By employing the random effect model the I^2 statistic showed 86%, the heterogeneity for Tau^2 was 0.68, x^2 being p<0.00001 and the overall effect for Z value being 2.65(p=0.008).

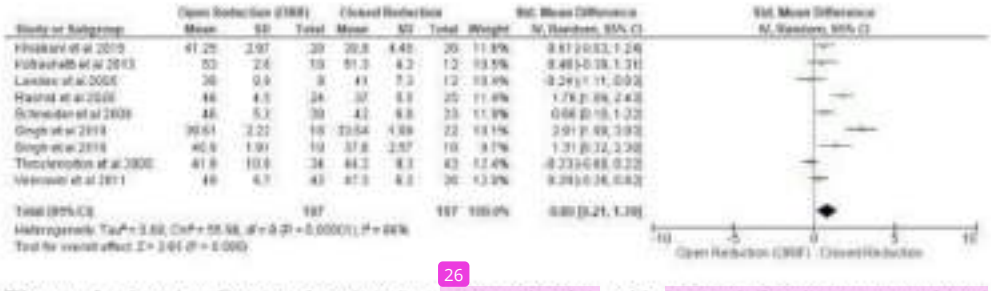

Figure 4: showing Forest plot showing open reduction with internal fixation versus closed reduction with regards to the maximum inter-incisal opening

The funnel plot did show significant asymmetry, indicating presence of publication bias as shown in **Figure 5.** Funnel plot showing asymmetric distribution with systematic heterogeneity of individual study compared to the standard error, showing a presence of publication bias in the meta-analysis.

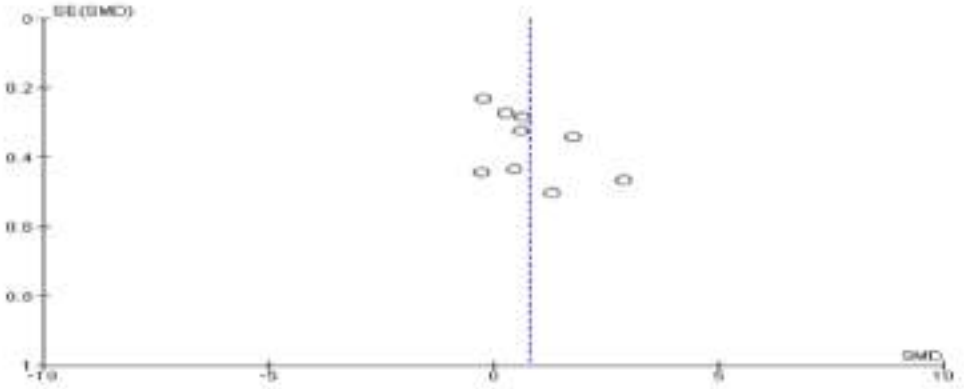

Figure 5: showing Begg's Funnel plot with 95% confidence intervals demonstrating asymmetric distribution with systematic heterogeneity of individual study compared with the standard error of each study, indicating a presence of publication bias.

B) **For laterotrusion**: As shown in **Figure 6,** five studies[18,19,22,28,29] containing data on 205 (n=205) patients, of which (n=99) patients were evaluated by open reduction with internal fixation and (n=106) patients were evaluated by closed reduction for the laterotrusion as an outcome. The Std. Mean Difference is 0.36 (-0.32 – 1.05) and the pooled estimates favours closed reduction. This signifies that the management of condylar fractures in terms of laterotrusion as an outcome is on an average is 0.36 times more by closed reduction as compared to open reduction with internal fixation but it is not statistically significant (p=0.30). Both are more or less equally. Among all the included studies, Throckmorton et al 2000 had highest weightage at the overall pooled estimate while the lowest weightage was observed for landes et al 2005 at the pooled estimate.

By employing the random effect model the I^2 statistic showed 91%, the heterogeneity for Tau^2 was 0.48, x^2 being (p=0.0004) and the overall effect for Z value being 1.05(p=0.30).

Figure 6: showing Forest plot showing open reduction with internal fixation versus closed reduction with regards to the laterotrusion

The funnel plot did not show significant asymmetry, indicating absence of publication bias as shown in **Figure 7.** Funnel plot showing symmetric distribution with absence of systematic heterogeneity of individual study compared to the standard error, showing an absence of publication bias in the meta-analysis.

Figure 7: showing Begg's Funnel plot with 95% confidence intervals demonstrating symmetric distribution with absence of systematic heterogeneity of individual study compared with the standard error of each study, indicating an absence of publication bias.

c) **For protrusion**: As shown in **Figure 8,** five studies[18,19,28,29,30] containing data on 203 (n=203) patients, of which (n=99) patients were evaluated by open reduction with internal fixation and (n=104) patients were evaluated by closed reduction for the protrusion as an outcome. The Std. Mean Difference is 0.42 (-0.33 – 1.17) and the pooled estimates favours closed reduction. This signifies that the management of condylar fractures in terms of protrusion as an outcome is on an average is 0.42 times more by closed reduction as compared to open reduction with internal fixation but it is not statistically significant (p=0.27). Both are more or less equally. Among all the

included studies, Throckmorton et al 2000 had highest weightage at the overall pooled estimate while the lowest weightage was observed for Singh et al 2016 at the pooled estimate.

By employing the random effect model the I^2 statistic showed 84%, the heterogeneity for Tau^2 was 0.60, x^2 being ($p<0.0001$) and the overall effect for Z value being 1.09($p=0.27$).

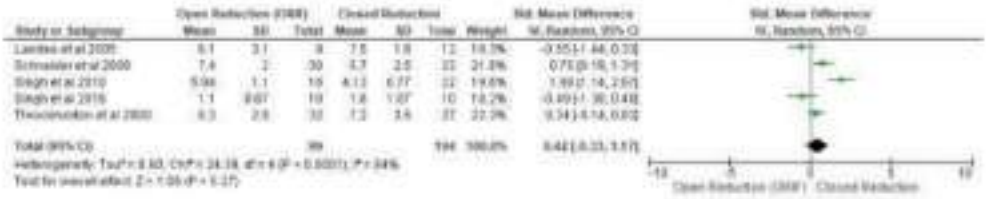

Figure 8: showing Forest plot showing open reduction with internal fixation versus closed reduction with regards to the protrusion

The funnel plot did not show significant asymmetry, indicating absence of publication bias as shown in **Figure 9.** Funnel plot showing symmetric distribution with absence of systematic heterogeneity of individual study compared to the standard error, showing an absence of publication bias in the meta-analysis.

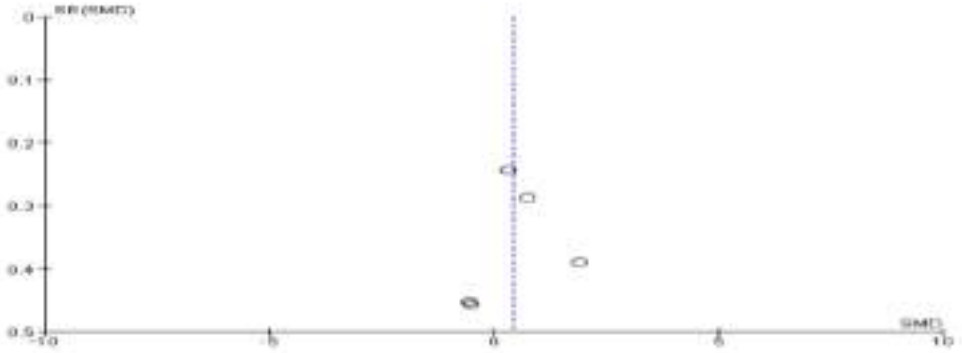

Figure 9: showing Begg's Funnel plot with 95% confidence intervals demonstrating symmetric distribution with absence of systematic heterogeneity of individual study compared with the standard error of each study, indicating an absence of publication bias.

Discussion

Mandibular fractures are frequent in facial trauma. Condylar process fractures are highly frequent and prevalent in maxillofacial injuries and represent about 25 – 40% of all mandibular fractures[1]. Management of mandibular condylar fractures (MCF) remains an ongoing matter of controversy in maxillofacial injury. At present, the rational treatment regimen of condylar fractures remains controversial. This controversy is reflected in the wide variety of opinions and proposed treatment modalities offered in the literature[2]. The best treatment strategy, that is, closed reduction or open reduction with internal fixation, remains controversial[3]. A general consensus is that non-displaced condylar fractures should be treated conservatively, while displaced or dislocated condylar fractures should be treated surgically[32].

Going through evidences, till date no study has provided a comprehensive, quantitative analysis of comparison of open reduction with internal fixation (ORIF) against closed reduction on which best treatment option for condylar fractures could be established. Therefore, we updated our research for related articles and conducted a systematic review with the aim to compare the open reduction with internal fixation (ORIF) against closed reduction according to the effect on maximum interincisal opening, laterotrusion and protrusion in adults with condylar fractures through a novel meta-analysis.

Several classifications have been provided for mandibular condylar fractures, Loukota et al. 2005[33] sorted mandibular condylar fractures into three types, including condylar head fracture (diacapitular fracture), neck fracture and basic fracture, the latter two were also called extra-capsular fractures. Kozaliewicz et al. 2018[34] further divided condylar neck fracture into high neck fracture and low- neck fracture separated by the head anterior border point. Actually, the side and level of bone fractures play indispensable roles in the selection of treatment options and functional outcomes of either treatment[28].

In general, the results of this study show that closed reduction (CR) leads to improvements in measures of post operative maximum inter incisal opening, laterotrusive and protrusive movements. Meta – analysis had a total of nine studies[18,19,22,26,31] containing data on 384 (n=384) patients, of which (n=197) patients were evaluated by open reduction with internal fixation and (n=187) patients were evaluated by closed reduction for the evaluation of management of condylar fractures. The mean age of participants was 34.67 years. For instance, this meta – analysis revealed that CR patients had a greater postoperative maximum inter incisal opening than patients treated with open reduction (ORIF) with internal fixation with

SMD = 0.80 (0.21 – 1.39), $p = 0.008$. Laterotrusive movements was better in CR patients than ORIF patients with SMD = 0.36 (-0.32 – 1.05), $p = 0.30$ and also the protrusive movements was better in CR patients than ORIF patients with SMD = 0.42 (-0.33 – 1.17), $p = 0.27$ but these were not statistically significant. Also, most results of heterogeneity tests were poor and influenced the validity of overall effects to some extent. Most of the funnel plots showed asymmetry, indicating presence of possible publication bias.

Although, there are various guidelines regarding the management of condylar fractures of mandible by open or closed reduction, there is still a continuing debate over how to best manage these fractures. This is in part attributable to a potential misinterpretation of the literature from decades prior, a lack of uniformity of classification of the various anatomical components of the mandibular condyle, lack of scientifically-valid studies comparing treatments and a perceived potential to cause harm through the open approach based in part on the surgeon's lack of experience and critical examination of the literature[35]. Other factors confounding the strategy for the management of condylar fractures are the anatomic position of the fracture, the influence of fracture and surgery on facial growth, and the potential complications such as malocclusion, chin deviation, ankylosis and internal derangement of the joint[36].

It must be remembered that when one selects ORIF, one is increasing the cost of treatment because ORIF engenders more operating room time, more expensive hardware and a longer general anaesthetic. One is also imposing a potential set of complications that must be carefully weighed to determine if the potential benefits of open treatment are worth the potential surgical and post – surgical risks. The potential complications injury to nerves and blood vessels, sialocele, salivary fistulae, facial scarring, etc[37].

It should also be mentioned that individuals, who publish studies on the treatment of condylar fractures usually have a great experience at whatever treatment they are providing. Even though the outcomes of the studies in the existing literature might favour any possible treatment measures for many of the outcomes variables, individual practitioners may not see that benefit if their surgical experience is not great. One must be able to safely perform these treatment procedures with minimal complications if one is to see the improved outcomes[37].

Conclusion

The results of our meta-analysis suggests that CR provides superior outcomes in terms of maximum inter incisal opening, laterotrusion and protrusion compared to ORIF in condylar fractures management. Better designed prospective randomized controlled clinical trials with adequate sample size and long follow up periods comparing open and closed treatment would be useful. Other variables such as treatment cost and patient satisfaction should be additionally studied to determine the differences between open and closed treatment of condylar fractures.

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Report- Dr.Shobha- Paper-3

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Report- Dr.Theertha

by Dr. Theertha

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Word count: 1454
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DR THEERTHA SASIDHARAN

I YEAR

Title: QUANTITATIVE ASSESSMENT AND CORRELATION OF SCLEROSTIN PRODUCTION IN GINGIVAL CREVICULAR FLUID IN INDIVIDUALS SUBJECTED TO SEGMENTAL CANINE RETRACTION WITH DIFFERENT MAGNITUDE OF RETRACTION FORCES - AN INVIVO EXPERIMENTAL STUDY

BRIEF RESUME OF THE INTENDED WORK

6.1 Need for the study:

In orthodontics, there is no consensus on the most competent manual methods for dental movements which are complex phenomena that according to the theory of pressure-tension occurs in three stages: obstruction in blood flow after the application of pressure to the periodontal ligament, release of chemical messengers, and activation of bone resorption[1]. Orthodontic tooth movement is essential for space closure in canine retraction. Canine retraction can be done by segmental or en-masse retraction. Several animals as well as human studies have been done to enhance the orthodontic tooth movement in an optimal way both invitro and in-vivo. One is the longitudinal studies whereas another method is studying the biomarkers in gingival crevicular fluid (GCF) expressed during orthodontic tooth movement. There are constraints in both the studies as it is not clearly indicated whether the expression of increased biomarkers is in relation to the magnitude of force applied or it is physiological. Hence there are several studies conducted to correlate biomarkers with orthodontic tooth movement.

Measuring the levels of biomarkers between two-time intervals and how much distance the tooth has moved concluded that expression of biomarker is correlated with force in orthodontic tooth movement. The biomarkers studied in the past in GCF are PGs, ILs. The expression of ILs and PGs in the human periodontium can be assessed non-invasively by GCF analysis, which reflects the cellular response of underlying periodontal ligament (PDL)space. Grieve et al[2] reported that the IL-1 and PGE levels in human GCF were elevated during the first 24 hours of tooth movement and returned to baseline in 7 days. Uematsu et al[3] showed similar results regarding ILs, tumor necrosis factor, and epidermal growth factor. They assumed that the re stored cytokine levels might be due to a lack of force consistency.

But very little has been studied on biomarker expressed from osteocytes such as Sclerostin.

It is a 190-residue glycoprotein encoded by the SOST gene, which is located on the long arm of chromosome 17. Sclerostin modulates bone mass by inhibiting osteoblastic cell proliferation, differentiation, and mineralization. It decreases the viability of osteoblasts and osteocytes, creating a discrepancy in bone turnover and favoring bone resorption. It acts as a bone morphogenic protein (BMP) antagonist and a Wingless-related integration site (Wnt) signaling antagonist. Sclerostin binds to low-density lipoprotein receptor protein (LRP) 5/LRP6 complex, thus blocking Wnt binding and Wnt/β-catenin signaling. The significance of sclerostin in bone metabolism has been clarified by recent in vitro and in vivo studies[4].

Hence this exposes a new area of research whether biomarkers expressed in GCF are in concordance with the biomarker of bone.

Biomarker research aims to pave the way for high-impact diagnostics, which can considerably enhance clinical diagnosis and treatment plans, patient education and acceptance. The biological fluids that can be used as a source for biomarkers are blood, serum, plasma, saliva, and gingival crevicular fluid (GCF). Compared to other sources, GCF provides more precise, sensitive, and reproducible data on a cellular response[4].

Problem statement:

There is very little evidence on the biomarker expressed from osteocytes, such as Sclerostin. There is no clear evidence stating the optimal level of sclerostin in GCF, and its possible variation in the expression of sclerostin in GCF with different magnitude of force within the optimal range to identify if it can be considered as a biomarker.

Considering the above biological effects of sclerostin, the present study is to investigate whether GCF sclerostin levels could be used as a biomarker of orthodontic tooth movement and if there is any variation in the expression of sclerostin in GCF with force application.

Research Question:

Is there any correlation between orthodontic force and sclerostin production in Gingival crevicular fluid and the degree of expression of sclerostin in relation to magnitude of force in segmental canine retraction and can it be considered as a biomarker for orthodontic tooth movement.

Null Hypothesis(H0):

There may be no correlation between orthodontic force applied and sclerostin production in gingival crevicular fluid in segmental canine retraction and it cannot be considered as a biomarker for orthodontic tooth movement.

Alternate Hypothesis(H1):

There may be correlation between orthodontic force and sclerostin production in gingival crevicular fluid in segmental canine retraction and it can be considered as a biomarker for orthodontic tooth movement.

Objectives of the study:

Primary objective:

1. To find out the optimum level of sclerostin in GCF.

Secondary objectives:

1. To find out whether sclerostin can be considered as a reliable biomarker for orthodontic tooth movement by estimating the difference in sclerostin levels before and after orthodontic tooth movement.
2. To find out the variation of sclerostin levels in GCF with varying orthodontic force in optimal range.

MATERIALS AND METHODS:

7.1 Source of data:

GCF samples will be collected from gingival crevice of canine in patients undergoing premolar extraction and segmental canine retraction in the Department of Orthodontics and Dentofacial Orthopedics, Dayananda Sagar College of Dental Sciences.

7.2 Method of collection of data

Study design: IN-VIVO EXPERIMENTAL STUDY

Sample size determination

Sample size was calculated using G-Power software version3.1.9.7, by entering the following inputs below in the site.

Test family- F – tests

Test type – ANOVA: Repeated measures, within factors

Type of power analysis- A priori

Effect size (f) = 0.3

Permissible α err prob = 0.05

Power (1- β err prob) = 0.95

Number of groups = 3

Number of measurements = 4

Corr among rep measures = 0.5

Non-sphericity correction = 1

The minimum sample size as estimated by the software is 81

Methodology

Individuals will be randomly selected for the study, based on the inclusion criteria (patients undergoing all first premolar extraction with segmental canine retraction). Three groups will be allocated based on the light continuous force (measured by Dontrix gauge) value ie.120g, 150g, 180g. Two of these three groups of force will be applied using NiTi closed coil spring on right and left quadrant in each patient undergoing segmental canine retraction. All of the participants will be advised to maintain a soft diet and to alternate mastication on both sides during the experiment. Maxillary canines are suitable as experimental sites because there are no tooth impeding the distal movement of the maxillary canine in the 4-premolar-extraction cases. The GCF samples will be collected from right and left quadrants at different time intervals of application of force as follows:

T0 -Before canine retraction.

T1 -24 hours after canine retraction.

T2 -72 hours after canine retraction.

GCF samples collected will be stored and sent for ELISA test for the estimation of biomarkers. GCF sampling will be performed in the clinic at approximately 20°C and 40% relative humidity. Appliance activation and sampling will all be done during the daytime, because of the possible diurnal pattern of cellular activity[5]. Each experimental tooth will be washed with water, isolated with cotton rolls, and dried gently with air.

Samples of GCF will be obtained using microcapillary pipettes. GCF samples will be collected from the same site of the test, before treatment, 24hours and 72hours after application of force for the assessment of sclerostin concentration in GCF. From each site, a standardized volume

of 2µL GCF will be collected and transferred to vials containing phosphate-buffered saline. These samples will be then stored in a freezer (liquid nitrogen) at −80°C[6].

Concentration of sclerostin in GCF will be determined using enzyme-linked immunosorbent assay (ELISA) based on the biotin double-antibody sandwich technology according to manufacturer's directions. Samples will be then assayed for sclerostin using ELISA kit.

Statistical analysis:

The categorical variables will be described by frequency in percentage, quantitative data by mean± SD or median (IQR) subjected to normality assumption. 95% confidence interval for mean/difference in means.

Descriptive analysis:

For analysis of objective -1, mean ± SD with 95% confidence interval.

Inferential Statistics:

1. For objective-2
   a) Within the group comparison (T0 to T1in all 3 groups) tested by paired t test / Wilcoxon signed rank test based on normality assumption i.e. T0 to T1.
   b) Comparison between all the 3 groups at T1 will be tested by one way ANOVA/Kruskal Wallis test. If results are found statistically significant, will further be continued with Post hoc test.
2. For objective-3
   a) from T1 to T2 in all the 3 groups will be tested by paired t test / Wilcoxon signed rank test based on normality assumption.
   b) Comparison between all the 3 groups at T1 and T2 will be tested by one way ANOVA/ Kruskal Wallis test. If results are found statistically significant will further be continued with post hoc test.

Report- Dr.Theertha

ORIGINALITY REPORT

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SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

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3	Z. Tuncer, O. Polat-Ozsoy, M. Demirbilek, E. Bostanoglu. "Effects of various analgesics on the level of prostaglandin E2 during orthodontic tooth movement", The European Journal of Orthodontics, 2013 Publication	2%
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Report- Executive summary

by Dscds .

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Word count: 5646
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1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

Education completes a person. This is the motto of late Sri. R Dayananda Sagar, an educationist and philanthropist who set up the Mahatma Gandhi Vidya Peeta Trust (MGVP) which has been nurturing over 28 educational institutions all over the country. 'Dayananda Sagar' is a well known name for offering quality education, especially providing a state-of-the-art healthcare education and services. In recognition of its long-standing contributions, recently, the Government of Karnataka has recognized it as a private university – **The Dayananda Sagar University (DSU).**

The Dayananda Sagar College of Dental Sciences (DSCDS) is a private, self-financing institution started by MGVP Trust under the able leadership of Honorable Chairman Dr D Hemachandra Sagar and Honorable Vice-Chairman Dr D Premachandra Sagar. The institution has been has been imparting quality dental education and oral healthcare since its establishment in 1991 and has to its credit, a glory of over 31 years.

The institution had its genesis with a small intake of only 40 students in its undergraduate program increased its annual strength to 60 in 2006. The Institution has added seven Postgraduate programs with an annual intake of 22 students and a PhD program in 4 specialties. DSCDS is affiliated to the RGUHS and is recognized by the DCI.

The College is consistently securing good positions in several national-level rankings. Below are the rankings of 2022 -

Outlook - 21

The Week – 24

India Today – 44

The institution has 76 competent faculty members who are all postgraduates, 4 of them with doctorates and two more pursuing their Ph.D. The faculty has good publications in high-impact journals. Our Institutional Review Board (**RDSC & IEC**) is registered with naitk.gov, which comes under the Dept. of Health Research (Govt. of India). The departments also have Memorandum of understanding with various institutions, organizations, professional bodies and research organizations through which a lot of student-centric activities are initiated. A recent association with the DERBI foundation-an innovation centre, caters to entrepreneurship training, development and incubation.

DSCDS caters to the important area of career guidance by establishing a career guidance & placement committee to help its students with their aspirations for higher studies, research opportunities and jobs in various organizations. DSCDS alumni have been occupying distinguished positions and the institution makes use of their services for furthering these activities. DSCDS has an actively-growing alumni association as well.

Our institutional library is equipped with 4214 books, 629 e-books and 1260 bound volumes of journals. In addition to this, we have access to the Central Library of the campus, which has digital library facilities like RIFD and ICD.

The institution has hostel facilities for both boys and girls within the green campus. We believe in an overall holistic development of an individual as per Shri. Parthasarathi Rajagopalachari, who said -***"Education really means to draw out of you, your best. To prepare you to be fit citizens who can serve society and pursue a balanced life"***. In tune with this motto, DSCDS imparts dental education training to the students in inter/multi-disciplinary approach, skill-based training, exposure to research even at undergraduate level, attending to a variety of CDE programs, workshops to deliver effective oral healthcare to the community.

Our institution has a mobile dental unit which is equipped to deliver specialized treatments through camps and field visits. Modern facilities like digital radiography, root canal treatments, surgical removal of teeth and denture rehabilitation are being delivered on site to the under-privileged population using the mobile dental unit. We have reached out to the dentalcare needs of more than 18,000 people in the last 5 years, through our extension activities in spite of many months having been lost due to COVID.

We not only impart dental education, but also invest in developing soft skills, sports, cultural activities of our students to develop a well-rounded human being, who is useful to the society and the country at large. For this, the institution has a Centre for learning and sports facilities viz., well-equipped gymnasium, yoga centre, meditation centre, squash court, football/cricket ground, table tennis, basket-ball courts, lawn tennis and several indoor activities. There are also auditoria and amphitheaters for social and cultural activities.

OUR VISION

Dayananda Sagar College of Dental Sciences aims to be amongst the world's foremost academic institutions in the pursuit of educational, clinical, and research excellence. The institution also aims to provide ample scope for ideation, innovation, and community service, to shape future leaders in dentistry by applying science, art and technology breakthroughs, thereby contributing to national/global oral healthcare, welfare and development initiatives.

OUR MISSION

Our mission is to realize our vision by:

- Imparting integrated education and training to the students on par with global standards in dentistry, for the prevention and treatment of various oral diseases and conditions, thus contributing to the improvement and sustenance of better quality of life among needy individuals of the society.
- Ensuring the development of comprehensive domain knowledge, skills and attitudes as required to meet the above-said objective.
- Inculcating necessary clinical, diagnostic, and treatment skills, to manage patients effectively and efficiently, and extending similar quality services to the community.
- Applying theoretical and analytical knowledge in various areas of dentistry to create novel clinical methods and engage in knowledge transfer for the benefit of the society locally and for mankind globally.
- Delivering quality education in basic and applied dental research to promote innovation and ensure dissemination of new knowledge through presentations at conferences and publications in high-impact journals.
- Mobilizing faculty expertise to implement local, national, and international initiatives in the field of dentistry to achieve global oral health goals by the year 2030.

OUR VALUES

Values that drive Dayananda Sagar College of Dental Sciences and support its vision include:

- **Pursuit of Excellence** - Strive continuously to improve ourselves and our systems with the aim of becoming the best in our field.
- **Fairness**-Ensuring objectivity and impartiality in all our processes, to earn the trust and respect of the society.
- **Leadership**-Lead responsibly and creatively while imparting education and delivering oral healthcare.
- **Integrity and Transparency**-Remain ethical, sincere, and transparent in our activities and treat all individuals with dignity and respect.
- **Empathy and Compassion**-Be respectful and develop a compassionate relationship between doctors, the auxiliary team, and patients.

QUALITY STATEMENT

We, at Dayananda Sagar College of Dental Sciences, are committed to imparting and inspiring life-long learning by providing the highest quality dental education, research opportunities, and dental services to the satisfaction of all the stakeholders.

CORE VALUES

The 3 D Concept - Discipline, Dedication, Deference

1.2 Institutional Strengths, Weaknesses, Opportunities and Challenges (SWOC)

Institutional Strengths:

1. Visionary Management with more than 6 decades of experience in delivering notable quality of dental education and oral healthcare.
2. 'Dayananda Sagar' is a well known brand providing quality education since long, in both professional (Medical and Engineering) as well as general Degree Programmes.
3. Excellent location of the institution in a lush green campus spanning more than 23 acres.
4. DSCDS is poised in an integrated campus with ample opportunities to collaborate with sister institutions like CDSIMER, Engineering, Physiotherapy, Pharmacy and Bio-technology, thereby enhancing the scope for multidisciplinary integration of dental education practices with other disciplines.
5. The campus attracts students from all over the country and abroad, leading to an envious educational environment with a vibrant, cosmopolitan and progressive cultural diversity.
6. Software-driven patient record-keeping and maintenance of digitized radiographic records which can be accessed by all departments and paperless transactions.
7. Highly dedicated, qualified faculty, with rich experience and commitment to efficient teaching, with a few members having representation in the Syndicate, Senate, Academic Council and Board of Studies of the Rajiv Gandhi University of Health Sciences.
8. Ours is one of the pioneering colleges in offering a structured Mentorship

Program with counselor support to the learners and patients.

9. The institution has tie-ups with Governmental and Non-Governmental Organizations facilitating setting-up of satellite dental clinics, to provide free/subsidized dental services to the community at large.

10. Research work is an integral part of our UG curriculum at DSCDS with the institution also generating research grants for the purpose.

Institutional Weaknesses:

1. Not done enough for leveraging stronger links with distinguished Alumni to increase engagement with them in terms of consultancy, training, research, FDP, and mutually-benefitting academic collaborations.

2. Imminent need to motivate faculty to pursue more research leading to an enhanced number of members with doctoral degrees.

3. Less number of students pursuing higher education, particularly from MDS to PhD programs.

4. To further increase the number of research publications in high impact journals

5. At present, the institution lacks latest diagnostic imaging and technology systems which deprive the opportunity of advanced diagnostics and its usage in augmented research.

6. Limited engagement of UG and PG students in R and D projects involving industries.

Institutional Opportunities:

1. To start relevant certificate courses under the RGUHS- Scope to provide add on and certificate courses like pharmacovigilance, computer simulations, basic biochemical analysis, clinical research, scientific writing, data analytics, biostatistics, financial and managerial skills under the ambit of RGUHS and/or through relevant MOOCs and other such OERs.

2. Establishing TMD clinic, Oro-facial pain clinic, Cancer clinic, in-house Aligner system, CAD CAM and CBCT training centres.

3. Establishing collaboration with other universities and Lead institutions at the national or international levels, for furthering interactive-learning and knowledge-transfer opportunities for both, students and faculty alike.

Institutional Challenges:

1. Incorporating cutting-edge curricular changes beyond the recommendations of the affiliating University.
2. Addressing the issue of drop in admissions.
3. Extending subsidized dental treatment to reach a larger population of patients.
4. Challenges of sustainability in our hitherto established student performance levels, due to lower admission eligibility criteria of NEET.

1.3 Criterion-wise summaries:

Criterion 1: Curricular Aspects:

DSCDS is affiliated to the RGUHS, which is mandated to follow the curriculum designed by it and as directed by the DCI. However, planning and implementation for all the programs is meticulously done by the Academic Advisory Committee (AAC) of our institution in association with each department. Annually, the college has an intake of 60 UG students and 22 PG students in 7 specialties. During the last five years, one of our senior faculty has served as the Dean of Faculty of Dentistry of RGUHS, two as BOS members, one as an Academic Council member and three as Master Trainers for the TOT programs conducted by the university.

AAC designs the annual academic calendar, time table and syllabus incorporating innovative and student-centric teaching practices. The committee meets, follows up the planning and implementation process.

The feedback collected from all stakeholders are analyzed by the feedback Committee for curriculum & implementation. This helps us to plan and implement appropriate corrective measures and action plans for ensuring incremental performance improvement. The interdisciplinary and interdepartmental training happens through workshops on dental implants, lasers, dental photography and several other newer techniques which emerge from time to time.

Before students start their clinics, they are sensitized to professionalism, ethics, infection control, safety protocols and communication skills through various value-added courses. The institution encourages conduct of value-added & add-on courses in areas such as Advanced Endodontics, magnification in dentistry, maxillo-facial prostheses and Basic Life Support (BLS) facilitating curriculum enrichment. Our community outreach programs, primary health center postings, camps and outpatient clinics adequately train the students to gain hands-on experience in

community skills & patient care. Health awareness programs, Youth for Seva, NSS activities and NMO makes our students acquire necessary social responsibilities. They are also sensitized to gender equality, environmental sustainability and bio-medical waste segregation/disposal practices. Personality development/soft-skill programs help our students in acquiring overall development. Career guidance programs are also organized for interns and alumni by the Career guidance and placement cell.

Criterion 2: Teaching-Learning and Evaluation:

- DSCDS follows a transparent, merit-based admission procedure through the process of NEET examinations and KEA policies as mandated by the Government. An average of 33.44% cultural and socio-economic diversity amongst students has been recorded for the last 5 years, making the institution socially-inclusive.
- Orientation program, celebration of important festivals from across the country, assisting non-local students in learning Kannada language are actively practiced by the institution.
- Among the committees formed for the betterment of student community, Anti-ragging, Mentorship, Internal Complaints Committee addressing anti-sexual harassment complaints, Academic Advisory committee are given utmost priority.
- Students are identified using customized criteria into slow performers and advanced learners. Both cohorts are trained extra, so that slow performers come on board with the rest and the advanced learners go on to achieve higher laurels.
- DSCDS has stated generic and programme-specific learning outcomes along with graduate attributes as per DCI/RGUHS norms. Teaching-learning methods have been designed keeping in mind the evolving student and is more hands-on and digitally enabled with ample use of ICT enabled classrooms, Simulation labs, OSCE/OSPE trainings, using digital platforms. Innovatively redesigned teaching strategies like peer teaching, case based learning, inter departmental case/concept discussions, are employed. UG research is encouraged with around 20 short term projects being accepted by ICMR and RGUHS.
- DSCDS has 76 well qualified, full-time faculty with 29 PG guides and 6 PhD guides currently. UG and PG student-teacher ratio is 3:1 and 1:1. The average teaching experience of faculty at DSCDS is 10.62 years with all faculty obtaining certification in educational methodology faculty training conducted by the RGUHS.
- The learning outcome is assessed with 3 CIEs, posting end tests conducted for UGs and the mock exams conducted for PGs. The evaluation process is completely digitized. Grievances are addressed as per the university norms and procedures. Based on students' performance appropriate course corrective measures are implemented whenever necessary.
- The students' attendance and performance is communicated to parents regularly and outstanding issues (if any) are discussed with the parents in person, and corrective measures (if need be) are resorted to.

Criterion 3: Research, Innovations and Extension:

The institution emphasizes and encourages research activities for students under the guidance of faculty, to orient them into indulging in meaningful research. The staff and students are encouraged to submit research proposals to extra-mural funding agencies and have received grants from bodies like ICMR (2 nos.) and RGUHS (10 nos.) amounting to around Rs. 3.4 lakh during the last 5 years. The Staff and students take up research projects under the framework and guidelines of the Institutional review board and the Institutional ethical committee and are guided and monitored by its expert panel. College encourages students to take up long- and short-term research studies by providing infrastructure at the college, collaborative agencies as well as the collaborating innovation centre housed in the engineering college campus. The total collaborations are 27 in number during the past 5 years. Staff and students have published books, Chapters, Scientific publications in Journals, which number to 12 and 257 respectively, during the last 5 years.

The commitment of the college towards community outreach programs and social responsibility towards the society are recognized and appreciated by various government and non-government bodies. Due consideration to oral hygiene, tobacco cessation programme, free denture camps, cancer screening programmes, *Swatch Bharath Abhyaan*, NSS programmes, blood donation camps etc. was laid during the last five years with a total of 191 camps catering to 18,551 patients and 1500 students participating in the same, with the utilization of the "State-of-art" customized mobile Dental van with 2 dental chairs, audiovisual patient education aid, portable X-ray machine, overhead tank, and other necessary instruments and facilities. The college has functional MOUs with 21 institutions. Students have been actively involved in covid vaccination drive since 2021. Faculty members and interns were actively involved in tele-consultation during covid times and also were recognized and appreciated by "Step One" for our active involvement in tele-consultations.

Criterion 4: Infrastructure and Learning Resources:

Dayananda Sagar College of Dental Sciences (DSCDS) has a state-of-the-art infrastructure facility situated in the heart of the city. It has adequate facilities for students, staff and patients. The college provides equal importance to sports and cultural activities and caters to various tournaments which are conducted through affiliating university.

DSCDS has well maintained ICT- enabled classrooms and a sophisticated teaching hospital. The campus is well known for its healthy Air Quality Index with ample greenery. There are laboratories for Preclinical, Basic Sciences training and Skill labs. Each department has modern facilities for clinical teaching and learning. Patient care is taken in 9 clinical departments. A multispecialty "Sagar Hospital" is also present in the same campus offering an array of medical, paramedical and related services including 24x7 accident and emergency care.

The College library has LIBSOFT software version 12.0, which is developed for library automation and efficient management of library services. The library is updated annually for books and journals and currently there are 4214 books and 1566titles and 550 e-books, PG dissertations and previous years' question papers. It subscribes to 21 international and 11 national journals. The library has HELINET consortium facility accessing electronic resources. The expenditure for the purchase of books, journals and e-resources in the last 5 years is 103.33 lakhs.

The institution has 5 attached satellite primary health centres and a mobile clinical service facility with a well-equipped Mobile dental van to reach and serve rural locations. The college has round-the-clock uninterrupted internet connectivity with a bandwidth ranging from 50-250 MBPS.

There is a common maintenance facility team for the Dayananda Sagar institutions with a team of carpenters, electricians, plumbers and gardeners who take care of maintenance of the campus. Maintenance of the sophisticated equipments is outsourced with necessary insurance coverage.

The sports and cultural activities of the students are looked after by the specific committee in place; the physical education director helps in maintenance of the gym/table tennis boards, carrom boards/ basketball. Total expenditure incurred, excluding salary, for infrastructure development and augmentation during the last five years is 166.38 lakhs. Total expenditure incurred on maintenance of physical facilities and academic support facilities excluding salary during the last five years 548.49 lakhs.

Criterion 5: Student Support and Progression:

The institution has a student-centric approach to facilitate overall personal and professional development and progression. 289 students were benefited in the form of scholarships from Government organizations and institution in the last five years. Soft skill programs are organized in collaboration with both, CIL-based within the campus and external resources. Yoga classes are conducted by the in-house yoga instructor and Yoga day is celebrated annually. Kannada classes are conducted to facilitate student-patient interaction since it is the local language. The white coat ceremony and Orientation day for students are conducted annually with lectures customized to their academic and clinical progression in the institution. NEET coaching and career guidance programs are organized annually for the outgoing students and if relevant, to 4th BDS students with 245 students benefitting in the last 5 years. The college provides conducive environment for academic and nonacademic activities of international students.

The institution has an Anti-ragging committee, Internal Complaints Committee and Student Welfare and Grievance Redressal Committee which meets on a regular basis to resolve issues of students. Anti-ragging workshops are conducted annually to sensitize students and make the campus, free of any ragging incidence.

Our students are placed in reputed organizations and most students are self employed during the last 5 years. Significant number of students have opted for higher education during 2017-22.

11 students have secured 20 awards in zonal and National level competitions during the last 5 years. 85 sports and cultural events have been conducted by the college in the last 5 years to encourage students to showcase their talents and sporting spirit. Student Council is actively involved in organizing cultural events, sports activities and publication of E magazine.

College has a registered Alumni Association, with 1331registeredalumni. Total contribution from the alumni is Rs. 2,92,550/-in the last 5 years and 18 meetings have been conducted.

Criterion 6: Governance, Leadership and Management

IQAC along with the College Governing Council and various other committees help in effective management of the institution. The institution has a clearly defined vision, mission and meticulously follows the service rules to ensure governance, leadership and management runs smoothly and effectively to achieve acceptable standards.

Institution believes in decentralization and participative management for an effective functioning. The principal-IQAC chairman with vice principal and associated Deans decide, monitor and ensure proper implementation of the same along with the departmental heads, professors, readers, senior lecturers and support staff.

Welfare measures are in place to motivate faculty to undertake various scientific researches, present papers in National/International Conferences, attend certification courses, fellowships and further encouraged to take-up higher responsible positions in various decision making bodies and specialty forums at University/State/National levels. ESI, Gratuity facility, concession for medical treatment and fee concession for children of staff joining the DSI schools is provided.

DSCDS has a structured system to appraise the performance of teaching and nonteaching staff. Self-appraisal by the staff with the details of conferences, workshops, seminars, training programs attended, books and scientific papers presented and published, research and academic administration carried out during the year is submitted to respective HODs, which is verified and submitted to the principal. Appraisal of nonteaching staff is done to evaluate strengths and weaknesses. HOD gives annual report to the Principal on conduct, discipline and performance. Faculty with laudable academic, co-curricular and extracurricular achievements are felicitated and encouraged further.

DSCDS is managed by the Mahatma Gandhi Vidya Peetha trust. The main financial resources are tuition fees collected from students, treatment charges paid by patients, funds from government/non-governmental organizations, alumni donation and management contributions. Finance is managed through SARAL TDS and Tally software and regular audits (internal and external) are conducted annually.

Criterion 7: Institutional Values and Best Practices:

DSCDS has kept its values and practices as one of its core principles and over the years has been footing to make transformational changes for the improvement of the institution.

A conducive environment is provided for women staff and students with specific committees for women welfare and grievances, women-centric facilities like common and counseling rooms, female security guards and gender sensitization programs.

College is set in a picturesque 23-acre campus with lush green landscaping all around. The institution is equipped with solar energy, does wheeling of excess energy to the grid, rain water harvesting systems, sewage treatment plant and other mechanisms for conservation of energy and waste disposal.

The college believes in social responsibility and thrives to provide an inclusive environment as its mission. DSCDS encourages students from different backgrounds to participate in various cultural, sports and other activities. Five satellite centres have been established at population with low socioeconomic status where treatments are done free of cost. Outreach programs are also conducted to cater to the disadvantaged population in rural areas of Karnataka and adjoining states with its state-of-the-art Mobile Dental Unit.

One of the institutional best practices being our service to the society, where we regularly conduct camps and other outreach activities within the state as well as the neighboring states to improve the oral healthcare needs of the disadvantaged populations. The state-of-the-art Mobile Dental Unit (MDU) is utilized during this process. Our MDU is equipped to function with electricity and generator. It has two dental chairs, a portable X-ray unit and other equipment to treat complex procedures like root canal, impactions and dentures which are otherwise limitedly available and unaffordable to these populations. The MDU also has provision to carry multiple portable chairs which are utilized to treat multiple patients simultaneously at the camp site.

As an institutional best practice, digitization has been implemented through patient registration and management software (DIMS), radiographs, LIBSOFT software in central library, NEMOCEPH in Department of Orthodontics.

Out best practices focus on nation building & use of modern technology to improve our services to the society.

The holistic development of the learners as nurtured by DSCDS through a multitude of student support facilities is the distinctiveness. In its thrust towards achieving the same, the institution

has an excellent student support system which promotes physically, mentally and spiritually, socially and vocationally a salubrious environment for learning.

Criterion 8: Dental part

Dayananda Sagar College of Dental Sciences offers a five-year Bachelor of Dental Surgery (B.D.S) program with an intake of 60 students per batch, a three-year Master of Dental Surgery (M.D.S) Program in seven departments and Ph.D. Program in four departments and is affiliated to Rajiv Gandhi University of Health Sciences, Bengaluru and recognized by Dental Council of India, Ministry of Health and Family Welfare.. Students are admitted based on the NEET ranking(mean 2021:77.51).

The institution has well-equipped preclinical laboratories to enable students with simulated practical experience. The preclinical exercises are conducted for Undergraduate and Postgraduate students as per the University Curriculum.

Institutional Infection Control Committee has prescribed Patient Safety Manual where in all the norms and protocols of disinfection, sterilization, biomedical waste segregation are followed during Clinical training apart from providing Provides Personal Protective Equipment. The Institution also ensures that all the faculty and the students undergo mandatory immunization for Hepatitis B and Covid-19.

Orientation programs are conducted every year for UG, PG and Interns in the first few days of the commencement of their academic session and one year rotatory internship program . Workshops on different aspects of patient care are conducted all through the year from all specialties that will help improve students' knowledge and enhance their skills further.

The institution trains the students in using high-end equipment such as Endodontic microscope, Dental Laser Unit and Imaging Software for diagnostic and therapeutic purposes. Specialized Comprehensive Clinic, Implant Clinic, Geriatric Clinic, Tobacco Cessation Clinic provides added learning and skill development.

The Institution has full-time dedicated and experienced faculty committed to efficient teaching-learning process, few of whom have additional degrees beyond the eligibility requirements procured from recognized centers/universities in India or abroad. The faculty are also trained to assess competencies of the students while doing formative assessment and during summative assessment, through objective, structured and transparent methodologies like OSCE and its applications The institution has developed dental graduate attributes which are implemented and evaluated as per the guidelines of the regulatory apex body. In the last five years an average per

capita of rupees 20.65 Lakhs expenditure is incurred on dental materials and other consumables used for students training. Dental Education Department of the institute conducts range and quality of Faculty Development Programs in emerging trends in Dental Educational Technology which enables in upgrading the faculty skill and enhancing quality improvement in teaching, learning skills and student assessment skills.

22. Any other relevant data, the institution would like to include (not exceeding one page).

The institution is driven by strong values which include pursuit of excellence, fairness to earn trust, respect of society and responsible leadership while imparting education. Integrity, transparency, empathy and compassion towards doctors, auxiliary team and patients forms the foundation of all our activities in providing patient care and inculcating right value system.

DSCDS has reached more than 18,000 people in last 5 years through its extension activities which has been our strength in serving the society. We are progressively making efforts to reduce our carbon foot print by making many changes within the college's daily activities. The institution maintains patient records in a paperless form by using Patient Management Software, a comprehensive tool to record the complete patient history, diagnosis, treatment plan, treatment done, payments as well as patient recall dates which was developed based on the inputs of all the staff. A completely digitized radiology department has made all radiographs available on the college server which can be accessed by all departments through a network connection. The library uses a Libsoft, a library inventory management software through which the staff and students can access and download 4214 books, 330 e-journals from 10 Journal titles, 550 e-books and 1260 bound volumes of journals. We try to promote the use of advanced technology through such initiatives.

Through career guidance for interns and campus recruitment initiatives our institution is striving to help our students in all possible ways. Speakers from renowned industries which require workforce from health care field are invited to inform and guide the students about opportunities in allied industries such as data analytics, data abstraction, clinical research, content writing, medical scribing, entrepreneurship, scanability/lean management, artificial intelligence, machine learning, health informatics, Doctor of Dental Surgery, Masters in Public Health and Hospital administration in foreign universities fostering global competencies among our students.

Our distinctiveness lies in our student support facilities, which helps in providing all possible support for the holistic development of learners. The institution is situated in a lush green campus with a picturesque landscape covering 23 acres of land right in the middle of busy city enhancing the learning environment. The campus also has a state of the art gym, squash court, basketball court, tennis court, football and cricket grounds promoting interest in sports among students. A structured IRB (Institutional Review Board) and a policy document

guiding the IRB ensures opportunities for intellectual development through new knowledge acquisition contributing towards quest for excellence.

The tie-ups with rural health centres help student interact and deliver oral health care to the under-privileged, making them responsible citizens. A well-designed mentorship program for the students helps groom them adequately and also intervene if any psychological/personal issues arise. The institution also boasts of Yoga/meditation centres providing training in yoga and meditation for the students. An ancient Shiva temple just adjacent to the yoga centre which dates back to more than 600 years adds to the positive vibes of the place. Overall, we strive to create & propagate a conducive atmosphere to learning, serving the society and contributing to nation building.

INSTITUTIONAL PREPAREDNESS FOR NEP 2020

Preamble:

DSCDS is an affiliated institution under the regulatory control of the RGUHS and the DCI. While the institution has sensitized the faculty and students regarding the NEP 2020, adoption and implementation of the policy can only be adhered to as and when our Statutory Regulatory Authorities instruct us to follow the guidelines set by them in this regard. The institution has planned to organize awareness programs for faculty regarding the NEP 2020 and ABC concept which is new to dental education. Also, the institution plans to implement ABC in accordance with the guidelines of Rajiv Gandhi University of Health Sciences, Bangalore and also the apex body Dental Council of India, whenever mandated.

In anticipation of the same however, the following preparedness of the institution in line with the expectations of the NEP 2020 are already in practice in the institution:

1. **Multidisciplinary/ Interdisciplinary subjects to be offered in the institution**	The art and science of dentistry is a multidisciplinary domain of the medical field. Our dental students are trained to deliver effective healthcare driven by the multidisciplinary curriculum laid down by the Dental Council of India. Both the undergraduate and postgraduate training in as per the regulations of the apex council and the university. The new education policy NEP has emphasized on the concept of multidisciplinary teaching, this aligns with the the institutional practices of conducting interdisciplinary Dental Implant workshops, treatment of special cases, workshops on research methodology, LASERS and also community outreach programs like anti-tobacco awareness, HIV awareness and importance of oral hygiene and dental healthcare.
2. **Academic Bank of Credits (Registration)**	Since DSCDS is an affiliated institution under the RGUHS, by itself it is not a degree-granting institution.
3. **Skill Development**	Skill development programmes are largely emphasised in the NEP. With an intention to implement this concept, the Institution has planned to conduct Certificate courses in the professional and social skills needed for a dental professional, for successful

	clinical practice. Young and enthusiastic teaching faculty are continuously upgrading the clinical skills, research and academics in the field of dentistry. The list of courses that are already offered are: • Soft skills • Patient safety and infection control • Minor oral surgical procedure • Rehabilitation of Maxillo-facial Defects • LASERS in dentistry • Paediatric behaviour management • Faculty Development Program.
4. Appropriate integration of Indian Knowledge system (Teaching in Indian Language, culture, using online course):	The teaching and training are governed by regulatory body, Dental Council of India. Revised BDS course Regulation 2007, along with amendments and MDS course regulation 2017, along with amendments are at present adopted. The Institution conducts communication skills programs as Add-on courses viz., Kannada Language, organising inter-religious programmes to promote National integration like, Onam, Holi, Kannada Rajyotsava, Ayudha Pooja and Founders Day. Further programmes in IKS as recommended by the SRAs shall be offered as and when mandated.
5. Focus on Outcome Based Education (OBE):	Prior to entering the clinical postings, the under graduate and post graduate students, are trained by the faculty as mandated by the regulatory body. This will help develop necessary skills and acquire knowledge for patient care. This will also help us assess the student's cognitive skill and knowledge. College regularly organizes CDE programs/workshops for undergraduate / postgraduate students and faculty. Additional Institutional fund will be provided for conference registration for paper / poster presentations. Funds are also provided to conduct research and publish in renowned journals. As envisioned in the NEP our institution is gearing up towards integration into the Dayananda

	Sagar University. This will give us more freedom in implementing the appropriate curriculum based on competencies and skills required for the holistic development of the student.
6. Distance education/Online education	During the COVID19 pandemic, our institution has taken a giant leap in online dental education and technological advancement. UG and PG classes, seminars, journal clubs, case presentations, inter-departmental meets and presentations were conducted through the online portal. All the education videos were also played in the classrooms for the benefit of the students. Online conferences were held for the benefit of both, students and faculty. Some of the Faculty development programs, CDE programs and workshops were conducted online for the bettering the skill and knowledge of the faculty. This has prepared us to continue online education for both students and faculty.

Note: Any other recommendations regarding the implementation of NEP 2020, as mandated by our SRAs shall also be adhered to both in letter and spirit.

Report- Executive summary

ORIGINALITY REPORT

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PRIMARY SOURCES

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Report- QIM write-up criterion-1

by Dscds .

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1.1

Curriculum Planning: Our institution, affiliated to the RGUHS, is mandated to follow the academic programs as designed by the Statutory Regulatory Authorities (SRA: DCI and RGUHS). The college broadly adheres to this curriculum with internal reforms which are discussed and passed through our institutional Academic Advisory Council (AAC), so that our Dental graduates acquire competencies needed to professional practice. These include scientific and evidence-based knowledge, general skills, and attitudes for diagnosis, treatment planning, manage practice with ethics and good communication and skills. Few of our faculty have been part of the curriculum reformation and advisory committees of RGUHS. One of our faculty was dean of dental faculty for RGUHS. These members help us bridge the gap with RGUHS. Curricular Delivery: Teaching schedules for preclinical, clinical and theory are prepared at the beginning of the academic year by AAC to complete the syllabus on time with adequate time for revision. Faculty is trained in Educational Methodology and evaluation through RAATI(RGUHS),also three of the faculty have been masters trainers for teachers in educational methodology by RGUHS, they update our faculty with any recent trends in teaching/learning methodology for effective delivery of curriculum to the students. Effective implementation of the curriculum begins with an orientation program for freshers (both UG and PG)

along with a 'white coat ceremony' to orient the students on effective management of academic and nonacademic performance with the right attitude. To enrich the curriculum, the institution offers add on and value added courses, conducts workshops and Continuing Dental Education (CDE) programs and encourages active participation of students to keep them abreast with recent advances in the field of dentistry. Faculty trained in research

methodology, guide the Postgraduates and undergraduates to undertake research projects and also apply for grants which are scrutinized by IRB. Research publications and scientific presentations are also encouraged. Schedules of theory classes, clinical discussions and demonstrations are incorporated in the time table as mandated by the University. Our college in collaboration with four primary healthcare centers, Abhalashrama, Sagar hospitals, Sevashrama hospital help in providing the students with appropriate clinical exposure. 1st year BDS students avail the services of our medical college (CIDSIMER) for anatomy practicals & dissection classes for hands on experience. On rotation, our postgraduates are posted at the emergency unit of CDSIMER to gain hands on experience in handling facial trauma Interdisciplinary workshops, meets and discussions are also conducted to help students develop an interdisciplinary approach.

Curriculum Evaluation: The institution has a well defined and robust Feedback Committee which receives and analyses a structured feedback on curriculum from all involved stakeholders, which in turn empowers the committee to recommend any need-based changes that may be needed in revising/reforming the curriculum design or delivery. These recommended changes are scrutinized by the Academic Advisory Council before any implementation at the institutional level or communicated to the affiliating university as suggestions for incorporation through the BoS members.

1.3

Response:

Cross-cutting issues are given importance to nurture students to develop into quality professionals who are also socially-responsible and ethical. To achieve this, the college along with academic programs, conducts several events specific to these issues. Women's Welfare Committee celebrates Women's day with themes on woman's oral & general health, importance of women, gender equality, rights of women, where renowned accomplished women speakers motivate and guide the students & faculty .

The campus follows go green concepts with many trees and no plastic zones. Institute organizes programs related to environmental sustainability like World environment day & disposal of biomedical waste. Along with NMO &NSS many Rallies, cyclathon, sapling plantation in and outside the campus are held for the students to learn about the responsible interaction with the environment. Plantation drive was organized with the theme of - 'You not me' on world environment day in association with NSS. Renowned speakers motivated our students in reducing the use of plastics. Our institution is moving towards a paperless campus incorporating technology and Use of e-records wherever possible.

The Infection Control Committee plays primary role in revision and adherence to guidelines for proper biomedical waste segregation and disposal. The committee also monitors the sterilization and infection control practices.

Empathy & human values are features of successful practitioner. During the pandemic, soft skill committee along with heartfulness institute organized a 6 day online meditation.

World Elders Day celebration and Danthabhagya program by prosthodontics department has been a boon to the elderly who cannot afford a denture which could change their quality of life. BLS training have been a regular practice for students and faculty

to attend to health emergencies.

Determinants of health like biological, behavioral, socio-cultural and socioeconomic, environmental factors and access to health care services are integrated into the curriculum. Along with NSS and NMO the institute organizes camps and awareness programs for important issues like, blood donation and its importance, AIDS awareness, oral hygiene awareness, organ donation and covid vaccination. Blood donations camps are regularly conducted, even in the covid pandemic.

Tobacco Cessation Cell conducts seminars, workshops, flash mobs, skits, rallies, poster and paper presentations, short films, rangoli competitions to create awareness about tobacco and its side effects among the masses. Door to door surveys have been done to examine the side effects of tobacco.

International yoga day celebrated every year where yoga instructors speak about the importance of yoga & conduct practical sessions for faculty & students.

Students, on orientation day are made aware of the code of conduct and behaviour expected from them in the campus. Code of conduct /ethics committee makes sure the parents are also aware of the same. Our institution has a strict anti-ragging policy with a committee actively monitoring students in this regard.

The one-year compulsory rotating internship requires the undergraduate student to experience all clinical disciplines of dentistry. They are posted in the PHC where they not only practice dentistry, they helped medical practitioners in the vaccination drive and apartment vaccination drive to break the chain of covid 19 pandemic.

Executive Summary

Criterion 1 – Curricular Aspects:

Affiliated to RGUHS,college is mandated to follow the Curriculum designed by it and as directed by DCI.However, planning and implementation for all the programmes is meticulously done by Academic Advisory Committee (AAC) and execution is done by all the departments as per its recommendations. Per year, the college has an intake of 60 UG students and 21 PG students in 7 specialties. During the last five years, one of our senior faculty has served as the Dean of Faculty of Dentistry of RGUHS, two as BOS members, one as an Academic Council member and three as Master Trainers for the TOT programs conducted by university.

AAC designs annual academic calendar, time table and syllabus incorporating innovative and student-centric teaching practices. The committee meets,follows up the plan and implementation process.

The feedback collected for curriculum & implementation from all stakeholders are analyzed by Feedback Committee. This helps us to plan and implement appropriate corrective measures and action plans for ensuring incremental performance improvement. Many planned interdisciplinary and interdepartmental training, implant modules for interns and PGs, dental photography, hands-on workshop for faculty and students on newer techniques are undertaken.

Before students start their clinics, they are sensitized to professionalism, ethics, infection control, safety protocols and communication skills through various value-added courses. The institution encourages conduct of Value-added & add-on courses in areas such as Advanced Endodontics, lasers, implantology and Basic Life Support (BLS) through workshops which also facilitate curriculum enrichment and keeps them abreast with the recent trends. Our community outreach programs, Primary Health Center postings, camps and outpatient clinics adequately train the students to gain hands-on experience. Health awareness programs, Youth for Seva, NSS activities and NMO makes our students acquire necessary social responsibilities. They are also sensitized to gender equality, environmental sustainability and Biomedical waste segregation/disposal practices.

Personality development / soft-skill programs help our students in acquiring overall development. Career guidance programs are also organized for interns and alumni by the

Career Guidance and Placement Cell.

Report- QIM write-up criterion-1

ORIGINALITY REPORT

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PRIMARY SOURCES

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Report- QIM write-up criterion-3

by Dscds .

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Submission ID: 1990665138
File name: QIM_write-up_-_Criterion_3.docx (26.9K)
Word count: 1414
Character count: 8323

3.2.1

Describe the available Incubation Centre and evidence of its functioning (activities) within 500 words

The institution provides a supportive environment for research and has created an ecosystem for innovation and transfer of new knowledge making it possible to motivate the faculty and students to focus on research-related endeavors driving them for knowledge in academics and research. The institution has Advanced Research Committee – **the institutional Research Board (IRB)** which looks into new Research ideas, proposals and supports them by providing grants and funds as well as space and infrastructure. The IRB is actively involved in scrutiny of research work. Research proposals that can be submitted for seeking intra & extra-mural grants.

We aim at instilling research and innovation mindset from the undergraduate level itself. Every year many of our undergraduate students apply for various funding agencies and are successful in obtaining grants from RGUHS, ICMR to name a few. Even our PG students and faculty have keen interest towards research and innovation.

Year	TITLE	Investigators
2017	Lingual DIGI - JIG	Dr.Dhruvi Parikh Dr. Hemanth M
	Canine tracker - A smart sensor for canine orientation	Dr. Aparna Nair Dr. Hemanth M
2018	Lost and found - A metal findeR	Dr. Theresa Mathew

		Dr. Karthik Kabbur
2021	Development of AI based software for the early detection of incipient bone loss Developing and validating an AI Algorithm in determination of cervical vertebral staging using lateral cephalograms.	Dr. Pavitra T Dr. Pallavi Nanaiah Dr. Sindhu Dr.Ramnarayan

Institution has signed an MoU with DERBI Foundation and in future would do the innovation programs in collaboration with it. DERBI Foundation is not for profit section 8 company, a healthtech focused technology business hosted by the Dayananda Sagar Institutions and is recognized and supported by Department of Science & technology, Ministry of Electronics & IT and Invest India from Government of India and Karnataka Innovation Society, Government of Karnataka. It supports healthcare startups across their business cycle, viz, from idea to commercialization through mentoring, go-to market strategies, pilot trials, prototyping support and grants and seed funding.

The two said institutions agree to the following general areas of interest and cooperation:

a. Sharing technical infrastructure with regard to using the Incubation centre and R & D facilities at DERBI Foundation, Bengaluru.
b. Sharing of Intellectual expertise for skill oriented training of Faculty, under Graduate and postgraduate students
c. Sharing of knowledge and promotion of skill based training in the field of Research and Development for the benefit of Post Graduate Students as well as per the existing University requirements.

d. Joint promotion of each other's expertise and capabilities

e. Supporting innovators and start-ups in idea validation, pilot testing and clinical trials

For promoting research, the institution has the required equipment and well-stocked laboratories as well as facilities to utilize the provisions of our sister institutions viz., Pharmacy college, various courses of engineering college, Bio-technology etc. for enhancing the knowledge. Institution also provides financial support for publishing research articles, for fellowships & knowledge-enhancement programs. Institution also conducts programs on IPR to create awareness & interest in patent filing & related process.

3.4.3.Describe the nature and basis of awards /recognitions received for extension and outreach activities of the Institutions from Government /other recognised bodies year-wise during the last five years within 500 words

Response: Our commitment towards community outreach programs and social responsibility towards the society are recognized and appreciated by various government and non-government bodies. Many screening and treatment camps were conducted regularly in the nearby areas, in various parts of the states and even in neighbouring states. Our faculty members, undergraduates and post graduates actively participated in the camps organized by the various government / recognized bodies and successfully treated thousands of patients who required various kinds of treatment.

Non-government recognized bodies like Rotary club, Lions club, private and public schools, old age homes, NGOs, NMO, Karnataka cancer society have appreciated our programs. A total of 191 camps have been conducted with 18,551 patients treated and 1500 students participating in the same with a number of appreciation letters.

Our students were actively involved in covid vaccination drive since its inception in 2021. Students were also involved with government primary health centres and different other private organizations for the same. Our service was recognized and appreciated by the Government primary health centre and other recognized bodies. Faculty members and interns were actively involved in tele-consultation during covid time and also were recognized and appreciated by "Step One" for our active involvement in tele-consultations.

We always aim at instilling social values and moral responsibility within the students through various such activities.

Government Organization:

Sl. No.	Activity	Award	Awarding agency	Year
	Treatment Camp:	Appreciation letter	Medical officer	2017 - 18
1	Anjaneya temple,			
2	Tata Silk farm			
3	Yediyur Dispensary			
4	Vyalikaval		MLA office	
5	BMTC Depot - Shantinagar - Jayanagar - Banashankari	Appreciation letter	DEPO manager	2018-19 2019-20
6	Government schools - KS layout - Urban school		Headmaster	
7	Karnataka public school, Hosayalanadu	Appreciation letter	Principal	2020-21
8	Shasakara Bhavana, Banashankari		MLA Office	
13	Tavarekere	Appreciation letter	NDHP district programme officer	2021-22

Non-Government Organizations:

Sl. No.	Activity	Award	Awarding agency	Year
	Treatment Camp:			2017-18
1	Balajinagar		Media relation	
2	Ittamadu	Appreciation letter		
3	Eliyaznagar		Mobility India	
4	G G Halli		rehabilitation and	
5	IQRA Public school		research centre	
6	chirantana valley		Principal	2018-19
7	Dayananda sagar college of physiotherapy		Principal	
8	GNES School		Principal	
9	Gnana sagar		Principal	
10	Rotary, Bangalore metro	Appreciation letter	Rotary club	
11	Rotary, Nagarabhavi			
12	Vishnu abhimanigala balaga		KVK Foundation	
13	Vismaya play school		Principal	
14	Noor primary school		Principal	
15	Alpine public school		Principal	2019-20
16	Ambedkar park, Jayanagar		Dr Jyothi	

17	Avanahalli public school	Appreciation letter	Community based rehabilitation department	
18	Baldwin high school		Principal	
19	Brilliance English school		Principal	
20	Christ university		Christ university	
21	Janamudri Vidyanikethan		Principal	
22	St france day school magadi road		Principal	
23	Jarganahalli BBMP park		Lions club	2020-21
24	Abalashrama, Basavanagudi		Karnataka cancer society	2021-22
25	Al-Jalil exports, Maddur		Al-Jalil Exports	
26	Banashankari temple		Banashankari temple	
27	Jayanagar 4th Block		Kannada Katte	
28	Jeevan sandhya old age home		Jeevan sandhya old age home	
29	Sri sai sneha foundation		Sr sai sneha foundation	
30	Anandhshram, old age home		General secretary	

3.4.4.Describe the impact of extension activities in sensitising students to social issues and holistic development within 500 words

Response: Institutional Social Responsibility and commitment towards our neighbourhood community has always been the vision and mission of our institution. We always aim at instilling social values and moral responsibility amongst our students. Community outreach programs and camps were conducted within our state and the nearby neighbouring states also. Regular visits to Old age homes and orphanages are organized. This kind of holistic approach and community outreach programs and initiatives help our students grow as socially responsible citizens.

Institution is tied up with various satellite clinics in collaboration with the state government PHC to provide service to the general public. State of the art mobile dental van is provided to reach the remote rural areas for screening and treatment of oral health related problems and also for oral health education. This has helped our students to improve their skill and also cultivate sense of social responsibility. Faculty and students are thoroughly trained in biomedical waste disposal. Seminar was conducted for Gender equality awareness.

Swachh Bharath Abhiyaan is aligned with clean campus initiative. Programs are conducted to work towards plastic free zone. Patient record system has been digitalised to become as paperless as possible. Our students actively participated in covid - 19 vaccination drive and also worked as volunteers in covid isolation centres. Students and faculty participated in Tele - consultation program by Step one which helped the home quarantined covid patients. Tobacco cessation cell is established which help the patients in quitting tobacco habits. Sapling plantation drive was organized to mark the environmental day awareness.

AIDS and HEPATITIS awareness program, No tobacco day awareness Walkathon was also organized. Blood donation camps are conducted regularly. Seminar was conducted for Group D workers during covid time. Free kits, medication were distributed and educated regarding hygiene maintenance. Our faculty were appointed in NSS advisory committee of RGUHS. We are working towards becoming sustainable campus by recycling water. Sewa basthi camps were conducted in association with NMO.

Yoga day is celebrated to provide more holistic approach towards the health care. Meditation and yoga centers are established within the campus for the benefit of faculty and students.

Single day dentures, free denture camps are organized under dantha bhagya yojana.

Report- QIM write-up criterion-3

ORIGINALITY REPORT

5%	5%	0%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.naac.gov.in Internet Source	4%
2	kcg.gujarat.gov.in Internet Source	1%

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		

Report- QIM write-up criterion-4

by Dscds .

Submission date: 10-Jan-2023 03:32PM (UTC+0530)
Submission ID: 1990665350
File name: QIM_write-up_-_Criterion_4.docx (34.97K)
Word count: 4463
Character count: 25482

Response 4.1.1

Our college has adequate and appropriate infrastructure to provide a quality Dental education Teaching-Learning environment which has enabled us to reach out sustained academic endeavors in the interest of our students. We have 2 buildings- The main building comprises the clinical section with 8 separate departments spread over 5 floors. The second building has office space, 2 board rooms, class rooms, library, preclinical laboratories and Basic science sections.

Facilities for ICT- enabled Teaching-Learning- Classrooms are well ventilated and furnished with desks, chairs, podium and lights. Each classroom and seminar room is ICT-enabled with a Smartboard/white board/LCD projector, laptops and with internet facilities to make the teaching-learning process more interactive and interesting.

Distance learning are also conducted via audio and video conferencing. When the Covid pandemic brought the nation to a standstill, our college seamlessly adopted teaching through online theory classes, Webinars, soft skill programs and Continuing Dental Education programs.

CCTV cameras are installed in every classroom and clinical departments, and reception areas ensuring round-the-clock security. The classrooms are Wi-Fi enabled which provide access to all staff members and students for educational resources and services.

2

The institution has seminar halls and auditoria to conduct workshops/Seminar/conferences/ and other curricular activities.

Computing equipment

Each department has 2 desktops connected with LAN and a touchscreen Tablet. The radiographs developed in Radiology department can be accessed through any department **through Carestream Imaging software and Sidexis Software.** All the departments in the college are provided with Wi-Fi facilities with 500Mbps interconnect speed with one network rack per floor of the building. For power backup, an online UPS with a total output of 3KV is available which can support all the network equipment and servers for a maximum of 12 hrs. Our institution also has 3 dedicated servers which run services like DMS software, Store

management software, Library software, Radiology software and such others.

Laboratory facilities

There are 2 pre-clinical skill laboratories for learning at the UG level namely pre- clinical prosthodontic and pre- clinical conservative labs. There are 40 phantom head manniquin for students' practical learning. For the postgraduate learning, there are skill labs in 3 departments namely Prosthodontics, Conservative and Orthodontic labs. Additionally for teaching and learning, the college uses skill labs from its sister institution i.e. CDSIMER.

There is a General Pathology lab for routine blood investigations for the outpatients. Separate laboratory is available for Microbiology, Anatomy, Physiology, Biochemistry and Pharmacology. Each lab is equipped with necessary equipment related to the subject, to carry out various experiments. During the tenure of research, students are also allowed to use the labs of other colleges available on campus.

There is a separate Anatomy Museum with various types of specimens well stored in formalin glass chambers. Osteology of human body is studied with Two full body skeletons, and specimens.

Facilities for Community outreach Learning:

Regular screening and treatment camps are conducted by the Public health dentistry department, where the UG and PG students and staff in charge participate in diagnosing and treating various cases. An air-conditioned mobile dental van and two portable dental chairs are exclusively reserved for treatment in camps. Our institution has set up 5 peripheral dental clinics for treating patients where interns and PGs are posted as part of their regular postings, where they learn how to manage different clinical cases.

A separate yoga and meditation centre is available in the campus for imparting holistic and spiritual education. Learning yoga has helped students maintain better ergonomics during dental treatment and also helps improve academic performance. There is also a Shiva temple for worship.

Response 4.1.2:

Dayananda Sagar college of Dental sciences has well equipped sports infrastructure. Sports, cultural activities are emphasised for the growth of the students. The physical wellness of the students is promoted and ensured by the physical education Director. The aim of the institution is to provide both, students and staff with a wide range of sports with individual coaches, and facilities for recreation and leisure activities.

The indoor sports complex is equipped with two international level squash courts, multi gymnasium and yoga/aerobics hall. The total built area of indoor sports complex is 558 sq.m. The outdoor play ground of area 6500 sqm has facilities for football, basketball, cricket, volleyball, throwball, kho-kho, and tennis. The sports facilities and the playground user rate per day is excellent.

The facilities for yoga and meditation for the faculty members and the students is adequately provided. Regular training sessions on yoga and meditation are conducted at the meditation centre. The meditation centre is spaced out in a 110sq.m.

During COVID 19 pandemic, many online sessions on yoga and meditation for the benefit of students and staff were conducted

Facilities for Cultural Activities

The college has an exclusive cultural division by the name "Dr D Premachandra Sagar centre for performing arts" through which we make sure that the students are given an equal chance and opportunity to showcase their talent. Also, the college conducts cultural day and sports meet annually which will be participated by most of the students. Individual teams for each art and auditions are conducted for students at the beginning of academic year. There is a separate media team taking care of photography, videography and design that covers all the events happening in the college. The institution has 700-seating capacity auditorium (Dr P C Sagar auditorium), another 120-seating capacity auditorium (C D Sagar auditorium) and an amphitheatre of area 237sq.m for conducting various cultural activities.

Individual teams for each art and auditions are conducted for students at the beginning of the academic year. There is a separate media team taking care of photography, videography and design that covers all the events happening in the college.

Response 4.1.3

DSCDS is located on a sprawling 23 acre campus, with a total built-up area of 1,04,071 sq. ft. As a dental institution that houses five floors with eight departments in the clinical block, and four floors of dedicated teaching and classrooms in the preclinical block, the institution offers modern infrastructure to meet the needs of students, faculty and patients, while offering the highest quality patient care and on campus experience of college life. The institution provides facilities such as ample parking spaces, a carbon-free environment to work and learn, and a good air quality index (AQI). Besides having a multi-specialty hospital with world class healthcare facilities, the campus has well aerated, spacious hostels for boys and girls in separate areas, a Conveno store for all stationary needs, and several canteens within walking distance. Each Department in the institution is well ventilated, with ample floor space, and ambient natural and LED lighting throughout. Equipped with modern infrastructure, the college boasts of abundant information technology facilities including high-end computer systems like workstations, tabs, etc. and an integrated patient management and library management software, in an effort to minimize paper wastage. Sagar Hospitals situated within the campus, is a 415 ward Super speciality hospitals offering an array of services including a 24x7 accident and emergency care with ambulance facility, OPD services, radiology and diagnostic services, pharmacy, and a well-equipped multi-speciality and neonatal ICU facilities, etc. The campus houses Hostel facilities for both boys and girls, which include mess halls and locker rooms. There is an entertainment area in both the boys' and girls' common rooms where television and sporting equipment are available for recreational use. During their time on campus, students have access to high-quality, hygienic food in the campus canteens, creating a sense of homely atmosphere in them. It also offers varied menu and comfortable surroundings, making it a popular student hangout area. Greenery on the campus includes greenhouses, nursery plants, and tree plantations like Teak, Sandalwood, Jackfruit to name a few. The greenery within the campus also contributes to maintaining soil quality and erosion control, amongst other positive aspects, to promote native species and forest regeneration on degraded lands. The college also provides Banking and ATM facilities (Bank of Baroda and Punjab National Bank) within the campus. Ramps are installed to facilitate ease of access to people with disabilities along with wheelchair provision. Toilets for general public use is provided in the parking area with signage boards to make it easy for the patient. Washrooms are provided in each department for students and faculty. Staff members of

the housekeeping department maintain the toilets to the highest standard on a daily basis. Sewage Treatment Plant established in the institution premises aims to remove contaminants and harmful substances from the water collected before being made reusable for fountains, foliage and also for recharging the ground water, thereby ensuring water preservation and conversation. Water treatment plant is installed in the campus where the water is treated by Reverse Osmosis (RO) plant before being supplied for drinking purpose. Alternate sources of energy employed in the institution include establishment of solar panels and generators, including a mobile generator facility available in the campus for emergency use.

Response 4.2.1

DSCDS complies with the dental hospital teaching-learning and laboratory facilities as stipulated by the DCI and RGUHS. Our college trains the BDS students in Basic Medical sciences and preclinical dental procedures. Apart from this the college utilizes three other hospitals for their practical training. These are 1) CDSIMER medical college, 2) Krishna Sevashrama Hospital, 3) Sagar Hospitals.

Facilities for Patient care- there are 9 departments for UG training of which 7 are involved in both UG and PG training.

Each specialty has an out-patient clinical facility with electric and manual chairs connected to a centralised compressor unit. To facilitate Patient education dental chair with intraoral camera with screen monitor is also available.

There are 5 satellite health centres with all basic facilities contemplated to improve accessibility to the remote area patients. The college has Comprehensive dental care wing on the first floor where all varied treatments are done in one area with extra care for geriatric patients and children with special needs. There is a fully equipped Air-conditioned mobile dental van to carry out dental services in camps organized in remote villages and schools, coupled with other facilities like an audio visual module with mic, speakers and TV for spreading awareness for the masses, portable generator for uninterrupted power supply and compressor.

The Hematology lab services are provided for patients at nominal cost to carry out blood investigations. The college has adopted Digitization of patient records through Patient Management software; Smart TVs are present in each department for providing Dental education to the patients.

There are three well-maintained dental museums. The museum maintained by Public health dentistry is open to patients and educates about oral cancer, oral hygiene, as well as the benefits of smoking cessation. Museum in the Department of Pediatric Dentistry, which is intended exclusively for teaching children. The Anatomy Museum helps students demonstrate live human specimens and models.

Clinical teaching -learning and laboratory facilities and equipments

During their rotational posting in the clinical departments, students are taught to take case history, radiographs, arrive at a clinical diagnosis, do the treatment planning as well as learn techniques of patient management and also perform various dental procedures. Advanced treatment procedures are done by post graduate students and faculty members. Postgraduate students present seminars and Journal clubs which are conducted regularly. Also, to facilitate students who are predominantly left handed, left handed dental chairs are made available in the clinical departments.

Each lab is enabled with required equipments to carry out several experiments. There are over 135 microscopes in all comprising of Monocular and Binocular and Trinocular microscopes available for students to observe blood smears and Histological sections.

The Acrylic and ceramic laboratories have cutting edge equipments for fabrication of implant prosthesis, acrylic metal and ceramic crowns and bridges and orthodontic appliances. Regular workshops are conducted in field of LASERS and Implants.

In the Prosthodontics Skill lab, Students learn fabrication of metal casting, ceramic crowns, bridges and acrylic dentures. Orthodontics lab-has separate UG lab and PG skill lab for the students to learn preclinical wire-bending work with advanced equipments like vacuum forming splints, vacuum mixing machines, electropolisher, Hydrosolder machine etc. There are diagnostic and therapeutic equipments like, Magnifying loupes, Centrifuge, Surgical microscope, TENS machine, Digital and Panoramic Radiography and such others. Soft tissue and hard tissue surgeries are performed with equipments like soft tissue LASER unit, cryosurgical unit, Electrocoagulation unit, Piezosurgical unit, Physiodispenser and implant kit.

Response 4.3.1

In line with the advent of technology in librarianship, our college library and information centre has brought about a radical change in library functioning through complete automation. This has helped to improve the user experience. The Institutional Library has introduced "LIBSOFT" an Institutional Library Management System or ILMS Software (Version 12.0). This is an integrated multi-user package designed and developed for library automation for efficient management of library functioning in all aspects. LIBSOFT is a Windows/Web-based software and runs in any Windows environment and therefore has an excellent graphical user interface. It's also an effective source of information that can be shared with people. Automation was initiated in 2013 and was successfully completed in 2015. Since then the software has been in regular use.

The "LIBSOFT" program, with its unique features, has brought about sweeping changes in the way our library is working. The software helps in creating a hassle-free acquisition process where one can access all the details of the book viz author, publisher, edition ISBN etc. at the click of a button.

The software also helps in generating barcode labels which makes the book-search easier. The software also helps in generating membership ID cards with all the required information stored in the digitized membership card. ILMS has simplified the transaction functions in the library. The software has simplified the process of issuing, returning, renewing and reserving books, improving the user experience.

The library is equipped with a WEB OPAC system, which allows the user to access books anywhere in our campus. The internal web address required for this is communicated to the user as part of their user education program. This allows the user to reserve books even if the book is not available. The librarian will monitor the process and release the reserved book as soon as itbecomes available.

The software also helps in generating the material report, membership report, usage statistics etc.The library also arranges for the procurement of the book or journal through

librarian contacts incase of non-availability in the college library.

The databases in the LIC are continuously updated as new documents are added to be displayed in the OPAC. Our users can have quick access to the latest information either by visiting the LIC or bysearching the Library OPAC anywhere in the campus and users can also download e-books, e- journals and previous years question papers, PowerPoint presentations of various topics engaged in classrooms , through OPAC using a username and password and asour entire campus is connected through Wi-Fi. technology.

Circulation management and barcoding is performed on all library document issues and returns of the all-library documents to the users through barcode scanning. This is not only saving the valuable time of the users but also increases the efficiency of the functioning of the Library and Information Centre.

Response 4.3.2

The Library and Information Centre (LIC) of Dayananda Sagar College of Dental Sciences is rapidly developing into one of the most sought-after teaching and research learning centre. It has a good collection of printed and electronic learning resources. It also subscribes to both national and international Journals. To enable its faculty members and students to keep abreast of the growth of knowledge in dental and medical sciences, it acquires the latest documents from time to time.

The Central Library has an extensive collection of documents; like textbooks, reference books, e-books and e-rare books and we have special collection of textbooks, PG Entrance guides, dictionaries, PG Dissertations, bound volume of journals etc.,

The library is updated annually for books and journals based on the annual budget and requirement of the users. The books cover all dental specialties and basic medical sciences. Currently there are 4214 books and 1566 titles and 550 e-books, PG dissertations and previous years question papers are available in the Library and Information centre. Apart from this, learning materials in the form of audio-visual media is also present, comprising 220 CDs for supporting student's learning.The library has 171 books received from the social welfare department which is issued only to thedisadvantaged group of students.

HELINET Consortium database is made available on annual subscription from the Rajiv Gandhi University of Health Sciences, Bangalore for dental, medical and allied health sciences for Accessing Electronic Resources; Electronic Journals, Electronic Books, Drug Monograms, Dental Introduction, Clinical Reviews, ProQuest & Wiley Online Library.

The selection of books is done through the Book Exhibition that is held in the library annually, from various publishers/vendors. HOD and faculty members physically visit the exhibition hall and select books related to their respective departments. The dates of these

exhibitions are decided by the library's advisory committee under the chairmanship of the director and the chairman of the committee together with its members.

The Library and Information centre also subscribes to 32 international and national journals. It owns 21 international and 11 national journals in different specialties which will be displayed for reference in the Reference section of the Library and Information centre. Photocopies of these journals are permitted on the photocopier available in the Library and Information centre and atthe end of the year these journals are bound by volumes and issues and these volumes have been produced. To date, there are 1260 bound volumes in the Library and Information centre.

The Library and Information Centre also has 221 printed and electronic PG dissertations, whichare maintained only for the reference part of the Library and Information centre.

Library collections as follows:

Source	**Collections**
Total No. of Text Books	4214
Reference Books (Titles)	1532
E-books at our library	550
E-Journals at our library	14 Titles 10 to 25 years Back volumes
Print Intl. Journals National Journals	21 11
RGUHS Helinet Consortia e-resources	6000 above e-books and 44 e-journals
Print/E-Dissertations	221
Bound Volumes of Journals	1260
E-Rare Books	61
Donated Books	516
SC/ST Book Bank	171

CD/DVD`s	220

Response 4.3.5

Library usage programs are organized by the Library faculty for teachers and students as extension activities like (i) Book Exhibition (ii) Orientation programs (iii) Library Software Orientation and few others.

In-Person and Remote Access Usage of Library:

The college library can be accessed by students and faculty and is monitored by the library staff. The students and faculty have in person access to the hard copies of books, current and previous journals, audio-visual resources, virtual library, thesis, dissertations, newspapers and magazines. The library has fully automated its entire collection which can be accessible through the Library Management System. The RGUHS HELINET Consortium database subscribed from the RGUHS every year gives IP based, on-campus access to dental and medical e-books, scholarly e-journals, educational videos, dissertation and thesis, trade journals, reports, works related to dentistry and health sciences. The Library Management System & OPAC allows students and staff to access e-journals, e-books and previous year question papers by using their username and password.

Library user education program is conducted in the beginning of the academic year for both UG and PG students by the Librarian to familiarize them about the Library Information and services available in the library. Training sessions are also organized whenever a new product or service is introduced.

Library User Education (Orientation) Program for Fresh BDS and MDS students

The main goal of library orientation is to introduce students to the library services and resources. The students are given a tour of the library by a member of the Library Committee showing access to books, journals, dissertations, newspaper and magazines. The students are also shown the access to Library management system OPAC search facility and others services available.

Log in IDs will be created for the students and faculty in coordination with NDLI and RGUHS for the access of e-resources at Dayananda Sagar college of Dental Sciences Library and Information Centre.

Training/Workshops Conducted by Library and Information Centre: -

A workshop for Training on usage of EBSCO DOSS database was conducted to familiarize students with the various tools of the EBSCO online platform and also on how to search various kinds of materials such as journal articles, book reviews and e-books. The session covered content under the title "Academic Search Premier- A multidisciplinary research database containing full-text articles and e-books".

Skill Development Programme on Career Opportunity for Undergraduates

Often skill development programs on 'Career Opportunities' for students are organized for encouraging the students to pursue higher studies outside the country and thus develop an extra educational boost to increase the chances to ace International competitive exams.

For instance, students are given an insight on how to approach each section of the IELTS exams, and various tactics to develop skills and strategies needed to improve the IELTS band score. Students are also guided to prepare for any English language tests and to increase the probability of being accepted by a foreign university.

Response 4.4.2

Dayananda Sagar College of Dental Sciences provides a number of computers and employs various information technology facilities to necessitate the learning needs of its students, so much so that a dedicated Electronic Data Processing Department (EDP) is operating at the institution. This department, under the direction of a Systems Manager, is comprised of several System Administrators and Network Maintenance Engineers. This department is responsible for maintaining all computers and network equipment in the institution via periodic maintenance, which is ensured by a routine maintenance schedule covering every aspect of the IT infrastructure. The IT team also comprises of staff of dental college who provide an in-depth purview of the latest developments in technological and computational softwares pertaining to efficient diagnosis and adept treatment planning catering to the latest developments happening in their respective fields. To enable smooth functioning, the college is equipped with tablets and desktops from the reception to individual departments in the college premises, with programs and softwares accessible only via the college server thereby ensuring data safety. The computers installed are updated on a periodic basis to ensure optimum workflow efficiency. Upgrades to processors, RAM, graphics cards, and hard drives are also made as and when necessary. In order to keep up with the rapid change in technology and tools used by the organization, the institution has developed IT Infrastructure plans. As well as hardware upgrades, the institution maintains AMC's for software licenses and upgrades, which are renewed annually. The college has indigenously developed web interface for NAAC, which is a preparatory step for SSR preparation. The college also has in effect, a patient management software in an effort to be more environment friendly and reduce unnecessary paper wastage. The Dental Management Software or DMS in short, has been in effect in the institution premises streamlining the flow of patient data and keeping track of the treatments rendered. Diagnosing and Treatment planning softwares such as Carestream, NemoCeph 3D, Sidexis are also employed within the institution to keep the students abreast of the new and evolving trends in rendering high quality standardised care to patients. Windows-based licenses are available in the machines by virtue of the Microsoft campus agreement, which is renewed periodically. Other softwares that are licensed or open source is used in the machines. The institutional library employs a unique library management software LIBSOFT, wherein one can access all details of a particular book. The students and faculty have access to digital library facilities through platforms such as HELINET for accessing

electronic resources such as e-Books, Journals, Drug monograms, Clinical reviews, etc. and WEB OPAC granting access to books anywhere in the campus. All the available systems in the college are connected in 500 mbps LAN and provided with Internet facility. The networking of all departments is made through Optical Fibre Cables (OFC). The installation of certain specific devices include but are not limited to, CCTV cameras in various class rooms, lecture halls, Examination halls, etc. The installation of LCD projectors and Smart Boards make learning more interactive and explanatory. The installation of audio-video recording devices showcase procedures and surgical techniques to cater to vast audiences during demonstrations, workshops, etc. and the softwares needed to ensure the smooth flow of these mentioned devices. The IT department caters to the installation and up gradation of all the above mentioned hardware and software needs thereby being abreast of the latest needs and facilities to keep with the industry standards and norms. As well as hardware upgrades, the institution maintains AMC's for software licenses and upgrades, which are renewed annually.

Response 4.5.2

The facilities in the form of classrooms, laboratories and dental clinics are optimally utilized. The faculty are provided with the staff rooms and student rooms are available. The campus is disabled friendly with use of ramps, lifts, reserved car parking and wheel chairs.

Maintenance of physical infrastructure-

There is a common maintenance facility team for the Dayananda Sagar institutions with a team of carpenters, electricians, plumbers and gardeners who take care of maintenance of the campus.

Repair and maintenance of the sophisticated equipment's are outsourced with the insurance coverage

Library- there is a central library with a seating capacity of 150 and adequate number of books, journals and reference books. There is a senior librarian and two assistant librarians for management and maintenance.

Along with this each department has its own library and collection of essential books pertaining to the departmental speciality.

The number of visitors students and staff on a daily basis are maintained in a register. The schedule for the schedule of issue/ return of books etc... will be taken care by the library committee.

Sports

The sports and cultural activities of the students are looked by the support committee in place, this committee along with the physical education director helps in maintenance of the gym/table tennis boards, carrom boards/ basket-ball.

Students are encouraged to participate in annual sports and cultural activities conducted by other institutions and inter-institutional and universities events.

Computers

All the departments are equipped with desktops, laptops, and tablets. An adequate number of computer systems are provided for the seamless learning and functioning of the departments.

Classrooms

Well ventilated spacious classrooms and department seminar halls, labs, clinics both the auditoriums are maintained by the house attendants and by housekeeping staff. 24/7 security service provided in the campus, and for the hospital by the Dayananda Sagar institutions.Equipments like generators, compressors water motors water purifiers coolers are maintained by the central facility team of Dayananda Sagar institutions. Fire extinguishers are placed in every department, classrooms, auditoriums and also maintained by the central facility team consisting of engineers and technicians.

Maintenance committee meets thrice a year to discuss and suggest the measures to be taken to improve the overall maintenance.

Report- QIM write-up criterion-4

ORIGINALITY REPORT

19%	19%	0%	0%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.dapmrvdc.edu.in Internet Source	15%
2	doczz.net Internet Source	1%
3	dsatm.edu.in Internet Source	1%
4	nitpoly.edu.in Internet Source	<1%
5	www.grips.ac.jp Internet Source	<1%
6	A Roerden. "The inelastic response of porous, hybrid-fiber composites", Composites Science and Technology, 2000 Publication	<1%
7	www.britishcouncil.in Internet Source	<1%
8	Shrinivasa V., A. M. Manjunatha. "A Study on Managing Sports Programs at Colleges In	<1%

Karnataka", International Journal of Physical Education & Sports Sciences, 2018
Publication

9	www.sfrcollege.org Internet Source	<1%
10	mafiadoc.com Internet Source	<1%

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Exclude bibliography	On		

Report- QIM write-up criterion-5

by Dscds .

Submission date: 10-Jan-2023 03:33PM (UTC+0530)
Submission ID: 1990665523
File name: QIM_write-up_-_Criterion_5.docx (18.17K)
Word count: 1385
Character count: 7792

Qlm-Criterion 5

5.1.4

DSCDS has a focused mechanism for handling International Student affairs. The Student welfare and grievance committee of the institution extends the required support and assistance to the international students. The committee coordinates closely with the administrative staff in regard to international students to make their official documentation as easy as possible to avoid any cumbersome complications from day 1 of their admission to the college.

As per government norms,15% seats of the total intake of students per year was permitted for admissions to international students. Though the selection of college was at the discretion of the student seeking admission, the admissions were through Rajiv Gandhi university of health sciences, Bengaluru. The university was responsible for the verification of documents of international students and issue of eligibility certificate. The students would then approach the college with eligibility certificate to secure their admission. The details of the admitted students were notified to the Ministry of health and family welfare (MOHFW), New Delhi. MOHFW issued the no objection certificate (NOC) after verification of documents that officially permitted international students to progress with their course. The college issues the bonafide certificate to the international students to authorize their course continuation in the college annually. Based on the submission of bonafide certificate, the residential permit is renewed annually by the foreigner's regional registration office.

The Management has consciously made an attempt to have an NRI hostel with need based modern facilities to make their stay comfortable during their course of study. This includes mess and canteen facilities that caters to their specific needs. The student welfare & grievance committee frequently checks on these facilities and interacts with students for their feedback to affect any improvements (if needed).

Taking into consideration that the medium of dental education offered in the college is English, international students are counselled to understand their language limitations (if any) and appropriate measures are taken up to reach out appropriate English language classes to them. They are also trained in Kannada language classes before they commence their academic sessions with clinical patients, to facilitate

them to acquire necessary communication skills. The committee monitors the Remedial classes conducted by various departments to help them cope with their academics and are engaged in regular additional assignments. Peer learning is also encouraged for them to learn through interactions with their classmates. The mentorship sessions are taken very seriously for the international students since the challenges faced by them can be of varied types in comparison to domestic students. The committee encourages them to actively participate in sports by identifying their inherent interest in any specific sport. Their involvement in cultural activities is encouraged by involving them in Annual cultural activities and various celebrations that happen throughout the year since they ultimately go on to be our cultural ambassadors. The outgoing students are appropriately encouraged, guided and assisted with recommendation documents to pursue their higher studies/career abroad. They are also registered in the alumni association to be in a long-term relationship with the Alma mater in varied capacities.

5.1.3

Student council members are nominated by the student body of the college every year. The nominated student council members play a proactive role in planning, designing and implementing events throughout the academic year. The council comprises of a President, Vice President, Member secretary, Cultural secretary, Sports secretary, Magazine editor, all students as from 1st, 2nd, 3st, 4th year BDS, Interns and PGs, and faculty representatives as members. The normal tenure is for a year and is renewable based on fresh nomination. The roles and responsibilities of the executive body are predefined and allotted among the council members after the election. The meetings are held twice a year.

The student council plays a definite and vital role in:

- Representing and implementing students' thoughts and views in academic and related perspectives.
- Encouraging students to take up and handle organizational responsibilities.

- Imbibe the students with the core values of the college.
- Seeking unbiased opinions on issues relating to their welfare and academic support.
- To build a positive association/ liaison between the students and the administration.
- Organize and allot duties for the purpose-oriented events.
- Fostering a team spirit.

The student council has a magazine editor who works at the prime position with regards to the release of an e-magazine, integrating articles, poems, literature and the scrutiny of the same. The students get the opportunity to portray their talents through different means. All strata of novelty and creativity are constantly entertained by all the members of the committee. Funding for different events is arranged through participation fees collected for various events.

The activities and events volunteered by the student council include teachers' day celebrations, cultural fest, sports meet, freshers' day, convocation ceremony to list a few. The cultural committee and the sports committee in accordance with the student council make decisions with regards to scheduling and conducting the events in an organized manner. The students play an integral part in managing and accommodating the needs of the events conducted throughout the academic year. Besides the above listed events, the students have representation in anti-ragging committee and student welfare & grievance cell.

At the end of the academic year the student council will pass on the roles and duties to the newly nominated committee along with a hand book that discusses the responsibilities of individual members.

5.4.1

The Dayananda Sagar College of Dental Sciences Alumni Association has been registered with the Registrar of Societies, under the Bangalore Urban District, Karnataka as on 12.09.2019. Since then, this association has been proactively involved and is constantly contributing to the growth of the Institution by active engagement of the Alumni Members of the College which has over 1300 members comprising of students who graduated from the various disciplines the college offers such as Bachelor of Dental Surgery (BDS), Masters of Dental Surgery (MDS) as well as Ph.D. Degrees. All students mandatorily need to register in the DSCDS Alumni Association after course completion. Registration into the Alumni Association is made easy with the use of Digital Forms via Google Forms for convenience and ease of maintenance of Alumni Registrations and related data.

The Alumni Association office bearers have a blend of Alumni who are now Faculty at the Dental College, noted Alumni in other top positions as well as some members who have completed their Under Graduate/ Post Graduate/ Ph.D. programs from DSCDS. Within the college, there is an administrative committee [Alumni Coordination Committee] which contacts the office bearers of the Association for collaborative programs that can be organised at the DSCDS.

The Alumni Association has been meeting regularly since its registration until February 2020, where the Annual General Body meetings were held on 04.11.2019 and 03.03.2020. However, During the COVID-19 Pandemic, the Association could not meet due to the restrictions in place.

The Association has been regularly conducting activities by means of Scientific Programs and informal connect with the Members. Several of our Alumni who are now in other countries visit the Institution regularly to reminisce on their time during their stay at DSCDS and also volunteer on contributing to the growth of the Institution by means of Donations that are directed towards improvement of facilities available at the College. Furthermore, our visiting alumni also engage with our current students and share their experiences and guide them to enjoy their stay and learning experiences at DSCDS.

Alumni from the DSCDS have made several contributions such as Equipment, Digitalization and in several other ways to their Alma Mater and have showed active interest in the growth of the Institution.

The Office bearers of the Alumni Association have been meeting regularly to plan when the Alumni meet can be held for the benefit of all the Alumni and has slated to organize an Alumni meet at the end of 2022 during the month of December 2022 which will comprise of events that are both professional as well as cultural where alumni members can 'Meet and Greet' and spend time with each other. Several events have been planned that include scientific sessions and a gala luncheon.

The Alumni Association plans to conduct more programs in the ensuing years to improve the Alumni engagement and interact with the Alumni by means of Professional enrichment programs that will be mutually rewarding to the Alumni as well as to the student community of DSCDS.

Report- QIM write-up criterion-5

ORIGINALITY REPORT

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by Dscds .

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Criterion VI - Governance, Leadership and Management

6.1.1 The Institution has clearly stated vision and mission which are reflected in its academic and administrative governance.

Describe the Vision and Mission of the institution, nature of governance, perspective plans and stakeholders' participation in the decision-making bodies highlighting the activities leading to institutional excellence. Response to be provided in 500 words

Response:

The pride of DSCDS is its leadership team comprising of thinkers, planners, Institution builders, medical doctors themselves, enriched with the insight gained from hands-on work experience with a piece of worldly wisdom in all that they do. Institution has clearly stated vision and mission statements which are reflected very well in academics, administration and governance.

Vision

Dayananda Sagar College of Dental Sciences aims to be amongst the world's foremost academic Institutions and oral health care providers, through the pursuit of educational, clinical, and research excellence. Institution provides utmost scope for scientific innovation, community services while shaping future leaders in dentistry who can apply science, art, and technological breakthroughs contributing to the national/global welfare and development.

Mission

Impart quality dental education to our students, train them in acquiring necessary diagnostic acumen and clinical skills enabling them to manage patients with varying dental needs. Also, motivate them to take up research work, higher studies and continue to be lifelong learners committed to work for the benefit of the society.

Nature of governance

The college is established in 1991 under Mahatma Gandhi Vidya Peetha Trust (MGVP), is managed by the Board of Members and the Governing council. The Principal, being the executive head of the Institution is assisted by the Vice-principal, Associate Deans, Department Heads, faculty, and various committees to ensure an efficient and transparent governance.

Based on feed-back obtained from the stakeholders, the Institutional quality policy is framed and the IQAC is given full responsibility to drive the quality movement of the college as per its perspective plan.

Perspective plan

The strategic plan is developed by the IQAC on a project mode, based on the vision, mission, SWOC analysis, inputs from all the stakeholders and staff members of the Institution. Gaps in attainment of objectives are identified and strategies are developed to bridge these gaps. To streamline the same, various committees at the Institutional level are formed, which look into academic and administrative activities by promoting the following:

- Inclusion of value-added certification courses, fellowship programs, continuing dental education programs and other supportive initiatives.
- Upgrading the facilities regularly by procuring need-based latest dental equipment and

improvising the teaching-learning methodologies.

- Channelizing the efforts of teachers and students in conducting quality dental research work and disseminating the knowledge by encouraging presentations at various scientific forums and publishing the same in reputed journals.
- Generating more funds and grants for conducting research work.
- Encouraging the faculty to undertake fellowship and PhD programs.

Stakeholders' participation

There is a systematic feedback mechanism to procure feedback from the stakeholders on a regular basis, which is then analyzed and timely improvisations made based on the suggestions obtained, which has helped our organization to scale higher in the All India ranking provided for dental colleges in Bengaluru and all over India.

6.1.2 Effective leadership is reflected in various institutional practices such as decentralization and participative management.

Describe the organogram of the college management structure and its functioning system highlighting decentralised and participatory management and its outcomes in the institutional governance within 500 words

Response:

The Institution has an elaborate and distinguishing method of organizing and overseeing the administrative work by allocating the tasks in manageable proportions and delegating the same to specific committees which will efficiently expedite the same.

The functional organization of the Institution is very well structured and involves active participation of all the members. The Management, Board of Directors and the Principal play a key role in the strategic development of the Institution.

The efficient and harmonious functioning of the Institution is executed through appropriate committees under the supervision of an experienced senior faculty, including student representatives as fellow members. These committees make the decisions, supervise, scrutinize the judgements and conduct timely reviews. The feedback system implemented in the Institution plays a vital role by employing through timely and constructive criticisms.

Admission to various courses (UG/PG/PhD/Dental technicians/hygienists), conducting university theory and practical examinations in the college, coordinating DCI and RGUHS inspections, supervising staff recruitment, student welfare, faculty development programs and patient care services are all meticulously monitored through participative management.

The entire team of Professors, Readers and Senior Lecturers of respective departments ensure that the academic, research work and clinical programs for undergraduate and postgraduate students are conducted as per university norms. Students are encouraged to build their portfolio

right from the undergraduate level, by involving them diligently in research activity and helping them endeavor to greater academic and professional heights.

The institution entails the support of not only the administrative and teaching faculty, but also the various support staff – medical and dental technicians, dental hygienists, nurses and group D staff, who have been serving the institution relentlessly and unconditionally to take the Institution to greater heights.

Smooth functioning of the administrative work is due to a planned decentralization and coordination between the Principal, Superintendent, accountant, receptionist, clerks and other ministerial staff. The Institution also has support staff consisting of engineers, electrician, mechanic, audio-visual technician, hostel warden, security guard, housekeeping staff, equipment and consumables maintenance / purchase personnel and gardeners.

All these practices have helped us establish a decentralized mode of governance and aided the Institution to achieve the planned targets and outcomes, to the satisfaction of all stakeholders.

6.2.1 The Institution has well defined organisational structure, Statutory Bodies/committees of the College with relevant rules, norms and guidelines along with Strategic Plan effectively deployed

Response:

Dayananda Sagar College of Dental Sciences has a well-defined organizational structure comprising of the management, governing council, Principal, vice principal, associate deans, various departmental heads and college committees with relevant rules, norms and guidelines. The IPSP as developed by the college through the initiative of IQAC, is meticulously deployed to realize the need-based outcomes through following committees:

- The admission monitoring committee resolves the queries received from student community with regard to admissions and provide all information related to UG and PG admissions.
- Academic advisory council is responsible for regulating and implementing all the academic activities of the undergraduate and post graduate programs.
- Committee for Dental education technology organizes various CDE, workshops and faculty development programs which focuses on improving teaching learning methodologies, quality improvement programs etc.
- Advanced research committee and Institutional review board committee monitors research activities, follows up various proposals for funds and grants and looks into scientific paper publications and scrutinizes synopsis, dissertations, provides ethical clearance for the same.
- Library advisory committee ensures allocation of funds for procuring latest books, journals in various specialities, framing and suggesting amendments to library code of conduct.
- Feedback committee assesses and takes timely action based on the inputs of stakeholders for constant upgradation.
- Alumni committee is intended to develop a sustainable connection with the students by conducting annual meets and engaging them in various programs. It helps to motivate the juniors on the success of alumni and thereby improving credibility and college reputation.

- Student support, anti-ragging committees, grievance redressal, mentorship, soft skill development committees help to improve and maintain a healthy cordial atmosphere between students and teachers. Exam related grievances are also addressed.
- Career guidance and placement committee functions towards organizing career guidance programs, generating training opportunities and placement for the students.
- Student council, sports and cultural committee promote and organizes various events to bring-out the hidden talent amongst the students and encourage them in extracurricular activities for their overall development.
- Facilities management committee ensures proper maintenance of the departments and college premises.
- Internal complaints committee ensures safety of girls and women faculty.

The institution has developed a robust strategic plan as appended, with specific timelines and targets to realize the vision, mission and goals. It aims at addressing the issues and challenges pertaining to knowledge acquisition, skill advancements & emerging trends in the dental field.

The Strategic Plan of the college mainly addresses the following important domains;

1. Improving teaching and learning quality
2. Obtaining Research grants and funds
3. Conducting Skill development, career guidance and Community based out-reach program
4. Applying for accreditations and recognitions
5. Digitization

These time bound goals constantly propel us towards excellence. The governing body/board of management reviews activities of the institution and provides necessary support for upgradation.

6.3.1 The Institution has effective welfare measures for teaching and non-teaching staff

Response:

Management of DSCDS has established a set of well-defined welfare measures for both teaching and non-teaching staff members as enlisted below:

Leaves:

1. Casual leave: 15 days annually

2. Earned leave: 20 days annually.

3. Sick leave: 10 days, which if not availed will be added to earned leave.

4. OOD/Special casual leave: provided to participate in conferences, CDE programs, examiner ship, inspections etc.

5. Maternity leave: provided as per the Government norms.

6. Paternity leave: 15 days leave can be availed.

Gratuity: paid according to Gratuity Payment Act of 1972.

Provident Fund: All eligible employees as per the statute are entitled to management contribution of Provident Fund.

Recreational Facilities: Gymnasium, yoga, meditation centre and sports ground are available for recreational purposes.

Internal complaints committee: Institution has a well-placed policy as per the Supreme Court of India directive and sexual harassment of women at workplace (Prevention, prohibition and redressal) Act 2013. Actively functioning internal complaints committee ensures a safe working environment for women.

Grievance Redressal: All employees may report grievances if any to the grievance-redressal committee constituted by the Institution.

Health Benefits: A full-fledged medical and dental hospital located within the campus provides concessional benefits for investigations and treatments.

Progression & Motivational measures: Institution motivates staff to pursue higher studies. They are provided the benefit of salary during study and are promoted following completion.

Teaching staff and non-teaching staff are trained through internal capacity building workshops, seminars, activities and developmental programs.

Management ensured that faculty were not affected monetarily during the Covid lockdowns.

Recognition: Faculty members are acknowledged for holding positions in various forums. They are felicitated for their contribution to state & national organizations such as StepOne, Vaccination drive, etc.

Celebrations – Teachers' day, birthdays, team build-up programs and festivals are celebrated to have a happy and cheerful working environment. Founders' day on 24th July is exuberantly celebrated to commemorate the birth anniversary of our founder late Shri Dayananda Sagar R.

Parking, canteen facilities are available.

ESI Scheme – included for employees with less than Rs 21,000/- month salary as per ESI Act 1948.

Creche: facility for children of faculty was available till pre-covid times.

Additional welfare measures for teaching staff:

Financial assistance:

- Scientific Publications: Faculty members are provided with financial assistance towards publications in reputed/refereed journals.
- National/International conferences: Reimbursement of conference registration amount to the faculty for scientific presentations at National/ International conferences is provided, limited to once in two years per faculty.
- Certificate courses/ Fellowships: faculty members will be provided financial assistance for Certificate courses/Fellowships from recognized forums.
- Intramural research fund: To encourage faculty to pursue research, financial assistance by means of intra-mural funding is provided.
- Concession in tuition fees for children enrolled in Dayananda Sagar ICSE school is provided for employees of DSCDS.

Additional welfare measures for non-teaching staff:

- Uniforms and PPE are provided
- Festival advance will be given.

6.3.5 Institution has Performance Appraisal System for teaching and non-teaching staff

Describe the functioning of the performance Appraisal System for teaching and non-teaching staff within 500 words

Response:

Performance appraisal system for teaching and non – teaching staff

Dayananda Sagar College of Dental Sciences has a structured approach to appraise the performance of teaching and non – teaching staff members which is carried out once in a year. The process is outlined below:

For teaching staff:

Faculty members are requested to provide information regarding the measures taken in teaching and clinical training, research work, scientific presentations and publications. In addition, faculty member's service to the Institution and to the community are equally important. They should participate in the activities of committees and councils, and offer scientific contributions inside and outside the college. This helps them to achieve balance by building their portfolio in areas that require more attention.

Teaching is a continuous learning process and meaningful feedback and Self-appraisal forms are an integral part.

The self-appraisal form is filled by the staff providing details of conferences, seminars, workshop, training programmes attended, books authored, scientific papers presented and published, research and academic administration carried out during the year and submit the form to their respective HODs.

HODs verify supporting documents, submit it to the principal's office along with a recommendation note.

Principal then submits it to the management along with a recommendation note for increment. Management takes the final decision of the appraisal submitted.

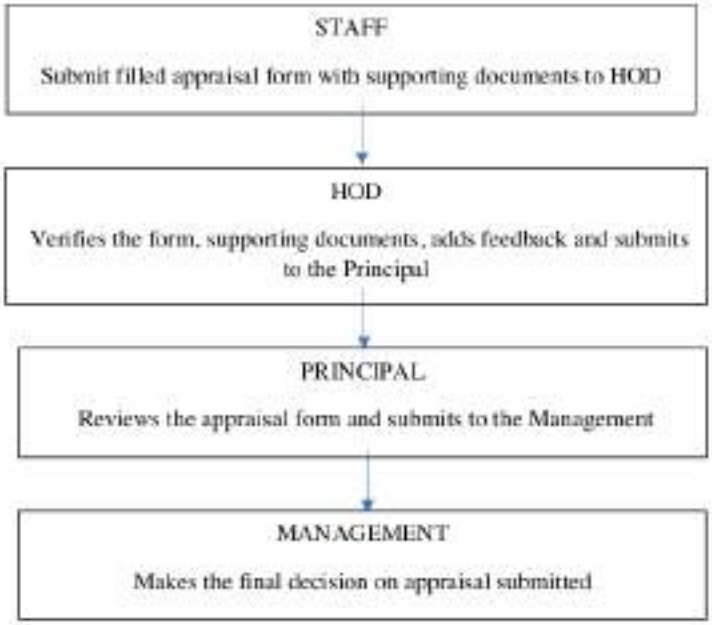
For non – teaching staff

The non-teaching, administrative and technical staff play a very important role in smooth functioning of an Institution; hence performance appraisal is done to evaluate their strengths and weaknesses. This will ensure an effective delivery of quality services and improvement of systems and processes.

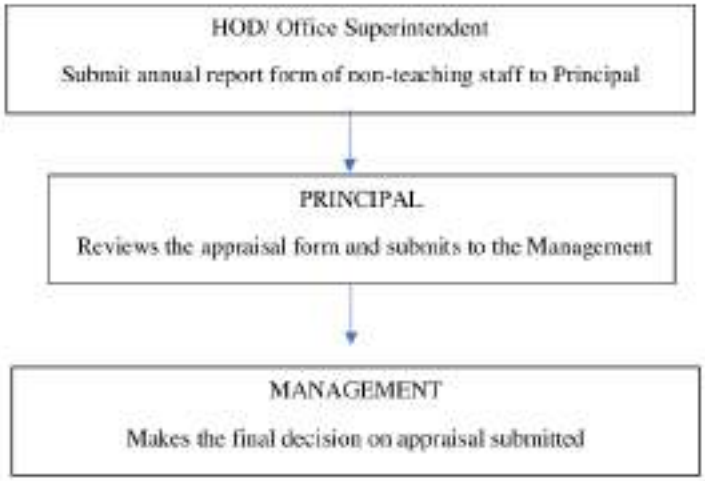
HOD/ Office Superintendent will give an annual report in regard to conduct, discipline and performance as per guidelines which will be submitted to the principal for review. It is then submitted to the management. Management takes the final decision of the appraisal submitted.

DAYANANDA SAGAR COLLEGE OF DENTAL SCIENCES

Performance appraisal system for teaching staff



Performance appraisal system for non-teaching staff



6.4.1 Institutional strategies for mobilisation of funds and the optimal utilisation of resources

Describe the resource mobilisation policy and procedures for optimal utilization of resources within 500 words

Response

Financial Resources

Funds are necessary for the procurement of facilities, equipment, electronic and communication gadgets needed for smooth running of an institution. Funds are required to pay the salaries of administrative, academic and non-academic staff and to settle current liabilities and expenditure incurred in the course of administration.

DSCDS conducts audits regularly. A robust financial allocation for college administration would not only enhance goals attainment, but its sustainability. College has a full-fledged accounts department since its inception, to ensure maintenance of annual accounts and various types of audits.

Individual departments maintain a record of budgetary information on cash inflow, purchase of stocks, expenditure incurred etc. HODs of each department provide budgetary information based on their requirements as per the inputs from staff and students to the principal. Based on this, annual budget considering potential expenditures is prepared and submitted to the management for approval and ensures optimal utilization of the sanctioned fund.

College finance committee has the authority to allocate the funds in consultation with stakeholders such as department heads, senior teachers and students, teaching/nonteaching staff to ensure funds are utilized effectively and efficiently.

Source of college fund is from Mahatma Gandhi Vidya Peetha Trust, from secured and unsecured loans, student fees, funds and grants from government and non-government organizations and interests from savings bank.

The auditor validates and approves the utility of funds for every project, as per the norms of the funding agency before the closure of the funded project's research activity.

A separate research & development account is maintained by the college and the project amount will be deposited to that account, which could be utilized for various types of research purposes.

For all the above activities, proper planning, direction, utilization and control is a must which will ensure the smooth & controlled running of the trust towards their achievement of trust's activities and goals.

6.4.2 Institution conducts internal and external financial audits regularly

Enumerate the various internal and external financial audits carried out during the last five years with the mechanism for settling any audit objections within 500 words

Response:

Dayananda Sagar College of dental sciences conducts internal and external audits regularly. The institution has a full-fledged accounts department since its inception to ensure maintenance of accounts and various types of audits annually.

Departments maintain budgetary information on financial transactions, stock information, purchases and other departmental expenditures. HODs of individual departments provide budgetary information based on their requirements and inputs from the staff members.

INTERNAL AUDIT

At institution level, internal audit will be done by the management annually on the expenditure. The departments propose their annual budgetary requirement to the principal, who puts forth the same to the management for approval after scrutinizing thoroughly. Annual budget for the institution is prepared at the beginning of financial year, considering potential income and expenditures (recurring and non-recurring) involved for that year.

The financial audits are conducted whenever a funded project is approved by any funding agency (government or a non-government agency). The auditor verifies and approves the utility of funds for every project, as per the norms of the funding agency before the closure of the project.

EXTERNAL AUDIT

All the accounts of the Institution are audited regularly by the statutory auditors appointed by the management regularly on annual basis and submitted to governing body for final approval. Financial records are audited by an external auditor D.P.Rao & co. at the end of each financial year and certified.

Every year's audit reports are filed to the income tax department and the records are maintained

6.5.1 The institution has a streamlined Internal Quality Assurance Mechanism

Describe the Internal Quality Assurance mechanism in the Institution and the activities of IQAC within 500 words

Response

The institution has a streamlined Internal Quality Assessment Cell which has been established as per the guidelines of NAAC and UGC.

Though it is not mandatory for the IQAC in the first cycle, the IQAC has been established since 2021 to actively work towards performance evaluation, quality upgradation, assessments and accreditation. The IQAC undertakes activities that include all aspects of the institute's functioning and is committed to providing quality education through comprehensive institutional policy.

The IQAC of the institute is a structured committee under the Principal of the institution who is also the Chairman of the committee. It comprises of a member secretary who supervises the functioning and implementation of the committee recommendations. The committee consists of members of the faculty, student, industry representation, alumni, Parents and from the local society.

OBJECTIVES

To enhance the standard and quality of education by proposing innovative ways to improve the academic and administrative performance of the institution.

To promote the internalization of quality culture and the institutionalization of best practices to improve institutional performance.

QUALITY POLICY

To establish the system of quality enhancement by working towards improving and maintaining standard and quality of education thereby striving to spread quality culture within the organization.

To identify and propose new ways to use teaching aids, developing suitable infrastructure and offering suggestions for new value added courses.

FUNCTIONS

1. Establishing a feedback system for students, parents and other stakeholders regarding quality-related institutional processes.
2. Providing leadership to organize conferences, seminars and workshops required for the benefit of the faculty and students.
3. Enhances the quality of research within the institution by promoting faculty research publications.
4. Preparation of an Annual Quality Assurance Report as per the guidelines of NAAC and UGC.

5. Periodic meetings held every three months for the purpose of planning, directing, implementing, and evaluating the activities of the College with respect to teaching, research, and publication

STRATEGIES

The following are some of the salient initiatives undertaken by the Internal Quality Assurance Cell of the institution since inception.

1. Students soft skill development programs
2. Faculty development programs
3. Research and development programs
4. Identifying slow and fast learners to work upon areas of improvement
5. Conduct regular quality related workshops
6. Recommend implementation of ICT enabled teaching in classrooms
7. Implementation of guidelines suggested by subcommittees for various activities
8. To implement the suggestions obtained by feedback thereby enhancing the quality of education and training.
9. Facilitating academic and administrative audits for quality assessment.
10. Preparing the institution for first cycle of NAAC accreditation.
11. Preparing SWOC analysis to analyse the institution strength, address the challenges and identifying opportunities to deliver best quality practice.
12. Encouraging green initiatives in the institution.

As part of its mandate, IQAC shall develop mechanisms and procedures for

1. Achieving academic, administrative, and financial goals in a timely, efficient, and progressive manner;
2. Academic programs be accessible to all sections of society and be affordable;
3. Networking with other Indian and international institutions and sharing of research findings.

Report- QIM write-up criterion-6

ORIGINALITY REPORT

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SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

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Report- QIM write-up criterion-8

by Qim Write-up Criterion-1 .

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Submission ID: 1990665981
File name: QIM_write-up_-_Criterion_8.docx (29.62K)
Word count: 2964
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Criterion 8 –QIM

8.1.2. QIM	***The Institution ensures adequate training for students in pre-clinical skills*** Describe the steps taken to improve pre-clinical skills along with details of facilities available for students such as pre-clinical skill labs (within 500 word) **File Description:** 1. Geo tagged Photographs of the pre clinical laboratories 2. Any other relevant information	**5**

RESPONSE

The Institution ensures adequate training for students in pre-clinical skills

The practice of dentistry is all about applying sound theoretical knowledge to an individual's practical/clinical work. The curriculum as prescribed by RGUHS caters to developing and honing the required pre-clinical skills of dental graduate students prior to treating patients.

Preclinical exercises are as per the guidelines of Statutory Regulatory Authorities (SRAs) (RGUHS and DCI), which are briefly detailed below:

Subjects	Preclinical Exercises				
	I BDS	II BDS	III BDS	IV BDS	POSTGRADUATE
Prosthodontics	1)Mixing of Plaster of Paris 2)Manipulation of alginate material ,Impresion materials 3) Identificat	1) Fabrication of Denture Base, Preparation of occlusal rims. 2)Mounting the articulator 3)Teeth Arrangement 4)Acrylization process		Crown Preparation on typodont models	Preparation of study casts and anatomical landmarks, Fabrication of cast partial denture, Fixed partial dentures, Onlay, Veneer and maxillofacial prosthesis.

	ion of Anatomical landmark on cast.				
Conservative & Endodontics		1)Manipulation/mixing of various dental cements 2)Preparation of Plaster Models and different class cavity preparations 3)Cavity Preparations and application of dental cements on typodont models			1)Sectioning of tooth Cavity, post and core, Inlay and Only ,Crown ($3/4^{th}$ and $1/4^{th}$) on typodont models preparation 2)Veneer Preparation 3)Model Analysis 4)Smile Analysis
Periodontics			Demonstration and hands-on Principals of Instrumentation on Cast		Suturing Principles and tecniques on typhodont model, Splinting and occlusal adjustments on casts
Paedodontics				1)wax carving of primary teeth 2) root canal procedures on extracted teeth	
Oral Surgery				Suturing Exercise on Models	Inter-maxillary fixation on casts preclinical exercise.
Orthodontics			wire bending and discussion of case history of sample cases	wire bending, Study model analysis	Basic wire bending, Appliances fabrication

Recognizing the importance of building this foundation, our institution has set-up need-based pre-clinical laboratories to train our students to gain adequate simulated practical experience and

acquire relevant skills before entering clinics and to facilitate the above, institution has well equipped, pre-clinical labs as part of the college infrastructure, which are as follows:

- Prosthodontics preclinical labs with a seating capacity of 40 numbers has individual bunsen burners and other laboratory equipment like model trimmers, lathe and acrylizers.
- UG Phantom head lab comprising of 38 phantom heads and manikins are used for simulated practical training.
- The courses of Prosthodontics and Conservative/Endodontics PG pre-clinical labs are equipped with 2 phantom heads/manikins and 6 phantom heads/manikins respectively for simulated learning.
- Oral and Maxillo-facial Surgery organizes Basic Life Support programs every year on manikins to provide these skills to students and faculty alike .

Some of the additional steps taken to improve pre-clinical skills are:

- Structured Pre-clinical postings with small batches for undergraduates to enable the faculty to give individual attention to students.
- Regular assessments to evaluate the pre-clinical skills outcomes.
- Planned modules for Postgraduate training in a phased and timely manner
- Regular Continued Dental Education programs and workshops to provide additional training to students.
- Faculty is encouraged to attend Continued Dental Education programs, workshops, conferences and Faculty development programs to acquire latest techniques/new pedagogies for transfer of such skills to our students thereafter.

8.1.4. QlM	***Orientation / Foundation courses practiced in the institution for students entering the college / clinics / internship:*** Describe in less than 500 words about a. Orientation for fresh students b. White coat ceremony c. Workshops on patient care (community skills, infection control, biomedical waste management, professional ethics) d. Internship orientation	**5**

	e. Any other **Provide weblink to** • Orientation circulars • Programme report	

RESPONSE

DSCDS offers useful and focused orientation/foundation courses to freshers (UG/PG) entrants of the college each academic year as detailed below:

Orientation for Freshers

Orientation day is held every year at the inception of the academic session. Eminent personalities from various walks of life who can enthuse and motivate students are invited as Chief Guests along with an academician of repute as the Guest of Honor. Students are welcomed and briefed about the programs, courses, curriculum, rules and regulations of the institution, facilities available in the campus, academic and non-academic activities planned for the year and available student support system. Undergraduate students are then escorted on a campus tour to show them around the classrooms, library, preclinical labs, clinical departments, hostel and canteen. While on this campus tour, they are also introduced to the faculty members and departments of the college. They are instructed to attend the Kannada communication classes and soft skills programs which would help them to adapt to the professional practice.

Postgraduate students are given an insight into the PG program, Curriculam, Synopsis writing, presentations of journal clubs and seminars, professional ethics, infection control, sterilization, biomedical waste management and basic etiquettes of professional practice of dentistry.

White coat ceremony

The institution conducts this annual event to orient the third year students before they begin hands-on working with patients in clinics. Experienced faculty members enlighten them about

the protocols to be followed in clinics including professional etiquette, proper communication with patients, maintenance of clinical case records, usage of Patient Management Software (PMS), guidelines of proper sterilization, safety norms of radiation and mercury usage norms, handling medical emergencies, patient/doctor-friendly ergonomics and professional ethics of patient-care and dentistry practice.

Workshops on patient care

Workshops and continued dental education programs on community skills, infection control, biomedical waste management, professional ethics and patient-care are conducted each year. The students are encouraged to participate in Oral Hygiene Day program conducted annually through which they are involved in different activities of oral health promotion in house and as well as in camps. The Postgraduates undergo training in softskill through workshop which are conducted annually.

Internship orientation

This program is conducted at the beginning of the one-year mandatory rotatory internship. The roles, duties and responsibilities of interns are elucidated and they are oriented about the activities of internship when they are posted in different departments, as per the RGUHS guidelines. They are also oriented about the social responsibility and encouraged to participate.

Others:

Postings in Forensic Medicine at BMCRI and casualty at CDSIMER, satellite clinics and rural postings equip interns to face real-life challenges. Few value-added courses for interns like Implant and laser courses expose them to advancements in clinical practice. The institution has initiated campus-interview-style placements with a few students being successfully placed in various companies. Educative programs for career guidance, about opportunities and placements at the national and international level are also conducted. The interns are also encouraged to participate in scientific Essay competations and present scientific papers in student conventions at both state and national levels.

8.1.8. QIM	**The Institution has introduced objective methods to measure and certify attainment of specific clinical competencies by BDS students/interns as stated in the undergraduate curriculum by the Dental Council of India** Describe theobjective methods adopted by the College to measure and certify the attainment of clinical competenciesby BDS students/interns as stated in the undergraduate curriculum by the Dental Council of India Response to be provided within 500 words **Provide weblink to:** • Report on the list and steps taken by the College to measure attainment of specific competencies by the BDS students/interns stated in the undergraduate curriculum during the last five years • Geotagged photographs of the objective methods used like OSCE/OSPE • List of competencies • Any other relevant information	**10**

RESPONSE

The institution strictly follows the mandated objective methods as stipulated in the undergraduate curriculum mandated by the DCI, in the measurement and attainment certification of specific clinical competencies of BDS students and interns, as detailed below:

1. Professionalism
2. Communication skills
3. Health promotion and maintenance
4. History taking and examination
5. Ethics and law
6. Patient care including diagnosis and treatment
7. Behavior management of anxious patients
8. Prevention and interception
9. Critical thinking
10. Leadership

Faculty are trained to assess the above said competencies of the students using various formative assessments and a summative assessment objectively.

Each course has a policy document which includes formats for objective assessment of competencies during the formative assessments. Skill-specific checklists for various clinical skills as performed in their clinical / practical postings are verified regularly and records maintained meticulously.

The list of objective assessment methods followed in our institutions by the courses offered are:

Sl. No.	Objective Assessment Methods
1	Assignments
2	Objective Structured Clinical Examination (OSCE) and Objective Structured Practical Examination (OSPE)
3	Viva voce
4	Subject seminar
5	Problem solving exercises
6	Projects for community Oral hygiene and dental care, field survey and field visits
7	Research projects
8	Quizzes
9	MCQ tests
10	Project-Based Learning

Three internal assessments comprising of Case history recording, Case examination and Clinical skills or Psychomotor skills are scheduled. These are evaluated by the faculty not only for diagnosis, treatment planning, but also for critical thinking and problem-solving abilities and performing course-specific clinical skills on patients along with theory assessments. The posting-end clinical internal assessment also has viva voce for all students to know their communication skills, diagnosis, treatment planning & critical thinking abilities. Short research projects sensitize them to research & develop professionalism, critical thinking, and communication. Earlier, Objective Structured Clinical Examination (OSCE) and Objective Structured Practical Examination (OSPE) methods were followed in a simple manner by training students in spotters & slides and now we have started full-fledged OSCE/OSPE stations to train students .

Each course uses any of the suitable objective methods mentioned in the above table to evaluate the student. Assignments are to be written for specific topics which will be evaluated as per the policy document adapted by respective courses. The weightages / marks obtained in all of these assessment methods are combined together to award marks in each of the internal assessments. The method of assessment in each course is informed to the student at the beginning of the year. All the details are shared with them to keep the process transparent & objective.

During internship, various clinical skill competencies, projects, surveys, MCQs on specific topics (eg. Implants, lasers etc) are assessed as a part of their overall evaluation while in training.

The institution strives to provide skills related to BLS (Basic Life Support) to all the students in their final year BDS or while doing internship, in collaboration with the American Heart Association (AHA). The participants are trained using manikins/simulators to impart clinical skills required to handle patients during medical emergencies. A certificate from AHA is awarded to students who clear the MCQ based test, ratified by AHA certified BLS trainers. The above assessment efforts of the institution ensure laudable and professional clinical practice and community service for our UG and PG student.

8.1.10. QIM	***The College has adopted methods to define and implement Dental graduate attributes with a system of evaluation of attainment of such attributes.*** Describe the Dental graduate attributes developed by the College and the steps taken to implement and assess the attainment of such attributes. Provide weblink to: • Dental graduate attributes as described in the website of the College. • Any other relevant information.	**10**

RESPONSE

Graduate Attributes is a quality or feature or a characteristic which is ascribed to a person. Dental graduates will have to be trained to have these attributes which are displayed on the college website.

1. Academic Attributes
2. Professionalism And Ethics
3. Community Oral Health Perspective
4. Soft Skills

1. Academic attributes:

- To be knowledgeable, skilled and competent and provide preventive, promotive and rehabilitative dental care.
- To perform procedures independently both in rural and urban settings
- To analyse, correlate and have clarity in the knowledge required and apply with independent judgment during patient care.
- To perform procedures independently both in rural and urban settings
- To meet the challenges in oral health care with reasonable and informed decisions.

Implementation

- A planned curriculum is followed diligently to impart knowledge which includes student centric learning techniques along with didactic lectures.
- The postings in pre-clinical labs and clinics help them acquire hand–on experience in treating patients and become competent.
- Attending camps in rural areas, postings in satellite and peripheral centers, equip the students to treat patients in any setting independently, which also helps them learn community oral health perspective
- The under graduate students are also encouraged to take up short research projects which helps them to conceptualize evidence based solutions and sensitize them to research.
- Basic study of forensic odontology is introduced in UG curriculum.

2.Professionalism and Ethics

- To understand and fulfill the social responsibilities towards public health in general and community oral health.
- To imbibe and uphold values and principles of this noble profession

- To become a lifelong learner and develop a sense of enquiry and application
- To maintain professional inter-relationship ethics
- To adapt to changing scenarios and develop sustainable forms of treatment delivery to the public
- To preserve moral and ethical integrity while discharging duties to a wide and varied
- patients of different cultural and socioeconomic backgrounds

Implementation

The institution conducts orientation day, white coat ceremony where topics pertaining to professionalism, ethics are dealt with in detail.

3. Community oral health perspective

- To understand the patient's needs at an individual and community level
- To participate and contribute to research at various local, national and international levels
- To be able to conceptualize evidence based solutions which are cost effective
- To have an understanding of the effect of disease and its managements on the legal and cultural systems

Implementation

- Continuous dental education programs not only enhance knowledge on scientific topics but also on legal and social responsibilities of dental graduates.
- Apart from these, Camps, Special training programs and Oral health promotion activities are carried out to enhance the above skills.
- Students are trained in dealing with geriatric dental problems .

4. Soft skills

- To have the ability to communicate effectively with patients and professionals
- To help alleviate the pain with empathy and respect
- To work as a team member and team builder

- To develop a sense of inter-personal understanding, problem identification and problem solving with social responsibility
- To have the knowledge of and work effectively within the legal frame work

Implementation

Programs for improvement in soft skills are conducted every year where students hone their communication skills and learn about empathy and many other essential skills.

8.1.12. QnM	***Establishment of Dental Education Department by the College for the range and quality of Faculty Development Programmes in emerging trends in Dental Educational Technology organized by it.*** Describe the Faculty Development Programmes organized by the department of the College in the areas of emerging trends in Dental Educational Technology during the last 5 years. Response to be provided within 500 words **Provide weblink to:** • List of seminars/conferences/workshops on emerging trends in Dental Educational Technology organized by the DEU year-wise during the last five years. • List of teachers year-wise who participated in the seminars/conferences/ workshops on emerging trends in Medical Educational technology organized by the DEU of the College during the last five years • Any other relevant information	**10**

Year	Name of the programme	Number of teachers attended

RESPONSE

A majority of teachers in dentistry just learn to teach by themselves, probably emulating their teachers. In this context specific training is required for them in teaching skills, assessment skills and to get further up gradation. In this connection our college took initiative in establishing a **"Dental Education Technology Unit (DETU) in 2019.** This unit is managed by a special committee comprising of a Chairperson, Co-chair person, Coordinator and Members.

The committee is responsible for conducting faculty development programs in up skilling the faculty and enhancing quality improvement in teaching, learning skills and student assessment skills. The goal is to create a team of teachers which is excellent in the profession of teaching, passionate about teaching and dare to engage in innovative teaching.

In order to attain the goal, the following objectives are formulated:

1. To ensure continuous quality improvement in teaching, learning and assessment in the institution.
2. To update the faculty of the current trends in dental education by conducting seminars, symposium, workshops and conferences.
3. To promote conducting dental education research and discover special techniques of teaching , assessment on learning so that we can expand the existing body of end users.
4. To promote educational research publication in standard and high impact journals like medical teachers , academic medicine , advances in health science education
5. To promote inter professional education since our management has medical , physiotherapy and nursing colleges and planning to start allied health science institutes

Our Dental Education Technology Unit has a physical and functional presence. The unit operates from a room having physical space of about 300 sq ft with the required furnishing and a computer.

All our faculty have undergone training under Basic Course on Education Methodology (BCEM) offered by RGUHS Academic &Administrative Training Institute (RAATI) , in-house by the college. Two faculty members are recognized as master trainers and have undergone boot camp course training by Rajiv Gandhi University of Health Sciences. One of the faculties has

accomplished PG diploma in health profession education offered by KLE University in collaboration with university of Illinois, Chicago.

Dental Education Technology unit has organized multiple programs like BCEM, Orientation on Conduction of Journal club, Workshops on Mentorship , Scientific writing , OSCE and OSPE, LASERS and DENTAL IMPLANT .During covid 19 pandemic Webinar Series on soft skills and Awareness Program on Intellectual Property Rights (IPR) were conducted. The DETU has also developed a series of faculty developing programs in the various domains of health profession education for the next 2 years. We are striving towards bridging the international practices and institutional practices to ensure quality educational exposure to all the learners.

Note: Table with dates, programs organized, number of beneficiaries for each and any other information during the 5 years is provided as **weblink .**

Report- QIM write-up criterion-8

ORIGINALITY REPORT

17%	17%	1%	0%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

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Report- Soraisam Bidyapati Devi

by Soraisam Bidyapati Devi

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Abstract

Background and objectives: Potentially malignant disorders of oral cavity and oral cancer remain a cause of concern to the clinician despite intensive research and development in the field. Saliva comprises of a wide range of analytes (glycan, protein, mRNA and DNA, etc.) that can be utilized as biomarkers for early diagnosis. One such biomarker is Alkaline Phosphatase Level (ALP).

Aim and Objectives

To assess and to compare Salivary Alkaline Phosphatase (S-ALP) level in healthy individuals(Control group), in individual with Oral Potentially Malignant Disorder (OPMD) and Oral Squamous Cell Carcinoma (OSCC).

Methods: Study individuals were selected from department of Oral Medicine and Radiology, Dayananda Sagar College of Dental Sciences, Bengaluru and other oncology centres in Bangalore. The sample size for the study was 159 individuals comprising three groups: Group 1: Healthy individuals, Group2: Individuals diagnosed with Oral Potentially Malignant Disorder (OPMD) Group3: Individuals diagnosed with Oral Squamous Cell Carcinoma (OSCC), each consisting of 53 individuals. 2ml unstimulated saliva was collected, ALP level was assessed in saliva using kinetic Photometric Method

Results: There was a statistically significant increased level of salivary ALP level in individuals diagnosed with OPMD and OSCC as compared to healthy individual.

Interpretation and conclusion: Salivary ALP can be used as a promising diagnostic biomarker in the early detection of patients at risk of developing PMD and Oral cancer

Key words: Salivary biomarker, salivary ALP, Oral cancer, OPMD

INTRODUCTION (75-100)

Oral cancer mostly occurs as a result of malignant transformation of pre-existing potentially malignant disorder. Despite the recent surgical advances, the survival of patient with oral cancer remains poor and this is mainly due to late detection. Because of detection in the late phase, the chances of cure are very low, almost negative; leaving five year survival rates around 20% only.[1]

Early detection of dysplastic lesion leading to malignancy is a continuing goal. The major challenge encountered is to predict which premalignant lesion might transform into carcinoma. In order to predict this transformation, the discoveries of biological markers have been proposed to be significant value. The identification of biomarkers from biological fluids (blood, urine, saliva) has the potential early diagnosis.

The use of saliva for early cancer detection is a new promising approach and also has many advantages such as readily available, safe and non- invasive method. Among the salivary biomarkers Alkaline phosphatase (ALP) have been of prime interest especially from dental aspects.[2]

MATERIALS AND METHODS

The current observational study was carried out after obtaining ethical clearance and patient consent. Study was carried out on patients who reported to Department of Oral Medicine and Radiology, Dayananda Sagar College of Dental Sciences, Bangalore and other oncology centre in Bangalore city. Total estimated sample size was 159 individuals with 53 individuals in each group.

INCLUSION CRITERIA

- Individuals in the age range of 20- 65 years were included in our study.
- Group I consists of 53 healthy individuals with no oral mucosal lesions without any use of tobacco habit.

• Group II consists of 53 clinically and histopathologically diagnosed individuals with Oral Potentially Malignant Disorder.

• Group III consists of 53 clinically and histopathologically confirmed individuals with Oral Squamous Cell Carcinoma.

EXCLUSION CRITERIA:

• Individual who had bone fracture in past 3 months.

• Individuals with systematic disease/ conditions such as diabetes, renal failure, liver cirrhosis, obstructive jaundice, hyperparathyroidism and bone disease such as rickets.

• Individuals taking medication that could alter salivary characteristics in past 6 months.

• Patients treated for cancer (surgery, chemotherapy, radiotherapy).

Patients were selected after taking a detailed case history and after considering the inclusion and exclusion criteria. The individuals were explained about the purpose of the study, and informed consent was obtained. A volume of 1.5-2 ml of unstimulated saliva was collected from all individuals by spitting method. The individuals were instructed not to take food for 2 hours prior to saliva collection. They were asked to rinse their mouth with water and 10 mins later, they were advised to sit upright with head slightly tilted forward to collect saliva in the floor of the mouth and then spit into a sample container. Samples were stored in refrigerator at -4 degree Celsius. After collection, all the saliva samples were transported to BIOCORP SCIENTIFIC Lab, Bangalore and then centrifuged at 3000 rpm for 15 mins and the supernatant saliva was obtained. 20 micro litre of it was mixed with ALP reagent for the estimation of S-ALP levels. Kinetic photometric method in an automated analyser was used to measure S-ALP levels. S-ALP concentrations were expressed in terms of IU/L.

RESULTS

Data obtained were subjected to statistical analysis using SPSS software version 21.0.

In Group 1(control group) the lowest value of salivary ALP level is 6.65IU/L and highest value is 19.65 IU/L, and the mean value in control group is 13.8IU/L. In group 2 (OPMD) the lowest value of salivary ALP level is 47.55 IU/L and highest value is 70.25, and the mean value in OPMD is 57.2 In group 3 (OSCC) the lowest value of salivary ALP is 98.65 ± 163.35 and the mean value is 131.9IU/L.

ANOVA test showed statistical significance difference in S-ALP level among the groups with p value 0.00 which was highly significance.(Table1)

To know if there is any difference in S-ALP levels between the groups, multiple comparisons were done within group using POST HOC (Tukey D). On comparing Group 1 and Group 2, mean difference was -43.4 and p value was 0.000 for salivary ALP concentration, which was statistically significant. On comparing Group1 and group 3, mean difference was 118.1 and p value was 0.000 for salivary ALP concentration, which was statistically significant. On comparing group 2 and group 3, mean difference was-0.74.7 and p value was 0.000 for salivary ALP concentration, which was statistically significant.(Table2)

DISCUSSION

Potentially Malignant Disorders plays a crucial role in pathogenesis of squamous cell carcinoma in the oral cavity.[3] The constant contact of tobacco, areca nut and others factors causes prolonged exposure of oral mucosa causing abrasion of epithelium linings and initiating a cascade of an inflammatory process which could be present clinically as Oral Potentially Malignant Disorders (OPMDs) like leucoplakia, Oral Sub Mucous fibrosis (OSMF), Oral Lichen Planus (OLP), etc. It is also known for high rate of malignancy transformation if neglected.[3,4]

The concept of early detection will have a significant impact on cancer survival. Various routinely practiced techniques for oral cancer screening are visual and physical examination, biopsy, vital staining, imaging, VELscope, spectroscopy, etc. An important approach for early detection is to measure biomarkers which are produced by the tumor itself or in response to the tumor.[5] ALP is one such biomarker. It is a hydrolase intracellular enzyme participating in the metabolic processes of cells found throughout the body. Rise in salivary S ALP levels reflects inflammation and destruction of healthy tissues suggesting a clinical biomarker.[6] Serum ALP levels are elevated in patients with primary and metastatic tumors of the liver and bone, such as hepatic metastasis of colorectal cancer and bone and liver involvement in breast cancer[7]. In patients with malignancies, therefore, an elevated

serum ALP may be an indicator of metastatic disease. However, the role of ALP in OPMD, OSCC is barely investigated. With this perspective, we intend to conduct our study.

OPMDs are common seen in the age group of 21 – 60 years. In our study out of 159 patients, 69 of them were in the age range of 21-34 years i.e 43.4%, 52 of them were in the age range of 35-48 years i.e 32.7% and 38 individuals were between 49-65 years i.e 23.9%. The present study showed peak age incidence of patients were in the age range of 38 ± 11.8.

Our current study shows male predilection i.e among 159 study population 107 (67.3%) were males and 52 (32.7%) were females . This may be due to higher prevalence of tobacco and alcohol use among men as compared to women.[8]

Saliva has high responsiveness and reflected bodily health and act as good media for wide range of metabolites, proteins, hormones, etc. Even though currently biopsy still holds the gold standard, non-invasive methods like analysis of saliva may provide a cost effective approach for screening a large population as it is a unique fluid, easy to collect, store, and transport, repeatable and can be obtained at low cost in sufficient quantities for analysis. Different methods for collecting saliva are draining saliva, spitting method, suction method and swab method. In our study we used spitting method to collect unstimulated saliva from the patients as it is simple and convenient for both the patients and researcher. After saliva is collected it is mixed with storage ALP buffer that contains DMSO, cellulose, threalose and propendiol and stored immediately at refrigerator at – 4degree Celsius.

Data obtained were subjected to statistical analysis using SPSS software version 21.0.

In our current study, among healthy individuals (group 1), the lowest value of salivary ALP level was 6.65IU/L and highest value was 19.65IU/L with the mean value of 13IU/L (Table 1) (Graph 1). Similar result is found in previous studies.[9,10] Among Group 2 (OPMD) the lowest value of S-ALP was 47.55IU/ and highest value was 70.25 IU/L with mean value of 57.2 IU/L (Table 1) (Graph 1). Similar result is found in previous study.[10] However in some of the previous studies higher mean salivary ALP level was found with mean value 65IUL.[9,11] Among Group 3(OSCC) the lowest salivary ALP level found was 98.65IU/L and highest value was 163.35 IU/L with mean value of 131.91 IU/L(Table 1) (Graph1). A very few study with very less sample size has been conducted to estimate

S-ALP level in OSCC. In a study conducted in 2019, among 15 individuals mean value found was 72 IU/L with standard deviation of 13.83, 89 In our study mean salivary ALP level was lowest in healthy individual i.e 13.8±3.07 followed by individuals with OPMD i.e 57.2±7.82 and individuals with OSCC i.e 131.9±17.8 (Table 1, Graph 1).

In our present study, comparison of S-ALP values between the group was done using ANOVA test using Post hoc (Tukey D). On comparing salivary ALP level between group I (healthy individuals) and group II (individuals with OPMD) we found statistically increased of salivary ALP in group II (individuals with OPMD) with mean difference of -43.4. We found that salivary ALP were significantly higher in individuals with OPMD (Table 2). Similar increased in S-ALP values was observed in various studies.[8,11,12,13] On comparing salivary ALP level between group I (healthy individuals) and group III (Individuals with OSCC), we found statistically increased of salivary ALP in group III with mean difference of 118.1 (Table2). On comparing salivary ALP level between group II (individuals with OPMD) and group III (individuals with OSCC), we found statistically elevation of salivary ALP in group III with mean difference of -0.74.7 (Table 2). Thus the study found statistically increased of Salivary ALP level was lowest in the healthy individuals, higher in individuals with OPMD and highest in the individuals with OSCC with p value 0.00 which is highly significant and lowest in healthy individuals. Similar results are found in various studies.[8,13,14,15,16]

The increased S-ALP levels in OPMD and OSCC patients could be a result of the increased oxidative stress linked with this condition. Increased production of ALP in the saliva is caused by an increase in reactive oxygen species, which causes cellular damage. Increased cellular turnover in OPMD can lead to an increase in ALP synthesis by epithelial cells, either as a reactive response or due to genetic mutation. The enhanced inflammatory response seen could be another reason leading to the elevated levels of S - ALP.[17]

In our study sample among 159 individual, 107 were males and 52 of them were females. On comparing mean ALP level among males, mean difference is 62.1 with standard deviation ±44.8. On comparing mean ALP level among females, mean deviation of 78.9 with standard deviation of ±58.6

with p value 0.047 which is statistically significant but not highly significant.(Table 3)(Graph2). Thus inspite of unequal size we have observed higher ALP values in females than males.

In our current study, our study population was divided into 3 age groups. i,e (21-34), (35-48), (49-65). There was significance difference of salivary ALP level among these three groups. Salivary ALP level is lowest in age group 21-34 years, and higher in age group 35 – 48 years and highest in 49-65 years (Table4)(Graph3). To the best of our knowledge, none of the studies have compared Salivary ALP level with different age groups. In our study it is found that there is statistically increased of S-ALP as the age increases.

Based on our findings and collaborative reports, we can suggest that salivary ALP can be used as a reliable biomarker in detecting patients who are at risk of developing PMDs and oral cancer. However main limitation of our study is small sample size. Further studies with larger sample size should be undertaken to validate the present findings and to analyse the isoenzyme activity in OPMD.

CONCLUSION

In our study, Salivary ALP values in healthy individuals, in individuals with OPMD and Individuals with OSCC has significant changes. Least Salivary ALP level is found in healthy individuals, higher Salivary ALP level in OPMD and highest in OSCC. On the basis of our study, we conclude that Salivary ALP level can be used as a promising biomarker in the very early diagnosis of oral cancer and OPMD, as significant increase is observed in the levels of ALP in saliva with good positive correlation.

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Table1

Group	N	Lowest Value (IU/L)	Highest Value (IU/L)	Mean ±SD	P value
Healthy individuals	53	6.65	19.65	13.8±3.07	0.00**
Oral potentially malignant disorders (OPMD)	53	47.55	70.25	57.2±7.82	
Oral squamous cell carcinoma(OSCC)	53	98.65	163.35	131.9±17.8	

Table 2

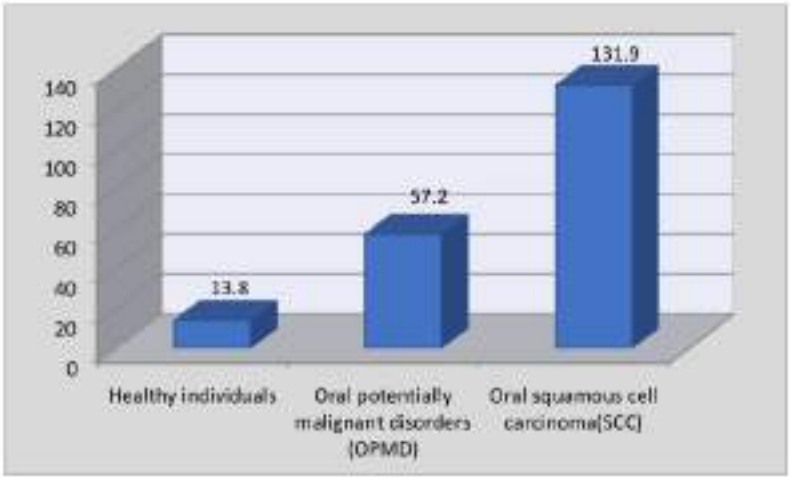
Dependent Variable	Group	Group	Mean difference	P value
Salivary Alkaline Phosphatase Level	Healthy individuals	Oral potentially malignant disorders (OPMD)	-43.4(*)	0.000
		Oral squamous cell carcinoma(SCC)	118.1(*)	0.000
	Oral potentially malignant disorders (OPMD)	Oral squamous cell carcinoma(SCC)	-0. 74.7(*)	0.000

Table 3

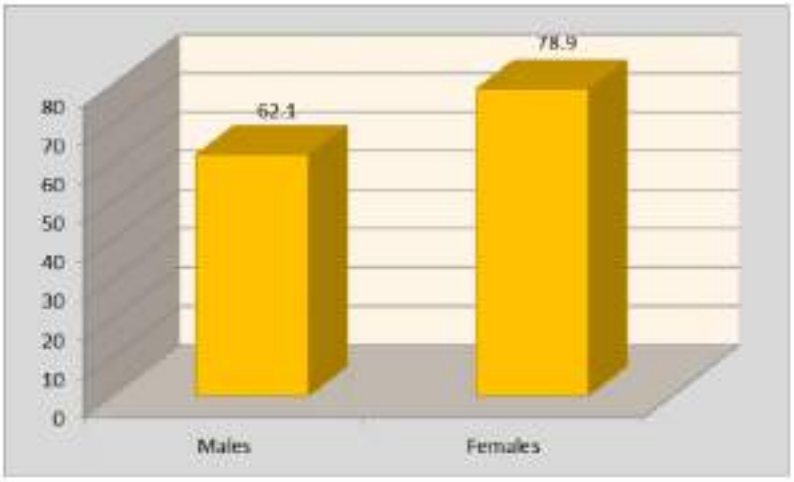
Gender	N	Mean± SD	P value
Males	107	62.1±44.8	0.047*
Females	52	78.9±58.6	

Table 4

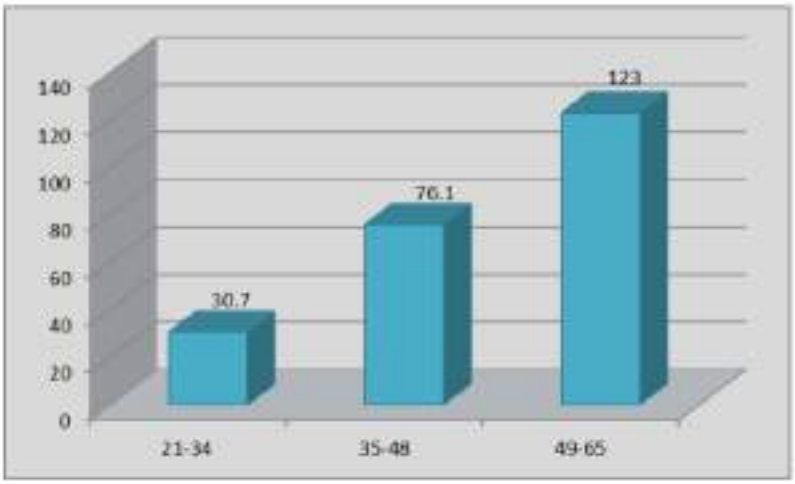
Age(years)	N	Mean± SD	P value
21-34	69	30.7±30.05	0.000**
35-48	52	76.1±41.9	
49-65	38	123.0±30.0	



Graph 1: Distribution of study Population based on mean salivary Alkaline Phosphatase Level between the groups



Graph 2 : Distribution of Study Population Based on Age group and Mean Salivary Alkaline Phosphatase Level between the genders



Graph 3: Distribution of Study Population Based on Mean Salivary Alkaline Phosphatase Level between the Age.

Report- Soraisam Bidyapati Devi

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TITLE- **Platelet rich fibrin and Bioactive calcium phosphosilicate putty (Novabone)in periodontal endoosseous defects - A clinical and radiographic study**

ABSTRACT

AIM: To determine the regeneration potential of Bioactive calcium phosphosilicate putty (Novabone) with Platelet-Rich-Fibrin and Bioactive calcium phosphosilicate putty (Novabone) alone clinically and radiographically when used in periodontal endoosseous defects

MATERIALS AND METHOD: Present study was carried out in 20 defects present in 20 patients aged between 25 and 55 years. The patients were randomly divided into 2 groups The groups were: Group I (n=10): Those to be treated with bioactive glass (Novabone®putty) only Group II (n=10): Those to be treated with a combination of Platelet rich fibrin and bioactive glass (Novabone®putty). All the patients were followed up for a period of 9 months.

RESULTS: A significant reduction in probing pocket depth, relative attachment level gain and bone fill was noted at the end of 9 months in both the treatment groups. The improvement in the parameters were greater while using Novabone®putty alone as grafting material when compared to Novabone putty® with PRF.

CONCLUSION: Both the regenerative materials were efficient in improving the clinical parameters and both the groups showed evidence of radiographic bone fill in the defect sites at the end of 9 months. But calciumphosphosilicate putty (Novabone®putty) when used alone displayed slightly superior effect in relation to clinical parameters.

Key Words: Bone grafts, Regeneration, PRF, Novabone putty

INTRODUCTION

Periodontitis is an inflammatory disease of the supporting structures of the tooth that results in gingival inflammation, periodontal pocket formation, and loss of connective tissue attachment and alveolar bone around the affected teeth.[1,2] Periodontal surgical procedures have aimed at reducing and eliminating hard and soft tissue defects including probing depth and osseous defects by regenerating new attachment.[3] Various regenerating techniques including use of bone and bone derivatives and substitutes, placement of barrier membranes for guided tissue regeneration have demonstrated significant gain of clinical attachment and resolution of bony defect.[4]

Alloplasts are synthetic bone substitutes that are used in regeneration procedures.The main advantages of alloplastic bone substitutes involve their biological stability and volume maintanance that allow cell infiltration and remodelling.They exhibit biocompatibility,osteoinduction and osteoconduction properties. NovaBone® Putty is an alloplast, a pre-mixed composite of bioactive calcium-phospho-silicate particulate and a synthetic, absorbable binder. The bioactive particulate is composed solely of elements that exist naturally in normal bone(Ca, P,Na, Si, O).[5,6]

Wound healing in periodontal tissues is a multifaceted process involving an interaction between epithelial cells, gingival fibroblasts, periodontal ligament cells, and osteoblasts. It involves interruption of vasculature contributes to fibrin formation, platelet aggregation, and release of various growth factors into tissues.[7] Platelets area an array of growth factors and cytokines which play key roles in inflammation and wound healing.[8] Also presence of fibrin, fibronectin, and vitronectin, in platelets act as a matrix for the connective tissue and as adhesion molecules for more efficient cell migration.[9] This has led to the idea of using platelets as therapeutic tools to improve tissue repair particularly in periodontal wound healing. Choukroun et al has developed PRF for the first time in France for use in Oral and Maxillifacial surgery. Due to the slow rate of polymerization the physiologic architecture of PRF support the healing process.[10] The biochemical analysis of the PRF composition indicates that this biomaterial consists of an intimate assembly of cytokines, glycanic chains, and structural glycoproteins enmeshed within a slowly polymerized fibrin network. The biochemical components have well known synergetic effects on healing processes.[1,11]Combining bone graft material with platelet concentrate can enhance bone regeneration. Platelet concentrate also amplies the graft volume without injuring the maturation quality in new bone.[12]

Studies exist that describe the effects of Platelet-Rich-Fibrin and Bioactive calcium phosphosilicate putty on bone regeneration. However, there is a paucity of studies comparing the effects of Bioactive calciumphosphosilicate putty alone and in combination with Platelet-Rich-Fibrin on bone regeneration. Hence this study was undertaken to evaluate and compare, clinically and radiographically, the efficacy of Bioactive calcium phosphosilicate putty (Novabone) with Platelet-Rich-Fibrin and Bioactive calcium phosphosilicate putty (Novabone) alone in the treatment of periodontal endosseous defects.

MATERIALS AND METHODOLOGY

Study population and design

A Randomized clinical study was carried out in 20 patients with 20 defects aged between 25 and 55 years in the Department of Periodontology after obtaining ethical clearance. The participants included in the study were categorized as chronic periodontitis (based on the AAP World Workshop 1999 classification of periodontal diseases and conditions), depth ≥ 5mm and radiographic evidence of angular bone loss ≥3mm deep.Smokers and patients who underwent periodontal flap / regenerative therapy within the past 1 year were excluded from the study.

20 surgical sites were identified and were randomly divided into 2 groups.

Group I (n=10 defects): Those to be treated with bioactive glass (Novabone®putty) only

Group II (n=10 defects): Those to be treated with a combination of Platelet rich fibrin and bioactive glass (Novabone®putty)

Clinical and Radiographic Parameters assessed

Plaque Index (Sillness and Loe (1964) and Gingival index (Loe and Sillness (1963)), Probing Pocket Depth (PPD) ,Relative attachment level. (RAL) and Gingival recession (GR) were recorded pre-operatively at baseline.PPD and RAL were recorded to the nearest millimeter by a single examiner using a UNC-15 probe.

Intra-oral periapical radiographs were taken using digital method and standardized by means of paralleling technique to radiographically assess the depth of the defects at baseline, 3 months, 6 months and 9 months following surgery. The vertical dimension between the projection of the bone crest on the root surface (BCP:Bone crest projection) and the most coronal level along the root surface where the periodontal ligament space was considered to have a normal width (BoBD: Bottom of the bone defect) was measured as BCP-BoBD which gives the depth of the intrabony defect.

SURGICAL PROCEDURE

After Revaluation of phase I therapy, the sites with persistent pockets were subjected to periodontal flap surgery Under local anesthesia (2% lignocaine hydrochloride with 1 in 80,000 adrenaline), crevicular incisions were given using No.15 blade and the periodontal flaps were raised by means of blunt dissection with the help of a No.9 molt periosteal elevator.

A thorough debridement was carried out using periodontal curettes in all the defect areas. All the granulation tissue was removed to ensure a clean site. Before the placement of the graft, pre-suturing was carried out using a 3-0 non resorbable braided silk suture..

PRF preparation

Choukroun et al(2006)[10] proposed the protocol for PRF preparation. The patient's blood samples were drawn prior to the surgery and centrifuged at 3000 rpm for 10 minutes in the table top centrifuge. In the middle of the test tube a structured fibrin clot formed, just between the red corpuscles at the bottom and acellular plasma at the top (Platelet Poor Plasma-PPP). PRF was separated from red corpuscles at the base, preserving a small red blood cell (RBC) layer, using a sterile tweezer and scissors just after removal of Platelet Poor Plasma (PPP) and then transferred into a sterile dappen dish. The gel obtained was mixed with Novabone putty®

The graft placement site was selected randomly.

Group I patients received synthetic bioactive graft material (Novabone® putty) alone (Figure 1) and Group II patients received Platelet Rich Fibrin and Synthetic bioactive graft material (Novabone® putty) in combination (Figure 2). The suturing was then completed and Non-eugenol periodontal dressing (Coe pack™, GC America Inc., Chicago, IL, USA) was placed.

POST OPERATIVE CARE

Suitable antibiotics and analgesics were prescribed (amoxicillin 500 mg three times per day for 5 days and a combination of Acetaminophen 500 mg; Diclofenac Sodium 50 mg twice daily per day for 3 days).Patients were advised to rinse with chlorhexidine digluconate (0.12%) twice a day for 2 weeks following surgery.

POST SURGICAL EVALUATION AND REVIEW

Gingival Index (GI) and Plaque Index (PI) were re-evaluated at 3 months, 6 months and 9 months. Probing pocket depth ,Relative attachment level, Gingival Recession were also reevaluated at 3 months, 6 months and 9 months using previously used acrylic stents to provide a reproducible insertion axis.

Depth of the defect was reassessed at, 3 months, 6 months and 9 months following surgery.

STATISTICAL ANALYSIS

Statistical analysis was done using the SPSS software. Student t test is used for statistical analysis.

RESULTS

Intragroup Comparison- Group I (Figure 1 ,Graph 1)

From baseline to 9 months there was a significant reduction in probing pocket depth from 9.100± 2.331 to 4.300± 0.675 (Table 1). There was a change in relative attachment level from 10.400± 1.430 to 4.500± 0.527 with a gain of approximately 5.9 mm at the end of 9 months (Table 2).The difference in the mean PPD and RAL was found to be statistically significant between all the time intervals. The gingival recession from 1.500± 1.080 at baseline was increased to 2.100± 0.738 at 3 months, 1.800 ± 0.919 at 6 months and reduced to 1.700 ± 0.949 at the end of 9 months(Table 3).

Intragroup Comparison- Group II (Figure 2 ,Graph 1)

The Probing Pocket Depth reduced from 8.700± 2.406 to 4.400± 0.738 at the end of 9 month(Table 1). There was a change in relative attachment level from 10.500± 1.581 to 4.500± 0.527 with a RAL gain of approximately 6.0 mm at the end of 9 months(Table 2).The difference in the mean PPD and RAL was found to be statistically significant between all the time intervals. The gingival recession from1.700± 1.059 at baseline increased to 2.100± 0.876 at 3 months, 1.800 ± 0.919 at 6 months and reduced to 1.700 ± 0.949 at the end of 9 months(Table 3).

Intergroup Comparison

The mean difference in the Probing pocket depth values between two groups at baseline, 3 months, 6 months and 9 months were0.400, 0.000, 0.400 and 0.200 respectively. No significant difference is observed between the two groups at any of the time intervals with respect to mean PPD (P>0.05) (Table 5,Graph 2). The mean difference in the Relative Attachment level values between two groups at baseline, 3 months, 6 months and 9 months were 0.100, 0.100,0.100 and 0.000 respectively. No significant difference is observed between the two groups at any of the time intervals with respect to mean RAL (P>0.05) (Table 5). The mean difference in the Gingival Recession values between two groups at baseline, 3 months, 6 months and 9 months were -0.200, 0.000, 0.000 and 0.000 respectively. No significant difference was observed between the two groups at any of the time intervals with respect to mean GR (P>0.05) (Table 6).

Radiographic Parameters

The radiographic parameters were analysed to identify the mean percentage of radiographic bone fill (BL)in Group I and Group II (Table 4, Graph 3).The intergroup differences were statistically insignificant (P<0.05) which indicate the percentage change in the radiographic bone fill (BL)was equal in both the group (Table 7, Graph 4). .

Probing Pocket depth

Table: 1 Intra- group comparison

GROUP -I			GROUP-II			
Time Interval	**Mean**	**Std Dev**	**Time Interval**	**Mean**	**Std Dev**	**P-Value**
Baseline	9.100	2.331	Baseline	8.700	2.406	<0.001*
3 months	6.500	1.434	3 months	6.500	1.780	
Baseline	9.100	2.331	Baseline	8.700	2.406	<0.001*
6 months	5.100	0.738	6 months	5.500	1.179	
Baseline	9.100	2.331	Baseline	8.700	2.406	<0.001*
9 months	4.300	0.675	9 months	4.100	0.738	

*Denotes significant difference

Relative attachment level

Table: 2 Intra- group comparison

GROUP -I			GROUP-II			
Time Interval	**Mean**	**Std Dev**	**Time Interval**	**Mean**	**Std Dev**	**P-Value**
Baseline	10.400	1.430	Baseline	10.500	1.581	<0.001*
3 months	7.400	1.174	3 months	7.300	1.059	
Baseline	10.400	1.430	Baseline	10.500	1.581	<0.001*
6 months	5.700	0.823	6 months	5.600	0.699	
Baseline	10.400	1.430	Baseline	10.500	1.581	<0.001*
9 months	4.500	0.527	9 months	4.500	0.527	

*Denotes significant difference

Gingival Recession

Table: 3 Intra- group comparison

GROUP -I				GROUP-II			
Time Interval	**Mean**	**Std Dev**	**P-Value**	**Time Interval**	**Mean**	**Std Dev**	**P-Value**
Baseline	1.700	1.039	0.037*	Baseline	1.500	1.079	0.005*
3 months	2.100	0.786		3 months	2.100	0.718	
Baseline	1.700	1.039	0.758	Baseline	1.500	1.079	0.394
6 months	1.800	0.917		6 months	1.800	0.908	
Baseline	1.700	1.039	1.000	Baseline	1.500	1.079	0.591
9 months	1.700	0.931		9 months	1.700	0.919	

*Denotes significant difference

Depth of the Defect

Table: 4 Intra- group comparison

GROUP -I			GROUP-II			
Time Interval	**Mean**	**Std Dev**	**Time Interval**	**Mean**	**Std Dev**	**P-Value**
Baseline	11.300	1.494	Baseline	11.200	1.549	<0.001*
3 months	7.800	1.033	3 months	6.300	1.418	
Baseline	11.300	1.494	Baseline	11.200	1.549	<0.001*
6 months	5.900	0.568	6 months	4.800	0.919	
Baseline	11.300	1.494	Baseline	11.200	1.549	<0.001*
9 months	3.900	0.568	9 months	3.800	0.919	

*Denotes significant difference

Table: 5

Inter- group comparison- Probing Pocket depth and Relative attachment level

	Time Interval	Group	Mean	Std Dev	Mean Difference	P-Value
PPD	Baseline	Group I	9.100	2.331	0.400	0.710
		Group II	8.700	2.406		
	3 months	Group I	6.500	1.434	0.000	1.000
		Group II	6.500	1.780		
	6 months	Group I	5.100	0.738	0.400	0.375
		Group II	5.500	1.179		
	9 months	Group I	4.300	0.675	0.200	0.535
		Group II	4.100	0.738		
	Time Interval	**Group**	**Mean**	**Std Dev**	**Mean Difference**	**P-Value**
RAL	Baseline	Group I	10.400	1.430	0.100	-0.884
		Group II	10.500	1.581		
	3 months	Group I	7.400	1.174	0.100	0.844
		Group II	7.300	1.059		
	6 months	Group I	5.700	0.823	0.100	0.733
		Group II	5.600	0.699		
	9 months	Group I	4.500	0.527	0.000	1.000
		Group II	4.500	0.527		

Table: 6

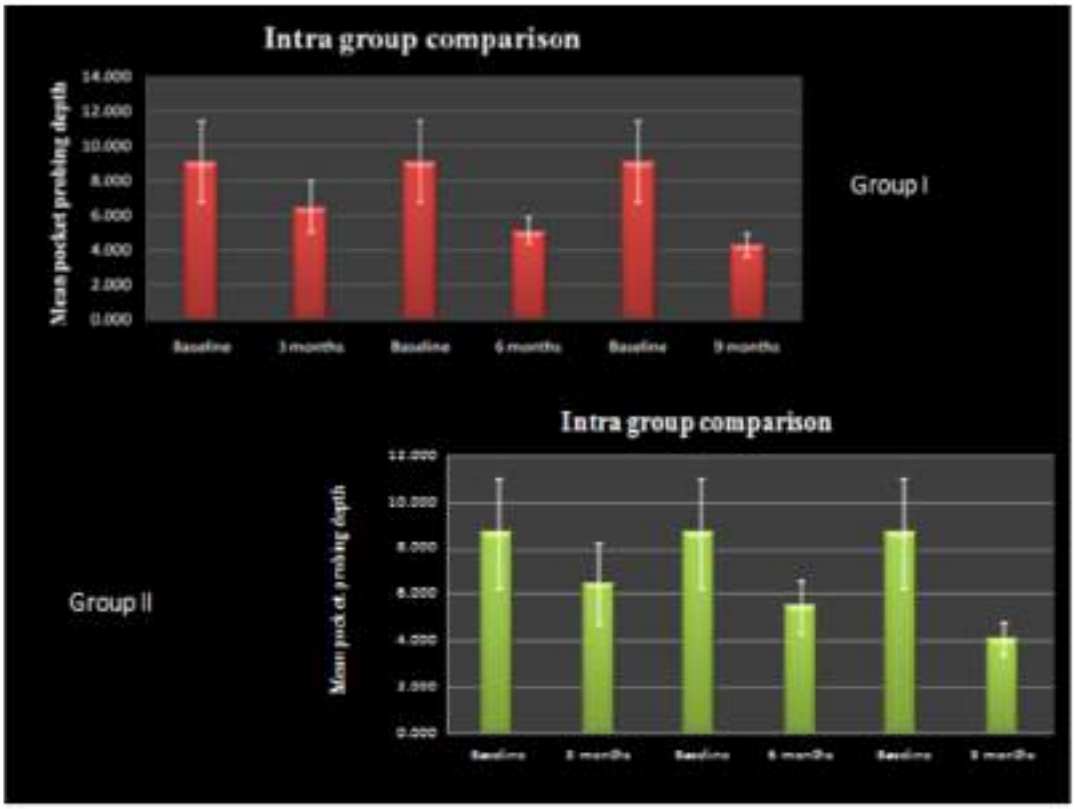
Inter- group comparison- Gingival Recession

	Time Interval	Group	Mean	Std Dev	Mean Difference	P-Value
Gingival Recession	Baseline	Group I	1.700	1.039	-0.200	0.661
		Group II	1.500	1.079		
	3 months	Group I	2.100	0.786	-0.600	1.000
		Group II	2.100	0.718		
	6 months	Group I	1.800	0.917	0.000	1.000
		Group II	1.800	0.908		
	9 months	Group I	1.700	0.931	0.000	1.000
		Group II	1.700	0.919		

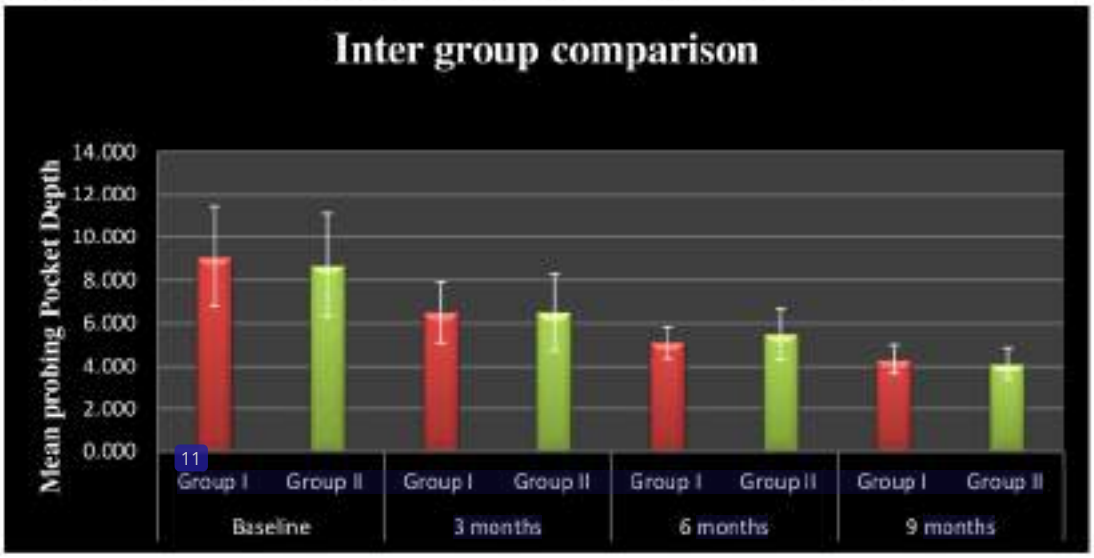
Table: 7

Inter- group comparison- Depth of the defect

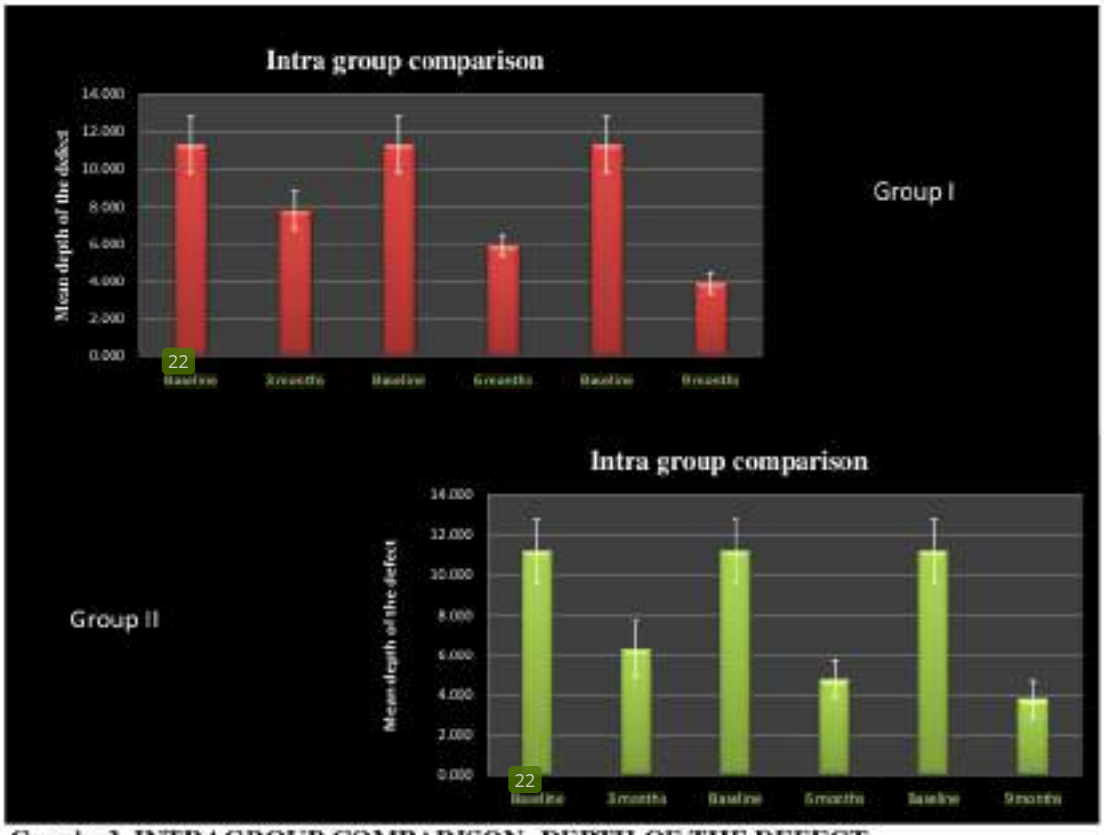
	Time Interval	Group	Mean	Std Dev	P-Value
Depth of the defect	Baseline	Group I	11.300	1.494	0.885
		Group II	11.200	1.549	
	3 months	Group I	7.800	1.033	0.015
		Group II	6.300	1.418	
	6 months	Group I	5.900	0.568	0.015
		Group II	4.800	0.919	
	9 months	Group I	3.900	0.568	0.773
		Group II	3.800	0.919	



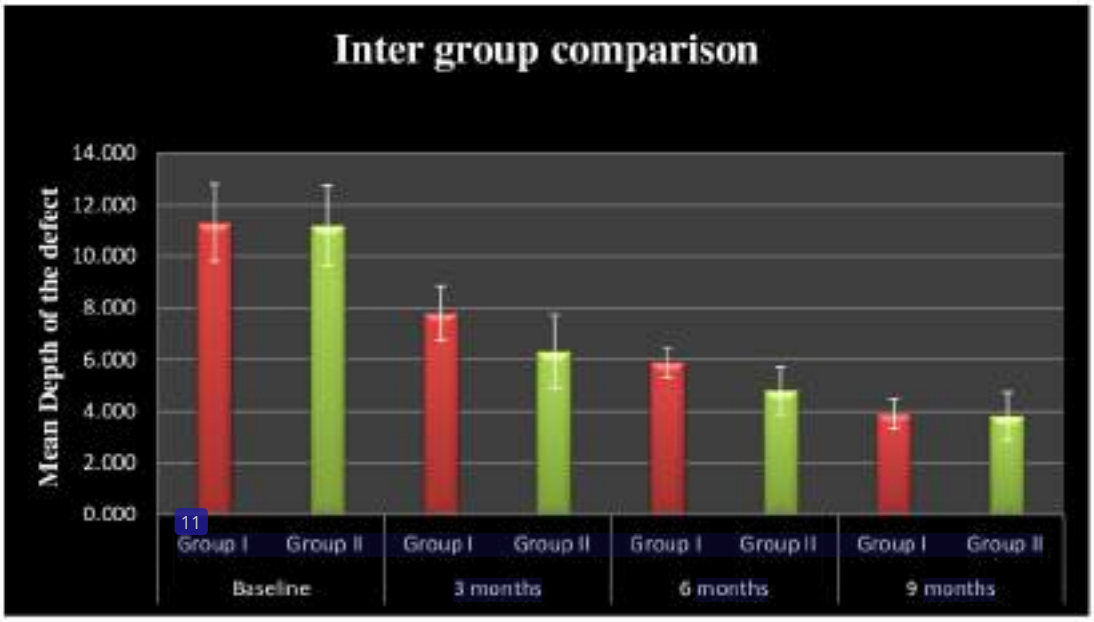
Graph-1 INTRAGROUP COMPARISON- PROBING POCKET DEPT



Graph- 2 INTERGROUP COMPARISON- PROBING POCKET DEPTH



Graph- 3 INTRAGROUP COMPARISON- DEPTH OF THE DEFECT



Graph- 4 INTERGROUP COMPARISON- DEPTH OF THE DEFECT

DISCUSSION

The results of the present study show that treatment of infrabony defects with bioactive glass (Novabone putty) alone and bioactive glass (Novabone putty) in combination with PRF leads to significant PPD reduction, attachment gain and radiographic bone fill compared to baseline values. NovaBone® Putty is a pre-mixed composite of bioactive calcium-phospho-silicate particulate and a synthetic, absorbable binder. Platelet rich fibrin (PRF) is a second generation platelet concentrate whose biochemical components have well known synergetic effects on healing processes.[11] Combining bone graft material with platelet concentrate can enhance bone regeneration. Platelet concentrate, in adjunction with bone graft material makes it possible to amplify the graft volume without injuring the maturation quality in new bone.[12]

The present study has included only those sites that have shown radiographic evidence of angular bone loss ≥3mm deep. Laurell et al who has shown that to benefit from regenerative procedures, depth of defect should be at least 3-4 mm.[13] Lindhe et al, has proved that surgical procedures would induce loss of attachment if done in pockets shallower than 4.2mm.[14]

Payne et al[15] has quoted that Probing Pocket Depth (PPD) and Relative Attachment Level (RAL) measurements reflect changes in the underlying bone level over time and hence are good clinical parameters to assess the potential effects of regenerative materials in the treatment of endosseous defects. The Probing Pocket Depth and Relative Attachment Level have been measured as the basic clinical parameters in studies by Subbaiah R, and Sharma A.[16,17]

Hence Probing Pocket Depth (PPD) and Relative Attachment Level (RAL)were the clinical parameters measured in the present study.

Gingival recession (GR) is another clinical parameter that has been considered in the study. Satyanarayana KV [18] has conducted studies evaluating the influence of various grafting materials and wound healing on gingival recession.

In the present study both the plaque and gingival index were considered as parameters to monitor patient's oral hygiene and its effects on the soft tissue. The results of the study showed a statistically significant decrease in the plaque and gingival index from baseline to 9 months in both the groups as quoted in the study by Dori et al.[19,20]

The probing pocket depth (PPD) is an another important parameter assessed in the study. The results of the present study showed that the probing pocket depth reduced from baseline to 9 months with a statistically significant difference indicating that there is progressive reduction in the PPD at sites treated with Novabone®putty. This reduction in probing pocket depth can be attributed to soft and hard tissue improvements following resolution of inflammation and to the osteogenic potential of the bone graft material used in the study. Froum, et al.[3] Lovelace et al.[21] Mengel et al quoted similar results in their study.Similarly the probing pocket depth reduced from baseline to 9 months with a statistically significant difference indicating that there is progressive reduction in the PPD at sites treated with Novabone®putty in combination with PRF.

K. Malathi[22] et al and Bansal C[23] et al has quoted that PRF in combination with various graft materials resulted in probing pocket depth reduction and clinical attachment level gain. The results of present study support the role of various growth factors present in the PRF in accelerating the soft and hard tissue healing. However, intergroup comparison showed no statistically significant difference suggesting that both the treatment modalities are equally efficacious in reduction of PPD.

The results of RAL in the present study has showed that there was a gain in the attachment of both the groups at the end of 9 months which was statistically significant. The reason could be periodontal regeneration, long junctional epithelium formation and soft tissue healing at the base of the pocket. Zamet J.S. et al[24] and Froum SJ et al[3] has quoted similar results. On the other hand Ong et al[25] reported no significant effect of bioactive glass on implantation in periodontal defects.

The results seen in PRF group were in concordance with similar studies by Sharma A et al[26] .Pavan Bajaj et al[27], K. Malathi, et al[22] and Bansal C et al[23] where improvements in the clinical parameters with the use of PRF alone as a grafting material as well as its combination with allografts like DFDBA were seen. However there was no statistically significant difference noticed between the two groups at any of the time intervals suggesting that both the treatment options are equally efficacious and PRF in combination with Novabone® putty doesn't have any added benefit with respect to gain in the attachment level

In case of gingival recession intergroup comparison has shown no significant difference at any of time intervals. An increase in gingival recession seen at the end of 9 months may be credited to the shrinkage of gingival tissues with the resolve of inflammation. These findings are in uniformity with studies by Froum, et al,[3] Mengel et al,[28] Sculean, et a.l[29]

New bone formation is frequently used as an important outcome variable in controlled clinical trials for regenerative procedures. In the present study intra-oral periapical radiographs were taken using digital method (Photostimulable phosphor (PSP, DigoraOptime® Soredex, Helsinki, Finland) and standardized by means of paralleling technique to radiographically assess the depth of the defects and thereby the bone fill at baseline, 3 months, 6 months and 9 months following surgery.Digital radiography has certain advantages over conventional radiography. These include low dose of radiation, computer manipulation and automated image analysis, no film processing, time reduction, storage of data on digital storage media, easy and quick image transfer.[30]
There was a significant Bone fill (BL) at the end of 9 months in group I in accordance with studies of Mengel et al,[28] Froum et al[3] and Lovelace et al[21] The bioactive glass synthetic bone graft particles(Novabone® putty) is an element-enriched dental bone-grafting system that actively supports bone regeneration. Filling the site with Novabone putty® initiates a unique chemical reaction known as "osteostimulation," which encourages new bone activity while its scaffolding network supports the new growth. Novabone® putty is uniquely versatile and effective in healthy bone regeneration and ideal for a wide range of osseous conditions as a graft material,

Novabone® putty is seen to be quite successful in the treatment of the periodontal endosseous defects. This is in accordance with studies by Satyanarayana KV, Subbaiah R, Froum SJ, Pandit N.[3,16, 31,18]

The use of PRF has resulted in the improvement in clinical and radiographic parameters in other studies seen in the literature.The results were similar to studies by Lekovic V,Rosamma Joseph.[52,53] PRF has the characteristic of polymerizing naturally and slowly during centrifugation. The slow polymerization mode confers to the PRF membrane a particularly favorable physiologic architecture to support the healing process(Dohan et al, 2006). [9] PRF has been shown to act as suitable scaffold for breeding human periosteal cells in vitro, which may be suitable for bone tissue engineering applications.[26] PRF also induces proliferation of various cells in vitro with strongest induction effect on osteoblasts.[26]

CONCLUSION

Within the limitations of the study it can be concluded that both the regenerative bone graft materials were efficient in improving the clinical parameters as well as radiographic bone fill in the treatment of human periodontal infrabony defects. It was seen that the improvement in the parameters were greater while using Novabone® putty as grafting material when compared to Novabone putty® with PRF. However there was no statistically significant difference in any of the above mentioned parameters between the two graft materials. Many studies have shown that presence of growth factors in PRF helps in accelerating the soft and hard tissue healing and there by improvement in clinical and radiographic parameters when compared to other bone grafts.But the present study has shown contradictory results. The reason might be the small sample size, differences in the dimensions and morphology of the defects and patient related factors. However, long-term, multicenter randomized, controlled clinical trials will be required to determine the certain clinical and radiographic effects of these graft materials and to reach at a conclusion.

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LEGENDS FOR FIGURES

Figure (a) Centrifugation at 3000 rpm for 10 minutes

Figure (b) Fibrin clot formed in the middle of the tube

Figure (c) PRF gel

Figure 1: Group I (a) preoperative probing pocket depth (b) radiograph of defect (c) debridement of the defect area (d) placement of Novabone putty (e) Significant reduction in probing pocket depth after 9 months of surgery (f) significant fill of defect after 9 months of surgery

Figure 2: Group II (a) preoperative probing pocket depth (b) radiograph of defect (c) debridement of the defect area (d) placement of Novabone putty in combination with PRF (e) Significant reduction in probing pocket depth after 9

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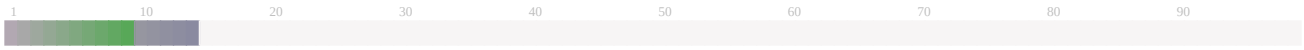

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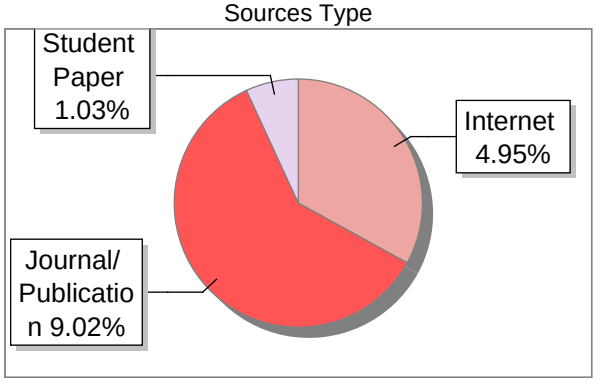

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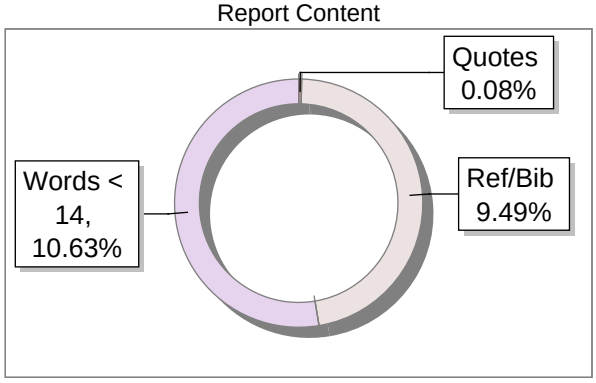

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MYTHS SURROUNDING ORAL CANCER

Introduction

India has the largest number of oral cancer cases and one-third of the total burden of oral cancer globally. Oral cancer poses a serious health challenge to the nations like India which are undergoing economic transition.[1]

GLOBOCAN predicted that cancer cases in India would increase to 2.08 million, accounting for a rise of 57.5 per cent in 2040 from 2020[2]. The increasing number of cases of oral cancer are the most important concern for community health as it is one of the common types of cancers in India.[3] As compared to the west, the concern of oral cancer is significantly higher in India as about 70% of the cases are reported in the advanced stages (American Joint Committee on Cancer, Stage III-IV). Because of detection in the late phase, the chances of cure are very low, almost negative; leaving five-year survival rates around 20% .[4]

Many cancers are curable, provided they are detected early by screening and treated effectively. Cancer myths and misconceptions are potential barriers to early cancer diagnosis and treatment compliance. The social, emotional, and financial devastation that all too often accompanies a diagnosis of cancer is, in large part, due to the cultural myths and taboos surrounding the disease. Certain popular ideas about how cancer starts and spreads, though scientifically wrong, can seem to make sense, especially when those ideas are rooted in old theories. This can lead to needless worry and even hinder appropriate prevention and treatment decisions. Some of the common cancer myths include the notion that being diagnosed with cancer equates to a death sentence and that cancer is an individual's fate and not preventable. Preference for opting for alternative therapies not backed by adequate scientific evidence for the treatment of cancer and considering these strategies as free of any side effects is another common myth. This can lead to delays in seeking medical care, resulting in cancer progression and decreasing survival outcomes. Cancer myths can create fear and anxiety in patients, causing them to worry about the effectiveness of their treatment, the likelihood of survival, and the potential side effects of treatment. This can have a negative impact on their mental health and quality of life. Some cancer myths suggest that certain foods or diets can cure cancer or prevent it from recurring.[5]

Cancer is a disease where myth can bring an end to a life. Undoubtedly, cancer is still a dreadful challenge for oncologists and researchers but that does not stop us from combating this killer disease. Diagnosis of cancer does not indicate that the person is suffering from an incurable disease where death is inevitable. Therefore, the need of the hour is to emphasize on debunking innumerable myths and misconceptions associated with cancer.

Myth: Only Smokers Get Oral Cancer

Contrary to popular belief, smoking is not the sole cause of oral cancer. While tobacco use, including both smoked & smokeless forms, are major risk factors, other also contribute to the development of oral cancer. These include excessive alcohol consumption, human papillomavirus (HPV) infection, poor oral hygiene, and a family history of the disease. It's crucial to recognize that non-smokers can also be at risk, and a comprehensive understanding of all risk factors is essential for early detection and prevention.

Myth: Mouth Cancer Only Affects Older Individuals

While the risk of developing mouth cancer increases with age, it can affect individuals of any age, including younger people. The prevalence of oral cancer in younger individuals is rising, emphasizing the importance of regular screenings and awareness campaigns targeting diverse age groups. Early detection is key, and everyone, regardless of age, should be vigilant about their oral health and seek medical advice if they notice any unusual symptoms.

Myth: Mouth Cancer is Rare, So Regular Check-ups Are Unnecessary

While it's true that mouth cancer is not as common as some other types of cancer, it is still a significant health concern. The incidence of oral cancer in the India has been on the rise, underscoring the importance of regular dental check-ups and screenings. Routine examinations by dental professionals can aid in the early detection of precancerous lesions or early-stage cancer, significantly improving treatment outcomes.

Myth: Mouth Cancer is Easy to Spot, So I Don't Need Regular Check-ups

One of the dangerous misconceptions is assuming that mouth cancer is always easily visible. In reality, early stages of oral cancer may be asymptomatic or present with subtle symptoms that are easy to overlook. Regular dental check-ups are crucial because professionals can identify abnormalities that may not be apparent to individuals. Visual examinations, along with advanced diagnostic tools, play a pivotal role in early detection, making regular dental visits a proactive step in preventing and managing mouth cancer.

Myth: Oral Cancer Is Not a Serious Health Issue

Oral cancer can have severe consequences if not detected and treated promptly. Delayed diagnosis can lead to the spread of cancer to other parts of the body, making treatment more challenging. Additionally, the impact on an individual's quality of life,

including difficulties in eating, speaking, and facial disfigurement, underscores the seriousness of this disease. Education and awareness are crucial to dispel the myth that oral cancer is a minor concern, emphasizing the importance of prevention and early diagnosis.

Myth: Using a Mouthwash Can Prevent Mouth Cancer

Debunked: While using mouthwash is an excellent practice for maintaining good oral hygiene, it alone cannot prevent mouth cancer. Good oral hygiene practices, including regular brushing, flossing, and using mouthwash, contribute to overall oral health, reducing the risk of various dental issues. However, the prevention of mouth cancer requires a holistic approach, including avoiding tobacco and excessive alcohol consumption, maintaining a healthy diet, and scheduling regular dental check-ups.

Myth: Mouth Cancer is Always Painful

Debunked: Contrary to the belief that mouth cancer always presents with pain, especially in the early stages, it can be asymptomatic or exhibit mild symptoms. Pain may only occur in later stages when the cancer has progressed. This highlights the importance of not relying solely on pain as an indicator of oral health. Regular self-examinations, coupled with professional check-ups, are crucial for detecting any abnormalities or changes in the oral cavity, even in the absence of pain.

Myth: Mouth Cancer is Contagious

Debunked: Mouth cancer is not contagious and cannot be transmitted from person to person through casual contact. The primary risk factors for developing oral cancer are related to lifestyle choices, genetic predisposition, and certain infections such as HPV. Understanding that mouth cancer is not contagious helps dispel unnecessary fears and promotes a more informed and supportive community for individuals affected by the disease. Apart from cervical cancer (caused by human papilloma virus)[6]and liver cancer (caused by hepatitis B and C virus)[7], none of the other forms of cancer are contagious.

Myth: If There's No Lump, It Can't Be Cancer

Debunked: Unlike some other types of cancer, oral cancer may not always present as a visible lump. It can manifest as white or red patches, sores, or ulcers that do not heal. Additionally, changes in the texture or color of the tongue, persistent hoarseness, and difficulty swallowing can be indicative of oral cancer. Relying solely on the presence of a lump may lead to delayed diagnosis. Regular self-examinations and professional screenings are essential for detecting a range of potential symptoms.

Myth: Oral Health Doesn't Affect Overall Health

Debunked: The health of your mouth is interconnected with your overall well-being. Neglecting oral health not only increases the risk of oral cancer but is also linked to various systemic health issues such as cardiovascular disease, diabetes, and respiratory infections. Maintaining good oral hygiene, adopting a healthy lifestyle, and attending regular dental check-ups contribute not only to preventing mouth cancer but also to promoting overall health and well-being.

Myth: Cancer is always fatal
Debunked: Though there has been a sharp rise in cancer related mortality, but improved treatment options have made it possible for thousands of patients to improve survival rate.

Myth: Biopsies as well as surgery aggravates cancer.
Debunked: Biopsies are the effective diagnostic tools for detection of cancer. Avoiding biopsies may lead to late detection and poor prognosis of the disease process.

Myth: Every abnormal growth is cancerous.
Debunked: Benign tumours do not possess the capability to metastasize. In case of any clinical problem, these can be surgically removed.[8]

Myth: Cancer is a hereditary disease.
Debunked: Genetic predisposition is an important factor which contributes towards development of cancer, but all cancers are not liable to develop from genetic inheritance. Only 5-10 per cent of all cancers are attributed to genetic defects and the remaining 90-95 per cent has their strings attached to environment and lifestyle.

Myth: Nausea, sickness and pain are part and parcel of cancer treatment.
Debunked: Individual variation exists regarding response to a particular treatment regimen. Recent advancements with antiemetics have made it possible to reduce the side effects like nausea and sickness. Pain relieving medications and exercises provide better quality of life to the patients.

Myth: Clinical trials are highly experimental and patients are treated like "guinea pigs" and are a risky undertaking.
Debunked: Clinical trials generally incorporate the best available medicine and then add to it or adjust it to observe if enhancements can be made to improve the quality of life of patients or their response rates. Clinical trials are closely monitored by the doctors and caregivers, as well as an Institutional Review Board assigned to each trial and details are carefully documented.

Myth: Sugars feed cancer. Sugar is not responsible for the spread of cancer.
Debunked: Excess intake of sugar can lead to obesity and, therefore, can enhance the risk of oral cancer. Naturally occurring sugars like those found in fruits, vegetables and whole grains are all needed to help maintain muscle and weight during cancer treatment and have been shown to help fight cancer.[8]

Myth: Positive attitude is enough to cure cancer.
Debunked: Positive attitude is always desirable during cancer treatment but this cannot be the only option for cancer cure, since proper medication and therapy are the foremost priority in case of cancer patients.

Myth: There is no need to talk about cancer.
Debunked: It is always good to have an open and frank discussion about cancer, which might help to create awareness, therefore, improving outcomes at an individual, community level.

Myth: One having cancer treatment cannot live at home, work or go about usual activities.
Debunked: Very often patients need to get admitted to a hospital for treatment. At times it may be helpful to travel to a specialty medical centre for treatment. The truth is that many people with cancer may be treated on an outpatient basis. A great deal of effort is ongoing to make it easier for cancer patients to live a normal life during their treatment.

Myth: Supernatural factors and ill fate influence cancer.
Debunked: Very often people attribute an illness to supernatural factor, ill fate and witch craft with the occurrence of cancer. These affect the well-being of the patients due to bereavement in decision making and delayed medical care.[8]

Myth: Cancer research is fruitless.
Debunked: Oncology, the study and management of cancer, is the fastest evolving branch of modern medicine today. Though the cause of cancer is still an enigma, the advanced interdisciplinary research has increased the scope of fighting the disease. Cancer research has brought in a number of new molecules which has helped to blend the targeted therapy, hormone therapy along with better surgical options, radiotherapy and chemotherapy to improve the disease free survival of the cancer patients.[9]

Discussion

Not only myths, social taboos also are an obstacle in dealing with cancer. A diagnosis of cancer is a life-changing event commonly evoking feelings of shock, fear, anger, sadness, loneliness and anxiety. Cancer remains taboo and people with cancer are even subjected to stigma and discrimination that may stop them from admitting that they have cancer.

Negative public concept of cancer can perpetuate a cycle of fear and misinformation that hinders raising awareness about cancer prevention and the importance of early detection.

Lack of awareness is the root cause of the oncologic misconceptions. Cancer awareness programmes are foremost initiatives which are needed to debunk these myths. In a pilot survey conducted by Chittaranjan National Cancer Institute, Kolkata, India, on 900 people to assess the level of cancer awareness only 8 % had experienced any cancer awareness programme conducted by any organization, 37% had heard cancer awareness programme on All India Radio, 36% had viewed awareness programme on Doordarshan / private television channels, 34% had read cancer awareness articles and only 13% as seen cancer awareness posters and hoardings (unpublished findings). The results envisaged a great lacuna in cancer awareness prevailing with the common mass.

The oncologic myths can be managed with effective palliative care services which would identify the misconceptions regarding cancer and help the patients as well as their family members to cope with the disease. Appropriate communication through trained social workers and health workers is an absolute necessity which would create a liaison between health care providers and the community. According to the World Health Organization, majority of the cancer cases are detected only in the advanced stages, when they are untreatable.

This has led to devastating consequences especially in developing countries. Educating people and spreading awareness against cancer and more organized network of cancer screening clinics would help to diagnose even an asymptomatic patient at an early stage. An early diagnosis of cancer and proper medical intervention would certainly lead to better prognosis and enhance the chances of disease free survival.

Conclusion

Dispelling myths about oral cancer is a crucial step in promoting awareness and encouraging proactive measures for prevention and early detection. By staying informed, prioritizing regular check-ups, and adopting a holistic approach to oral health, individuals can contribute to reducing the impact of oral cancer on the population. Remember, knowledge is a powerful tool in the fight against oral cancer, and a well-informed community is better equipped to protect and prioritize their health.

Aaddressing these myths necessitates multifaceted approaches, including targeted education, public health initiatives, and collaborative efforts among healthcare professionals, researchers, and advocacy groups. By fostering a culture of knowledge dissemination and empowerment, individuals can make informed decisions about oral health practices and seek timely medical attention when necessary.

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File name:	fungus_review_article.docx
File size:	28.48K
Page count:	8
Word count:	3,635
Character count:	22,019
Submission date:	02-Nov-2022 04:15PM (UTC+0530)
Submission ID:	1942312765

Systemic review of Fungal infections in oral cavity

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Submission author:	Dr. Sangeetha R
Assignment title:	Quick Submit
Submission title:	Report- Dr.Sangeetha R
File name:	l_Implant_Recognition_in_Forensic_Odontology_A_review_Fin...
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Page count:	15
Word count:	3,083
Character count:	20,156
Submission date:	23-Jan-2024 11:46AM (UTC+0530)
Submission ID:	2276529627

Title Page

Form of the paper: Review Article

Title: "Revolutionizing Victim Identification: Cutting-Edge Dental Implant Recognition in Forensic Odontology": A review

Authors' Names

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Corresponding Author [1]

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Phone No. 7760999400

Email address: sangeethar@dsce.edu.in

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Submission ID:	1951774890

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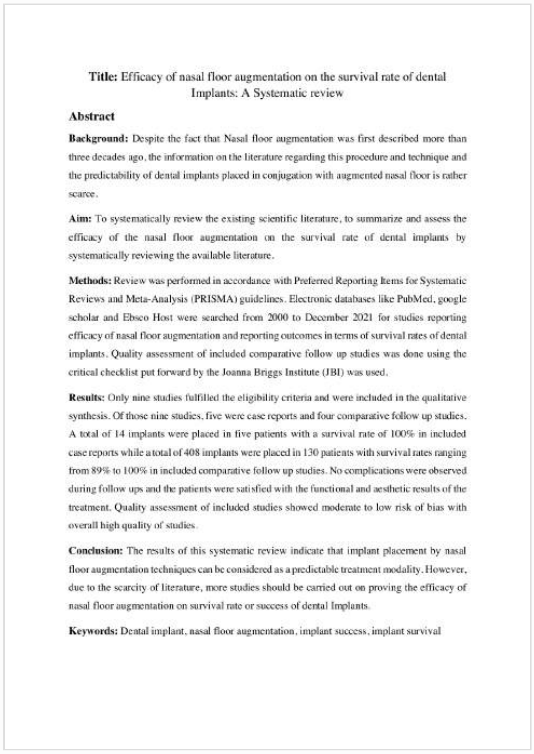

Title: Efficacy of nasal floor augmentation on the survival rate of dental Implants: A Systematic review

Abstract

Background: Despite the fact that Nasal floor augmentation was first described more than three decades ago, the information on the literature regarding this procedure and technique and the predictability of dental implants placed in conjugation with augmented nasal floor is rather scarce.

Aim: To systematically review the existing scientific literature, to summarize and assess the efficacy of the nasal floor augmentation on the survival rate of dental implants by systematically reviewing the available literature.

Methods: Review was performed in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. Electronic databases like PubMed, google scholar and Ebsco Host were searched from 2000 to December 2021 for studies reporting efficacy of nasal floor augmentation and reporting outcomes in terms of survival rates of dental implants. Quality assessment of included comparative follow up studies was done using the critical checklist put forward by the Joanna Briggs Institute (JBI) was used.

Results: Only nine studies fulfilled the eligibility criteria and were included in the qualitative synthesis. Of those nine studies, five were case reports and four comparative follow up studies. A total of 14 implants were placed in five patients with a survival rate of 100% in included case reports while a total of 408 implants were placed in 130 patients with survival rates ranging from 89% to 100% in included comparative follow up studies. No complications were observed during follow ups and the patients were satisfied with the functional and aesthetic results of the treatment. Quality assessment of included studies showed moderate to low risk of bias with overall high quality of studies.

Conclusion: The results of this systematic review indicate that implant placement by nasal floor augmentation techniques can be considered as a predictable treatment modality. However, due to the scarcity of literature, more studies should be carried out on proving the efficacy of nasal floor augmentation on survival rate or success of dental Implants.

Keywords: Dental implant, nasal floor augmentation, implant success, implant survival

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Assignment title:	DSI Students
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Word count:	6,472
Character count:	36,191
Submission date:	12-Nov-2022 01:16PM (UTC+0530)
Submission ID:	1951775639

Title: Comparative evaluation of open reduction with internal fixation against closed reduction methods for condylar fracture management– A Systematic review and meta- analysis

Abstract

Background: Mandibular fractures are frequent in facial trauma. Management of mandibular condylar fractures (MCF) remains an ongoing matter of controversy in maxillofacial injury. A number of techniques, from closed reduction (CR) to open reduction and internal fixation (ORIF) can be effectively used to manage these fractures. The best treatment strategy, that is, closed reduction or open reduction with internal fixation, remains controversial.

Aim: To systematically review the existing scientific literature to determine whether open reduction with internal fixation or closed reduction is a better treatment alternative for the patients with condylar fractures through a meta-analysis.

Methods: Review was performed in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines. Electronic databases like PubMed, google scholar and Ebsco Host were searched from 2000 to December 2021 for studies reporting management of condylar fractures through open reduction with internal fixation against closed reduction and reporting the outcome in terms of mean and standard deviation (SD). Quality assessment of included case control and cohort studies was done using Newcastle Ottawa Scale and randomized studies was evaluated using Cochrane risk of bias (ROB) -2 tool through its domains. The risk of bias summary graph and risk of bias summary applicability concern was plotted using RevMan software version 5.3. The standardized mean difference (SDM) was used as summary statistic measure with random effect model and p value <0.05 as statistically significant.

Results: Seventeen studies fulfilled the eligibility criteria and were included in qualitative synthesis, of which only nine studies were suitable for meta -analysis. The pooled estimate through the Standardized Mean Difference (SMD) of 0.80, 0.36 and 0.42 for maximum inter incisal opening, laterotrusion and protrusion favours CR compared to ORIF for condylar fracture management. Also, most results of heterogeneity tests were poor and most of the funnel plots showed asymmetry, indicating presence of possible publication bias.

Conclusion: The results of our meta-analysis suggests that CR provides superior outcomes in terms of maximum inter incisal opening, laterotrusion and protrusion compared to ORIF in condylar fractures management. It is necessary to conduct more prospective randomized studies and properly control confounding factors to achieve effective results and gradually unify clinical guidelines.

Keywords: Closed reduction, condyle, fracture, laterotrusion, mouth opening, protrusion, open reduction

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Word count:	4,675
Character count:	26,592
Submission date:	11-Jan-2023 04:39PM (UTC+0530)
Submission ID:	1991179621

2.2.3: RESPONSE:

DSCDS provides ample opportunities for students to build and sustain their innate talent/aptitude through extramural activities. We recognize that every individual student is endowed with his/her own distinct potential. This may manifest in fields as diverse as academics & research, to sport or even in a cultural field. An effective means to identify this in our students may be available as early as in the first year of their study when students exhibit greater interest or curiosity in a particular activity/subject. We, at our institution strive to identify these talents & nurture them through effective means so that every student achieves an all round holistic growth as both an individual and as a healthcare professional.

While academics forms the cornerstone of our endeavors where in our students are put through a robust training mechanism which involves theory classes, practical/clinical postings, exams, etc., students are also encouraged to participate in student conferences, competitions, CDE programs workshops as organized by the college to ensure that every student is kept abreast with the latest in Dentistry.

The institution through the Department of Public Health Dentistry conducts many camps in and around Bengaluru in which interns & post graduate students take part on rotation basis. These camps while being of enormous help to the underprivileged sections of the society, also help in the growth of our students as able administrators, clinicians and as responsible citizens with awareness of their social responsibilities. Important days in the healthcare & community domain like Oral Health Day, World No-Tobacco Day, Womens Day, Oral Cancer Day are celebrated within & outside of college by our students by conducting Skits, Flash Mobs, Dances, Rallies, Processions.

DSCDS gives equal importance for both classroom and beyond classroom activities to keep students interested. Vibrant cultural & sports activities makes up the remainder of the students' talent & skill development experience. Having students with us from different parts of the country, a diverse & comprehensive cultural week is celebrated wherein a theme is selected in advance and celebrations like events & competitions are planned accordingly. A student council has been constituted which plans to bring to DSCDS various beyond classroom activities through like fresher's day, graduation day international women's day, teacher's day, international yoga day, children's day, convocation ceremony to list a few. The cultural committee and the sports committee in accordance with the student council take decisions with regards to scheduling and conducting the events in an organized manner. Students are also encouraged to keep fit and take active part in sports with the intention of inculcating a sense of fair play & teamwork. Tournaments for both indoor & outdoor games are conducted annually wherein many students participate. Some of our students have also represented the institution at the state & national level games and have brought us many accolades.

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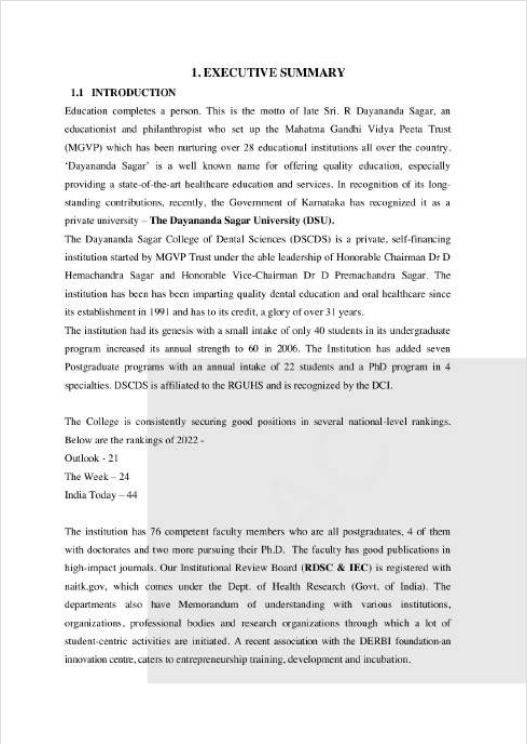

1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

Education completes a person. This is the motto of late Sri. R Dayananda Sagar, an educationist and philanthropist who set up the Mahatma Gandhi Vidya Peeta Trust (MGVP) which has been nurturing over 28 educational institutions all over the country. 'Dayananda Sagar' is a well known name for offering quality education, especially providing a state-of-the-art healthcare education and services. In recognition of its long-standing contributions, recently, the Government of Karnataka has recognized it as a private university – **The Dayananda Sagar University (DSU).**

The Dayananda Sagar College of Dental Sciences (DSCDS) is a private, self-financing institution started by MGVP Trust under the able leadership of Honorable Chairman Dr D Hemachandra Sagar and Honorable Vice-Chairman Dr D Premachandra Sagar. The institution has been has been imparting quality dental education and oral healthcare since its establishment in 1991 and has to its credit, a glory of over 31 years.

The institution had its genesis with a small intake of only 40 students in its undergraduate program increased its annual strength to 60 in 2006. The Institution has added seven Postgraduate programs with an annual intake of 22 students and a PhD program in 4 specialties. DSCDS is affiliated to the RGUHS and is recognized by the DCI.

The College is consistently securing good positions in several national-level rankings. Below are the rankings of 2022 -

Outlook - 21

The Week – 24

India Today – 44

The institution has 76 competent faculty members who are all postgraduates, 4 of them with doctorates and two more pursuing their Ph.D. The faculty has good publications in high-impact journals. Our Institutional Review Board (**RDSC & IEC**) is registered with naitk.gov, which comes under the Dept. of Health Research (Govt. of India). The departments also have Memorandum of understanding with various institutions, organizations, professional bodies and research organizations through which a lot of student-centric activities are initiated. A recent association with the DERBI foundation-an innovation centre, caters to entrepreneurship training, development and incubation.

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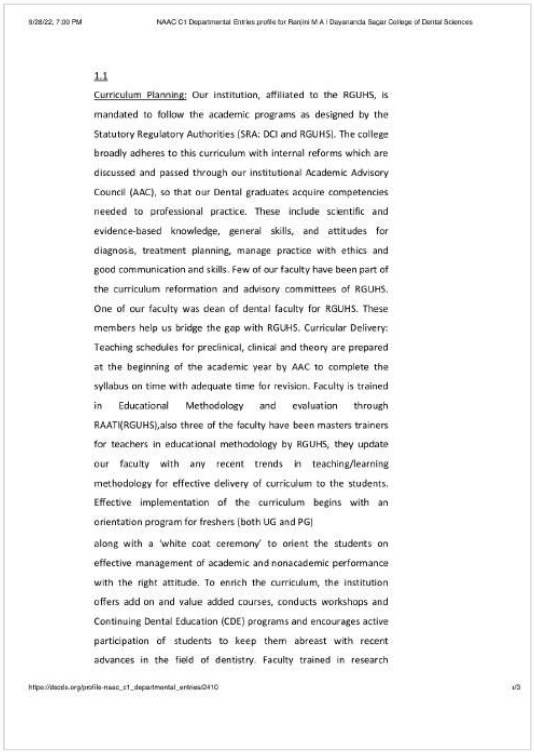

9/28/22, 7:09 PM NAAC C1 Departmental Entries profile for Ranjini M A | Dayananda Sagar College of Dental Sciences

1.1

Curriculum Planning: Our institution, affiliated to the RGUHS, is mandated to follow the academic programs as designed by the Statutory Regulatory Authorities (SRA: DCI and RGUHS). The college broadly adheres to this curriculum with internal reforms which are discussed and passed through our institutional Academic Advisory Council (AAC), so that our Dental graduates acquire competencies needed to professional practice. These include scientific and evidence-based knowledge, general skills, and attitudes for diagnosis, treatment planning, manage practice with ethics and good communication and skills. Few of our faculty have been part of the curriculum reformation and advisory committees of RGUHS. One of our faculty was dean of dental faculty for RGUHS. These members help us bridge the gap with RGUHS. Curricular Delivery: Teaching schedules for preclinical, clinical and theory are prepared at the beginning of the academic year by AAC to complete the syllabus on time with adequate time for revision. Faculty is trained in Educational Methodology and evaluation through RAATI(RGUHS),also three of the faculty have been masters trainers for teachers in educational methodology by RGUHS, they update our faculty with any recent trends in teaching/learning methodology for effective delivery of curriculum to the students. Effective implementation of the curriculum begins with an orientation program for freshers (both UG and PG)

along with a 'white coat ceremony' to orient the students on effective management of academic and nonacademic performance with the right attitude. To enrich the curriculum, the institution offers add on and value added courses, conducts workshops and Continuing Dental Education (CDE) programs and encourages active participation of students to keep them abreast with recent advances in the field of dentistry. Faculty trained in research

https://dscds.org/profile-naac_c1_departmental_entries/2410 1/3

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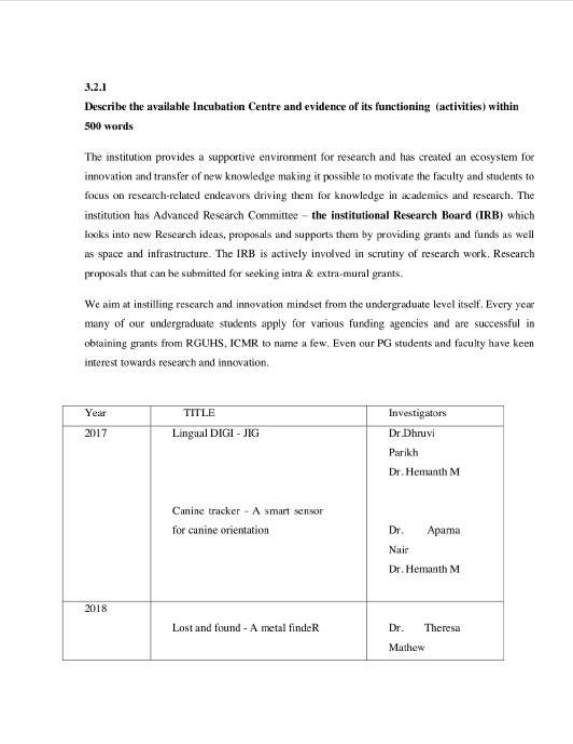

3.2.1

Describe the available Incubation Centre and evidence of its functioning (activities) within 500 words

The institution provides a supportive environment for research and has created an ecosystem for innovation and transfer of new knowledge making it possible to motivate the faculty and students to focus on research-related endeavors driving them for knowledge in academics and research. The institution has Advanced Research Committee – **the institutional Research Board (IRB)** which looks into new Research ideas, proposals and supports them by providing grants and funds as well as space and infrastructure. The IRB is actively involved in scrutiny of research work. Research proposals that can be submitted for seeking intra & extra-mural grants.

We aim at instilling research and innovation mindset from the undergraduate level itself. Every year many of our undergraduate students apply for various funding agencies and are successful in obtaining grants from RGUHS, ICMR to name a few. Even our PG students and faculty have keen interest towards research and innovation.

Year	TITLE	Investigators
2017	Lingual DIGI - JIG	Dr.Dhruvi Parikh Dr. Hemanth M
	Canine tracker - A smart sensor for canine orientation	Dr. Aparna Nair Dr. Hemanth M
2018	Lost and found - A metal findeR	Dr. Theresa Mathew

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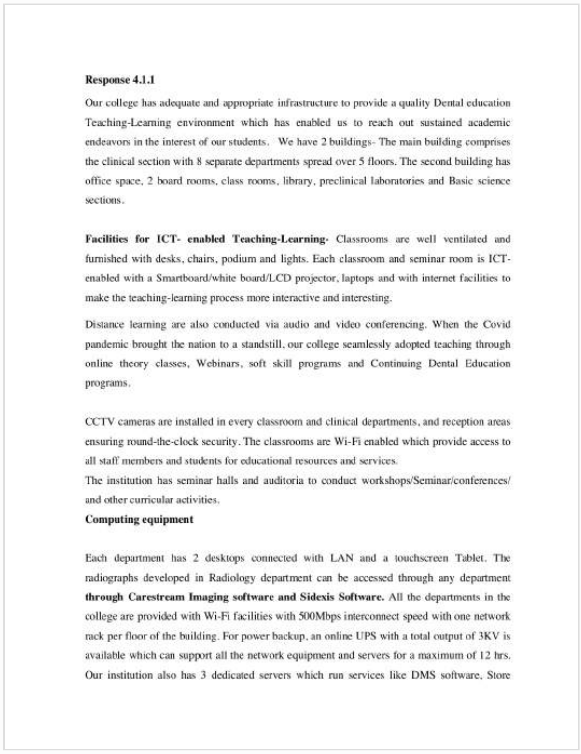

Response 4.1.1

Our college has adequate and appropriate infrastructure to provide a quality Dental education Teaching-Learning environment which has enabled us to reach out sustained academic endeavors in the interest of our students. We have 2 buildings- The main building comprises the clinical section with 8 separate departments spread over 5 floors. The second building has office space, 2 board rooms, class rooms, library, preclinical laboratories and Basic science sections.

Facilities for ICT- enabled Teaching-Learning- Classrooms are well ventilated and furnished with desks, chairs, podium and lights. Each classroom and seminar room is ICT-enabled with a Smartboard/white board/LCD projector, laptops and with internet facilities to make the teaching-learning process more interactive and interesting.

Distance learning are also conducted via audio and video conferencing. When the Covid pandemic brought the nation to a standstill, our college seamlessly adopted teaching through online theory classes, Webinars, soft skill programs and Continuing Dental Education programs.

CCTV cameras are installed in every classroom and clinical departments, and reception areas ensuring round-the-clock security. The classrooms are Wi-Fi enabled which provide access to all staff members and students for educational resources and services.
The institution has seminar halls and auditoria to conduct workshops/Seminar/conferences/ and other curricular activities.

Computing equipment

Each department has 2 desktops connected with LAN and a touchscreen Tablet. The radiographs developed in Radiology department can be accessed through any department **through Carestream Imaging software and Sidexis Software.** All the departments in the college are provided with Wi-Fi facilities with 500Mbps interconnect speed with one network rack per floor of the building. For power backup, an online UPS with a total output of 3KV is available which can support all the network equipment and servers for a maximum of 12 hrs. Our institution also has 3 dedicated servers which run services like DMS software, Store

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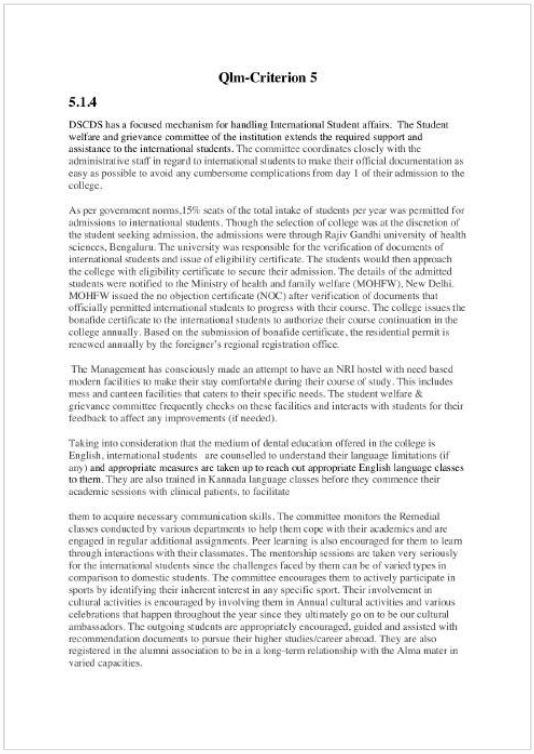

Qlm-Criterion 5

5.1.4

DSCDS has a focused mechanism for handling International Student affairs. The Student welfare and grievance committee of the institution extends the required support and assistance to the international students. The committee coordinates closely with the administrative staff in regard to international students to make their official documentation as easy as possible to avoid any cumbersome complications from day 1 of their admission to the college.

As per government norms,15% seats of the total intake of students per year was permitted for admissions to international students. Though the selection of college was at the discretion of the student seeking admission, the admissions were through Rajiv Gandhi university of health sciences, Bengaluru. The university was responsible for the verification of documents of international students and issue of eligibility certificate. The students would then approach the college with eligibility certificate to secure their admission. The details of the admitted students were notified to the Ministry of health and family welfare (MOHFW), New Delhi. MOHFW issued the no objection certificate (NOC) after verification of documents that officially permitted international students to progress with their course. The college issues the bonafide certificate to the international students to authorize their course continuation in the college annually. Based on the submission of bonafide certificate, the residential permit is renewed annually by the foreigner's regional registration office.

The Management has consciously made an attempt to have an NRI hostel with need based modern facilities to make their stay comfortable during their course of study. This includes mess and canteen facilities that caters to their specific needs. The student welfare & grievance committee frequently checks on these facilities and interacts with students for their feedback to affect any improvements (if needed).

Taking into consideration that the medium of dental education offered in the college is English, international students are counselled to understand their language limitations (if any) and appropriate measures are taken up to reach out appropriate English language classes to them. They are also trained in Kannada language classes before they commence their academic sessions with clinical patients, to facilitate

them to acquire necessary communication skills. The committee monitors the Remedial classes conducted by various departments to help them cope with their academics and are engaged in regular additional assignments. Peer learning is also encouraged for them to learn through interactions with their classmates. The mentorship sessions are taken very seriously for the international students since the challenges faced by them can be of varied types in comparison to domestic students. The committee encourages them to actively participate in sports by identifying their inherent interest in any specific sport. Their involvement in cultural activities is encouraged by involving them in Annual cultural activities and various celebrations that happen throughout the year since they ultimately go on to be our cultural ambassadors. The outgoing students are appropriately encouraged, guided and assisted with recommendation documents to pursue their higher studies/career abroad. They are also registered in the alumni association to be in a long-term relationship with the Alma mater in varied capacities.

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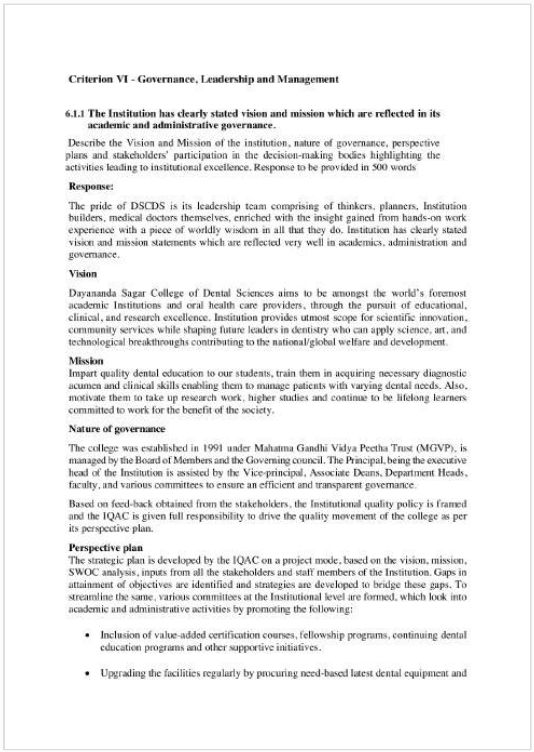

Criterion VI - Governance, Leadership and Management

6.1.1 The Institution has clearly stated vision and mission which are reflected in its academic and administrative governance.

Describe the Vision and Mission of the institution, nature of governance, perspective plans and stakeholders' participation in the decision-making bodies highlighting the activities leading to institutional excellence. Response to be provided in 500 words

Response:

The pride of DSCDS is its leadership team comprising of thinkers, planners, Institution builders, medical doctors themselves, enriched with the insight gained from hands-on work experience with a piece of worldly wisdom in all that they do. Institution has clearly stated vision and mission statements which are reflected very well in academics, administration and governance.

Vision

Dayananda Sagar College of Dental Sciences aims to be amongst the world's foremost academic Institutions and oral health care providers, through the pursuit of educational, clinical, and research excellence. Institution provides utmost scope for scientific innovation, community services while shaping future leaders in dentistry who can apply science, art, and technological breakthroughs contributing to the national/global welfare and development.

Mission

Impart quality dental education to our students, train them in acquiring necessary diagnostic acumen and clinical skills enabling them to manage patients with varying dental needs. Also, motivate them to take up research work, higher studies and continue to be lifelong learners committed to work for the benefit of the society.

Nature of governance

The college was established in 1991 under Mahatma Gandhi Vidya Peetha Trust (MGVP), is managed by the Board of Members and the Governing council. The Principal, being the executive head of the Institution is assisted by the Vice-principal, Associate Deans, Department Heads, faculty, and various committees to ensure an efficient and transparent governance.

Based on feed-back obtained from the stakeholders, the Institutional quality policy is framed and the IQAC is given full responsibility to drive the quality movement of the college as per its perspective plan.

Perspective plan

The strategic plan is developed by the IQAC on a project mode, based on the vision, mission, SWOC analysis, inputs from all the stakeholders and staff members of the Institution. Gaps in attainment of objectives are identified and strategies are developed to bridge these gaps. To streamline the same, various committees at the Institutional level are formed, which look into academic and administrative activities by promoting the following:

- Inclusion of value-added certification courses, fellowship programs, continuing dental education programs and other supportive initiatives.
- Upgrading the facilities regularly by procuring need-based latest dental equipment and

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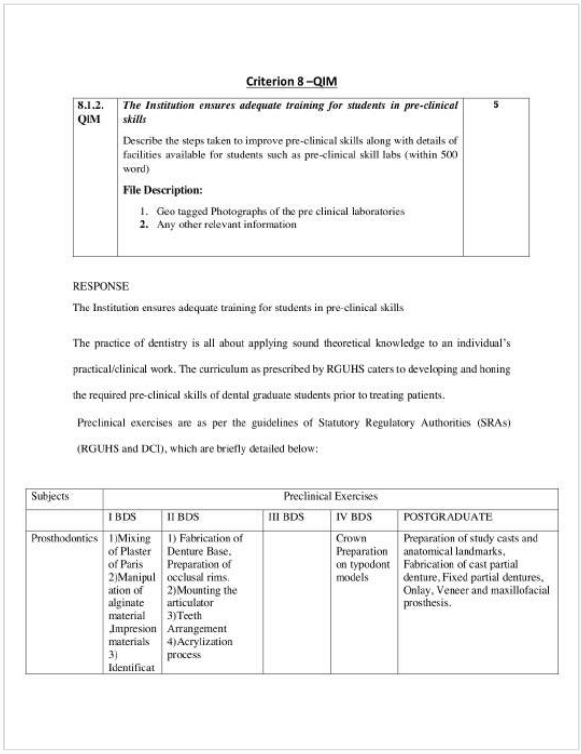

Criterion 8 –QIM

8.1.2. QIM	***The Institution ensures adequate training for students in pre-clinical skills*** Describe the steps taken to improve pre-clinical skills along with details of facilities available for students such as pre-clinical skill labs (within 500 word) **File Description:** 1. Geo tagged Photographs of the pre clinical laboratories 2. Any other relevant information	5

RESPONSE

The Institution ensures adequate training for students in pre-clinical skills

The practice of dentistry is all about applying sound theoretical knowledge to an individual's practical/clinical work. The curriculum as prescribed by RGUHS caters to developing and honing the required pre-clinical skills of dental graduate students prior to treating patients.

Preclinical exercises are as per the guidelines of Statutory Regulatory Authorities (SRAs) (RGUHS and DCI), which are briefly detailed below:

Subjects	Preclinical Exercises				
	I BDS	II BDS	III BDS	IV BDS	POSTGRADUATE
Prosthodontics	1)Mixing of Plaster of Paris 2)Manipulation of alginate material ,Impresion materials 3) Identificat	1) Fabrication of Denture Base, Preparation of occlusal rims. 2)Mounting the articulator 3)Teeth Arrangement 4)Acrylization process		Crown Preparation on typodont models	Preparation of study casts and anatomical landmarks, Fabrication of cast partial denture, Fixed partial dentures, Onlay, Veneer and maxillofacial prosthesis.

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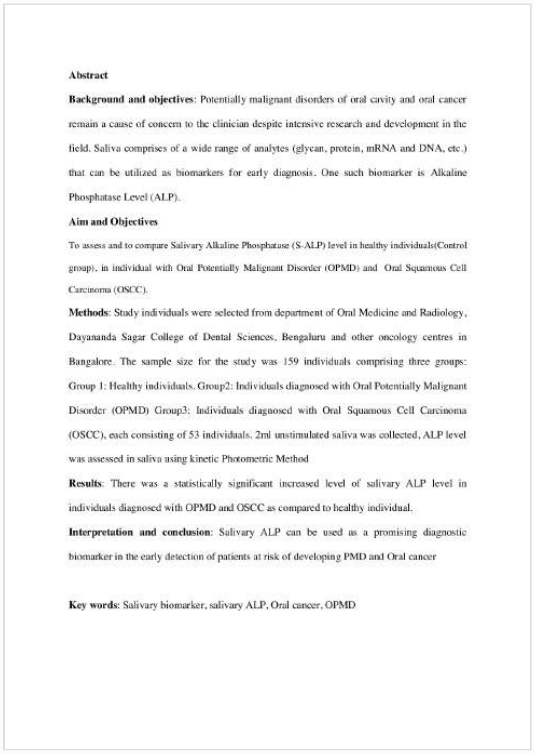

Abstract

Background and objectives: Potentially malignant disorders of oral cavity and oral cancer remain a cause of concern to the clinician despite intensive research and development in the field. Saliva comprises of a wide range of analytes (glycan, protein, mRNA and DNA, etc.) that can be utilized as biomarkers for early diagnosis. One such biomarker is Alkaline Phosphatase Level (ALP).

Aim and Objectives

To assess and to compare Salivary Alkaline Phosphatase (S-ALP) level in healthy individuals(Control group), in individual with Oral Potentially Malignant Disorder (OPMD) and Oral Squamous Cell Carcinoma (OSCC).

Methods: Study individuals were selected from department of Oral Medicine and Radiology, Dayananda Sagar College of Dental Sciences, Bengaluru and other oncology centres in Bangalore. The sample size for the study was 159 individuals comprising three groups: Group 1: Healthy individuals. Group2: Individuals diagnosed with Oral Potentially Malignant Disorder (OPMD) Group3: Individuals diagnosed with Oral Squamous Cell Carcinoma (OSCC), each consisting of 53 individuals. 2ml unstimulated saliva was collected, ALP level was assessed in saliva using kinetic Photometric Method

Results: There was a statistically significant increased level of salivary ALP level in individuals diagnosed with OPMD and OSCC as compared to healthy individual.

Interpretation and conclusion: Salivary ALP can be used as a promising diagnostic biomarker in the early detection of patients at risk of developing PMD and Oral cancer

Key words: Salivary biomarker, salivary ALP, Oral cancer, OPMD

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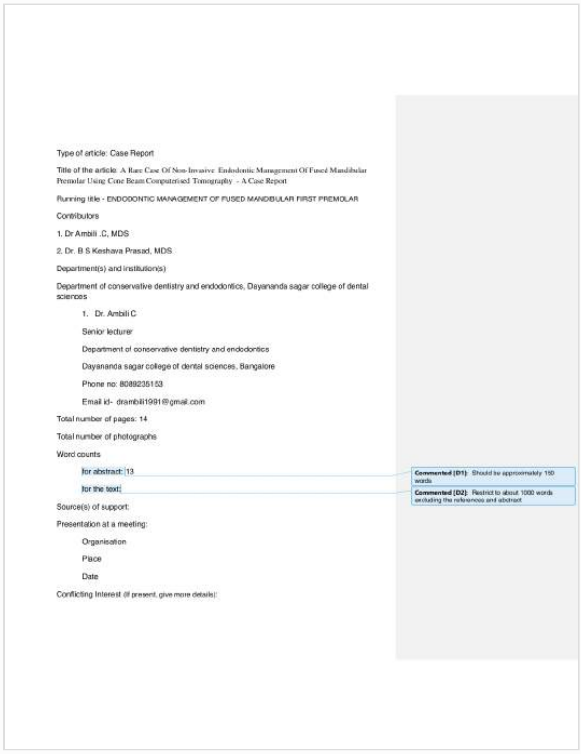

Type of article: Case Report

Title of the article: A Rare Case Of Non-Invasive Endodontic Management Of Fused Mandibular Premolar Using Cone Beam Computerised Tomography – A Case Report

Running title - ENDODONTIC MANAGEMENT OF FUSED MANDIBULAR FIRST PREMOLAR

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Biometric 30232

TITLE- **Platelet rich fibrin and Bioactive calcium phosphosilicate putty (Novabone)in periodontal endoosseous defects - A clinical and radiographic study**

ABSTRACT

AIM: To determine the regeneration potential of Bioactive calcium phosphosilicate putty (Novabone) with Platelet-Rich-Fibrin and Bioactive calcium phosphosilicate putty (Novabone) alone clinically and radiographically when used in periodontal endoosseous defects

MATERIALS AND METHOD: Present study was carried out in 20 defects present in 20 patients aged between 25 and 55 years. The patients were randomly divided into 2 groups The groups were: Group I (n=10): Those to be treated with bioactive glass (Novabone®putty) only Group II (n=10): Those to be treated with a combination of Platelet rich fibrin and bioactive glass (Novabone®putty). All the patients were followed up for a period of 9 months.

RESULTS: A significant reduction in probing pocket depth, relative attachment level gain and bone fill was noted at the end of 9 months in both the treatment groups. The improvement in the parameters were greater while using Novabone®putty alone as grafting material when compared to Novabone putty® with PRF.

CONCLUSION: Both the regenerative materials were efficient in improving the clinical parameters and both the groups showed evidence of radiographic bone fill in the defect sites at the end of 9 months. But calciumphosphosilicate putty (Novabone®putty) when used alone displayed slightly superior effect in relation to clinical parameters.

Key Words: Bone grafts, Regeneration, PRF, Novabone putty

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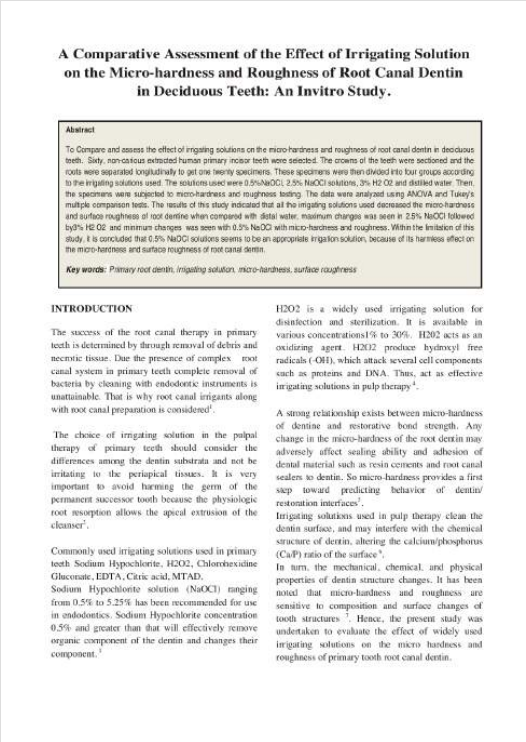

A Comparative Assessment of the Effect of Irrigating Solution on the Micro-hardness and Roughness of Root Canal Dentin in Deciduous Teeth: An Invitro Study.

Abstract

To Compare and assess the effect of irrigating solutions on the micro-hardness and roughness of root canal dentin in deciduous teeth. Sixty, non-carious extracted human primary incisor teeth were selected. The crowns of the teeth were sectioned and the roots were separated longitudinally to get one twenty specimens. These specimens were then divided into four groups according to the irrigating solutions used. The solutions used were 0.5%NaOCl, 2.5% NaOCl solutions, 3% H2 O2 and distilled water. Then, the specimens were subjected to micro-hardness and roughness testing. The data were analyzed using ANOVA and Tukey's multiple comparison tests. The results of this study indicated that all the irrigating solutions used decreased the micro-hardness and surface roughness of root dentine when compared with distal water, maximum changes was seen in 2.5% NaOCl followed by3% H2 O2 and minimum changes was seen with 0.5% NaOCl with micro-hardness and roughness. Within the limitation of this study, it is concluded that 0.5% NaOCl solutions seems to be an appropriate irrigation solution, because of its harmless effect on the micro-hardness and surface roughness of root canal dentin.

Key words: *Primary root dentin, irrigating solution, micro-hardness, surface roughness*

INTRODUCTION

The success of the root canal therapy in primary teeth is determined by through removal of debris and necrotic tissue. Due the presence of complex root canal system in primary teeth complete removal of bacteria by cleaning with endodontic instruments is unattainable. That is why root canal irrigants along with root canal preparation is considered[1].

The choice of irrigating solution in the pulpal therapy of primary teeth should consider the differences among the dentin substrata and not be irritating to the periapical tissues. It is very important to avoid harming the germ of the permanent successor tooth because the physiologic root resorption allows the apical extrusion of the cleanser[2].

Commonly used irrigating solutions used in primary teeth Sodium Hypochlorite, H2O2, Chlorohexidine Gluconate, EDTA, Citric acid, MTAD.
Sodium Hypochlorite solution (NaOCl) ranging from 0.5% to 5.25% has been recommended for use in endodontics. Sodium Hypochlorite concentration 0.5% and greater than that will effectively remove organic component of the dentin and changes their component.[3]

H2O2 is a widely used irrigating solution for disinfection and sterilization. It is available in various concentrations1% to 30%. H202 acts as an oxidizing agent. H2O2 produce hydroxyl free radicals (-OH), which attack several cell components such as proteins and DNA. Thus, act as effective irrigating solutions in pulp therapy[4].

A strong relationship exists between micro-hardness of dentine and restorative bond strength. Any change in the micro-hardness of the root dentin may adversely affect sealing ability and adhesion of dental material such as resin cements and root canal sealers to dentin. So micro-hardness provides a first step toward predicting behavior of dentin/ restoration interfaces[5].
Irrigating solutions used in pulp therapy clean the dentin surface, and may interfere with the chemical structure of dentin, altering the calcium/phosphorus (Ca/P) ratio of the surface[6].
In turn, the mechanical, chemical, and physical properties of dentin structure changes. It has been noted that micro-hardness and roughness are sensitive to composition and surface changes of tooth structures [7]. Hence, the present study was undertaken to evaluate the effect of widely used irrigating solutions on the micro hardness and roughness of primary tooth root canal dentin.

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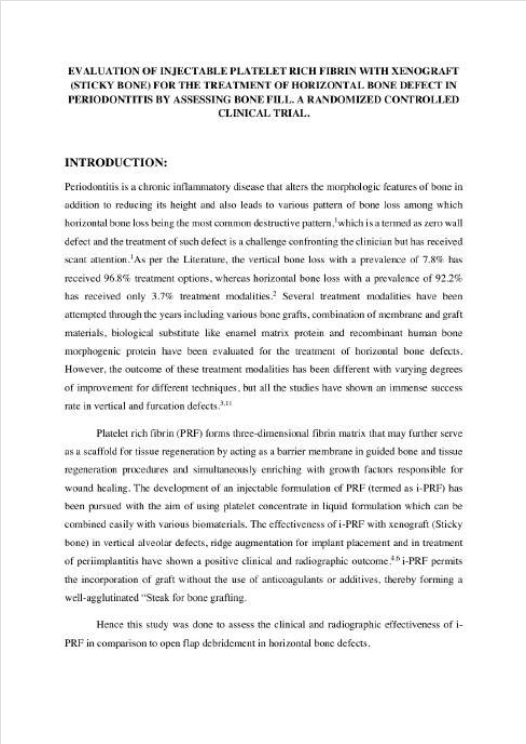

EVALUATION OF INJECTABLE PLATELET RICH FIBRIN WITH XENOGRAFT (STICKY BONE) FOR THE TREATMENT OF HORIZONTAL BONE DEFECT IN PERIODONTITIS BY ASSESSING BONE FILL: A RANDOMIZED CONTROLLED CLINICAL TRIAL.

INTRODUCTION:

Periodontitis is a chronic inflammatory disease that alters the morphologic features of bone in addition to reducing its height and also leads to various pattern of bone loss among which horizontal bone loss being the most common destructive pattern,[1]which is a termed as zero wall defect and the treatment of such defect is a challenge confronting the clinician but has received scant attention.[1]As per the Literature, the vertical bone loss with a prevalence of 7.8% has received 96.8% treatment options, whereas horizontal bone loss with a prevalence of 92.2% has received only 3.7% treatment modalities.[2] Several treatment modalities have been attempted through the years including various bone grafts, combination of membrane and graft materials, biological substitute like enamel matrix protein and recombinant human bone morphogenic protein have been evaluated for the treatment of horizontal bone defects. However, the outcome of these treatment modalities has been different with varying degrees of improvement for different techniques, but all the studies have shown an immense success rate in vertical and furcation defects.[3,11]

Platelet rich fibrin (PRF) forms three-dimensional fibrin matrix that may further serve as a scaffold for tissue regeneration by acting as a barrier membrane in guided bone and tissue regeneration procedures and simultaneously enriching with growth factors responsible for wound healing. The development of an injectable formulation of PRF (termed as i-PRF) has been pursued with the aim of using platelet concentrate in liquid formulation which can be combined easily with various biomaterials. The effectiveness of i-PRF with xenograft (Sticky bone) in vertical alveolar defects, ridge augmentation for implant placement and in treatment of periimplantitis have shown a positive clinical and radiographic outcome.[4-6] i-PRF permits the incorporation of graft without the use of anticoagulants or additives, thereby forming a well-agglutinated "Steak for bone grafting.

Hence this study was done to assess the clinical and radiographic effectiveness of i-PRF in comparison to open flap debridement in horizontal bone defects.

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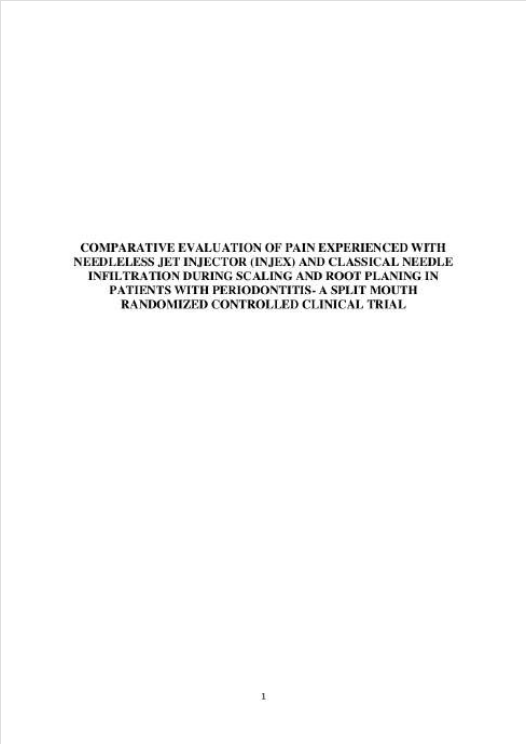
COMPARATIVE EVALUATION OF PAIN EXPERIENCED WITH NEEDLELESS JET INJECTOR (INJEX) AND CLASSICAL NEEDLE INFILTRATION DURING SCALING AND ROOT PLANING IN PATIENTS WITH PERIODONTITIS- A SPLIT MOUTH RANDOMIZED CONTROLLED CLINICAL TRIAL

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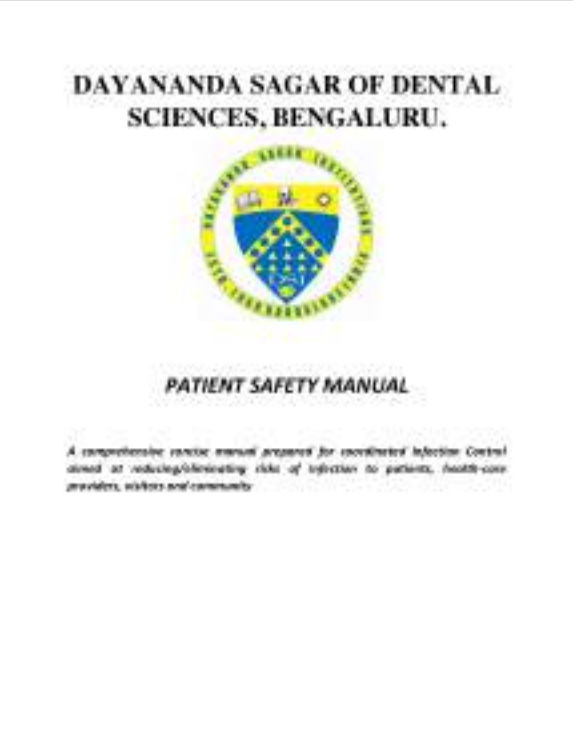

DAYANANDA SAGAR OF DENTAL SCIENCES, BENGALURU.

PATIENT SAFETY MANUAL

A comprehensive concise manual prepared for coordinated Infection Control aimed at reducing/eliminating risks of infection to patients, health-care providers, visitors and community

Artificial Intelligence in Oral Medicine and Radiology- A Review

by Sindhu P

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Artificial Intelligence in Oral Medicine and Radiology- A Review

Abstract: Artificial Intelligence (AI) is a technology which is quickly advancing and has captivated the minds of researchers across the globe. The adoption of artificial intelligence (AI) in healthcare is developing and profoundly changing the face of healthcare delivery. There is a marked increase in the evolution of AI from the last decade, which has been showing tremendous improvement and dentistry is of no exception. AI has its importance in dentistry, especially in Oral Medicine and Radiology. This review is conducted by searching a web-based initiated using PubMed/Medline database searching for articles from year 2016 to 2022, which were written in English using the key terms "Artificial Intelligence", "Machine learning", "Deep Learning", "Convolutional neural network", "Oral Medicine", and "Oral Radiology". AI has showed a promising results in patient diagnosis, storage of patient data, and the assessment of radiographic information which will provide improved healthcare for patients. Regardless of many improvements and advances, AI is still in its teething stage, but its potential is boundless. This technology is tremendously utilized for easy and early diagnosis, proper treatment of lesions of oral cavity, advanced breakthroughs in image recognition techniques, screening of suspicious premalignant and malignant lesions of oral cavity with satisfying outcome. A thorough knowledge regarding the adaptation of technology will not only help in better and precise patient care but also in reducing the work burden for the clinician.

Introduction

Artificial Intelligence (AI) is a branch of computer science dedicated to the development of computer algorithms to accomplish tasks traditionally associated with human intelligence, such as the ability to learn and solve problems. AI has importance in dentistry, especially in Oral Medicine and Radiology(OMR), including from storage of patient data till patient diagnosis and the assessment of radiographic information. Without a doubt, AI is a 'game-changing' device. This review is taken to know the clinical application and diagnostic performances of AI in OMR, which can help dentist who is at forefront to lead the application of AI to health care.

Methods

To get up-to-date information, a web-based search was initiated using PubMed/Medline database searching for articles from year 2016 to 2022, which were written in English. Peer-reviewed articles were targeted using the key terms "Artificial Intelligence", "Machine learning", "Deep Learning", "Convolutional neural network", "Oral Medicine", and "Oral Radiology" to determine the scope of coverage in well-documented articles. The sites of specialized scientific journals in the areas of Oral Medicine and Radiology, Artificial Intelligence, and other relevant journals were also used. Available full-text articles were read, and related articles were also scrutinized.

Artificial Intelligence

Artificial Intelligence is composed of two words **Artificial** and **Intelligence**, where Artificial defines *"man-made,"* and intelligence defines *"thinking power"*, hence AI means *"a man-made thinking power."* AI is the part of computer science concerned with designing an intelligent computer system that exhibits characteristics we associate with intelligence in human behaviour-understanding language, learning, reasoning, problem solving, and many more.[1]

Machine Learning(ML) is a subset of AI that is mainly concerned with the development of algorithms which allow a computer to learn from the data and past experiences on their own. ML enables a machine to automatically learn from data, improve performance from experiences, and predict things without being explicitly programmed (Fig 1). Machine learning is classified into the broad categories of supervised, unsupervised, and reinforcement learning (Fig 2). Supervised learning is a type of ML method in which we provide sample labelled data to the machine learning system in order to train it, and on that basis, it predicts the output. Unsupervised learning is a learning method in which a machine learns without any supervision. Reinforcement learning is a feedback-based learning method, in which a learning agent gets a reward for each right action and gets a penalty for each wrong action. The agent learns automatically with these feedbacks and improves its performance. [2]

Deep Learning(DL) is the subset of machine learning or can be said as a special kind of machine learning. It works technically in the same way as machine learning does, but with different capabilities and approaches. It is inspired by the functionality of human brain cells, which are called neurons, and leads to the concept of artificial neural networks. In deep learning, models use different layers to learn and discover insights from the data (Fig 3). [3] Convolutional Neural Networks(CNN) are a special type of feed-forward artificial neural network in which the connectivity pattern between its neuron is inspired by the visual cortex. Basically, it consists of adding an extra layer, which is called convolutional that gives an eye to the Deep Learning model because with the help of it we can easily take a 3D frame or image as an input as opposed to our previous artificial neural network that could only take an input vector containing some features as information. [4]

Artificial Intelligence in Oral Medicine and Radiology

Artificial intelligence can be a highly useful modality in the diagnosis and treatment of oral lesions. Altered mucosa undergoing premalignant and malignant changes can also be screened and classified using this advanced system.

Radiology is deemed to be the front door for AI into medicine as digitally coded diagnostic images are more easily translated into computer language. Thus, diagnostic images are seen as one of the primary sources of data used to develop AI systems for the purpose of an automated prediction of disease risk, detection of pathologies and diagnosis of disease. [5]

Artificial Intelligence in Patient Management

Artificial Intelligence-based virtual dental assistants can perform numerous tasks related to dentistry with greater precision, minimum errors and less manpower compared to humans. It can be used for various purposes ranging from scheduling appointments, and managing insurance and paper works to assisting clinical diagnosis or treatment planning. It is very useful in alerting the dentist about a patient's medical history as well as habits like alcoholism and smoking. In dental emergencies, the patient has an option of emergency tele assistance especially when the practitioner is unavailable. Thus a detailed virtual database of the patient can be created which will go a long way in providing the best treatment for the patient. [6]

Artificial Intelligence in the Detection of Dental Caries

Dental caries is the most prevalent dental disease worldwide, and neural networks and artificial intelligence are increasingly being used in this field. Many studies have contributed

to the field of dental caries detection using neural networks with different dental images.

Table 1 gives an overview of studies conducted using artificial intelligence in the detection of dental caries.

Artificial Intelligence in the Early Detection of Oral Cancer

An early oral cancer diagnosis is the key to successful treatment. In dental practice, a routine should be established: a full mouth examination to identify changes that lead to early diagnosis. There are references that professionals and students are insecure in their diagnoses. This created an opportunity to develop an auxiliary device for the diagnostic exam, based on artificial intelligence in identifying early signs. Computational diagnosis allows for the ability to detect changes that the untrained human eye cannot detect, thereby improving patient care.[12] Studies using Artificial intelligence algorithms for the early detection of Oral cancer are given in table 2.

Artificial Intelligence in the Diagnosis of TMJ Disorders

TMJ disorder can be diagnosed through medical history, clinical diagnosis, and radiographic examination. TMJ disorders clinically show characteristic signs, including the limited movement of the lower jaw due to pain, crepitus, and local paraspinal tenderness in a joint promotion. These disorders can be determined when a radiographic examination shows a structural bone change.[18] The various AI algorithms have been applied to image and non-image data for TMDs diagnosis and are shown in Table 3.

Artificial Intelligence in the Diagnosis of Cysts and Tumors.

The cysts and tumors of the jawbone are usually painless and asymptomatic unless they grow so large as to involve the entire jawbone, causing noticeable swelling or weakening it to cause pathologic fractures. Although rare, a carcinomatous change of benign jaw lesions has also been described. late-stage radical surgery, involving ablation and reconstruction accompanying bone grafts and free flaps, drastically affects patients' lives, causing facial deformity and subsequent social and emotional incompetence. Early diagnosis is the only option to ensure healthy years of life.[26] Along with new AI technologies to study the maxillofacial region, several studies on the automatic detection of odontogenic cysts and tumors have been shown in Table 4.

Artificial Intelligence in the Diagnosis of Fractures

Fractures are one of the most frequent injuries in oral and maxillofacial surgery. Most common among those are Mandibular fractures, which occur as a result of an assault, vehicle accident, fall or fight among others. Radiologists mostly diagnose mandibular fractures using CBCT and panoramic radiography. Artificial intelligence and deep learning are progressing and expanding rapidly, and have shown promising applications for the detection of fractures in recent years.[32] Some of the studies are given in table 5.

Artificial Intelligence in Forensic Odontology

Forensic odontology involves the management, examination, evaluation and presentation of dental evidence in criminal or civil proceedings, all in the interest of justice. It has the ability to bring justice where dental remains are the only available evidence. Artificial intelligence technology has proven to be a breakthrough in providing reliable information in decision-making in forensic sciences.[38] Some studies are given in table 6.

Challenges of Artificial Intelligence

The management and sharing of clinical data are major challenges in the implementation of AI systems in health care. Personal data from patients are necessary for initial training of AI algorithms, as well as ongoing training, validation and improvement. Furthermore, the development of AI will prompt data sharing among different institutions and, in some cases, across national boundaries. To integrate AI into clinical operations, systems must be adapted to protect patient confidentiality and privacy. Thus, before considering broader distribution, personal data will have to be anonymized.

The transparency of AI algorithms and data is an another substantial issue. The quality of predictions performed by AI systems relies heavily on the accuracy of annotations and labelling of the dataset used in training. Poorly labelled data can lead to poor results. Clinic-labelled datasets may be of inconsistent quality, thus limiting the efficacy of the resultant AI systems. [43]

Advantages of Artificial Intelligence

- The Abundance of Data management:

Patient encounters at each step of the treatment cycle generate many types of data. Booking an appointment, taking the impression of patient's teeth for a crown, or taking the routine bitewing X-rays create potentially helpful data. And it is not just during the patient's treatment-cycle many types of data are also generated outside of the dental clinic. Examples include when a dentist markets his practice, or when a patient leaves a review on social media sites or other online forums and hundreds of research papers that are being published around the world.

Wherever there are large complex datasets, there is the opportunity to improve understanding of AI. Useful data is generated in many formats, e.g. natural text, tables, digital images/videos, and audio. AI can not only perform data analytics but can also carry out routine tasks and functions to help dentists reduce overall workload, be more efficient, and build stronger patient relationships.

❖ Accuracy in diagnosis:

AI technology can certainly be trained to read an x-ray and there have been some trials to suggest that they can do it better and identify key conditions that we often misread. A world with AI diagnosis that is accurate and quicker will save time, money, and lead to better dental health among patients.

❖ Saves time:

There are many administrative tasks in the dentistry that can be sped up and made more cost effective with the use of AI. An AI computer can do some of these tasks and be able to free up more time to focus on more important matters and improve job performance as well. One primary use of AI is virtual consultations. This saves patients time when they come in as the Doctor already knows what the next steps in their treatment will be. [44]

Disadvantages of Artificial Intelligence

❖ Distributional shift:

A mismatch in data due to a change of environment or circumstance can result in erroneous predictions. For example, over time, disease patterns can change, leading to a disparity between training and operational data.

❖ Insensitivity to impact:

AI doesn't yet have the ability to take into account false negatives or false positives.

❖ Black box decision-making:

With AI, predictions are not open to inspection or interpretation. For example, a problem with training data could produce an inaccurate X-ray analysis that the AI system cannot factor in.

❖ Unsafe failure mode:

Unlike a human doctor, an AI system can diagnose patients without having confidence in its prediction, especially when working with insufficient information.

❖ Automation complacency:

Clinicians may start to trust AI tools implicitly, assuming all predictions are correct and failing to cross-check or consider alternatives.

❖ Reinforcement of outmoded practice:

AI can't adapt when developments or changes in medical policy are implemented, as these systems are trained using historical data.

❖ Self-fulfilling prediction:

An AI machine trained to detect a certain illness may lean toward the outcome it is designed to detect.

❖ Negative side effects:

AI systems may suggest a treatment but fail to consider any potential unintended consequences.

❖ Reward hacking:

Proxies for intended goals serve as "rewards" for AI, and these clever machines are able to find hacks or loopholes in order to receive unearned rewards, without actually fulfilling the intended goal.

❖ Unsafe exploration:

In order to learn new strategies or get the outcome it is searching for, an AI system may start to test boundaries in an unsafe way.

❖ Unscalable:

oversight Because AI systems are capable of carrying out countless jobs and activities, including multitasking, monitoring such a machine can be near impossible. [44]

Future of Artificial Intelligence in Oral Medicine and Radiology

In Oral Medicine and Radiology, AI is being used for different applications. Some examples already given above. For machines to perform tasks such as reading radiographs, they must be "trained" on huge data sets to recognize meaningful patterns. They must be able to understand new information in the form of spoken language, written text, or images with proper context and nuance. Finally, they must be able to make intelligent decisions regarding that new information and then learn from mistakes to improve the decision making process. In order for an AI system to have a practical benefit in the real world, all of this must happen in about the same time that a human being can perform the same task. Until very recently, applications of AI on a broad scale weren't technically feasible or cost-effective, so the reality of AI hasn't yet matched the possibilities.

With the ability to analyse vast numbers of diagnostic images such as X-rays, CT scans, and MRIs, systems like this can point doctors and radiologists to the most probable areas of concern, increasing both the speed and probability of detection. And now, with the FDA creating regulatory pathways to encourage developers of medical decision support software, analysts predict that the use of artificial intelligence in healthcare will grow tenfold in the next five years. Commercial availability of a reliable caries-detection tool based on deep learning artificial intelligence appears likely in the next 12 to 24 months. Applications for detecting periodontal disease and the bone loss that accompanies it aren't far behind. With the continued adoption of CBCT, interpreting cone beam images is another area in which AI can boost productivity. At this point, analysing cone beam data requires a specific level of training and expertise. This analysis can be time-consuming, involving sifting through hundreds of image slices. With AI, the entire process of interpretation can be automated to assess the image as a whole to detect dental pathologies more quickly and accurately. Clearly, the stage is set for the rapid proliferation of truly impactful applications of AI in oral medicine and radiology over the next year or two. In 10 to 15 years, the use of AI-based technologies in the practice will be as common place and pervasive as practice management and imaging systems are today. [45]

Conclusion

The field of artificial intelligence is rapidly evolving to fill an ever-expanding niche in oral medicine and radiology. Most AI research is still in its nascent stage. Increased availability of patient data can accelerate research into artificial intelligence, machine learning, and neural networks. Research has shown that data-driven AI is reliable, transparent, and in certain cases, better than humans in diagnosis. AI can replicate human functions of reasoning, planning, and problem-solving. Its application can save time and storage, reduce manpower and eliminate human errors in diagnosis.

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Author	Year	Objective of study	Algorithm	Outcome
Sarah Mertens et al.[7]	2021	To assess the impact of artificial intelligence (AI)-based diagnostic-support software for proximal caries detection on bitewing radiographs.	Convolutional Neural networks	Dentists with AI showed a significantly higher mean (95% CI) area under the Receiver-Operating-Characteristics curve than those without AI
Liwen Zheng et al.[8]	2021	To accurately diagnose the deep caries and pulpitis on periapical radiographs is a clinical challenge	Convolutional Neural networks	The CNN of ResNet18 demonstrated the best performance with accuracy =0.82, 95% confidence interval, compared with VGG19 and Inception V3
F. Schwendicke et al.[9]	2021	To compared the cost-effectiveness of proximal caries detection on bitewing radiographs with versus without AI.	Convolutional Neural networks	AI showed an accuracy of 0.80; dentist's mean accuracy was significantly lower at 0.71
Shinae Lee et al.[10]	2021	To develop a CNN model using a U-shaped deep CNN (U-Net) for caries detection on bitewing radiographs and investigated whether this model can improve clinicians' performance.	Convolutional Neural networks	The diagnostic performance of the CNN model on the total test dataset showed precision, 63.29%; recall, 65.02%; and F1-score, 64.14%, showing quite accurate performance.
J. Kuhnisch.[11]	2022	To develop a deep learning approach with convolutional neural networks (CNNs) for caries detection and categorization and to compare the diagnostic performance with respect to expert standards.	Convolutional Neural networks	The CNN was able to correctly detect caries in 92.5% of cases.

Table no 1: Studies showing Artificial intelligence in the detection of Dental caries.

Author	Year	Objective of study	Algorithm	Outcome
Uthoff RD et al.[13]	2018	To describe dual-modality, dual-view, point-of-care oral cancer screening device, developed for high-risk populations in remote regions with limited infrastructure, implements autofluorescence imaging (AFI) and white light imaging (WLI) on a smartphone platform, enabling early detection of pre-cancerous and cancerous lesions.	Convolutional Neural network	To classify 170 image pairs into 'suspicious' and 'not suspicious' with sensitivities, specificities, positive predictive values, and negative predictive values ranging from 81.25% to 94.94%.
T. Morikawa et al.[14]	2019	To determine the usefulness of optical instruments in oral screening.	Fluorescence visualization	Objective evaluations showed sensitivity and specificity were 61.9% and 62.7% for mean luminance, 90.3% and 55.7% for luminance ratio, 56.5% and 67.7% for standard deviation of luminance, and 72.5% and 85.4% for coefficient of variation of luminance.
Mohammed Zubair et.al.[15]	2020	To evaluated the efficacy of six deep convolutional neural network (DCNN) models using transfer learning, for identifying pre-cancerous tongue lesions directly using a small dataset of clinically annotated photographic images to diagnose early signs of Oral Cancer	Deep Convolutional Neural network	Mean Classification accuracy of 0.98, sensitivity 0.89 and specificity 0.97. ResNet50 DCNN Mean classification accuracy of 0.97.
B. Ilhan et al.[16]	2020	It provides an overview of emerging optical imaging modalities and novel artificial intelligence-based approaches, as well as evaluates their individual and combined utility and implications for improving oral cancer detection and outcomes.	Deep learning algorithm	Combined imaging and artificial intelligence approaches can improve oral cancer outcomes through improved detection and diagnosis.
Qiuyun Fu et al.[17]	2020	To develop a rapid, non-invasive, cost-effective, and easy-to-use deep learning approach for identifying oral cavity squamous cell carcinoma (OCSCC) patients using photographic images.	Deep learning algorithm	The deep learning algorithm achieved an AUC of 0.983, sensitivity of 94.9%, and specificity of 88.7% on the internal validation dataset (n = 401), and an AUC of 0.935.

Table no 2: Studies showing Artificial intelligence in the early detection of Oral cancer

Author	Year	Objective of study	Algorithm	Outcome
Haghnegahdar et al. [19]	2016	Local binary patterns for assessment of TMDs	Random forest, Naïve Bayes, SVM, KNN, Local binary pattern, Histogram of oriented gradients	**KNN** a) Accuracy: 92% b) Sensitivity: 94% c) Specificity: 90% **SVM** a) Accuracy: 84% b) Sensitivity: 84% c) Specificity: 85% **Naïve Bayes** a) Accuracy: 75% b) Sensitivity: 78% c) Specificity: 73% **Random forest** a) Accuracy: 73% b) Sensitivity: 75% c) Specificity: 73%
De Dumast et al. [20]	2018	The deep neural network to assess shape changes in TMJO	CNN	Accuracy Training data: 93% Testing data: 95%
Nam et al. [21]	2018	NLP to differentiate TMD and TMD mimicking conditions	NLP	**The goodness-of-fit of the model: 0.643** a) Accuracy: 96.6% b) Sensitivity: 69.0% c) Specificity: 99.3% d) Positive-predictive value: 90.9% e) Negative-predictive value: 97.0%
Ribera et al. [22]	2019	Deep neural network to assess bony changes in TMJOA	CNN	Accuracy 47% of exact classification (91% for an error of +/–one group)
K S Lee et al. [23]	2020	To develop a diagnostic tool to automatically detect TMJOA from CBCT images with artificial intelligence.	ANN	Accuracy:0.85 Precision:0.84
Kim D et al. [24]	2020	To develop an algorithm that can extract the condylar region and determine its abnormality by using CNNs and Faster region-based CNNs	CNN	Sensitivity:0.54 Specificity:0.94 Accuracy:0.84

Choi, E., Kim, D., Lee, JY. et al. [25]	2021	To develop an artificial intelligence model and compare its TMJOA diagnostic performance with OPGs	Confusion matrix	Accuracy: 0.78, Sensitivity: 0.73 Specificity: 0.82

Table no 3: Studies showing Artificial intelligence in the diagnosis of TMJ Disorders.

Author	Year	Objective of study	Algorithm	Outcome
Lee JH et al. [27]	2020	To evaluate the detection and diagnosis of three types of odontogenic cystic lesions, odontogenic keratocysts, dentigerous cysts, and periapical cysts-using OPG and CBCT images based on a deep convolutional neural network.	CNN	**CBCT images** Sensitivity: 96.1% Specificity: 77.1% **OPG images** Sensitivity: 88.2% Specificity: 77.0%
Hyunwoo Yang et al. [28]	2020	To evaluate the diagnostic performance of the real-time object detecting deep convolutional neural network You Only Look Once (YOLO) v2—a deep learning algorithm that can both detect and classify an object at the same time—on panoramic radiographs.	DNN	Accuracy: 0.663 F1 score: 0.693 Precision: 0.707 Recall: 0.680

Kwon O et al. [29]	2020	To automatically diagnose odontogenic cysts and tumors of both jaws on panoramic radiographs using deep learning.	DCNN	**Dentigerous cysts** sensitivity: 91.4% specificity: 99.2% accuracy: 97.8% AUC: 0.96 **OKC** sensitivity: 98.4% specificity: 92.3% accuracy: 94.0% AUC: 0.97 **Periapical cysts** sensitivity: 82.8% specificity: 99.2% accuracy: 96.2% AUC: 0.92
Roopa S. Rao et al. [30]	2021	To create a histopathology image classification automation system that could identify odontogenic keratocysts in hematoxylin and eosin-stained jaw cyst sections.	DLT	VGG16 DenseNet-169 Accuracy: 93%
Yu, D., Hu, J., Feng, Z. et al. [31]	2022	To develop an explainable and reliable method to diagnose cysts and tumors of the jaw with massive panoramic radiographs of healthy peoples based on deep learning	DNN	Accuracy: 88.72% Precision: 65.81% Sensitivity: 66.56% Specificity: 92.66% F1 Score: 66.14%

Table no 4: Studies showing Artificial intelligence in the diagnosis of cysts and tumors.

Author	Year	Objective of study	Algorithm	Outcome
Lee J et al. [53]	2020	To evaluate the detection and diagnosis of three types of odontogenic cystic lesions using OPG and cone CBCT images based on a deep convolutional neural network	CNN	CBCT images showed good diagnostic performance of AUC = 0.914, sensitivity = 96.1%, specificity = 77.1%. OPG images showed AUC = 0.847, sensitivity = 88.2%, specificity = 77.0%.
Hyunwoo Yang et al. [54]	2020	To evaluate the diagnostic performance of deep convolutional neural network YOLO that can both detect and classify an object at the same time—on OPG.	CNN	YOLO ranked highest among (YOLO, oral and maxillofacial surgeons, and general practitioners) the three groups precision= 0.707, recall = 0.680
Dan Yu et al. [55]	2022	To develop an explainable and reliable method to diagnose cysts and tumors of the jaw with OPG radiographs of healthy peoples based on deep learning		average accuracy: 88.72%. precision: 65.81% sensitivity: 66.56% specificity: 92.66% F1 score: 66.14%

Table no 5: Studies showing Artificial intelligence in the diagnosis of Fractures.

Author	Year	Objective of study	Algorithm	Outcome
Fidya, F., & Priyambadha, B. [37]	2017	This study aimed to quantify the respective accuracy of the Naive Bayes, decision tree, and multi-layer perceptron (MLP) methods in identifying sexual dimorphism in canines	Naive Bayes, Decision tree and Multi-layer perceptron.	Accuracy rate of the Naive Bayes method was 82%. Accuracy rate of the decision tree and MLP amounted to 84%.
Tobel et al. [38]	2017	An automated technique for staging the development of lower third molar	Deep Learning Convolutional Neural Network	Mean accuracy 0.51, mean absolute difference was 0.6 stages and mean linearly weighted kappa was 0.82.
Patil et al. [39]	2020	ANN for gender determination DANet (Dental Age Net) & DASNet (Dental Age and Sex Net), to estimate the chronological age of a subject from the OPG image.	ANN	An overall accuracy of 69.1%, logistic regression showed an accuracy of 69.9% and ANN exhibited a higher accuracy of 75%
Matsuda S and Yoshimura H. [40]	2020	The aim of this study was to verify the usefulness of personal identification with paired OPG obtained in a relatively short period using convolutional neural network (CNN) technologies	CNN architectures: VGG16, ResNet50, Inception-v3, InceptionResNet-v2, Xception, and MobileNet-v2.	The VGG16 model achieved the highest accuracy (100.0%) with pretraining and with fine-tuning.
A Thurzo et al. [41]	2021	To introduces a novel workflow of 3D CNN analysis of full-head CBCT scans. 1. sex determination, 2. biological age estimation, 3.3D cephalometric landmark annotation, 4. growth vectors prediction, 5.facial soft-tissue estimation from the skull.	CNN	3D CNN application in forensic medicine, leading to unprecedented improvement of forensic analysis workflows.
Seunghyeon Kim et al. [42]	2022	To provide AI-based diagnostic system for age-group estimation by incorporating a convolutional neural network (CNN) using first molars extracted via panoramic radiography.	CNN	The accuracy of the tooth-wise estimation was 89.05 to 90.27%. The AUC scores ranged from 0.94 to 0.98 for all age groups.

Table no 6: Studies showing Artificial intelligence in Forensic Odontology.

Artificial Intelligence in Oral Medicine and Radiology- A Review

ORIGINALITY REPORT

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Report- DSCDS- Criteria 2 QLMs

by Dscds .

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Word count: 4675
Character count: 26592

2.2.3: RESPONSE:

DSCDS provides ample opportunities for students to build and sustain their innate talent/aptitude through extramural activities. We recognize that every individual student is endowed with his/her own distinct potential. This may manifest in fields as diverse as academics & research, to sport or even in a cultural field. An effective means to identify this in our students may be available as early as in the first year of their study when students exhibit greater interest or curiosity in a particular activity/subject. We, at our institution strive to identify these talents & nurture them through effective means so that every student achieves an all round holistic growth as both an individual and as a healthcare professional.

While academics forms the cornerstone of our endeavors where in our students are put through a robust training mechanism which involves theory classes, practical/clinical postings, exams, etc., students are also encouraged to participate in student conferences, competitions, CDE programs workshops as organized by the college to ensure that every student is kept abreast with the latest in Dentistry.

The institution through the Department of Public Health Dentistry conducts many camps in and around Bengaluru in which interns & post graduate students take part on rotation basis. These camps while being of enormous help to the underprivileged sections of the society, also help in the growth of our students as able administrators, clinicians and as responsible citizens with awareness of their social responsibilities. Important days in the healthcare & community domain like Oral Health Day, World No-Tobacco Day, Womens Day, Oral Cancer Day are celebrated within & outside of college by our students by conducting Skits, Flash Mobs, Dances, Rallies, Processions.

DSCDS gives equal importance for both classroom and beyond classroom activities to keep students interested. Vibrant cultural & sports activities makes up the remainder of the students' talent & skill development experience. Having students with us from different parts of the country, a diverse & comprehensive cultural week is celebrated wherein a theme is selected in advance and celebrations like events & competitions are planned accordingly. A student council has been constituted which plans to bring DSCDS various beyond classroom activities through like fresher's day, graduation day international women's day, teacher's day, international yoga day, children's day, convocation ceremony to list a few. The cultural committee and the sports committee in accordance with the student council take decisions with regards to scheduling and conducting the events in an organized manner. Students are also encouraged to keep fit and take active part in sports with the intention of inculcating a sense of fair play & teamwork. Tournaments for both indoor & outdoor games are conducted annually wherein many students participate. Some of our students have also represented the institution at the state & national level games and have brought us many accolades.

2.3.1: RESPONSE:

Our institution focuses extensively on Student-centric learning, which is reviewed, renewed and reinforced periodically by various committees monitoring the Teaching-Learning system.

Experiential Learning (EL):

EL is an essential learning method in dentistry and inculcated in our students by training through pre-clinical exercises such as, hands on learning on models and phantom heads. Then, they begin handling patients by first learning the verbal and communication skills through soft skill programs tailored for the same. Students are then trained in clinics, from taking case history to case discussions, chair side viva and then start with the application of treatment procedures on patients once they have been trained and are confident enough.

Integrated/Interdisciplinary Learning: Inter-disciplinary Learning is ingrained in our students through integrated methods which help in training our students to learn and deliver sound & comprehensive treatment planning. Students are encouraged to discuss each case with all departments and involving their opinion in treating the patient as a whole. Inter departmental committee exists within the institution through which interdepartmental meets are periodically conducted to ensure comprehensive treatment plan is achieved for every single patient.

Participatory Learning:

Students from first BDS are trained to actively participate in seminars and scientific events conducted in the college as well as elsewhere in competitive fora, to enhance their learning through active participation.

Problem Solving:

Students develop the problem-solving skills through exposure to Case-based scenarios, mock patient scenarios, models and power point presentations. Students are trained to comprehensively analyze and deduce the appropriate solution customized for individual patients regarding diagnosis, treatment planning and possible treatment outcomes.

Patient-Centric and Evidence-Based Learning:

Right from their formative pre-clinical days our students are guided and trained to have a patient-centric and evidence-based clinical approach that keeps the best interests of the patient at the core of our treatment philosophy. To augment this, students are adequately trained to develop necessary communication skills to garner patients' trust and confidence, base their diagnosis & treatment planning through evidence-based learning backed by latest scientific knowledge.

Learning In The Humanities:

With the help of our Public Health Dentistry Department, we organize many camps, public outreach programs in nearby areas and have even adopted a village to cater to the oral health needs of the people there. With this, our students & faculty get an experience of the various cultures, philosophies of different groups of population, understand the problems faced by the common man and derive the needed skill set to deal with such scenarios. Teamwork, social responsibility, critical thinking are some of the key areas our students get trained for as learning in the humanities.

Self-Directed Learning (SDL):

With increased access to information digitally, the college has Provided HELINET & NDLI access in the Library for our students, to acquire adequate Self-directed learning. Students are encouraged to present seminars, journal clubs, dissertations which promotes self-directed learning. The institution also encourages peer teaching to promote SDL.

2.3.3: RESPONSE:

In addition to traditional teaching methods, our institution ensures that the Teaching-Learning sessions are made more interesting and interactive by making use of ICT-enabled tools & platforms. This has been made possible with the use of Power-point presentations which is conducted in all the classrooms which are sufficiently equipped with Overhead projectors and screens. The college has a dedicated Wi-Fi connection for augmented educational delivery.

The challenges of the pandemic times, has brought a positive change in the teaching-learning methodologies by our faculty who have been delivering e-content using various virtual platforms like ZOOM, WEBEX and GOOGLE TEAMS to ensure continuous education to the students. Many classes, meetings & discussions are supplicated with use of these platforms. Online video clippings of relevant study material are also used from free platforms like YOUTUBE and such clips are hyperlinked to PPT presentations. Some innovative adaptations of these virtual practices are followed in Department of Oral Pathology where histopathology slides are focused in a digital microscope to show the intended field on a big screen for the clarity of all students simultaneously.

The messaging platform of WHATSAPP also serves as a virtual notice board for students where circulars and announcements are made available instantly by messaging the required content on it. All students are enlisted according to their year in respective class groups on WHASTAPP and are kept in virtual communication accordingly.

Many clinical departments make use of digital means to treat patients which also serve as a means of learning for students.

The Dental Management Software Clinical patient management software that is in use in every department of the college enriches the subject knowledge of the students. Through this, every patient is mapped and his/her treatment particulars, radiographs, reports are all uploaded in a digital format after scanning. This way, the patient particulars are visible for all in the college to see, to follow up on previous treatments, to have interdepartmental/interdisciplinary discussions and to arrive at the best diagnosis & treatment plan for every patient. This software helps us become a paperless campus as even the radiographs are instantly uploaded into the server and can be accessed in any department through the login portal of the X-ray server. Our institution possesses latest technological innovations which assist in the diagnosis of dental conditions like Radio visuography, Digital Ortho pantomograph, and digital microscope, nemoceph.

Department of Oral Medicine uses a digital OPG machine to record & house radiographs of patients in a digital format while Department of Conservative Dentistry makes use of Microscopes in dental treatment whose images are stored in a digital format on computer systems which aid in the clinical Teaching-Learning process.

The central library is equipped with access to e-resources from different sources like HELINET, NDLI, etc. These platforms give students access to books, journals and events in which they can learn and participate in various competitive fora.

2.3.5: RESPONSE:

DSCDS understands that in today's constantly evolving world, especially since the pandemic, inculcating creative thinking in students is an important way to hold on to their interests which has a direct bearing on their performance and eventual success. Therefore, our institution attaches utmost importance in employing creative teaching methods with an intent on inculcating innovative thinking in students.

To accomplish this, teaching methods have been redesigned, with various techniques of teaching being employed in every department. Spotters of material and instruments are maintained so that the students are taught about the various armamentarium used for variety of procedures. Quizzes, group discussions are regularly held at department levels to keep students updated with the new advancements. These exercises also help teaching students the essence of team work to arrive at a effective solution to a particular issue by way of consensus. Assignments and projects given are more practical in nature wherein students can appreciate results and this kind of hands on Project-Based Learning not only encourages participation but also has increased their curiosity & interest in the subjects. Pre clinical patient simulation labs are areas where students are allowed to work on patient simulators and this immensely helps them to deal with life-like situations which they might encounter at a later date. Tooth carving is another area where students get creative with their hand skills and are trained to carve out life-like teeth. The hand-eye co-ordination has improved with this practice. They are also sent out for intercollegiate competitions, table clinic preparations, paper & poster presentations, where their imagination & ability to come up with creative ideas are given wings.

The institution also stresses on learning and practicing evidence-based dentistry. The various case-based discussions, journal clubs are times when students are made to come up with tangible solutions and treatment approaches all of which is intended to promote analytical skills. Students also develop the skills of teamwork and group discussions by this and also enables the students to discuss and present the projects to a larger audience which helps in boosting their confidence levels.

Our institution has also made available many CDE programs to introduce the concept of IPR & Patents to students with the intention of giving them an edge in areas of entrepreneurship & startup culture. DSCDS encourages students to pursue research in various fields of dentistry. Students are guided to apply for research grants at state & national level platforms and some students have even been successful in receiving scientific research grants to take forward & complete their research.

The institution also recognizes that a healthy mind & body is essential for any growth. For this, the college has a dynamic soft skill program, counseling sessions and a physical activity room that makes sure that all the wellness needs of all our students are met with.

2.5.1: RESPONSE:

DSCDS strictly adheres to the academic calendar as mandated by RGUHS & is prepared in advance so as to keep all the stakeholders informed of the key dates through the academic year which includes amongst many other schedules, the dates for commencement of academic session, dates for fee payment, Continuous Internal Evaluation (CIE), examination schedules.

The Institution ensures annually, three CIEs are conducted for undergraduates, in the form of written theory examinations, clinical / practical examinations and viva-voce. The exact dates for the CIE are announced through circulars and WhatsApp group messages, well in advance so the students have ample time to plan and prepare. The institution follows a centralized system to conduct the CIE. The Examination Hall/s are under video surveillance. The CIE question paper pattern and duration are set as per RGUHS guidelines. The set question paper/s are submitted to the examination coordinator who then is responsible for the safe keeping of the question paper and timely disbursal of the same on the day of the CIE. After the exam process, the answers scripts are sent to the respective departments where faculty members evaluate them. The list of each CIE marks is displayed on the departmental notice-board for the students to view. The evaluated scripts are also shared with the students and any doubts or issues regarding the valuation are clarified and resolved by the concerned subject faculty. Makeup assignments are given and remedial test/retest is conducted for students who have missed the CIE and also for poor performers. Following the theory exams, practical exams are conducted. Three practical CIEs are conducted for 1st, 2nd and 3rd BDS students as per the CIE time table and as for the 4th year students two posting end test are conducted at the end of their clinical posting in the respective departments. Depending on the availability of time, one common final practical test is conducted just before the submission of the final marks to the university. The average marks of three such continual internal assessments are then considered as the final internal marks which is then sent to the University. In order to maintain total transparency, the final marks list is displayed on the notice board for the students to see and their signatures are obtained before uploading the marks to the RGUHS website.

Post graduates are continually assessed on various exercises like Seminars, Journal Club presentations, pre-clinical & clinical work, scientific papers & posters presentations at conferences, conventions, etc. Feedback for all these are provided by the respective departmental faculty and corrective actions needed are undertaken. The Post Graduate students have 2 University examinations, one at the end of their first year which assess them in basic sciences and one more at the end of their 3rd year which is the main exam. Mock exams are conducted prior to University exams in the 1st and 3rd MDS years. Mock practical examinations are conducted by departments wherein one departmental faculty becomes an internal examiner & another faculty member from a different college is invited as an external examiner to assess the postgraduate student.

2.5.2: RESPONSE:

The institution makes effective arrangements for the smooth conduct of the CIE. The CIE question paper pattern & duration are set as per RGUHS guidelines. After the exam process, the answers scripts are sent to the respective departments where faculty members evaluate them. The evaluated scripts are shared with the students and any doubts or issues regarding the valuation are clarified and resolved by the concerned subject faculty. Grievances reported are generally related to the nature of questions asked in the question papers, totalling mistakes, and clarifications related to the quality of answers written for which marks are awarded. The faculty deal with all these grievances on an individual case-to-case basis. The grievances are patiently listened to, addressed, and resolved. In order to maintain total transparency, the final marks list is also shared with the students, and their signatures are obtained before uploading the marks to the RGUHS website.

The exams conducted by the university are done under strict video surveillance by the University authorities themselves. The University appoints an Observer for the entire duration of the exams. Along with this, there is also a flying squad of the University that makes surprise visits to the examination hall to make sure that the examination process is being conducted in a fair manner. After completion of every exam, the student's answer scripts are scanned and uploaded for digital valuation on the same day by designated staff members. To maintain transparency, the scanning is done under video surveillance and in the presence of the exam chief superintendent and university-appointed squad member. After the results of the university examinations are announced, if students have any grievances regarding the evaluation or the marks obtained, the same is brought to the notice of the student support, welfare, and grievance redressal committee of the college. The committee is chaired by the principal along with other faculty members and office personnel. The committee provides guidance to the students on the application process within the stipulated time as mandated by the university. The University has a provision for the students to apply for a photocopy of the answer script and also to apply for re-totaling. On behalf of the students, the Liaison Officer of the college receives the request application form and letter duly signed by the student and countersigned by the principal and submits it to the university. Once the student receives the photocopy of the answer scripts the committee encourages the students to get it reviewed by the college faculty of the respective subject. Further, if required the committee guides the students to apply for re-totalling. After the University resolves the grievance and a response is received by the institution it is conveyed to the students and also to the grievance redressal committee.

2.5.3: RESPONSE:

1. **Examination procedures:**

Annual examinations are conducted as per RGUHS regulations. The entire process is digitized starting from a downloadable question paper as sent by RGUHS, the copies of which are printed 10 mins prior to the start of each exam. Students are instructed to compulsorily carry their exam hall tickets and student IDs. Students are not allowed to leave the examination hall during the first 30 minutes of the exam. Students must obtain the Examination Chief Superintendents' permission to leave the hall anytime thereafter and before the end of the examination. Students who carry any unauthorized or prohibited material/s into the examination hall are liable to face disciplinary action.

2. **Process integrating IT:**

Exam application form for BDS and MDS is downloaded from the RGUHS website. Students, internal assessment marks, and attendance are uploaded well before the university exams. Answer scripts are scanned and uploaded through the RGUHS website, immediately after the examination. Digital valuation of the uploaded answer scripts is completed within the allotted date. Practical exam marks and viva-voce are conducted within 2weeks of the completion of the Theory exams usually. The marks obtained are uploaded through the RGUHS website at the end of the exam. Students can avail the photocopy of the answer script through online request portals.

3. **Continuous internal assessment system:**

Three centralized CIEs are conducted in an academic year for the undergraduates and the average of these tests is sent to the university. One centralized mock exam is conducted for the first and final-year postgraduate students prior to the university exam.

4. **Competency-based assessment:**

The competency of the students is assessed based on their habitual and consistent use of knowledge, technical skills, clinical reasoning and communication in daily clinical practice. This is done for both UG and PG students by internal assessments, chair side discussions or viva, and direct observation and feedback by all the faculty of the respective departments.

5. **Workplace-based assessment:**

Workplace-based assessment is done for both undergraduates and postgraduates in order to assess their clinical competency through case-based discussions and direct observations. This procedure involves patients in clinical departments and laboratory procedures/patient simulators in non-clinical departments. The 3rd and 4th BDS students are assessed during the end posting tests by the faculty of their respective departments and the postgraduates are assessed throughout the regular clinical assessments and also during their mock exams.

6. **Self-assessment:**

After completion of each chapter, the undergraduate students are given written tests and are made to evaluate themselves. Also, a class quiz is conducted for the students which motivate them to interact with their peers and perform well.

7. **OSCE/OSPE:**

Objective structured clinical examination is followed by all the clinical subjects. The students are assessed for various clinical skills – communication, history taking, physical examination, diagnosis, problem-solving, interpersonal skills, etc. The objective structured practical examination is followed by all the non-clinical/preclinical subjects. The students are assessed for practical skills – handling of materials, use of patient simulators, models, specimens and slides, and spotters.

2.6.1: RESPONSE:

Institution strictly follows the Learning Outcomes (generic and programme-specific) and graduate attributes as stipulated by the affiliating RGUHS and **the said document is uploaded for immediate reference and records.**

Learning outcomes of the BDS course: The Under-Graduate Dental student should have:

- Adequate knowledge of the scientific foundations on which dentistry is based and relevant scientific methods, principles of biological functions
- Adequate knowledge of the development, structure and function of the teeth, and other oral tissues both in health and disease and their relationship and effect on general-state of health, physical and social well-being of the patient.
- Ability to diagnose, plan treatment and manage any complications.
- Competency in control of pain and anxiety during dental treatment.
- Skills to carry out required investigative procedures and ability to interpret laboratory findings.
- Ability to promote oral health and help prevent oral diseases

Learning outcomes of the MDS course: The Post-Graduate Dentist should be able to:

- Describe etiology, patho-physiology and principles of diagnosis and management of common problems within the specialty
- Acquire and update knowledge by attending courses, conferences and seminars relevant to specialty
- Carryout research with the aim of publishing or presenting the work at various professional forums
- Acquire adequate skills and competence in performing various procedure required in the specialty
- Should be able to treat complex cases in their respective specialties and also by interdisciplinary approach

DENTAL GRADUATE ATTRIBUTES: Dental Graduates will have to be trained to have these attributes.

Academic attributes

- Professionalism and ethics
- Community oral health perspective
- Soft skills
- Perform all the above and be successful in evaluation by the guidelines of the regulating body and continuously upgrade their skills.

Implementation, evaluation and assessment of Learning Outcomes & Graduate Attributes:

- Through planned curriculum for each year followed by periodic internal assessments, yearly exam as per regulations of the university. Under Graduate (UG) students will have 3 internals of theory and practicals/clinicals.
- Pre clinical and clinical posting as per university regulations for both UG and Post Graduate (PG) students
- PG students will have clinical quota, evaluation of seminars, journal clubs , case presentations, thesis, library dissertation, university theory and clinical examinations.
- CDE programs/workshops
- Camps, peripheral postings
- Curated programs on soft skills for each year

All these are communicated to the students and faculty through college notice board, website and during undergraduate and post graduate orientation programme at the commencement of academic year.

2.6.3: RESPONSE:

Teaching, Learning & Assessment is a continuous & at the same time, a dynamic process that we at our institution take very seriously. We have adopted the GROW (Goal, Reality, Option & Will) model of coaching at our institution. This effective & structured mechanism of coaching has been the backdrop of our student training methods. Along with this, we have constituted a two pronged approach to achieve the required teaching- learning outcomes.

a. Measures directed at training the faculty
b. Measures directed at the students

The faculty are kept abreast to the latest and effective teaching methodologies and training methods by way of faculty development programs, teacher trainer programs and workshops that are conducted by the University and also by our institution. The faculty take theory, practical & clinical sessions for the students as per the academic calendar and all of this is whetted by the head of the respective department so that validated & relevant content is made available to the students. A feedback mechanism is also put in place wherein the students give a faculty feedback to a dedicated feedback committee in college. This mechanism makes sure the quality of teaching is maintained and also pointers given by this mechanism is used to improve the entire teaching-learning mechanism.

The students are taught keeping a structured curriculum development plan as the backbone. The teaching is carried out through various modes of blackboard and whiteboard teaching, power-point presentations, online platforms like zoom and WEBEX to stream classes when required. The students are assessed at regular intervals by means of continuous internal examinations (CIE), posting end tests, chair-side viva session, seminars, journal clubs, case discussions, etc. keeping in mind that dentistry is a highly skill based program, we have also incorporated pre-clinical & clinical exercises for students to train & test their clinical skill abilities. In addition to this, students who need extra attention and academic help are provided with remedial sessions & exams.

Our institution recognizes the need to change from a passive, lecture driven teaching mindset to a more active, engaging teaching-learning experience wherein students are encouraged to get hands on experience in learning topics, skills, etc made possible through the various continuous dental educations programmes, clinical workshops, conducted in college along with the numerous research opportunities & projects that the students are encouraged to apply and take up at the various platforms. Students also take part in various conferences & conventions to present scientific papers, posters, table clinics, models, etc wll of which add to their experience of learning better.

In addition to all these measures, we also have structured assessments like theory MCQs, home assignments, practical record completion, OSPE/OSCE training, group discussions on topics, etc. These constitute an array of our formative assessment framework and this coupled

with the regular CIEs, posting end tests & practical/clinical examinations, which are our summative assessment methods, certainly align our institutional teaching-learning methodology in line with the stated programme specific Learning Outcomes.

2.6.4: RESPONSE:

Communication regarding student performance & progress was decentralized and was done by individual by each department. The attendance extract & progress report of each student is sent to the parents through email or communicated over a phone call in cases where email facility wasn't feasible. Outstanding issues/problems were brought to the notice of the parents and discussed. Corrective measures where required are carried out in the form of:

i. One-on-one counseling,
ii. Remedial postings,
iii. Remedial exams,
iv. Meetings with their respective mentors were conducted to help students wherein any outstanding issues were discussed and tried to be solved.
v. Students who suffered from anxiety and low self-esteem were counseled and were given extra help and attention by means of counseling with an external expert.
vi. Additional theory tests, practical/clinical examinations were conducted for slow learners to improve both their confidence & performance in the examinations.
vii. The students are made to solve previous years question papers to aid them in preparing better for exams.
viii. Advanced learners were also identified and were individually encouraged to work more, take up student research activities & competitions organized by the University & Indian Council of Medical Research.
ix. They were helped with selecting topics they were interested in so that the same could be presented as short studies/ papers at various academic forums.

All these issues were discussed with the parents and necessary help was provided. Proceedings were briefed to the office.

With all these efforts we have noticed that our students have benefitted from these measures. We have seen an improvement in their performance, improvement in their outlook towards the course where they were counseled by the experts. These measures have been helpful and we will continue our efforts to further streamline them in order to provide greater assistance to the students who require it.

Going forwards, from this academic year on, a structured parents – teachers committee has been formed with defined roles & responsibilities for all members involved. Regular Parent Teacher Meetings will be scheduled according to a detailed policy document wherein a particular day & date will be earmarked for a physical meeting between parents & teachers of all departments. Where a physical meet wouldn't be feasible, alternate arrangements would be made to apprise the parents of their respective wards' progress/issues, etc. Meetings will be held accordingly and all the proceedings, outcome report & analysis will be submitted to the Office. All student grievances will continue to be solved albeit in a more planned and structured approach.

Report- DSCDS- Criteria 2 QLMs

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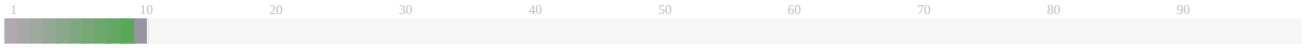

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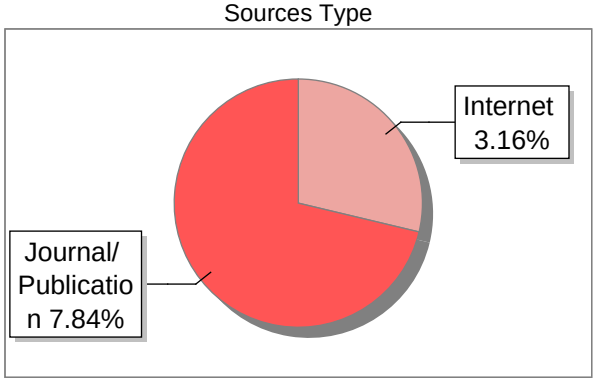

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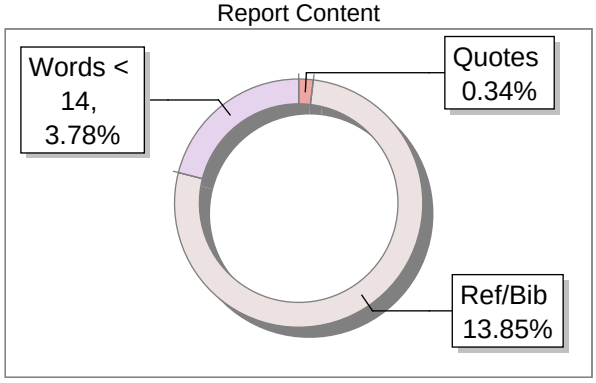

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1	In Vivo Endoscopic Optical Coherence Tomography of the Healthy Human Oral Mucosa by Albrecht-2020	8	Publication
3	www.ncbi.nlm.nih.gov	<1	Internet Data
4	www.ncbi.nlm.nih.gov	1	Internet Data
5	www.ncbi.nlm.nih.gov	1	Internet Data
6	balkandentaljournal.com	1	Internet Data
7	moam.info	1	Internet Data

REVIEW ARTICLE

REVOLUTIONIZING ORAL CANCER DETECTION: FUSING THE POWER OF LIGHT AND AI FOR EARLY DIAGNOSIS

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Abstract:

Early detection and accurate diagnosis of oral cancer are critical for improving patient prognosis. However, current screening methods often fail to identify all lesions, highlighting the need for more effective approaches. Optical Coherence Tomography (OCT), an advanced optical imaging technology, shows promise in detecting malignant cells. OCT images require specialized interpretation due to their detailed information. Artificial Intelligence (AI), leveraging trained algorithms, can analyze imperceptible variations, overcoming barriers that have delayed OCT integration into oral cancer screening. This review explores OCT's depiction of precancerous and cancerous oral lesions and discusses AI's role in enhancing detection and diagnosis.

Keywords: Oral cancer, early diagnosis, Optical Coherence Tomography (OCT), Artificial Intelligence (AI), Cancer detection

Introduction: Globally, oral cancer ranks sixth in cancer incidence, presenting significant health challenges [1]. Oral squamous cell carcinoma (OSCC), the predominant type, emphasizes the critical importance of early detection for effective treatment and improved survival rates [2, 3].

Optical Coherence Tomography (OCT) is an advanced, noninvasive imaging technique utilizing interferometry to produce high-resolution images [4]. Its rapid, three-dimensional imaging capabilities have made it increasingly valuable in various medical specialties, including oncology [5].

Artificial Intelligence (AI) has shown remarkable accuracy in biomedical imaging, aiding in personalized cancer treatment decisions [3]. The integration of AI into oral cancer research and clinical practice holds promise for improving patient outcomes [6]. AI, a field of computer science simulating human intelligence in machines, employs Machine Learning (ML) and Deep Learning (DL) techniques to analyze complex datasets and enhance diagnostic accuracy [7].

Mechanism of OCT: OCT uses light sources to penetrate tissues, interacting based on tissue properties such as absorption and reflection [1]. Unlike ultrasonography, OCT offers higher resolution and different receiving mechanisms, facilitating detailed imaging [7].

Interferometry is fundamental to OCT, involving the division of light into reference and sample beams to create interference patterns [1]. This principle enables OCT to capture intricate structural details from tissues, crucial for precise clinical imaging.

By combining the imaging capabilities of OCT with the analytical power of AI, researchers aim to innovate oral cancer detection, potentially improving screening accuracy and patient outcomes. (fig1)

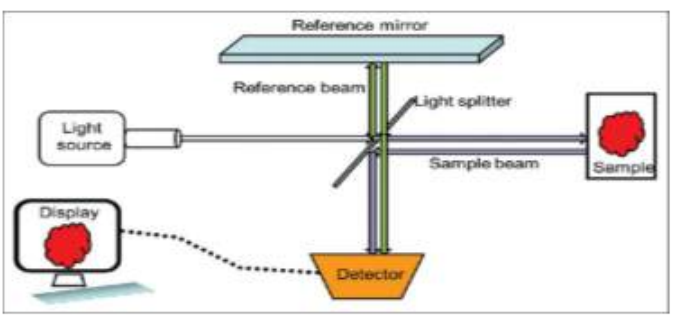


Fig1: Basic Principle of OCT [1]

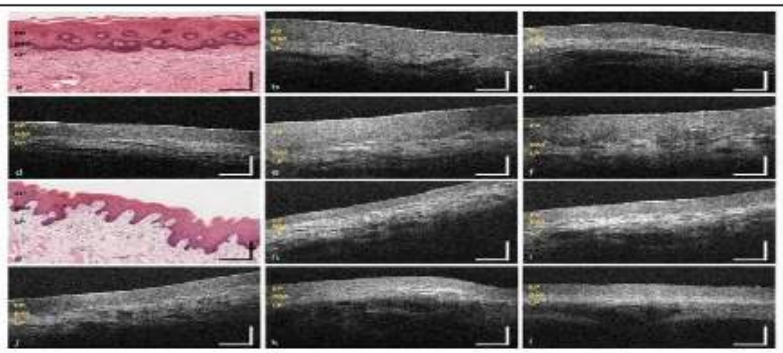
Different Types of OCT Devices

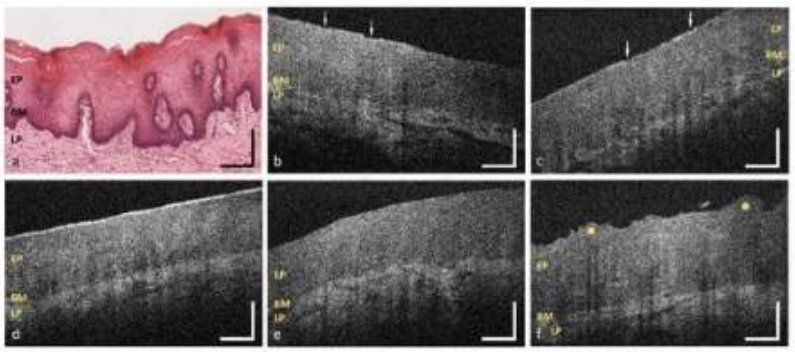
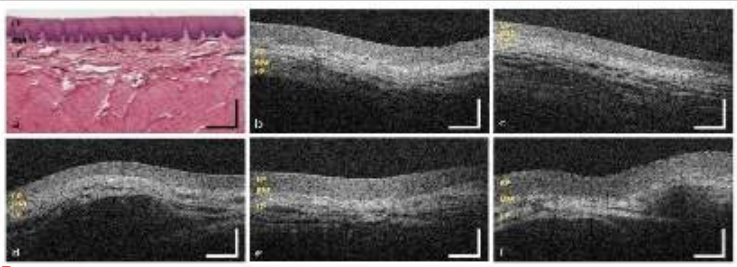
Optical Coherence Tomography (OCT) devices are classified based on their reference arm optics into time-domain and frequency-domain variants. Among frequency domain devices, two main types are spectral OCT (SD-OCT) and swept-source OCT (SS-OCT). SS-OCT employs an ultrahigh-speed laser beam with a wavelength in the kilohertz range and a center wavelength of 1300 nm. This configuration enhances system sensitivity, penetration depth, resolution, and scanning speed (achieving imaging in one second or less), thereby reducing acquisition time. The axial and transverse resolutions of SS-OCT are determined by the focal spot size and the width of the laser beam line, respectively [7].

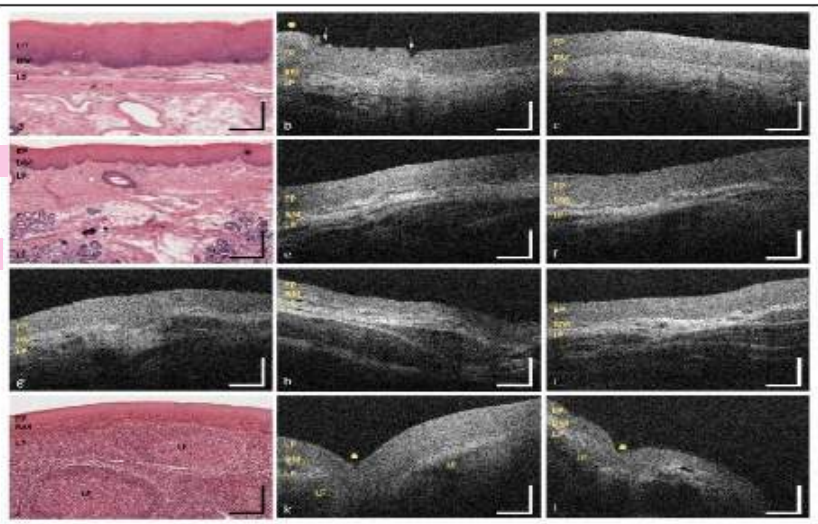
Time-domain OCT (TD-OCT) involves measuring optical path lengths (OPLs) by moving a reference reflector, while spectral domain OCT (SD-OCT) or Fourier domain OCT (FD-OCT) calculates OPLs using various wavelengths without requiring a moving reflection mirror. An SD-OCT system shares similar components with TD-OCT but includes additional elements like a grating, sensor array (typically a CC-array), or spectrometer [8].

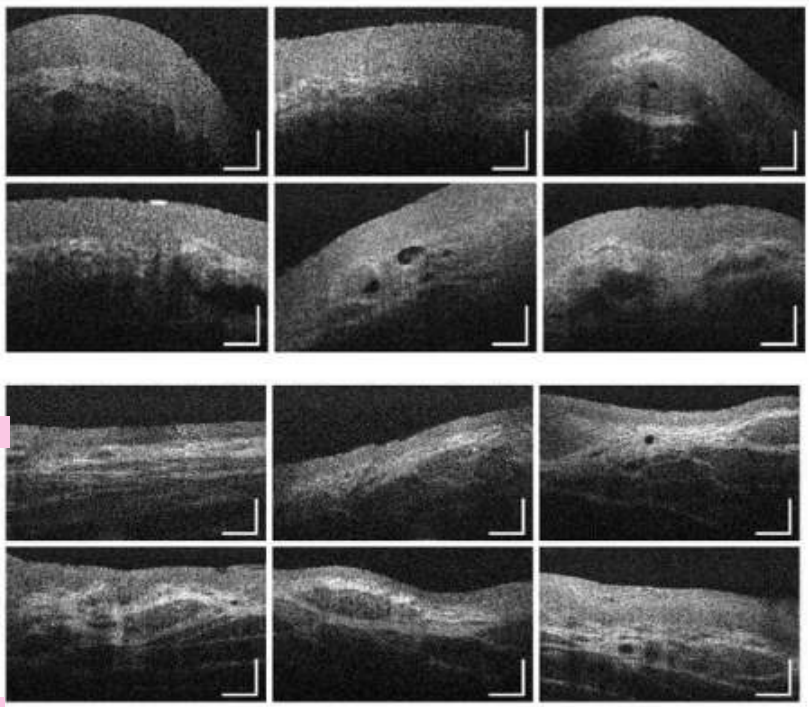
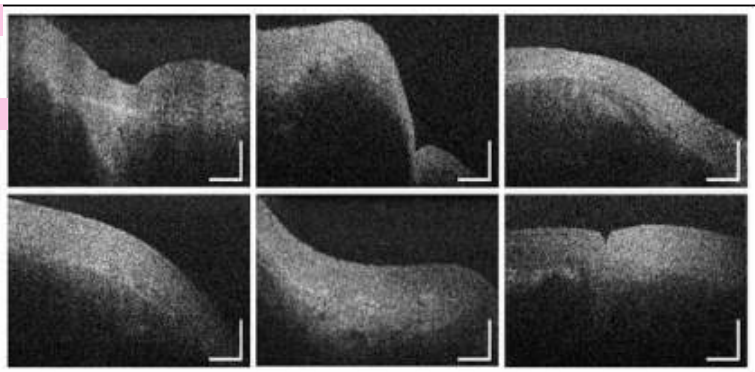
Normal Mucosa in OCT

A study conducted by Albrecht, et al. in 2020 on healthy human oral mucosa in OCT image [9] (table 1)

Normal Oral Mucosa	Characteristics in OCT	OCT and Histopathology Images
Labial and Alveolar Mucosa	The epithelial surface of the alveolar mucosa was found to be intact in 92.2% and 95.4% of measurements, with a homogeneous layer observed in 96.6% and an average thickness of 142 ± 15 µm	

		Optical coherence tomography (OCT) images show (b–f) the labial mucosa and (h–l) the alveolar mucosa. Representative images include the upper lip (MP1) (b, c), lower lip (MP3, MP4) (d–f), upper alveolar region (MP2) (h, i), and lower alveolar region (MP5) (j–l). Histological cross sections stained with hematoxylin and eosin (HE) depict the labial and alveolar mucosa (a, g) with modifications noted (EP: epithelium, BM: basement membrane, LP: lamina propria. Scale bars: 200 µm)."
Buccal Mucosa	Analysis of OCT images of the buccal mucosa showed surface alterations in 30.6% of cross-sections, a homogeneous epithelium in 74.6%, and an intact basement membrane in 60.8%. Vascular supply appeared moderate in 67.7%, but additional features were not discernible due to the presence of fat tissue and limitations in imaging depth..	 OCT images of the buccal mucosa are shown in (b–f). These images depict the (b, c) anterior (MP6), (d) central (MP7), and (e, f) posterior buccal regions (MP8). Histological cross sections stained with hematoxylin and eosin (HE) illustrate the buccal mucosa, highlighting key structures such as the epithelium (EP), basement membrane (BM), and lamina propria (LP). Arrows indicate areas of epithelial surface alteration, while yellow dots represent uneven surface profiles. Scale bars: 200 µm."
Sublingual Mucosa	OCT images from the ventral tongue and mouth floor showed intact epithelial surfaces, homogeneous structures, and extensive vascular	 OCT images of the ventral tongue (**b**,**c**) and the mouth floor

	supply due to large sublingual arteries and veins. 86.6% of sections were highly vascularized.	(MP11) (**d**–**f**). The sample pictures represent the anterior (MP9) (**b**) and posterior sublingual region (MP10) (**c**). Exemplary HE stained histological cross sections depicting the sublingual mucosa (**a**). (EP: epithelium, BM: basement membrane, LP: lamina propria. Scale bars: 200 µmm.)
Hard Palate	The hard palate shows various alterations in the epithelial surface, with convex ridges (38.8%) corresponding to transverse palatal folds. Approximately 37.5% of the epithelial layer exhibits inhomogeneity, reflecting adaptation to masticatory function. Female volunteers tend to exhibit lower values compared to males. The basement membrane appears indistinct, and minor salivary glands are observed in 15.0% of OCT cross-sections.	 OCT images depict the (b, c) hard palate (MP12), (e, f) soft palate (MP13), (g) uvula (MP14), (h, i) oropharynx (MP15), and (k, l) palatine tonsil (MP16). Histological cross-sections stained with hematoxylin and eosin (HE) illustrate the (a) hard palate, (d) soft palate, and (j) palatine tonsil. Key features such as the epithelium (EP), basement membrane (BM), lamina propria (LP), and lymphoid follicle (LF) are identified. Arrows indicate areas of epithelial alteration, while yellow dots represent palatal ridges and tonsillar crypts. Scale bars: 200 µm.

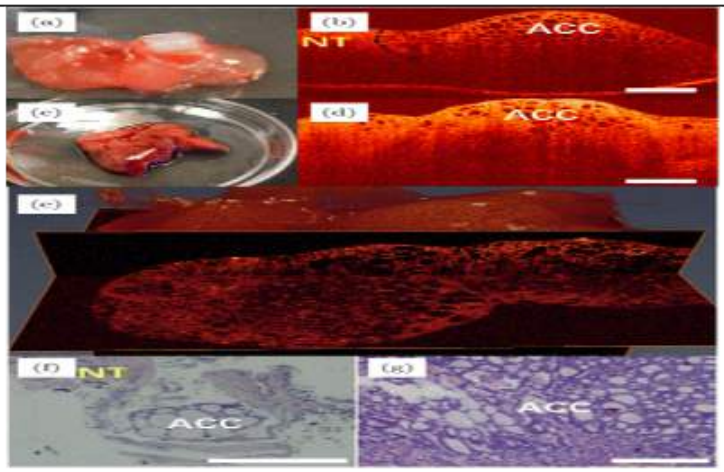
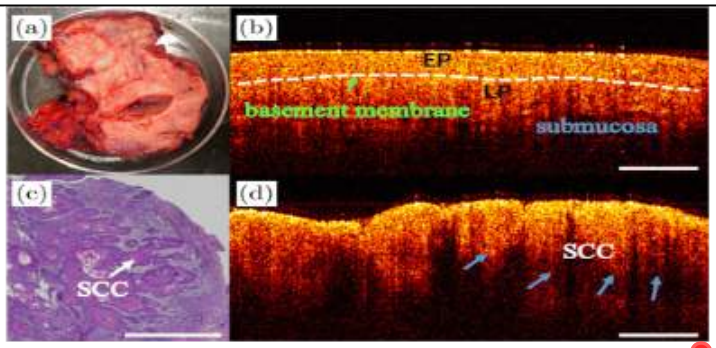
SoftPalate and Oropharynx	The soft palate, uvula, and oropharynx were evaluated for the integrity of their epithelial surface, revealing a consistently homogeneous epithelium. Significant vascularization by major vessels was observed in the majority of cases (56.1%), accompanied by a well-defined vessel network within the lamina propria. Clusters of salivary glands were identified in 47.4% of cases, indicating effective moistening of the alveolar region.	 Additional intensity-based OCT cross-sections of the mucosal tissue were obtained for the soft palate (MP13) and the oropharynx (MP15). Scale bars: 200 µm
Palatine Tonsils	OCT cross sections were used to analyze the palatine tonsil, revealing an intact epithelium in 70.6% of cases and an uneven surface profile in 87.5%. Age-related variations were noted, with reduced thickness observed in	 Additional intensity-based OCT cross sections of the mucosal tissue from the palatine tonsil (MP16) were included. Scale bars: 200 µm.

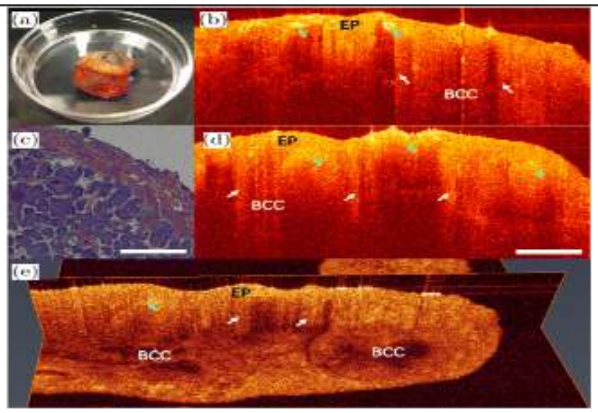
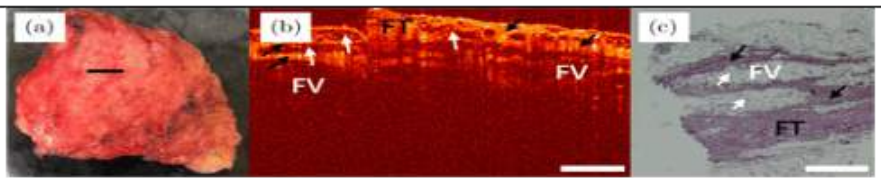
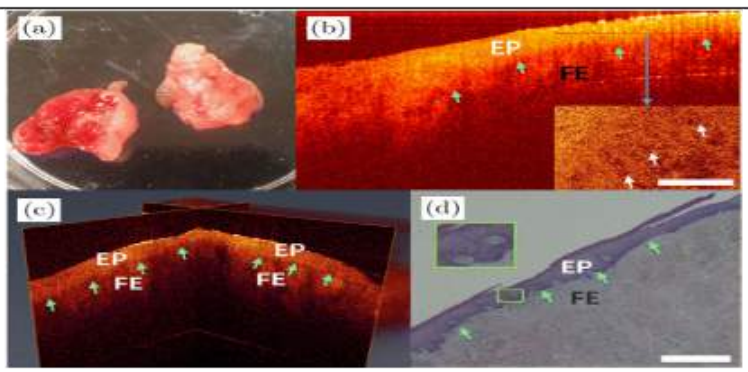
	participants aged 25-45. The basement membrane appeared indistinct in 52.2% of cases, while moderate vascularization was evident in 60.3%.	

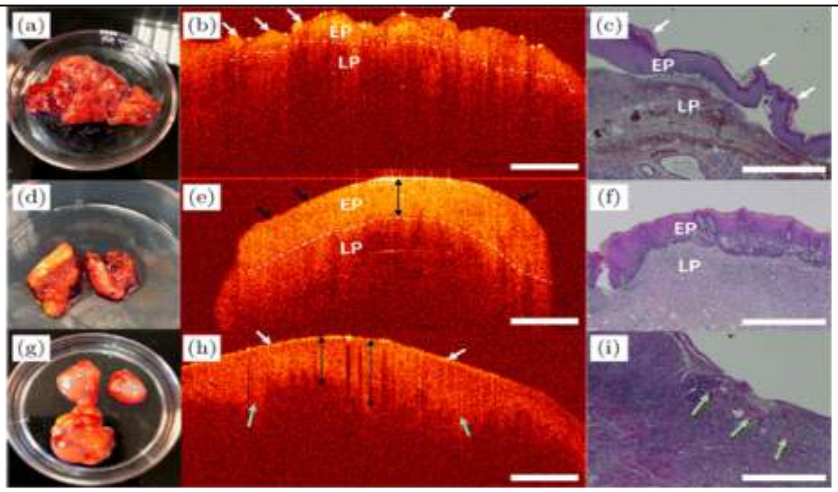
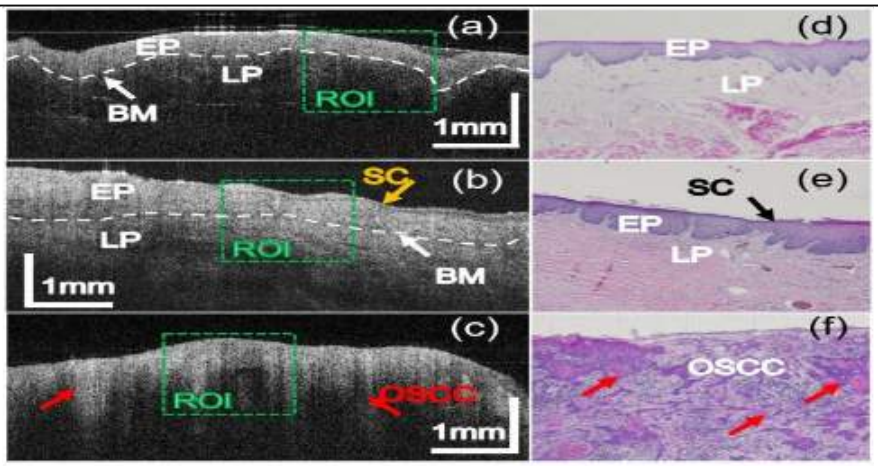
Table : 1: Normal Mucosa in OCT[9]

Cancer Indicators

Optical Coherence Tomography (OCT) images are capable of detecting neoplastic alterations in epithelial tissues characterized by abnormal cells with enlarged nuclei. Key histological indicators of malignancy include enlarged dysplastic cells, irregular stratification, basal hyperplasia, and elongated papilla cores. Dysplastic cells typically exhibit a scattered speckle pattern on OCT B-scans. Researchers have explored markers within the subepithelial tissue, basement membrane, and epithelial mucosa to differentiate between normal, premalignant, and cancerous tissues of the oral mucosa. Thickening of the basement membrane serves as an indication of tumor invasion, suggesting potential malignant changes. Both basement membrane integrity and epithelial thickness serve as reliable markers for distinguishing between invasive cancer and normal or dysplastic tissues. Dysplastic transformations may involve fibroblast proliferation, alterations in collagen and other extracellular components, and changes in the stromal environment [7].

Oral Lesions	OCT, Histopathologic images
Adenoid cystic Carcinoma	 Images of adenoid cystic carcinoma are presented as follows: (a) and (c) depict photographs of the specimen, while (b) and (d) show 2D OCT images of adenoid cystic carcinoma in palate tissue from two different patients. Additionally, (e) displays a 3D OCT image of adenoid cystic carcinoma. Corresponding histopathological images are provided in (f) and (g). ACC refers to adenoid cystic carcinoma, and NT indicates normal tissue.
Squamous Cell Carcinoma	 Furthermore, OCT images and corresponding histology of squamous cell carcinoma (SCC) are shown: (a) is a photo of the excised tissue specimen; (b) and (d) represent 2D OCT images from different positions of the same specimen, with (b) showing normal oral mucosa and (d) showing SCC. (c) presents the corresponding histopathological image of SCC. EP denotes the epithelial layer, and LP stands for lamina propria.

Basal-Cell Carcinoma	 Images of basal cell carcinoma (BCC) are presented as follows: Panel (a) shows a photograph of the excised tissue specimen, while panels (b) and (d) display 2D OCT images of BCC from the same patient. Panel (c) presents the corresponding histopathological image, and panel (e) shows the 3D OCT image. EP refers to epithelial tissue.
Lipoma	 Images of lipoma include panel (a) featuring a photograph of the excised tissue specimen. Panel (b) shows an OCT image of the lipoma, and panel (c) depicts its corresponding histopathological image. FT denotes fibrous tissue, and FV represents fat vesicle.
Fibrous Epulis	 For images of fibrous epulis, panel (a) shows a photograph of the excised tissue specimen. Panel (b) displays a 2D OCT image and an en-face OCT image derived from the dashed line of the fibrous epulis. Panel (c) illustrates

	the 3D OCT image of fibrous epulis, and panel (d) presents its histological image. EP denotes epithelial tissue, and FE stands for fibrous epulis.
Leukoplakia	 OCT images and their corresponding histopathological images of leukoplakia are presented as follows: Images (a) and (d) depict photographs of tissue samples, while Images (b) and (e) show 2D OCT images of leukoplakia from two different patients. Image (g) is a photograph and (h) is a 2D OCT image showing leukoplakia with signs of canceration. Histopathological images corresponding to (a), (d), and (g) are shown in (c), (f), and (i), respectively. EP denotes the epithelial layer, and LP stands for lamina propria.
Normal mucosa, Oral squamous cell carcinoma	 Morphological characteristics and statistical analysis of oral tissues are illustrated as follows: Panel (a) displays an OCT image of normal mucosa,

	while panels (b) and (c) show OCT images of leukoplakia with epithelial hyperplasia (LEH) and oral squamous cell carcinoma (OSCC), respectively. Corresponding histopathological images are shown in panels (d) to (f). The region of interest is indicated as 256 × 256 pixels.

Table:2: OCT images of various lesions

Integration of AI and OCT

The use of OCT in oncology faces limitations such as restricted penetration depth, scan volume, high resolution, noise, and challenges in image interpretation, which is often operator-

Stages in Integrating OCT with AI:

1. Data collection
2. Image processing
3. Development of AI models

4. Validation of AI models [11]

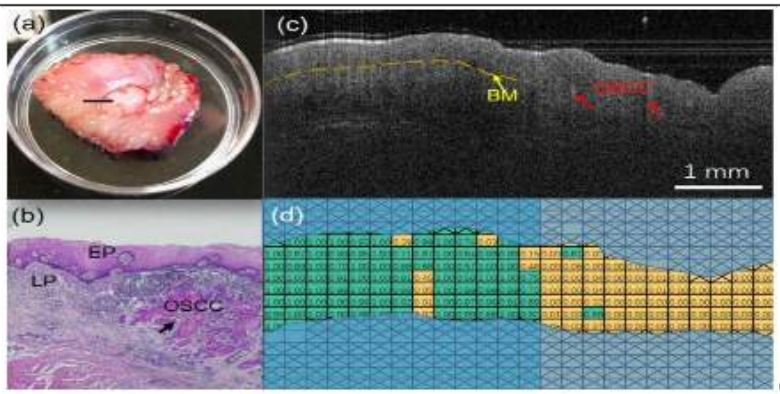
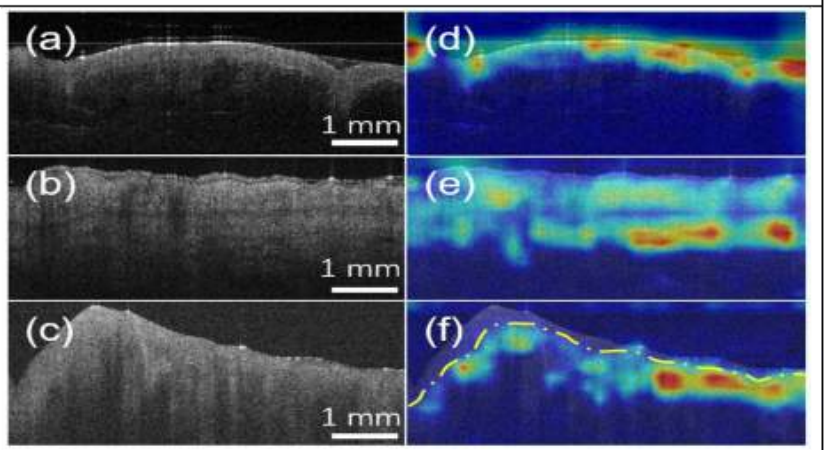
Artificial Neural Networks (ANNs) are machine learning algorithms consisting of layers of neurons, with convolutional neural networks (CNNs) being widely used for visual data analysis. These networks are trained using structured data to continuously enhance their performance.

Research employing various AI algorithms for interpreting OCT images is detailed in Table 3.

Name of the author	Year of the study	Objective of study	AI algorithm used	Outcome of the study
Pande P., Shrestha S., Park J., et al.[12]	2014	The objective of this study is to assess the feasibility of using image analysis algorithms for automated characterization and classification of OCT images in a hamster cheek pouch tumor model. Additionally, the study aims to evaluate the potential of OCT-based automated diagnosis of oral cancer.	Two algorithms were used : Algorithm 1- Algorithm for filtering A-lines in a B-scan. Algorithm 2- Algorithm for generating a binary mask corresponding to the epithelial region in a nonlayered B-scan.	The study presents a segmentation algorithm for identifying epithelial regions in OCT B-scans, achieving 80.6% sensitivity and classification accuracy, using random forest for robustness against noisy labels and overfitting.
Hwang DK,et al.[11]	2020	OCT macula cross-section scanning images from patients	AI models were developed using GGG16 and	The accuracy, sensitivity, and specificity of the models were

		with diabetic macular edema (DME) to classify the disease.	InceptionV3, with transfer learning applied.	92.82%, 93.09%, 96.48%, 95.15%, and 89.63%, respectively.
James et al.[13]	2021	The aim of this study is to develop a decision tree using an OCT diagnostic system to accurately identify and differentiate between cancer/dysplastic lesions and non-dysplastic lesions in oral cancer screening.	A MATLAB based simple algorithm-score and an Artificial Neural Network-Support Vector Machine (ANN-SVM) based model was used.	The study uses a retrained convolutional neural network to classify three-dimensional OCT images of head and neck mucosa, identifying normal and abnormal tissues with 100% sensitivity and 70% specificity. The algorithm predicts the severity of oral squamous cell carcinoma (OSCC) lesions based on 172 oral sub-sites. The scores for dysplastic lesions differ significantly, with sensitivity of 93% and specificity of 74%.
Wei Yuan,.et.l[10]	2022	The aim of this study was to develop the automatic noninvasive OSCC diagnosis approach to identify the malignant tissues on Optical Coherence Tomography (OCT) images.	This study used Multi-Level Deep Residual Learning (MDRL) network	The MDRL system attains the outstanding diagnostic performance, with 91.2% sensitivity, 83.6% specificity, 87.5% accuracy, 85.3% PPV, and 90.2% NPV in image-level, with 0.92 AUC value. Besides, it also implements 100% sensitivity, 86.7% specificity, 93.1% accuracy, 87.5% PPV, and 100% NPV in the resected patch-level.
Yang, Z.; Pan, H.; Shang, J.; Zhang, J.; Liang, Y.[2]	2023	To assess deep-learning-based algorithms for OCT images to assist clinicians in oral	Three CNNs(convolutional neural networks), including LeNet-5, VGG16, and ResNet18, and Machine learning	CNNs outperform machine-learning in detecting and diagnosing oral cancer, with accuracy of 92.52% and classification accuracy of up to 96.76%, demonstrating their logic and interpretability in OCT images.

		cancer screening and diagnosis. .		

Oral lesion	OCT image interpretation by AI
Oral squamous cell carcinoma	 (a) displays an image of the excised tissue specimen. (b) presents a histopathological image where the normal region is on the left and the cancerous region is on the right. (c) shows the OCT image corresponding to (a). (d) depicts the prediction visualization of oral squamous cell carcinoma (OSCC). [Source: Reference 2]
Normal mucosa, Oral squamous cell carcinoma	

	Grad-CAM visualization on OCT images of oral tissues is described as follows: (a–c) depict OCT images of normal mucosa, epithelial hyperplasia (LEH), and oral squamous cell carcinoma (OSCC), respectively. (d–f) show the corresponding activation maps highlighting distinct feature aggregations. [Source: Reference 2]

Table:3: Various studies conducted on integration of AI and OCT

Advantages of Integrating OCT and AI

1. **Early Detection:** AI can detect subtle changes in OCT scans that may be overlooked by human observers, enabling early identification of diseases or abnormalities.
2. **Improved Accuracy:** AI algorithms can analyze OCT images with exceptional precision and accuracy.
3. **Speed and Efficiency:** AI processes OCT images much faster than humans, leading to quicker diagnosis and treatment decisions.
4. **Quantitative Analysis:** AI enables quantitative analyses of OCT data, providing precise measurements crucial for monitoring disease progression, treatment efficacy, and research purposes.
5. **Accessibility:** AI's widespread adoption can extend advanced diagnostic capabilities to regions with limited access to specialized healthcare professionals.
6. **Enhanced Research Capabilities:** Combining OCT and AI accelerates medical research by providing large datasets for studying diseases, drug responses, and treatment outcomes, potentially leading to significant breakthroughs [2, 7, 11].

Limitations of Integrating OCT and AI

Challenges include the potential deskilling of physicians due to increased reliance on automation, AI's limitation in holistic clinical decision-making, the necessity for robust datasets to train AI models, and difficulties in accommodating the inherent ambiguity and variability of clinical medicine. Overcoming these obstacles requires standardizing data labeling, validating automated interpretations, and developing supportive infrastructures. Furthermore, supplying OCT imaging data for AI algorithms necessitates additional research [2, 7].

Conclusion

AI demonstrates promising diagnostic performance with high sensitivity in oral cancer detection. Continued advancements in image acquisition technology and AI algorithms are expected to further enhance diagnostic accuracy. AI algorithms have shown encouraging results in interpreting OCT images of oral mucosa, distinguishing between normal epithelium and precancerous or cancerous lesions. While integrating OCT and AI into clinical practice may take time, ongoing developments in AI for OCT image interpretation pave the way towards automated oral cancer screening using OCT

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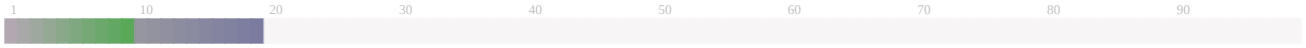

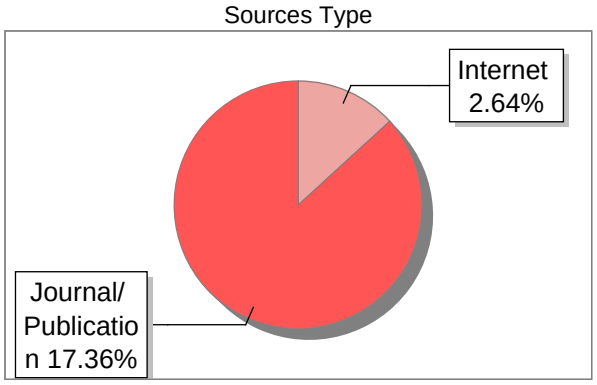

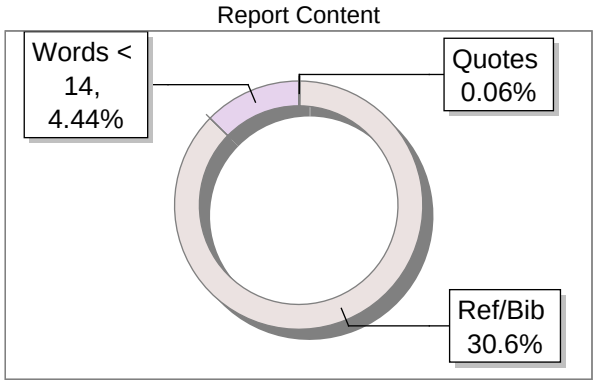

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Virtual and Augmented Reality in Oral and Maxillofacial Surgery- A Narrative Review

Dr. Shobha. E. S, Dr. Prashanth. N. T, Dr. Vinod Rangan, Anagha. M. D

Abstract: In recent years, there has been a growing interest in virtual reality (VR) and augmented reality (AR) technologies. This has led to the development of various VR/AR devices such as head-mounted displays, haptic devices, and AR glasses. In the field of oral and cranio-maxillofacial surgery, AR applications are becoming increasingly popular and widely adopted. The availability of surgery-specific head-mounted devices that ensure the accuracy required for surgical tasks and optimal ergonomics may encourage the widespread use of AR systems in the operating room..

Keywords: Virtual reality, augmented reality, head-mounted displays, surgery-specific.

Introduction:

Oral and craniomaxillofacial surgery is a specialised field that deals with treating conditions affecting the mouth, jaws, face, head, and neck. Patients often need a CT scan done before surgery because of the intricate nature of these disorders and the delicate structure of the affected areas. With the help of this scan, the surgeon can accurately replicate the surgical plan throughout treatment and plan a suitable surgical strategy [1].

In the field of dentistry, technological advancement has culminated in several developments, such as Augmented Reality (AR) and Virtual Reality (VR). Augmented reality is a technology that blends computer-generated images, audio, and videos with real-life surroundings. In contrast, VR is a simulated environment built from computer-generated graphics, sound, and images where users are fully immersed and cannot see the real world. [2], [3], [4].

The advancements in computer graphics and sensor technologies have created new possibilities for diagnostic and surgical techniques by leveraging VR and AR technologies. [5].

History:

Jaron Lanier is widely acknowledged as having coined the term virtual reality (VR) in 1986. This term encompasses a combination of technological components, including a computer capable of interactive 3D visualization, head-mounted displays (HMDs), and controllers equipped with one or more position trackers.[6].

In the early 1990s, the healthcare industry pioneered the use of virtual reality (VR) technology to visualize complex medical data during surgical procedures and to pre-plan surgeries.[7].

Discussion:

Surgical planning:

Virtual reality and augmented reality (VR/AR) devices were employed in orthopedic surgical procedures to address complex bone-related conditions, specifically those involving cranio-maxillofacial bones and the hip bone.[5].

In maxillofacial surgery, a mixed reality-based system plays a crucial role. This innovative system integrates a dental cast model with a 3D maxillofacial mesh model. Its primary objective is to coordinate the movement of the real-world dental cast model with the virtual 3D patient model. This synchronization is designed to facilitate precise movement of the 3D model in sync with the transformation of the dental cast model. [8].

In the realm of facial contouring surgery, a haptic device is employed to realistically simulate the reduction of a protruded zygoma and the precise insertion of a chin implant [9]. Furthermore, virtual reality-based systems have replicated mandibular angle reduction procedures, showcasing their potential in advancing surgical techniques [10]. With the integration of 3D virtual planning and computer simulation, the field of mandibular reconstructive surgery has witnessed substantial progress, paving the way for enhanced precision and effectiveness [11]. Moreover, the incorporation of a specialized cranio-maxillofacial reconstructive surgery setup, complete with an immersive workbench and 3D eyewear, promises to greatly facilitate these complex procedures. The inclusion of a semi-transparent mirror and a specifically-designed haptic device in the workbench serves to elevate the surgeon's involvement during surgical planning, providing a truly immersive experience. Furthermore, this innovative system, developed based on authentic surgical procedures, empowers surgeons to simulate intricate processes such as mandibulectomy and fibular transplant through the use of a 3D patient mesh model. It also grants surgeons the ability to experiment and pinpoint the optimal configurations of vessels and skin paddles, thereby contributing to more effective reconstructive surgeries [12].

Surgical Navigation:

AR-based technologies have been employed across a range of surgical procedures, including orthognathic surgery, face contouring, bone tumor resection, and neurosurgery [5]. In orthognathic surgery, AR-based navigation systems have been introduced to provide visual guidance and virtual surgical plans [1],[13-14]. Additionally, head-mounted devices (HMDs) have been utilized to display virtual surgical plans, aiding in the repositioning of patient bones during maxillofacial osteotomies [1].

A head-mounted display (HMD) is used in a system that combines a virtual surgical guide model and a 3D model of the patient's mandible in real-time to perform mandibular angle osteotomy surgery using augmented reality technology. With the aid of this device, surgeons can precisely execute cutting procedures and adhere to a surgical guide indicating the intended position. [15].

The implementation of markerless AR-based technology has contributed significantly to the advancement of support in oral and maxillofacial surgery. This cutting-edge technology facilitates the precise alignment of a patient's 3D teeth model with their real-time video image, thus enabling accurate tracking of their position. Furthermore, it allows for the seamless overlay of additional 3D anatomical models such as the maxillofacial bone, nerves, and vessels, resulting in comprehensive and enhanced surgical guidance.. [16].

Surgical Training:

Haptic devices have a well-established role in medical training, particularly for refining skills such as bone drilling, burring, and cutting. These sophisticated tools are essential for procedures in maxillofacial and neurosurgery, as well as orthopaedic fracture reduction[5].

An advanced workbench system, incorporating a haptic device, has been developed to facilitate training for orthognathic surgery procedures [17], [18]. Specifically designed for LeFort 1 procedures, the system encompasses functionalities for bone sawing, drilling, and plate fixing while providing haptic force feedback[5].

OssoVR offers a cutting-edge virtual reality simulation platform designed for immersive surgical procedure training. It utilizes an HMD and tracked hand-held controllers, allowing surgeons to interact naturally with the virtual world using their hands.. [19].

Advantages and disadvantages of Head Mounted Devices:

Incorporating augmented reality (AR) into surgical procedures can greatly enhance treatment effectiveness and precision by providing surgeons with seamless virtual navigation integrated within the physical surgical field[20].

Utilizing AR guidance enables surgeons to enhance their spatial awareness and perception of the patient's 3D anatomical structures, akin to an X-ray view. Through AR technology, surgeons can project task-specific geometrical shapes, such as tumor contour margins, skin incision lines, and craniotomy/osteotomy lines, based on preoperative planning data. This functionality significantly improves the efficiency and precision of intricate surgical tasks, leading to time savings in the operating room.. [1].

The integration of head-mounted displays (HMDs) in AR surgical applications offers improved ergonomics and a more personalized viewpoint for the surgeon, in contrast to traditional computer-assisted surgical systems [21-22].

However, it's important to address the challenge of achieving precise alignment between virtual content and the real surgical field for accurate guidance. Furthermore, it is essential to consider strategies to mitigate potential eye strain and visual discomfort associated with prolonged use of HMDs [1].

Accuracy:

We cannot consider the accuracy of the AR system, which refers to the precise positioning of the virtual scene over the surgical real scene, as a reliable benchmark since its definition was inconsistent across various papers. [1].

Conclusion:

AR applications are becoming increasingly popular and are gaining traction in the field of oral and maxillofacial surgery. The quality of the AR experience and the ability to seamlessly integrate the surgeon's perception and efficiency are the key factors that contribute to a successful outcome. The availability of ergonomic head-mounted devices that can ensure the accuracy required for surgical tasks can promote the widespread use of AR guidance in the operating room.

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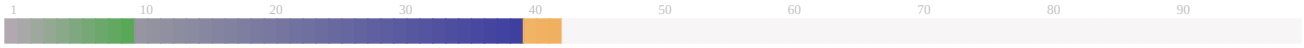

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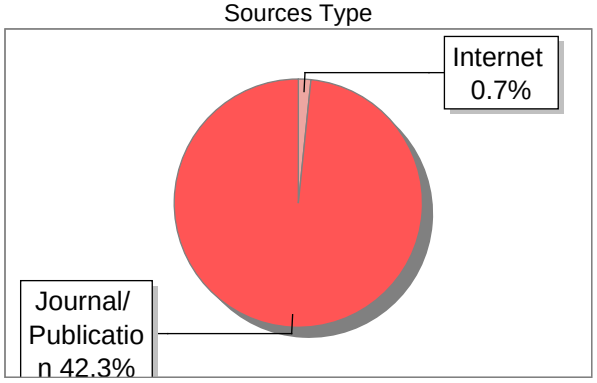

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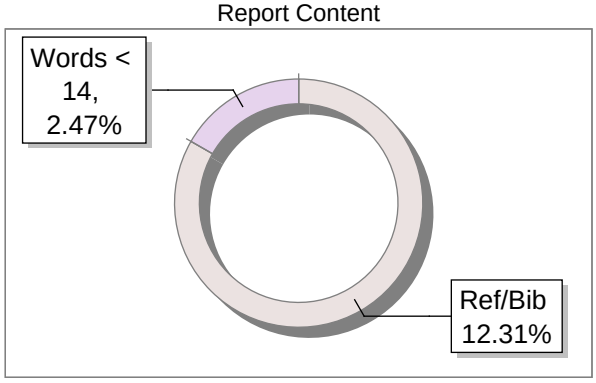

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Treatment of Skeletal Class II Malocclusion with Obstructive Sleep Apnoea Using Orthodontic-Surgical Approach

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Abstract: In the treatment of skeletal Class II retrognathic mandible, the airway should be considered for the progress and outcome of the treatment, here we present a case of 30 year old male patient with class II skeletal base with maxillary and mandibular dentoalveolar protrusion, with crowding in the maxillary and mandibular arch, increased maxillary mandibular plane angle and increased lower anterior facial height, he had convex profile with potentially incompetent lips .He had nocturnal choking, difficulty in breathing while lying down and snoring suggestive of obstructive sleep apnoea. Bilateral saggital split osteotomy (BSSO) advancement of 8mm and genioplasty of 4mm was done. The postoperative orthodontic treatment included settling the bite, monitoring the relapse, and managing the dental space for future prosthodontic rehabilitation.

Keywords: Obstructive sleep apnoea (OSA); Class II malocclusion; Hyperdivergent facial type

INTRODUCTION

Class II malocclusion is found in 14.6% of Indian population. This condition may be caused by maxillary excess or mandibular deficiency. In growing patients, the use of functional appliances could alter the dentoalveolar position and induce condylar remodelling. In adults with skeletal Class II malocclusion are conventionally treated with orthodontic camouflage or surgical-orthodontic treatment. In the orthodontic camouflage treatment, dental compensation is used to mask the skeletal discrepancy. Whereas in the surgical-orthodontic option, the skeletal deformity is corrected using jaw osteotomies with counterclockwise rotation and orthodontic detailing. Surgical-orthodontic treatment is more effective in maintaining the upper lip profile by less retraction in upper teeth and more advancement in mandible and chin. Thus, it is usually performed in patients with a more severe sagittal jaw bone discrepancy, especially mandible retrusion. For patients with a retrusive mandible, especially those with bird face-like profile, despite the oral function and aesthetic problem, the airway condition must be considered. The lateral cephalometric film should be evaluated for a narrow airway. If the

airway is considerably narrow, AHI Index and polysomnography (PSG) may be required to determine the presence of obstructive sleep apnoea (OSA). The case report illustrated the correction of skeletal Class II malocclusion with retrusive mandible.

CASE REPORT

A male patient named Paged 30 years came to the department with chief complaint of forwardly placed upper front teeth , reduced chin size & difficulty in breathing while lying down,nocturnal choking & snoring Familial malocclusion History:-His father has similar dental problems. He is internally motivated with positive attitude towards orthodontic treatment. On physical examination , he is moderately built with 168 cms in height weighs 64 kgs with mesomorphic body type.Patient had history of restless sleep ,Nocturnal choking & Witnessed apnea during sleep. Patient has undergone Sleep Study with Somno Touch Resp.

CLINICAL EXAMINATION

Extraoral Examination

In the frontal view, no significant facial asymmetry was noted. The patient had obvious lip incompetence with excessive upper tooth display. . His upper

dental midline was aligned with facial midline,mesocephalic head , mesoproscopic face , potentially incompetent lips ,consonant smile , incisor exposure on smile 7mm width ,no gingival exposure on smiling and a mesorrhine nose.

In profile view, Convex facial profile , vertical FMPA , Increased lower facial height ,Straight nasal dorsum ,Average nasolabial angle , Negative lipstep , Deep mentolabial sulcus , Receeding chin ,double chin appearance.

Intraoral Examination

The molar relationship was undefined due to teeth 35, 36, and 46 being missing. The buccal segmental and canine relationship was Class II on the right, end on left side with a deep bite and increased overjet (overbite was 6 mm, whereas the overjet was 9 mm). Her teeth 15, 18, 26, 32, 36, 42, and 46 were missing, with teeth 16 and 47 mesial tilting. A palatal crossbite in tooth 27 was noted . Her upper dental arch was tapered and symmetric, and her lower arch was ovoid and symmetric. General periodontal health was satisfactory. Her upper and lower arches both exhibited spacing due to missing teeth.

SUMMARY OF RESPIRATORY ANALYSIS

Increased Respiratory Effort-Related Arousals (RERA): The individual experiences a higher frequency of Respiratory Effort-Related Arousals, indicating disruptions in sleep due to respiratory events.

Desaturation to 85%: Oxygen saturation levels drop to 85%, suggesting significant episodes of oxygen desaturation during sleep. This is a critical concern as it may lead to hypoxemia.

Snoring: The presence of snoring indicates potential airway obstruction or restriction during sleep, contributing to respiratory disturbances.

Radiographic findings

PERMANENT DENTITION,MISSING 36,35,46 RC treated 17 Restored 26

Cephalometric Findings

1. The patient exhibits a Class II skeletal jaw base.
2. An increased mandibular plane angle is observed, measuring at -42 degrees on average, compared to the normal average of 28 degrees.
3. A vertical growth pattern is evident in the patient's facial structure.
4. There is an increased lower anterior facial height.
5. The patient presents with a divergent jaw base.

6. Proclination of the upper incisors to the sella-nasion (SN) plane is observed.
7. Both the upper and lower pharyngeal airways are reduced in size.
8. The upper pharynx measures at -14 mm (normal range: 15-20 mm).
9. The lower pharynx measures at -6 mm (normal range: 11-14 mm).
10. A decrease in mandibular corpus size by 6 mm is noted.
11. The patient exhibits an obtuse chin-throat angle.

Sagittal Relation:

1. The patient exhibits a skeletal Class II jaw base.

2. The ANB angle is 7°, indicating a significant discrepancy between the maxilla and mandible positions.
3. The mandibular plane angle is 42°, suggesting a particular orientation of the jaw structures.
4. Points A and B on the FH plane are 16 mm apart.
5. The Wits appraisal measures 5 mm, indicating the degree of maxillary and mandibular discrepancy.
6. The facial angle is 76°, suggesting a retrusive lower jaw.
7. The AB Plane Angle is -11°, further indicating a retrusive lower jaw.
8. Schwarz analysis reveals a maxilla to mandible ratio of 2.14:2.86, signifying an increased maxilla and decreased mandible.
9. Maxillary size is decreased by 2.6 mm, and mandible size is decreased by 5 mm.

Vertical Relation:

10. The patient exhibits a vertical growth pattern, with the maxilla and mandible diverging anteriorly.
11. SN-GO-GN angle is 45°, indicating a vertical growth pattern.
12. FMA is 42°, contributing to the vertical growth pattern.

13. The Jaraback Ratio is 61%, confirming a vertical growth pattern.

14. Y Axis N-S-GN is 80°, and Y Axis FH-S-GN is 74°.

15. Upper and lower gonial angles are 45° and 90°, respectively.

16. Basal plane angle is 43°.

17. The J Angle is 85°.

18. N-ANS measures 46 mm, indicating a decreased middle third of the face by 5 mm.

19. U1 to NF shows extruded incisors by 3 mm.

20. U6 – NF reveals extruded upper molars by 2 mm and intruded lower molars by 2 mm.

Soft Tissue Relation:

21. The patient has an average nasolabial angle.

22. A deep mentolabial sulcus is observed.

23. Upper lip thickness is 14 mm, with a basic upper lip thickness of 17 mm.

24. Lip strain is 3 mm.

25. Lower lip thickness is 14 mm, and lower lip length is 54 mm.

26. The soft tissue profile angle is 148°, indicative of a Class II soft tissue profile.

27. The total soft tissue profile angle is 124°, confirming a Class II profile.

28. The soft tissue facial angle is 79°, consistent with a Class II soft tissue profile.

Diagnosis:

29. Skeletally, the patient exhibits a Class II maxilla-mandibular relation with soft tissues matching.

30. A vertical growth pattern and increased lower anterior facial height.

31. Decreased mandibular corpus size is noted.

32. Divergent jaw bases are observed.

33. Dentally, there is a Class II incisor and canine relation, proclined upper incisors and lower incisors, and lower anterior crowding.

34. Increased overjet and overbite are evident.

35. Soft tissue features include a convex facial profile, average nasolabial angle, reduced chin thickness, protruded and incompetent lips, obtuse chin throat angle, double chin appearance, and a deep mentolabial sulcus.

PROBLEM LIST

Class II maxillo mandibular relation with convex facial profile,vertical growth pattern,incompetent & protruded lips d,ecreased upper & lower pharyngeal airway ,double chin appearance ,class II incisor & class II canine relation ,missing -46,36,35 , increased overjet & overbite and crowding in relation to upper & lower anteriors and proclined upper incisors.

AIMS AND OBJECTIVES OF TREATMENT

1. To correct skeletal class II base
2. To correct recessive mandible
3. To correct proclined upper and lower anteriors
4. To achieve ideal overjet and over bite
5. To prosthetic rehablitate -35
6. Achieve class I molar canine and incisor relation
7. To achieve a pleasing soft tissue profile
8. To achieve **ideal dimension of pharyngeal airway.**

TREATMENT PROGRESS

Levelling ,Aligning & Arch coordination-Upper :014 niti ,016 niti,018 niti,17x25 niti,19x25 niti,19x25 s.s

• Lower: 014 niti ,016 niti,018 niti,17x25 niti,19x25 niti,19x25 s.s and 018 AJW 2.SURGICAL PHASE: • Surgical correction of class-2 by BSSO advancement surgery & Rotational genioplasty

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POST SURGICAL CEPHALOMETRIC INTERPRETATION The post surgical orthodontic treatment skeletal relationship of the patient remained unchanged.The MxMd plane angle changed

VARIABLE	PRETREATMENT	POST-SURGICAL
SNA	77	79
SNB	70	75
ANB	7	4
Wits appraisal	5mm	7mm
Upper incisor to SN	103 (proclined)	102
Lower incisor to mandibular plane angle	97(proclined)	100
Interincisal angle	111(proclined)	110
Maxillary mandibular planes angle	43(vertical growth)	44
Upper anterior face height	46mm	51mm
Lower anterior face height	75 mm	77 mm
Jarabak ratio	61.5	60
Lower incisor to APog line	+10 mm(protruded)	9 mm
Lower lip to Ricketts E Plane	+4 mm	4 mm

3.POST SURGICAL ORTHODONTICS

• Implant assisted Protraction of 47,48,37,38 during post surgical orthodontics to achieve bilateral class 1 molar relation

• Settlling posterior occlusion. Prosthetic rehabilitation of 35 using FPD or implant. Retention- lingual fixed Retainer, removable retainer.

DISCUSSION

Skeletal class II malocclusion comprises a significant proportion of orthodontic patients. In adults with skeletal class II, the only option is camouflage or surgery. Although these patients come primarily for aesthetics, often the underlying craniofacial abnormality of a deficient mandible may serve as a significant predisposing factor for sleep disordered breathing or sleep apnea. The treatment approach should be planned taking into consideration the risk of future development of airway problems as well as the effect of treatment on the airway.

Sleep questionnaire (FOSQ) serves as a diagnostic screening test in individuals with sleep disordered breathing. Weaver et al was the first to describe this self-report measure to assess the impact of disorders of excessive sleepiness on multiple routine activities of everyday life as overall activity level, vigilance, general productivity, social behavior, and physical intimacy.

On the initial extraoral examination, we noticed a retrusive mandible, hyperdivergent facial type, and somewhat bird face-like profile. Congenital micrognathia often causes respiratory emergency in neonates. Although our patient's mandibular retrusion was not that severe, we aimed to address his airway condition. The gold standard treatment for OSA is CPAP therapy. Oral appliances such as mandibular advancement devices (MADs) can be used in carefully selected patients. Besides, some soft tissue surgical options can be considered for candidate cases, including adenotonsillectomy, nasal surgery, palatal surgery, and tongue-based surgery. The skeletal correction was mainly maxillomandibular advancement (MMA). Given the patient's chief complaint of profile, we considered OGS as the chief treatment plan. Mandibular advancement was considered because it could simultaneously improve his facial profile and enlarge his airway volume.. Overall, the patient's airway space widened considerably . The direction of surgical movement, the type of fixation, and the type of surgical technique and muscle adaptation affect surgery stability. According to Proffit et al., when rigid internal fixation is used, as the patient's anterior facial height was maintained or increased, the maxilla tends to move upward, thus the mandible is stable as moving forward after surgery.

However, the anterior facial height was reduced during surgery. In the postoperative skeletal changes, the maxilla had clockwise rotation and the mandible had backward movement with extensive remodeling in the chin contour. It indicated mild surgical relapse and significant surface remodeling. The relapse of OGS in patients with Class II malocclusion can result from more than 10-mm advancement. Moreover, the relapse can occur due to the surgery design. Some studies have indicated that in patients with skeletal Class II malocclusion and high MPA, the OGS correction of MPA can cause elongation of the suprahyoid muscle and extension of the pterygomasseteric sling, which may also be a risk factor for surgery relapse. The surgery caused the maxilla to have a counterclockwise rotation and impaction. This changes were similar with the finding of Proffit et el., when superior reposition of the maxilla, in the first 6 weeks, the posterior part of the maxilla was stable vertically while the anterior part of the maxilla could move downward. Therefore, we assume that in the postoperative period, although we did not use an accessory appliance for anterior incisor intrusion, the intrusion was maintained using the continuous arch wire technique . The explanation for this condition may be that the bite force attempted to maintain the upper occlusal plane at the same level whereas the maxilla relapsed with a clockwise rotation. Further investigation may be performed in this field

To sum up, the reason for the relapse pattern was quite serious for both of maxilla and mandible. The reasons may come from patient's initial status, including smaller TMJ form and hyperdivergent craniofacial morphology. Also, the surgical design (greater mandible advancement), fixation method and muscle adaptation can be the reasons too. The deformed TMJ might be a risk factor for CCWR of MMC. For the craniofacial type, the VME, high MPA and large AP discrepancy existed simultaneously in the initial condition.

Antegonial notching is often discussed with the mandibular growth and development. It is one of the 7 morphological indicators for prediction of mandibular growth pattern. The backward mandibular rotation during growth, as mentioned by Bjork and Skieller, has apposition below the gonial angle, which increases in concavity at the antegonial notch. It also leads to a long face or a hyperdivergent facial type, corresponding to that observed in our patient. Deep antegonial notch in the mandible border is correlated with greater lower AFH and steeper MPA, which corresponds with the patient's initial presentation. His lower AFH and steeper MPA condition should have caused an AOB, but this did not occur in this patient. This may be because of overgrowth in upper incisors, lower incisors, and the anterior part of the maxilla, leading to VME and gummy smile.

Overall, some aspects can still be improved, such as the noticeable notching at mandible margin, which is a common drawback of sagittal osteotomy advancement of the mandible. This may have occurred because of the deep antegonial notch or malposition of the proximal segment of the lingual fracture, thin mandible, or bad surgery split. This can be further managed by another surgery using bone grafts or lipofilling. Another aspect is that the lip posture was dropping down at bilateral cheilion, which gave the patient a frowny face whenever he was not smiling. This might occur due to the muscle traction. The length of the depressor anguli oris muscle, which originates from the external oblique line, could be altered during the mandible advancement and counterclockwise rotation. The hyperactive status of the perioral muscles may result in a frowny face. Botulinum toxin type A could be injected to relax the muscle. This problem can be ameliorated by consulting with a plastic surgeon.

CONCLUSION

For patients with skeletal Class II with retrognathic mandible, in addition to esthetic and functional objectives, the airway condition must be considered because a retrusive mandible often causes airway problems. Moreover, X-ray or CBCT can be used to verify the condylar anatomy and confirm the condylar status for the risk of relapse after Class II surgical-orthodontic treatment. Overcorrection of mandible advancement might be required to compensate the skeletal relapse and airway patency.

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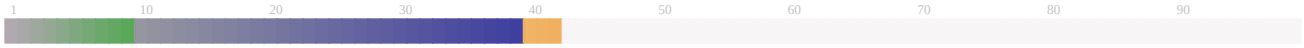

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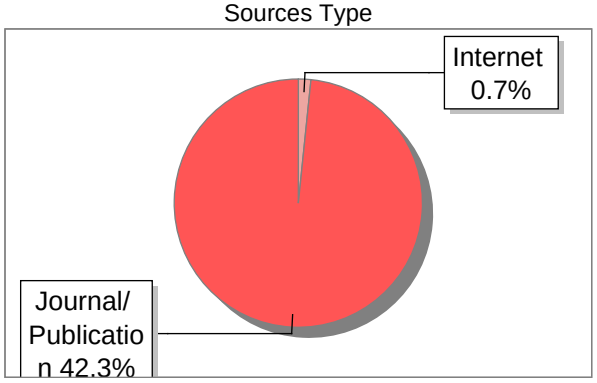

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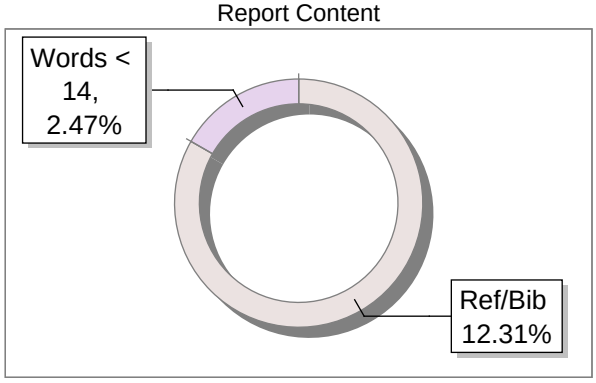

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3	A Randomized Trial Evaluating the Effectiveness of Sodium Oxybate Therapy on Qua by Weaver-2006	1	Publication
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Treatment of Skeletal Class II Malocclusion with Obstructive Sleep Apnoea Using Orthodontic-Surgical Approach

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Abstract: In the treatment of skeletal Class II retrognathic mandible, the airway should be considered for the progress and outcome of the treatment, here we present a case of 30 year old male patient with class II skeletal base with maxillary and mandibular dentoalveolar protrusion, with crowding in the maxillary and mandibular arch, increased maxillary mandibular plane angle and increased lower anterior facial height, he had convex profile with potentially incompetent lips .He had nocturnal choking, difficulty in breathing while lying down and snoring suggestive of obstructive sleep apnoea. Bilateral saggital split osteotomy (BSSO) advancement of 8mm and genioplasty of 4mm was done. The postoperative orthodontic treatment included settling the bite, monitoring the relapse, and managing the dental space for future prosthodontic rehabilitation.

Keywords: Obstructive sleep apnoea (OSA); Class II malocclusion; Hyperdivergent facial type

INTRODUCTION

Class II malocclusion is found in 14.6% of Indian population. This condition may be caused by maxillary excess or mandibular deficiency. In growing patients, the use of functional appliances could alter the dentoalveolar position and induce condylar remodelling. In adults with skeletal Class II malocclusion are conventionally treated with orthodontic camouflage or surgical-orthodontic treatment. In the orthodontic camouflage treatment, dental compensation is used to mask the skeletal discrepancy. Whereas in the surgical-orthodontic option, the skeletal deformity is corrected using jaw osteotomies with counterclockwise rotation and orthodontic detailing. Surgical-orthodontic treatment is more effective in maintaining the upper lip profile by less retraction in upper teeth and more advancement in mandible and chin. Thus, it is usually performed in patients with a more severe sagittal jaw bone discrepancy, especially mandible retrusion. For patients with a retrusive mandible, especially those with bird face-like profile, despite the oral function and aesthetic problem, the airway condition must be considered. The lateral cephalometric film should be evaluated for a narrow airway. If the

airway is considerably narrow, AHI Index and polysomnography (PSG) may be required to determine the presence of obstructive sleep apnoea (OSA). The case report illustrated the correction of skeletal Class II malocclusion with retrusive mandible.

CASE REPORT

A male patient named Paged 30 years came to the department with chief complaint of forwardly placed upper front teeth , reduced chin size & difficulty in breathing while lying down,nocturnal choking & snoring Familial malocclusion History:-His father has similar dental problems. He is internally motivated with positive attitude towards orthodontic treatment. On physical examination , he is moderately built with 168 cms in height weighs 64 kgs with mesomorphic body type.Patient had history of restless sleep ,Nocturnal choking & Witnessed apnea during sleep. Patient has undergone Sleep Study with Somno Touch Resp.

CLINICAL EXAMINATION

Extraoral Examination

In the frontal view, no significant facial asymmetry was noted. The patient had obvious lip incompetence with excessive upper tooth display. . His upper

dental midline was aligned with facial midline,mesocephalic head , mesoproscopic face , potentially incompetent lips ,consonant smile , incisor exposure on smile 7mm width ,no gingival exposure on smiling and a mesorrhine nose.

In profile view, Convex facial profile , vertical FMPA , Increased lower facial height ,Straight nasal dorsum ,Average nasolabial angle , Negative lipstep , Deep mentolabial sulcus , Receeding chin ,double chin appearance.

Intraoral Examination

The molar relationship was undefined due to teeth 35, 36, and 46 being missing. The buccal segmental and canine relationship was Class II on the right, end on left side with a deep bite and increased overjet (overbite was 6 mm, whereas the overjet was 9 mm). Her teeth 15, 18, 26, 32, 36, 42, and 46 were missing, with teeth 16 and 47 mesial tilting. A palatal crossbite in tooth 27 was noted . Her upper dental arch was tapered and symmetric, and her lower arch was ovoid and symmetric. General periodontal health was satisfactory. Her upper and lower arches both exhibited spacing due to missing teeth.

SUMMARY OF RESPIRATORY ANALYSIS

Increased Respiratory Effort-Related Arousals (RERA): The individual experiences a higher frequency of Respiratory Effort-Related Arousals, indicating disruptions in sleep due to respiratory events.

Desaturation to 85%: Oxygen saturation levels drop to 85%, suggesting significant episodes of oxygen desaturation during sleep. This is a critical concern as it may lead to hypoxemia.

Snoring: The presence of snoring indicates potential airway obstruction or restriction during sleep, contributing to respiratory disturbances.

Radiographic findings

PERMANENT DENTITION,MISSING 36,35,46 RC treated 17 Restored 26

Cephalometric Findings

1. The patient exhibits a Class II skeletal jaw base.
2. An increased mandibular plane angle is observed, measuring at -42 degrees on average, compared to the normal average of 28 degrees.
3. A vertical growth pattern is evident in the patient's facial structure.
4. There is an increased lower anterior facial height.
5. The patient presents with a divergent jaw base.

6. Proclination of the upper incisors to the sella-nasion (SN) plane is observed.
7. Both the upper and lower pharyngeal airways are reduced in size.
8. The upper pharynx measures at -14 mm (normal range: 15-20 mm).
9. The lower pharynx measures at -6 mm (normal range: 11-14 mm).
10. A decrease in mandibular corpus size by 6 mm is noted.
11. The patient exhibits an obtuse chin-throat angle.

Sagittal Relation:

1. The patient exhibits a skeletal Class II jaw base.

2. The ANB angle is 7°, indicating a significant discrepancy between the maxilla and mandible positions.
3. The mandibular plane angle is 42°, suggesting a particular orientation of the jaw structures.
4. Points A and B on the FH plane are 16 mm apart.
5. The Wits appraisal measures 5 mm, indicating the degree of maxillary and mandibular discrepancy.
6. The facial angle is 76°, suggesting a retrusive lower jaw.
7. The AB Plane Angle is -11°, further indicating a retrusive lower jaw.
8. Schwarz analysis reveals a maxilla to mandible ratio of 2.14:2.86, signifying an increased maxilla and decreased mandible.
9. Maxillary size is decreased by 2.6 mm, and mandible size is decreased by 5 mm.

Vertical Relation:

10. The patient exhibits a vertical growth pattern, with the maxilla and mandible diverging anteriorly.
11. SN-GO-GN angle is 45°, indicating a vertical growth pattern.
12. FMA is 42°, contributing to the vertical growth pattern.

13. The Jaraback Ratio is 61%, confirming a vertical growth pattern.

14. Y Axis N-S-GN is 80°, and Y Axis FH-S-GN is 74°.

15. Upper and lower gonial angles are 45° and 90°, respectively.

16. Basal plane angle is 43°.

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18. N-ANS measures 46 mm, indicating a decreased middle third of the face by 5 mm.

19. U1 to NF shows extruded incisors by 3 mm.

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Soft Tissue Relation:

21. The patient has an average nasolabial angle.

22. A deep mentolabial sulcus is observed.

23. Upper lip thickness is 14 mm, with a basic upper lip thickness of 17 mm.

24. Lip strain is 3 mm.

25. Lower lip thickness is 14 mm, and lower lip length is 54 mm.

26. The soft tissue profile angle is 148°, indicative of a Class II soft tissue profile.

27. The total soft tissue profile angle is 124°, confirming a Class II profile.

28. The soft tissue facial angle is 79°, consistent with a Class II soft tissue profile.

Diagnosis:

29. Skeletally, the patient exhibits a Class II maxilla-mandibular relation with soft tissues matching.

30. A vertical growth pattern and increased lower anterior facial height.

31. Decreased mandibular corpus size is noted.

32. Divergent jaw bases are observed.

33. Dentally, there is a Class II incisor and canine relation, proclined upper incisors and lower incisors, and lower anterior crowding.

34. Increased overjet and overbite are evident.

35. Soft tissue features include a convex facial profile, average nasolabial angle, reduced chin thickness, protruded and incompetent lips, obtuse chin throat angle, double chin appearance, and a deep mentolabial sulcus.

PROBLEM LIST

Class II maxillo mandibular relation with convex facial profile,vertical growth pattern,incompetent & protruded lips d,ecreased upper & lower pharyngeal airway ,double chin appearance ,class II incisor & class II canine relation ,missing -46,36,35 , increased overjet & overbite and crowding in relation to upper & lower anteriors and proclined upper incisors.

AIMS AND OBJECTIVES OF TREATMENT

1. To correct skeletal class II base
2. To correct recessive mandible
3. To correct proclined upper and lower anteriors
4. To achieve ideal overjet and over bite
5. To prosthetic rehablitate -35
6. Achieve class I molar canine and incisor relation
7. To achieve a pleasing soft tissue profile
8. To achieve **ideal dimension of pharyngeal airway.**

TREATMENT PROGRESS

Levelling ,Aligning & Arch coordination-Upper :014 niti ,016 niti,018 niti,17x25 niti,19x25 niti,19x25 s.s

• Lower: 014 niti ,016 niti,018 niti,17x25 niti,19x25 niti,19x25 s.s and 018 AJW 2.SURGICAL PHASE: • Surgical correction of class-2 by BSSO advancement surgery & Rotational genioplasty

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POST SURGICAL CEPHALOMETRIC INTERPRETATION The post surgical orthodontic treatment skeletal relationship of the patient remained unchanged.The MxMd plane angle changed

VARIABLE	PRETREATMENT	POST-SURGICAL
SNA	77	79
SNB	70	75
ANB	7	4
Wits appraisal	5mm	7mm
Upper incisor to SN	103 (proclined)	102
Lower incisor to mandibular plane angle	97(proclined)	100
Interincisal angle	111(proclined)	110
Maxillary mandibular planes angle	43(vertical growth)	44
Upper anterior face height	46mm	51mm
Lower anterior face height	75 mm	77 mm
Jarabak ratio	61.5	60
Lower incisor to APog line	+10 mm(protruded)	9 mm
Lower lip to Ricketts E Plane	+4 mm	4 mm

3.POST SURGICAL ORTHODONTICS

• Implant assisted Protraction of 47,48,37,38 during post surgical orthodontics to achieve bilateral class 1 molar relation

• Settlling posterior occlusion. Prosthetic rehabilitation of 35 using FPD or implant. Retention- lingual fixed Retainer, removable retainer.

DISCUSSION

Skeletal class II malocclusion comprises a significant proportion of orthodontic patients. In adults with skeletal class II, the only option is camouflage or surgery. Although these patients come primarily for aesthetics, often the underlying craniofacial abnormality of a deficient mandible may serve as a significant predisposing factor for sleep disordered breathing or sleep apnea. The treatment approach should be planned taking into consideration the risk of future development of airway problems as well as the effect of treatment on the airway.

Sleep questionnaire (FOSQ) serves as a diagnostic screening test in individuals with sleep disordered breathing. Weaver et al was the first to describe this self-report measure to assess the impact of disorders of excessive sleepiness on multiple routine activities of everyday life as overall activity level, vigilance, general productivity, social behavior, and physical intimacy.

On the initial extraoral examination, we noticed a retrusive mandible, hyperdivergent facial type, and somewhat bird face-like profile. Congenital micrognathia often causes respiratory emergency in neonates. Although our patient's mandibular retrusion was not that severe, we aimed to address his airway condition. The gold standard treatment for OSA is CPAP therapy. Oral appliances such as mandibular advancement devices (MADs) can be used in carefully selected patients. Besides, some soft tissue surgical options can be considered for candidate cases, including adenotonsillectomy, nasal surgery, palatal surgery, and tongue-based surgery. The skeletal correction was mainly maxillomandibular advancement (MMA). Given the patient's chief complaint of profile, we considered OGS as the chief treatment plan. Mandibular advancement was considered because it could simultaneously improve his facial profile and enlarge his airway volume.. Overall, the patient's airway space widened considerably . The direction of surgical movement, the type of fixation, and the type of surgical technique and muscle adaptation affect surgery stability. According to Proffit et al., when rigid internal fixation is used, as the patient's anterior facial height was maintained or increased, the maxilla tends to move upward, thus the mandible is stable as moving forward after surgery.

However, the anterior facial height was reduced during surgery. In the postoperative skeletal changes, the maxilla had clockwise rotation and the mandible had backward movement with extensive remodeling in the chin contour. It indicated mild surgical relapse and significant surface remodeling. The relapse of OGS in patients with Class II malocclusion can result from more than 10-mm advancement. Moreover, the relapse can occur due to the surgery design. Some studies have indicated that in patients with skeletal Class II malocclusion and high MPA, the OGS correction of MPA can cause elongation of the suprahyoid muscle and extension of the pterygomasseteric sling, which may also be a risk factor for surgery relapse. The surgery caused the maxilla to have a counterclockwise rotation and impaction. This changes were similar with the finding of Proffit et el., when superior reposition of the maxilla, in the first 6 weeks, the posterior part of the maxilla was stable vertically while the anterior part of the maxilla could move downward. Therefore, we assume that in the postoperative period, although we did not use an accessory appliance for anterior incisor intrusion, the intrusion was maintained using the continuous arch wire technique . The explanation for this condition may be that the bite force attempted to maintain the upper occlusal plane at the same level whereas the maxilla relapsed with a clockwise rotation. Further investigation may be performed in this field

To sum up, the reason for the relapse pattern was quite serious for both of maxilla and mandible. The reasons may come from patient's initial status, including smaller TMJ form and hyperdivergent craniofacial morphology. Also, the surgical design (greater mandible advancement), fixation method and muscle adaptation can be the reasons too. The deformed TMJ might be a risk factor for CCWR of MMC. For the craniofacial type, the VME, high MPA and large AP discrepancy existed simultaneously in the initial condition.

Antegonial notching is often discussed with the mandibular growth and development. It is one of the 7 morphological indicators for prediction of mandibular growth pattern. The backward mandibular rotation during growth, as mentioned by Bjork and Skieller, has apposition below the gonial angle, which increases in concavity at the antegonial notch. It also leads to a long face or a hyperdivergent facial type, corresponding to that observed in our patient. Deep antegonial notch in the mandible border is correlated with greater lower AFH and steeper MPA, which corresponds with the patient's initial presentation. His lower AFH and steeper MPA condition should have caused an AOB, but this did not occur in this patient. This may be because of overgrowth in upper incisors, lower incisors, and the anterior part of the maxilla, leading to VME and gummy smile.

Overall, some aspects can still be improved, such as the noticeable notching at mandible margin, which is a common drawback of sagittal osteotomy advancement of the mandible. This may have occurred because of the deep antegonial notch or malposition of the proximal segment of the lingual fracture, thin mandible, or bad surgery split. This can be further managed by another surgery using bone grafts or lipofilling. Another aspect is that the lip posture was dropping down at bilateral cheilion, which gave the patient a frowny face whenever he was not smiling. This might occur due to the muscle traction. The length of the depressor anguli oris muscle, which originates from the external oblique line, could be altered during the mandible advancement and counterclockwise rotation. The hyperactive status of the perioral muscles may result in a frowny face. Botulinum toxin type A could be injected to relax the muscle. This problem can be ameliorated by consulting with a plastic surgeon.

CONCLUSION

For patients with skeletal Class II with retrognathic mandible, in addition to esthetic and functional objectives, the airway condition must be considered because a retrusive mandible often causes airway problems. Moreover, X-ray or CBCT can be used to verify the condylar anatomy and confirm the condylar status for the risk of relapse after Class II surgical-orthodontic treatment. Overcorrection of mandible advancement might be required to compensate the skeletal relapse and airway patency.

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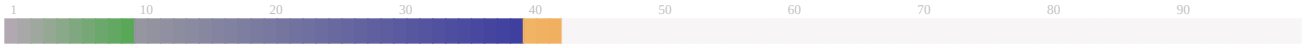

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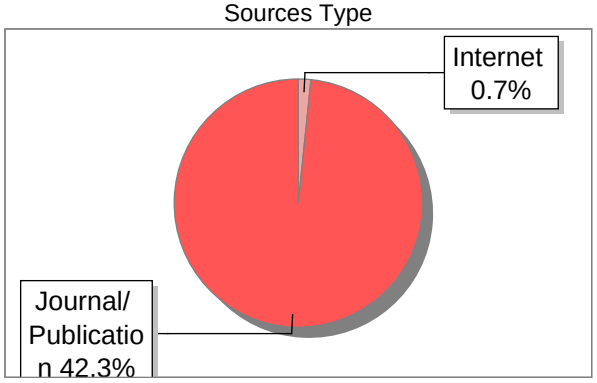

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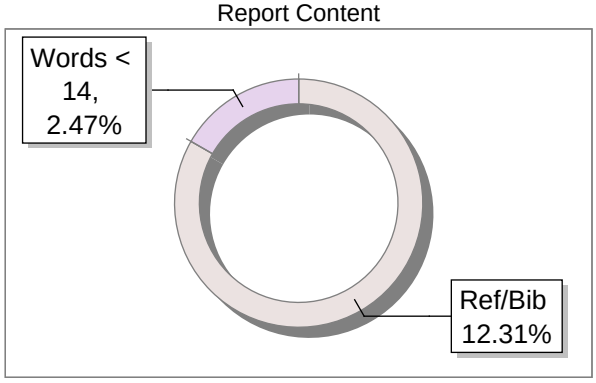

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8. To achieve **ideal dimension of pharyngeal airway.**

TREATMENT PROGRESS

Levelling ,Aligning & Arch coordination-Upper :014 niti ,016 niti,018 niti,17x25 niti,19x25 niti,19x25 s.s

• Lower: 014 niti ,016 niti,018 niti,17x25 niti,19x25 niti,19x25 s.s and 018 AJW 2.SURGICAL PHASE: • Surgical correction of class-2 by BSSO advancement surgery & Rotational genioplasty

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POST SURGICAL CEPHALOMETRIC INTERPRETATION The post surgical orthodontic treatment skeletal relationship of the patient remained unchanged.The MxMd plane angle changed

VARIABLE	PRETREATMENT	POST-SURGICAL
SNA	77	79
SNB	70	75
ANB	7	4
Wits appraisal	5mm	7mm
Upper incisor to SN	103 (proclined)	102
Lower incisor to mandibular plane angle	97(proclined)	100
Interincisal angle	111(proclined)	110
Maxillary mandibular planes angle	43(vertical growth)	44
Upper anterior face height	46mm	51mm
Lower anterior face height	75 mm	77 mm
Jarabak ratio	61.5	60
Lower incisor to APog line	+10 mm(protruded)	9 mm
Lower lip to Ricketts E Plane	+4 mm	4 mm

3.POST SURGICAL ORTHODONTICS

• Implant assisted Protraction of 47,48,37,38 during post surgical orthodontics to achieve bilateral class 1 molar relation

• Settlling posterior occlusion. Prosthetic rehabilitation of 35 using FPD or implant. Retention- lingual fixed Retainer, removable retainer.

DISCUSSION

Skeletal class II malocclusion comprises a significant proportion of orthodontic patients. In adults with skeletal class II, the only option is camouflage or surgery. Although these patients come primarily for aesthetics, often the underlying craniofacial abnormality of a deficient mandible may serve as a significant predisposing factor for sleep disordered breathing or sleep apnea. The treatment approach should be planned taking into consideration the risk of future development of airway problems as well as the effect of treatment on the airway.

Sleep questionnaire (FOSQ) serves as a diagnostic screening test in individuals with sleep disordered breathing. Weaver et al was the first to describe this self-report measure to assess the impact of disorders of excessive sleepiness on multiple routine activities of everyday life as overall activity level, vigilance, general productivity, social behavior, and physical intimacy.

On the initial extraoral examination, we noticed a retrusive mandible, hyperdivergent facial type, and somewhat bird face-like profile. Congenital micrognathia often causes respiratory emergency in neonates. Although our patient's mandibular retrusion was not that severe, we aimed to address his airway condition. The gold standard treatment for OSA is CPAP therapy. Oral appliances such as mandibular advancement devices (MADs) can be used in carefully selected patients. Besides, some soft tissue surgical options can be considered for candidate cases, including adenotonsillectomy, nasal surgery, palatal surgery, and tongue-based surgery. The skeletal correction was mainly maxillomandibular advancement (MMA). Given the patient's chief complaint of profile, we considered OGS as the chief treatment plan. Mandibular advancement was considered because it could simultaneously improve his facial profile and enlarge his airway volume.. Overall, the patient's airway space widened considerably . The direction of surgical movement, the type of fixation, and the type of surgical technique and muscle adaptation affect surgery stability. According to Proffit et al., when rigid internal fixation is used, as the patient's anterior facial height was maintained or increased, the maxilla tends to move upward, thus the mandible is stable as moving forward after surgery.

However, the anterior facial height was reduced during surgery. In the postoperative skeletal changes, the maxilla had clockwise rotation and the mandible had backward movement with extensive remodeling in the chin contour. It indicated mild surgical relapse and significant surface remodeling. The relapse of OGS in patients with Class II malocclusion can result from more than 10-mm advancement. Moreover, the relapse can occur due to the surgery design. Some studies have indicated that in patients with skeletal Class II malocclusion and high MPA, the OGS correction of MPA can cause elongation of the suprahyoid muscle and extension of the pterygomasseteric sling, which may also be a risk factor for surgery relapse. The surgery caused the maxilla to have a counterclockwise rotation and impaction. This changes were similar with the finding of Proffit et el., when superior reposition of the maxilla, in the first 6 weeks, the posterior part of the maxilla was stable vertically while the anterior part of the maxilla could move downward. Therefore, we assume that in the postoperative period, although we did not use an accessory appliance for anterior incisor intrusion, the intrusion was maintained using the continuous arch wire technique . The explanation for this condition may be that the bite force attempted to maintain the upper occlusal plane at the same level whereas the maxilla relapsed with a clockwise rotation. Further investigation may be performed in this field

To sum up, the reason for the relapse pattern was quite serious for both of maxilla and mandible. The reasons may come from patient's initial status, including smaller TMJ form and hyperdivergent craniofacial morphology. Also, the surgical design (greater mandible advancement), fixation method and muscle adaptation can be the reasons too. The deformed TMJ might be a risk factor for CCWR of MMC. For the craniofacial type, the VME, high MPA and large AP discrepancy existed simultaneously in the initial condition.

Antegonial notching is often discussed with the mandibular growth and development. It is one of the 7 morphological indicators for prediction of mandibular growth pattern. The backward mandibular rotation during growth, as mentioned by Bjork and Skieller, has apposition below the gonial angle, which increases in concavity at the antegonial notch. It also leads to a long face or a hyperdivergent facial type, corresponding to that observed in our patient. Deep antegonial notch in the mandible border is correlated with greater lower AFH and steeper MPA, which corresponds with the patient's initial presentation. His lower AFH and steeper MPA condition should have caused an AOB, but this did not occur in this patient. This may be because of overgrowth in upper incisors, lower incisors, and the anterior part of the maxilla, leading to VME and gummy smile.

Overall, some aspects can still be improved, such as the noticeable notching at mandible margin, which is a common drawback of sagittal osteotomy advancement of the mandible. This may have occurred because of the deep antegonial notch or malposition of the proximal segment of the lingual fracture, thin mandible, or bad surgery split. This can be further managed by another surgery using bone grafts or lipofilling. Another aspect is that the lip posture was dropping down at bilateral cheilion, which gave the patient a frowny face whenever he was not smiling. This might occur due to the muscle traction. The length of the depressor anguli oris muscle, which originates from the external oblique line, could be altered during the mandible advancement and counterclockwise rotation. The hyperactive status of the perioral muscles may result in a frowny face. Botulinum toxin type A could be injected to relax the muscle. This problem can be ameliorated by consulting with a plastic surgeon.

CONCLUSION

For patients with skeletal Class II with retrognathic mandible, in addition to esthetic and functional objectives, the airway condition must be considered because a retrusive mandible often causes airway problems. Moreover, X-ray or CBCT can be used to verify the condylar anatomy and confirm the condylar status for the risk of relapse after Class II surgical-orthodontic treatment. Overcorrection of mandible advancement might be required to compensate the skeletal relapse and airway patency.

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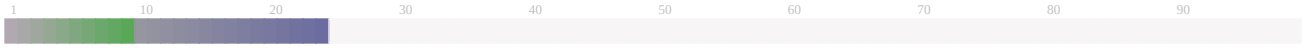

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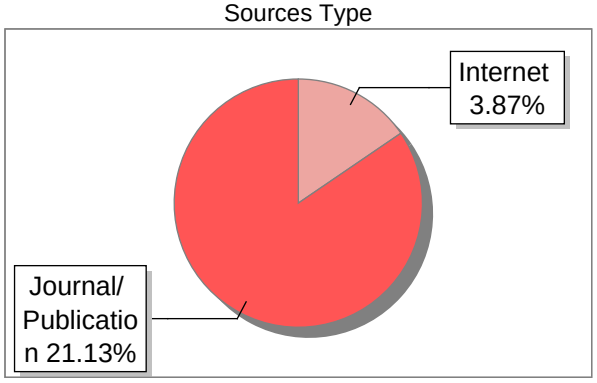

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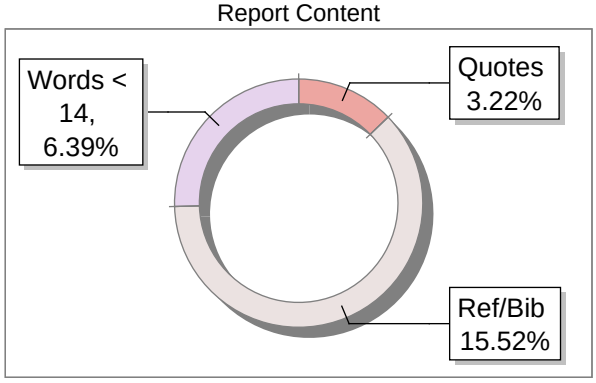

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AESTHETIC MANAGEMENT OF ANTERIOR MIDLINE DIASTEMA WITH DIRECT RESIN COMPOSITES- A CASE REPORT

Abstract

Midline diastema is a common complaint in patients seeking aesthetic dental procedures. The maxilla has shown to have a higher prevalence of midline diastema than mandible . Various physiological and pathological factors can lead to midline diastema. These include the presence of a high labial frenal attachment, microdontia, habits such as finger sucking, tongue thrusting, or lip sucking, dental malformations, dental-skeletal discrepancies, and imperfect coalescence of the interdental septum. Selection of the technique and material for an effective treatment are usually dictated by time, physical, psychological and economical limitations of the patient. Direct composite resins in diastema cases allow dentist and patient complete control of these limitations and formation of an aesthetically pleasing and natural smile. This article presents the aesthetic rehabilitation of anterior midline diastema with direct composite resin using the putty index technique.

Keywords: aesthetic dentistry, diastema, direct composite resin, putty index method

Introduction

Maxillary anterior spacing or diastema is one of the common aesthetic complaint among patients.[1] It has been described as spacing between the proximal surfaces of adjacent teeth in the anterior midline measuring > 0.5 mm.[2] The incidence of true maxillary midline diastema is (1.6%) more than that of true mandibular midline diastemas (0.3%).[3] The aetiology of midline diastema is multifactorial, causes being physiological and/ or pathological in nature such as high frenal attachment, incomplete coalescence of the interdental septum, microdontia, presence of a mesiodens or peg-shaped lateral incisors, congenital absence of lateral incisors, pathologies (e.g., cysts in the midline region), habits such as tongue thrusting, and/or lip sucking, discrepancy in the dental and skeletal parameters, and genetics.[4] Based on the etiology, the treatment plan may include a multi-disciplinary approach or the closure of the space using direct and/or indirect restorative materials. This further depends on the alignment and dimensions of the teeth being restored.[5] Hence, the assessment of tooth size and distribution of the space manually or using digital smile designing becomes an important tool in providing a natural smile.

The composite resins used for anterior restorations must exhibit good aesthetic characteristics. Avalability of composite resins with superior mechanical properties and excellent polishability allows the clinician to mimic the natural dentition as well as renders a long-lasting restoration to the patient. Nanohybrid composites are hybrid resin composites with nanofiller in a prepolymerized filler form, recently launched, that involve a combination of high initial polishing and supreme polish and gloss retention.[6] Additionally, composite resins allows a conservative treatment and offer quicker results.[7]

The use of putty index technique aids in acquiring a predictable anterior composite build up. This technique uses an impression of the diagnostic mock up to produce a palatal silicone index. This can be then used to transfer the required anatomy into the mouth during treatment further improving the treatment outcome.[8] This case report describes a direct aesthetic midline diastema closure using putty index technique.

Case presentation

A 32-year-old male patient reported to the Department of Conservative and Endodontics, Dayananda Sagar College of Dental Sciences with the chief complaint of spacing in the upper

front tooth region. The patient stated that the spacing was causing him social embarrassment and lowering his self-esteem. Patient had no associated symptoms, relevant past dental or medical history. The intraoral examination revealed the presence of midline diastema between maxillary central incisors (~3.5mm) secondary to tongue thrust habit confirmed by performing clinical tests (Fig 1) and spacing between the mandibular incisors. On radiographic examination no evident pathologies were detected. The first line of treatment suggested to the patient was to undergo orthodontic treatment for closure of the diastema and spacing between the mandibular incisors. However, as the patient was not willing for the same and wished for a faster and conservative approach, direct composite restorations for midline closure were considered. Fig 1: Pre-operative intraoral image of patient with midline diastema; (a) Frontal view; (b) Right lateral view; (c) Left lateral view. Closure of midline diastema using a direct composite build up using putty index was planned. Lower teeth spacing was not addressed as patient for not willing for the same. Informed consent from the patient was taken, and complete treatment plan was discussed with the patient. In first appointment, diagnostic impression and cast were made. Following the dental analysis of the patient, diagnostic wax up done on the cast (Fig 2 (a)) and a putty index was created (Fig 2 (b)). The fit of the putty index in the mouth was confirmed. (a) (b) (c)

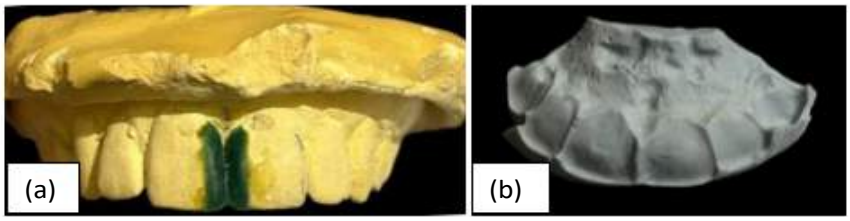
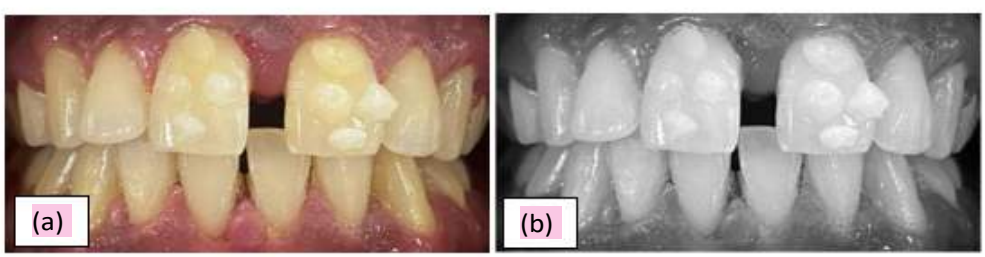


Fig 2: (a) Diagnostic mock up; (b) Silicone putty index

Following oral prophylaxis, shade selection was done using button technique under natural daylight (Fig 3 (a)and (b)). A1 shade of Filtek™ Z350 XT (3M/ESPE, St. Paul, MN, USA) was selected. Split-dam technique was used to isolate the maxillary teeth as the conventional rubber dam placement technique hindered the placement of the putty index palatally. In order to simulate natural A1 shade outlook, the shade A1 dentine and A3 enamel composite resin (Filtek Z350, 3M/ESPE, St. Paul, MN, USA) were used as layers. No preparation was done on the tooth surface prior to restoration. 37% phosphoric acid (Etching Gel, Kerr, USA) was applied on the mesial surface of both the central incisors to be restored for 15 seconds, rinsed for 20 seconds, and dried with oil- free air (Fig 3 (c)). Then, two coats of a single bottle bonding agent (One Coat Bond SL Coltene, Switzerland) were applied using applicator tips (Fig 3 (d)) and cured for 20 seconds with an LED light (Bluephase N MC, Ivoclar Vivadent, Schaan, Lichtenstein). Care was taken to apply uniform coats of the bonding agent on the proximal tooth surfaces especially near the gingival area since pooling of the bonding agent may compromise the solvent evaporation, after careful application of the bonding agent near the sulcus, it was air-thinned using a three-way syringe.

A thin layer of A3 shade composite resin was placed palatally on the putty index as enamel and placed into patient's mouth and cured for 40 seconds. A palatal shell of composite bonded to the tooth was formed by carefully removing putty index (Fig 3 (e)) which served as a reference for further placement of composite.



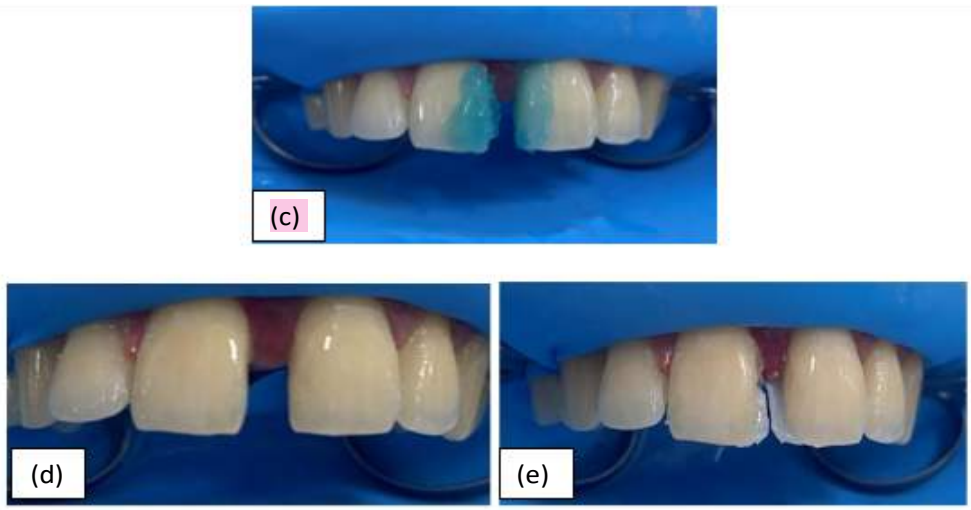


Fig 3: (a) and (b) Shade selection using button technique; (c) Etching using 37% phosphoric acid; (d) Application of bonding agent; (e) Palatal shell.

A1 dentine shade was placed in increments and manually contoured over the mesial surface of both the incisors using a long bladed titanium instrument. Posterior sectional matrix system was used to build the proximal surface of the teeth. A thin layer of A3 shade was used as the top enamel layer. All increments were cured for 40 seconds, both from labial and palatal aspects. The occlusion was verified in both centric and eccentric relations using an articulating paper.

Gross finishing was done using Tungsten carbide bur 134 014 (16 flutes yellow band). Final finishing was done using Shofu Super snap rainbow kit (Shofu INC, Japan). CompoSite Fine polishing tips (Shofu INC, Japan) were used along with polishing paste (Platina Hi-Gloss Composite polishing paste, PrevestDenPro) for polishing. The patient was motivated to maintain oral hygiene and instructed to floss before tooth brushing regularly and to avoid pigmented liquids cause staining of restoration. The patient has been recalled after 6 months for follow up.

Fig 4: (a) Proximal surfaces restored using posterior sectional matrix; (b) Immediate post operative image; (c) Post operative image following finishing and polishing; (e) Palatal aspect of the midline diastema closure. Discussion Various treatment modalities are available for closure of midline diastema such as orthodontic treatment, an indirect ceramic restoration, direct composite resins or an interdisciplinary approach.7 Direct composite resins are indicated for minimal to moderate diastema closure and when preservation of tooth structure is a priority serving as the most conservative approach.4,9 In this case report, a direct composite restoration was used for diastema closure as the patient was not willing to undergo an orthodontic treatment or habit correction and wished for a faster and conservative approach. However, the patient was made aware of the impermanence of such a closure as the aetiology was not address adequately during the treatment. Nonetheless, excellent outcomes have been reported by numerous authors who have used composite resins for diastema closures pertaining to the longevity (88% up to 10 years) and aesthetic outcome of such restorations.5,10,11 Highly aesthetic restorations made up of composite resins are now possible because of constant improvements in techniques, materials, and technology. The introduction of nanometer-sized particles has been one of the latest developments in the field which is said to offer superior aesthetics and polishability required for anterior restorations. Filtek Z350 (3M (a) (b) (c) (d)

ESPE, St. Paul, MN, USA) employed in this case report, is nanocomposite on the market that contains nanometric particles (nanomers) and nanoclusters (NCs). It shows high translucency, high polish and polish retention similar to those of microfilled composites whilst maintaining the physical properties and wear resistance equivalent to those of several hybrid composites.[12]

Successful restorations rely mostly on the effective control of moisture and saliva from the tooth being restored as contamination remains an important cause of bond failure. Therefore, rubber dam isolation was done in this case to prevent moisture contamination. A silicone putty index was used in this case as it perfectly defines the sagittal dimensions, the length, and the incisal edge position, incisal thickness, mesial and distal line angles of the required final restoration; it reduces the need for extensive final finishing and polishing procedures. Hence, the practitioner can fully target the application of composite layers.[8] Putty index technique is easy to perform, and it creates correctmidline with optimal contact area. Additionally, this technique allows the clinician in reproducing the palatal anatomy accurately overcoming the most challenging part of anterior restorations.

Dual layering technique was used in this case to mimic the three dimensional appearance of natural teeth. For an overall shade of A1, Dentine A1 and Enamel A3 was used in layers.

However, there were certain limitations in the case presented such as the impermanence of diastema closure as the aetiology was not address adequately during the treatment. Furthermore, there are some distinct disadvantages of doing composite restorations as they posses less colour stability compared to that of ceramics. This of course is related to the quality and degree of polishing but also depends on the patient maintenance.[13]

Conclusion

The clinical outcome of this case report demonstrated that the putty index replicating the palatal region for composite restoration can be a reliable procedure for direct composite restorations. Nanohybrid composites can be used to provide an acceptable colour match along with a conservative approach.Though some disadvantages are noted, such as discolorations, when used judiciously, they can serve as the material of choice for patients with aesthetic problems of anterior teeth and with maintainable hygiene practice.

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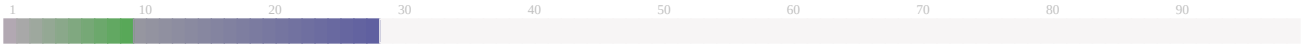

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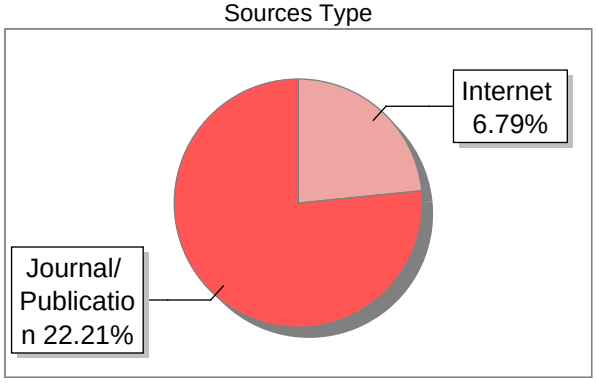

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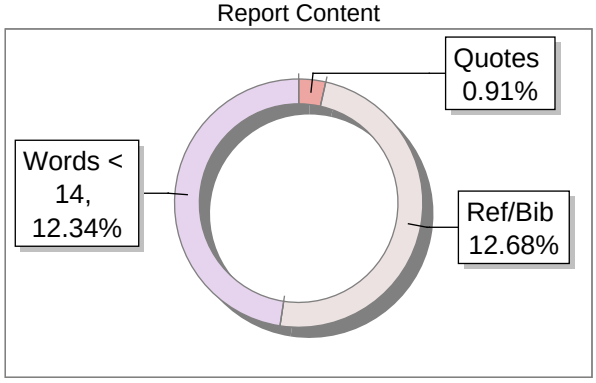

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17	ejmcm.com	1	Internet Data

MIDDLE MESIAL CANAL IN MANDIBULAR I MOLAR: UNRAVEL THE HIDDEN ANATOMY.

ABSTRACT:

Endodontic treatment of mandibular molars is challenging because of variable root canal morphology. Thorough knowledge of the internal dental morphology is extremely important for effective cleaning and shaping the root canal system. The possibility of additional canals, should be explored with the aid of technologies such as magnification and illumination among others. Clinicians experience has also shown to be a key factor in negotiation and management of these aberrant canal configurations.

This case report presents the treatment of a mandibular first molar with five root canals, of which three were located in the mesial root. A third canal was found between the mesiobuccal and mesiolingual root canals

Key words : Five canals, mandibular second molar, middle mesial canal

INTRODUCTION

The primary aim of endodontic therapy is complete debridement of the root canal system and three dimensional obturation of the same. Thorough knowledge of the internal dental morphology is important so as to identify aberrant anatomy of teeth pre-operatively. Permanent mandibular molars, which are the earliest posterior teeth to erupt, are the most commonly encountered type of tooth for endodontic treatment. Mandibular molars present usually as 2-rooted teeth with 2 canals in the mesial root and 1 or 2 canals in the distal root.[1,2]

During tooth maturation, secondary dentin apposition can cause vertical partitions within the root canal cavity, creating multiple canals. Similarly, a third root canal may be created within the root canal cavity of mandibular molars. Such third canals are situated centrally between the buccal and lingual root canals and exhibit relatively smaller diameter.[3] The probability of a fifth canal in mandibular first molars, is around 1–15%.[4]

Vertucci and Williams were the first to report the middle mesial canal in a mandibular molar.[5] Thereafter many case reports presented aberrant canal morphology in the mesial root. Magnification with loupes or microscope improves the visibility and thus helps in the detection of small hidden canals.

The purpose of this article is to report the successful endodontic treatment in a mandibular molar with three mesial canals.

CASE 1:

A 23-year old female patient presented with a chief complaint of decayed tooth and associated pain over her left mandibular region since 2 weeks. History of presenting illness showed dull, continuous pain on chewing. On intraoral examination, deep carious lesion was present wrt 36. Tooth exhibited no mobility and was tender on vertical percussion. Her medical history was noncontributory. Periodontal probing was within the normal limit.

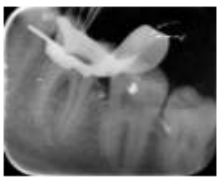
Preoperative periapical radiograph revealed deep carious lesion involving pulp with widening of apical periodontal ligament space in 36 [Figure 1]. The involved tooth gave exaggerated response to electric pulp tester in comparison to the contralateral tooth. A diagnosis of Symptomatic irreversible Pulpitis with Symptomatic apical periodontitis was made for the involved tooth and endodontic therapy was planned. The goal of the treatment was to relieve pain through root canal treatment followed by suitable Post endodontic restoration.

After administration of local anesthesia with 2% lignocaine, dam isolation was done and all carious tissue was removed. An endodontic access preparation was made. After pulp extirpation and copious irrigation of the pulp chamber, two distal and two mesial canal orifices were located. Using the dental loupes and endodontic explorer, a thorough examination of the groove between the mesiobuccal and mesiolingual canal orifices was done, which revealed the middle mesial canal orifice, that was subsequently negotiated with a size 6 K file [Figure 2].

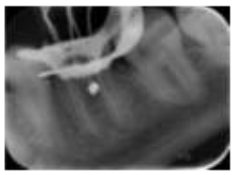
The electronic apex locator was used to establish the working length, that was confirmed with a radiograph. Radiographs taken at multiple angles showed independent mesiolingual canal and middle mesial canal confluent with mesiobuccal canal. The canals were initially instrumented with stainless steel K files upto size 20. Irrigation was done with copious amounts of 3% sodium hypochlorite and 17% ethylene diaminetetraacetic acid with saline irrigation intermittently. Rotary instrumentation was carried with Neoendo flex files till 25.4% for each canal and a master cone radiograph was taken [Figure 4]. After preparation, the canals were flushed with saline, dried with sterile paper points. Calcium hydroxide based intracanal medicament was given and temporized with cavit. At the subsequent visit after a week, the tooth was asymptomatic. The intracanal medicament was flushed out and the canals were irrigated with 17% EDTA for one minute. Saline was used as the final irrigant, canals were dried with paper points and obturated with gutta percha cones and zinc oxide eugenol-based sealer. A post obturation radiograph was taken [Figure 5]. Appropriate post-endodontic restoration was performed in the subsequent visit, to ensure an adequate coronal seal.

CASE 1:

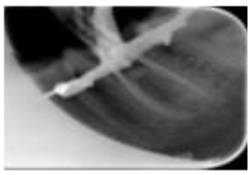
1. Pre- op



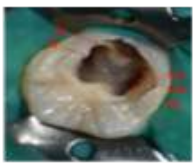
2. Negotiated 3 mesial



3. WL

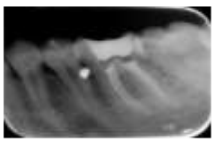


4. Master cone



Canal orifices after cleaning and shaping

5. Immediate post-op (straight view)



Immediate post-op (angled view)

3 month follow up

Post endo ??

CASE 2:

A 48 year old male patient presented with a chief complaint of pain in his lower left back teeth region since past 1 month. On clinical examination, mandibular left first and second molar were tender to horizontal percussion and exhibited grade II mobility with abscess draining through the gingival sulcus. No relevant medical history was noted. Both the teeth were non carious, and showed no response to thermal or electrical pulp sensibility tests.

Diagnosis was made of pulpal necrosis with symptomatic apical periodontitis in 36, 37. Treatment plan was made to perform endodontic treatment for 36, 37 followed by periodontal therapy for the same.

On first appointment oral prophylaxis was done and local anesthesia was administered for root canal treatment of 36, 37. Access opening was done under rubber dam isolation.

After pulp extirpation and copious irrigation of the pulp chamber, two distal and two mesial canal orifices were located in 36 and two mesial canals and one distal canal were located in 37. Using the dental loupes and endodontic explorer, a thorough examination of the groove between the mesiobuccal and mesiolingual canal orifices was done, which revealed the middle mesial canal orifice in 36, that was subsequently negotiated with a size 6 K file [Figure 2]. The electronic apex locator was used to establish the working length, that was confirmed with a radiograph [Figure 3]. Radiographs taken at multiple angles showed independent mesiolingual canal and middle mesial canal confluent with mesiobuccal canal in tooth 36.

The canals were initially instrumented with stainless steel K files upto size 20. Irrigation was done with copious amounts of 5% sodium hypochlorite and 17% ethylene diaminetetraacetic acid with saline irrigation intermittently. Rotary instrumentation was carried with ProTaper gold file till F2 for each canal and a master cone radiograph was taken [Figure 4]. After preparation, the canals were flushed with saline, dried with sterile paper points. Calcium hydroxide based intracanal medicament was given and temporized with cavit. At the subsequent visit after 2 months, the tooth was asymptomatic. The intracanal medicament was flushed out and the canals were irrigated with 17% EDTA for one minute. Saline was used as the final irrigant. canals were dried with paper points and obturated with gutta percha cones and AH plus sealer. A post obturation radiograph was taken [Figure 5]. Post endodontic restoration was done with composite resin. The patient was referred back to dept of periodontics for further periodontal therapy wrt 36 and 37.

Discussion

This case report, presents the endodontic management of mandibular first molars with confluent middle mesial canals. Several studies have been reported with aberrant canal morphology in mandibular first molar. [6,7,8]

A good preoperative peri-apical radiograph taken from at least two different horizontal angles helps in accurate interpretation of the complete root canal system. [9] Clinically, the location of the canal orifices by a proper access cavity preparation, examination of the pulp chamber floor with a sharp explorer, troughing of grooves with ultrasonic tips, staining the chamber floor with 1% methylene blue dye, and performing the sodium hypochlorite "champagne bubble" test, fibrooptic transillumination, visualizing canal bleeding points and the feeling of a "catch" on the canal wall during instrumentation are important aids.

Advancements in ultrasonic activation systems have improved the detection, exploration and effective debridement of the additional canals. The radiographic findings suggestive of additional canals include the fast break phenomenon, eccentric location of the endodontic file during working length determination, inconsistent apex locator readings, and the tracing of a sinus tract laterally away from the main canal.[10]

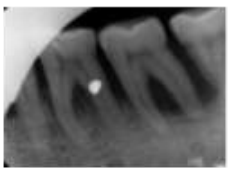
Dental loupes are one of the most common magnification systems used in dentistry. It provides better visualization as it enables the clinician to treat cases which are labeled as having poor prognosis or untreatable. Magnification has been found to increase the detection of extra canals. In this paper, both cases were successfully managed endodontically using dental loupes.

(

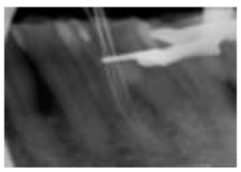
Conclusion:

The management of additional root canals may be challenging but it is more imperative to accurately locate and successfully treat root canals to reduce failures. Even though the incidence of middle mesial canal is low, every effort made in looking for this canal has a high clinical relevance. A clinician should be vigilant and use additional aids for canal negotiation, whenever an additional or aberrant canal anatomy is suspected.

CASE 2



1 Pre- op



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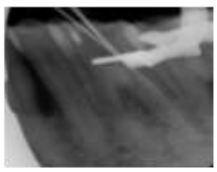
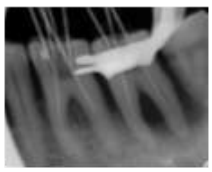
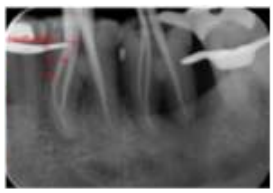


Negotiated of distal canals

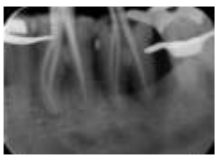


3.WL

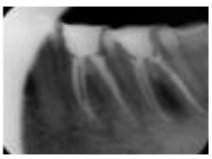
Canal orifices after cleaning and shaping



Obturation



Master cone



4. Immediate post-op (angled view)

Immediate post-op (straight view)

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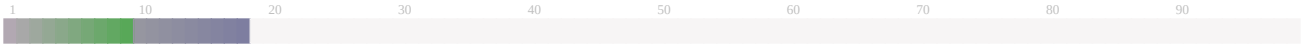

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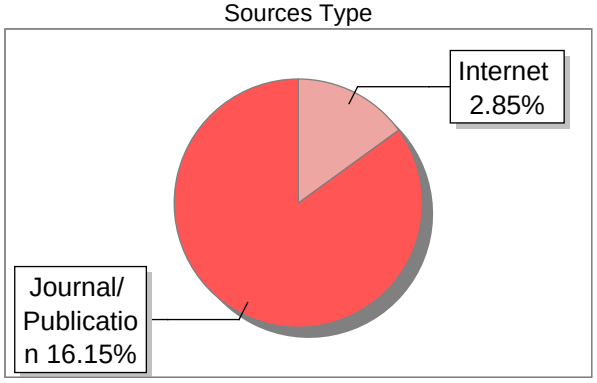

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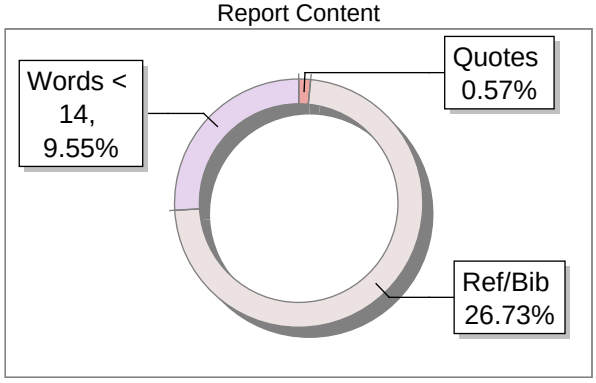

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A COMPARATIVE CLINICAL AND RADIOLOGICAL ANALYSIS TO CORRELATE THE BONE DENSITY AND PRIMARY IMPLANT STABILITY USING CONE BEAM COMPUTERIZED TOMOGRAPHY AND INSERTION TORQUE

ABSTRACT

AIM / OBJECTIVES: The aim of this study was to assess the bone quality with density values obtained by cone beam computed tomography (CBCT) and to determine the correlation between bone density and primary stability of implants using insertion torque values.
MATERIALS AND METHODS: Twenty Root Form Implants were inserted into individuals with edentulous areas in upper and lower jaws in whom rehabilitation with implants was possible. The bone densities of implant recipient sites were preoperatively determined by the density value using CBCT. The maximum insertion torque value of each implant was recorded manually using a torque wrench with calibrations. Spearman's correlation coefficient was calculated to evaluate the correlations among density values and insertion torque values.
RESULTS: The density values in Hounsfield units ranged from 209.91 to 667.13Hu. The mean density value and insertion torque of all implants were 464.69 + 135.74 Hu and 49.0 + 8.20 Ncm respectively. There was a highly significant correlation statistically between bone density and insertion torque (rs 0.89, P< 0.001).
CONCLUSION: The bone density evaluated by CBCT showed a high correlation with the primary stability of the implants (insertion torque). Therefore, the use of a CBCT pre-operatively may greatly help the implant surgeon in predicting the primary implant stability. Hence CBCT can be used as a predictor diagnostic tool for implant success.

Key words: cone-beam computed tomography, dental implants, insertion torque, primary stability

INTRODUCTION

The success of a dental implant procedure depends on a series of patient related as well as procedure dependent parameters, including general health conditions, biocompatibility of the implant material, the feature of the implant surface, the surgical procedure and quality and quantity of the local bone.[1] Over the last 10 years, reconstruction with dental implants has changed considerably. Rather than merely focussing on the tooth to be replaced, today's implant practitioner considers a complex set of interwoven factors before formulating an implant treatment plan.[2] The success of a dental implant relies maorly on both the quality and quantity of the bone available for implant placement.[3] Bone density is a key factor to take into account the prediction ofs implant stability.[4]

Bone density plays a pivotal role, influencing implant stability, particularly in the mandible compared to the upper maxilla.[5] Misch (2008) used computed tomography (CT) to objectively classify bone density into 5 types based on Hounsefield units (HU). Various

imaging techniques, including computed tomography (CT) and cone-beam computed tomography (CBCT), are employed for presurgical and postsurgical examinations, offering 3D perspectives crucial for assessing bone quality.[6]

CBCTs are increasingly being considered essential for optimal implant placement, especially in the case of complex reconstructions.[7] The cone beam configuration is ideal for the maxillofacial region because the dimensions of the beam allow for a panoramic view, sparing patients the radiation exposure of separate scans of the maxilla and mandible.[8] The past two decades have seen continual efforts by manufacturers, researchers and clinicians to improve the success of implant treatment outcomes through evaluation in implant designs, materials and clinical procedures.[9] One such aspect is co-relation of available bone density with primary implant stability.

Primary implant stability, referring to immediate stability post-implantation, is a critical factor in the osseointegration process. Evaluation methods like insertion torque tests and resonance frequency analysis provide noninvasive insights into local bone quality, guiding decisions on immediate loading with prosthetic reconstruction.

Several studies have explored the correlation between bone density, as assessed by CT or CBCT, and primary implant stability. Notably, a study by Isoda et al. demonstrated a strong correlation between specific CBCT-evaluated bone quality and primary implant stability.

This study aims to contribute to this body of knowledge by comparing CBCT-estimated bone density with primary implant stability, using insertion torque measurements. Understanding this relationship enhances the predictability of implant treatment outcomes, facilitating more informed decision-making in clinical practice.

AIMS AND OBJECTIVES

To assess the bone quality with density values obtained by cone beam computed tomography (CBCT) and to determine the correlation between bone density and primary stability of implant by insertion torque value.

MATERIALS & METHODS

The study was done to compare and correlate clinically and radiologically the bone density and primary implant stability using cone beam computerized tomography and insertion torque, on patients who visited the Department of Oral & Maxillofacial Surgery, Dayananda Sagar College of Dental Sciences, Bangalore for implant supported prosthetic rehabilitation. Twenty out- patients with missing single/ multiple teeth and who were suitable for implant rehabilitation were considered for the study.

INCLUSION CRITERIA:

- 20 healthy individuals with edentulous areas in upper and lower jaws in whom rehabilitation with implants was possible were taken up for the study.
- Patients with missing single/ multiple teeth for implant replacement.

EXCLUSION CRITERIA:

- Patients with uncontrolled systemic/ psychiatric illness.
- Patients with previous history of/ undergoing radiotherapy or chemotherapy
- Pregnant patients
- Clinical cases of post implant removal
- Implants placed in sinus lift and immediate extraction sites.

PRE-OPERATIVE ASSESSMENT:

- Patients selected from the above criteria were evaluated and recorded on a custom made Case sheet. (Performa Attached)
- A written informed consent was obtained from all patients and a standardized pre-surgical and surgical protocol was followed for all the patients.
- Pre-operative bone density of implant sites was evaluated using cone beam computerized tomographic scans.
- Bone density measurements were derived using 3DiagnoSys version 4.1 Software It is a licensed product from 3DIEMME Bio imaging Technologies. 3DiagnoSys® is a diagnostic imaging, analyses and 3D simulation software, tailored for the Clinician. 3Diagnosys® software helps to interact with the 3D-model of the Patient, which is obtained by importing TC/CBCT/RM images in DICOM format, in a simple and intuitive way. The tools included in this software are not bound to a morphological reconstructions but are also able to extract from the DICOM data the densitometric values for a bone functional evaluation.)
- Pre-operative evaluation of bone height and bone width was done using Cone Beam Computed Tomographic scan and appropriate implants were selected to be placed.
- The bone height and width measurements were achieved using the "Carestream Dental Imaging Software v6.13.3.3 CS imaging software" (Fov-15x9cm)"
- All CBCT scans were obtained using the "KODAK 9500machine" (10ma 90 Kvp, 200-micron resolution, 10.9sec exposure, 605mgy per cm2).

SURGICAL PROCEDURE OF IMPLANT PLACEMENT:

1. In all instances, implants were placed under local anesthesia using 2% lignocaine hydrochloride with 1:200,000 adrenaline.
2. Different implant systems were used and all were root form implants.
3. Surgical preparation and isolation of surgical field was accomplished according to standard operative protocols.
4. Surgical template prepared on the model pre-operatively was used to identify the implant placement site.
5. A Crestal incision was placed with a No.15 BP blade.

6. Mucoperiosteal flap was reflected and alveolar bone was exposed, and the implant placement site was identified by the marking made with the aid of the surgical probe.
7. Osteotomy site preparation was done with a Reduction gear hand piece (1:16/64) with an external irrigation attached to the handpiece.
8. Implant osteotomy was performed using standard sequential drill bits as per the dimensions of the implant.
9. A speed of 800 RPM and torque of 25-30 ncm was standardized for the procedure.
10. The osteotomy was proceeded till the desired depth as per the selected implants.
11. The orientation of the osteotomy was verified using paralleling pins when placing two or more implants, using the long axis of the adjacent teeth as a reference plane.
12. The implant was inserted into the osteotomy site with the use of a manual torque wrench until the final depth was achieved.
13. All Implants placed were of tapered design and their lengths ranging from8 to 16 mm and diameters from 3-5 mm.
14. Following the placement of the implant, its stability was assessed manually using the insertion torque test with a calibrated torque wrench.
15. The insertion torque reading was measured and recorded at the maximum torque resistance achieved.
16. The cover screw over the implant was then placed.
17. Flap closure was done using 3-0 vicryl.

RADIOLOGICAL ASSESSMENT:

Post-operative OPG and IOPA was taken.

POST OPERATIVE PROCEDURE:

1. Routine Antibiotics and anti-inflammatory drugs were prescribed along with oral hygiene maintenance instructions.
2. Patients were recalled for regular follow ups.
3. Permanent prosthesis was given after 3 months

HEIGHT MEASUREMENTS USING CARESTREAM SOFTWARE:

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Scale: 1-20, Implant site: 9-12 (FIG 1) (FIG 2) WIDTH MEASUREMENTS USING CARESTREAM SOFTWARE:

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Scale: 1-20, implant site:9-12 (FIG 3) (FIG 4) PRE-OPERATIVE BONE DENSITY MEASUREMENTS USING 3DIAGNOSYS VERSION 4.1 SOFTWARE

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(FIG 5) ARMAMENTARIUM FOR IMPLANT PLACEMENT

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Basic armamentarium Reduction gear hand pieces 1:64 and:16 (FIG 6) (FIG 7) ADIN IMPLANT KIT BIOMET 3I IMPLANT KIT (FIG 8) (FIG 9) SURGICAL PROCEDURE PRE OP DIAGNOSTIC CAST IMPLANT SITE MARKING WITH SURGICAL STENT AND STRAIGHT PROBE (FIG 10) (FIG 11)

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INCISION PLACED WITH NO-15 BLADE CRESTAL INCISION (FIG 12) (FIG 13) (FIG 14) (FIG 15) (FIG 16) (FIG 17)

RESULTS

TABLE 1:DISSERTATION CHART

CASE NO	PATIENT NAME	AGE/SEX	IMPLANT SITE	BONE DENSITY (Hu)	IMPLANT SIZE (mm)	INSERTION TORQUE (Ncm)
1	CASE 1	27/F	41	475.663	3.75X13	45
2	CASE 2	22/M	22	246.112	4x13	40
3	CASE 3	19/F	36	495.72	3.75X11.5	55
4	CASE 4	35/M	46	622.001	4.2X16	60
5	CASE 5	35/M	16	261.467	3.75X8	40
6	CASE 6	19/F	46	445.702	3.75X13	45
7	CASE 7	59/F	46	526.827	3.75X13	60
8	CASE 8	59/F	47	573.108	3.75X13	60
9	CASE 9	35/M	36	528.656	4.2X16	60
10	CASE 10	35/M	26	274.744	3.75X8	40
11	CASE 11	36/F	37	452.033	4.2X11.5	40
12	CASE 12	35/M	36	429.832	3.75X16	45
13	CASE 13	43/F	35	562.797	3.75X13	40
14	CASE 14	43/F	36	549.734	3.75X13	40
15	CASE 15	20/M	36	664.002	4.2X11.5	60
16	CASE 16	35/F	14	209.913	3.75X13	60
17	CASE 17	35/F	16	469.218	3.75X8	40
18	CASE 18	35/F	34	667.134	3.3X13	60
19	CASE 19	51/F	16	344.879	3.75X8	50
20	CASE 20	51/F	46	494.260	3.75X13	55

STATISTICS

The statistical analyses were performed using SPSS version 16.0 software (SPSS Inc., Tokyo, Japan). Spearman's correlation coefficient (rs) was calculated to evaluate the correlation among density values and insertion torques. A value of P <0.05 was considered to be statistically significant.

RESULTS

The density value ranged from 209.91 to 667.13 hU. The mean density value and insertion torque of all implants were 464.69 + 135.74 Hu and 49.0 + 8.20 respectively. There was highly significant correlation between bone density and insertion torque (rs 0.89, P< 0.001)

Table 2. Age distribution of study population

	Mean	Standard Deviation	Range
Age (years)	36.45	11.96	19-59

Table 3 . Gender distribution of study population

	Number	Percentage
Male	7	35
Female	13	65

Table 4. Mean values of bone density and insertion torque

	Mean	Standard Deviation	Range
Bone density (Hu)	464.69	135.74	209.91-667.13
Insertion torque (Ncm)	49.0	8.20	40-60

Table 5. Correlation between bone density and insertion torque

	Insertion torque (Ncm)	P value
Bone density (Hu)	0.89	<0.001 **

Spearmans correlation test

** P<0.001 highly significant

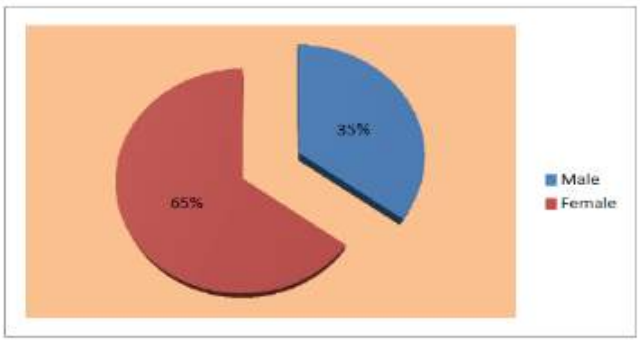

Fig 1. Gender distribution of study population

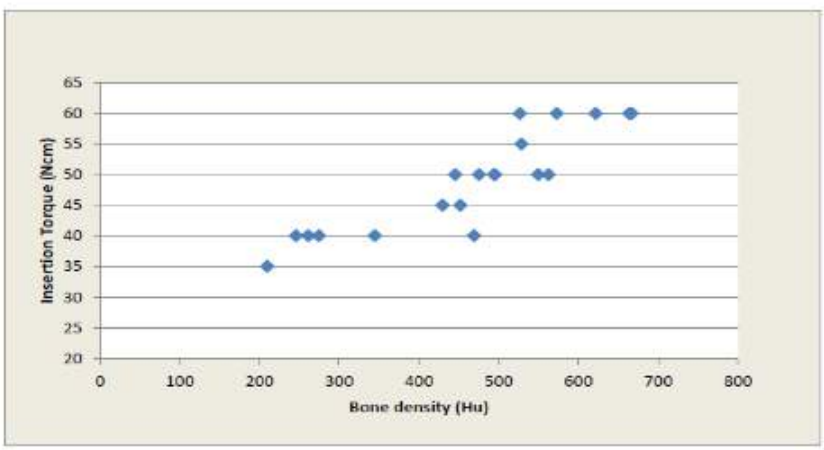

Fig 2. Scatter plot for correlation between bone density and insertion torque

DISCUSSION:

Preoperative evaluation of the bone quality is important for the clinician to establish an optimum treatment plan for implant supported dental rehabilitation. Accurate information and assessment of the bone density will help the surgeon to identify suitable implant sites and determine accurate implant designs.[1] A precise evaluation of the bone configuration is essential prior to implant placement.[1] One of the most important factors in determining implant success is proper treatment planning and with the advent of advanced imaging technology, Cone Beam Computerized Tomography (CBCT) is increasingly being considered as an essential tool determining the bone quality and quantity thus helping for optimal implant planning and placement.[2]

Presurgical dental implant planning for Implant placement requires specific and accurate data to assess the implant site so that the dental implants placed has the greatest chance of success.[3] It has been proven that the success of an inserted implant strongly depends on the quality, beside the quantity, of the surrounding bone (Jaffin & Berman 1991; Jemt et al. 1992).[4]

Various bone classification systems have been proposed to assess bone quality. In 1985, Lekholm and Zarb introduced a system that uses radiographs to subjectively classify bone density into four types based on the proportions of cortical and trabecular bone. This classification has gained worldwide use due to its simplicity and minimal investment requirements. Misch (2008) developed a classification system using computed tomography (CT) to objectively categorize bone density into five types based on Hounsfield units (HU) (Hounsfield 1980). This method provides a precise and objective evaluation of bone quality.[1]

Lekholm and Zarb used radiographs to subjectively classify bone density into four types based on the amount of cortical and trabecular bone. This classification system has been utilized Worldwide because it is easy to use without considerable investment. Misch (2008) used computed tomography (CT) to objectively classify bone density into 5 types based on Hounsfield units (HU) (Hounsfield 1980). This method allows for a precise and objective assessment of bone quality.[1]

Significant correlations between the density values of CBCT and Hounsfield unit (HU) of multi slice CT were also reported in recent studies (Naitoh et al. 2009; Nomura et al. 2010). In a recent study, Pauwels et al. (2013) investigated the correlations between CBCT derived gray values and multi slice CT-derived gray values. The authors found controversial results showing good correlations between CBCT and CT but also large errors when using gray values in a quantitative way. Consequently, deriving bone density values from CBCT images seems controversial. In the literature, there are only limited number of studies about the correlation between bone density estimated by CBCT and primary implant stability.[6]

Primary stability is associated with the mechanical engagement of an implant with the surrounding bone. Where as bone regeneration and remodelling phenomena determine the secondary (biological) stability to the implant. A secure primary stability is positively associated with a secondary stability.[7]

In the present study 20 healthy individuals, who visited the Department of Oral & Maxillofacial Surgery, Dayananda Sagar College of Dental Sciences, Bangalore for implant supported prosthetic rehabilitation were taken up.

Helical CT scans provide bone density measurements in HU. In contrast, CBCT lacks a standardized unit like HU because it has not been calibrated. Several studies have found a high correlation between CBCT density values and the HU of multi-slice CT (Aranyarachkul et al. 2005; Naitoh et al. 2009; Nomura et al. 2010). Radiographic examinations can offer preoperative bone density information. HU is a standardized scale used for reporting reconstructed CT values (Shapurian et al. 2006).

In a previous study, 32 helical CT scans of patients were examined, revealing mean bone density values ranging from 77 to 1421 (Norton & Gamble 2001). Bone density values from 20 patients evaluated via CBCT ranged from 238 to 777 (Song et al. 2009). Additionally, the bone density values of three human mandibles (dry bone) varied between 267 and 553 HU, with a mean of 113 HU (Turkyilmaz et al. 2009). The density values recorded in the present study are comparable to those reported in these studies and can be considered analogous to HU values assessed by helical CT. In our study, density values ranged from 209.91 to 667.13 HU, with a mean density value of 464.69 ± 135.74 HU for all implants.

The study reveals a robust correlation (0.89) between Cone Beam Computed Tomography (CBCT)-derived bone density and implant stability, endorsing CBCT as a valuable tool for preoperative assessment. Previous research also indicates correlations between bone density and implant stability. However, conflicting results exist, with some studies showing no correlations. The present clinical study emphasizes the importance of including cortical bone evaluation in preoperative bone density assessments. CBCT examinations before implant surgery prove instrumental in predicting primary stability, guiding optimal loading times for implants in prosthetic rehabilitation. While CBCT shows promise, further research is essential to explore correlations across diverse variables influencing implant stability.

CONCLUSION:

In the study conducted in the Department of Oral and Maxillofacial surgery, Dayananda Sagar College of Dental Sciences, we aimed to evaluate bone quality by using density values obtained from cone beam computed tomography (CBCT) pre-operatively and to determine their correlation with insertion torque values recorded during the implant placement procedure.

Based on the observations and results obtained, we can conclude that this study demonstrates the relationship between bone density values derived from Cone Beam Computed Tomography (Hu) in the maxilla and mandible and bone quality as classified by Lekholm & Zarb.

The primary implant stability measured with the insertion torque test (ITV) depends on bone density values, bone quality and implant location. Implants Placed in location with higher bone density have more stability, and we can probably predict the implant insertion torque based on the bone density values (Hu) and the implant location. Finally, with higher bone density values (Hu) and higher primary implant stability measured in ITV values; Hounsfield units can be used as a diagnostic parameter to predict possible implant stability.

This study employs torque wrenches to assess primary stability, as an alternative device for monitoring dental implant stability were prohibitively expensive. There is potential for further enhancement of the study to yield more robust outcomes.

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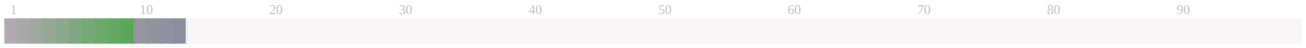

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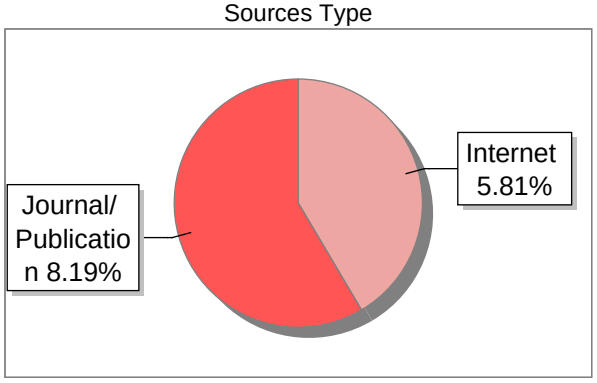

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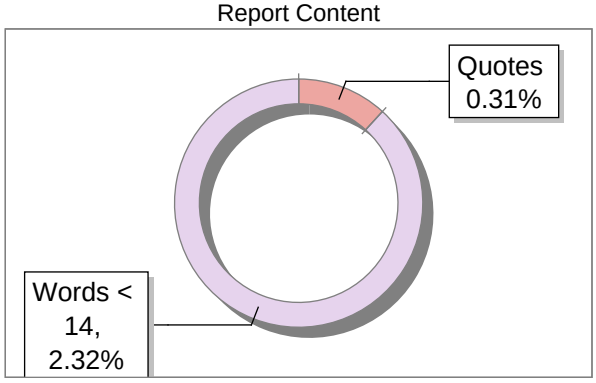

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AN ATYPICAL CHAUFFEUR: TONGUE DRIVEN WHEELCHAIR

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ABSTRACT
The human body is a machine that enables living and performing various task. Once the functional ability is lost a vital part of life will be compromised.
The loss of function may be due to various causes and can be unilateral/bilateral which can be localized to a part or generalized. [5] Various wheelchairs currently available in the market uses electrically powered wheelchairs to allow individuals to complete daily tasks with greater independence and community environments. One of the newer concept in this area is a tongue driven wheelchair system.
The tongue as an operating system can be beneficial because unlike the feet and hands, which are connected by brain through spinal cord, the tongue and brain has a –direct connection through cranial nerve that generally escapes damage in severe spinal cord injuries or neuromuscular disease. [2] Tongue being a strong muscle provides faster and accurate movements that do not require much concentration or effort.
Paralyzed patients can move around independently with the tongue driven wheelchairs creating a huge demand for this assistive technology in future. Further research in the field can make mobility far more accessible to people who are facing various challenges.

INTRODUCTION

The ability to move about freely, brings a sense of freedom to all. The loss of it can greatly impact a person's life. The loss of function of limb/limbs can be due to various causes. The most common causes leading to amputation are diabetes mellitus, peripheral vascular disease, neuropathy, and trauma.[1]
According to the World Health Organizations report on disability, currently about 15% of world population lives with some type of disability out of which 2-4 % of the population experience significant difficulties in their day to day activities. Wheelchair usage is not just limited to paralyzed people but also blind, physically handicapped and people having neuromuscular and spinal cord issues .[2]

Current modalities

There are currently multiple variants of wheelchairs available in the market. This includes the manual wheelchair.

1. **Manual wheelchairs** are great for people who can operate them independently. However, the downside is that users can quickly become fatigued especially if they travel long distances or move around for an extended period of time on their own. [3]
2. **Powered wheelchairs** have undergone an enormous change in the last decade. The development of micro processing capabilities allowed developers of powered mobility technology to include a wide range of functions in these devices.[3] A motorized wheelchair like this resolves the issue of fatigue as well as disabilities that restrict the use of manually operated wheelchairs.

- **Joystick controlled wheelchair** is one of these modalities. A joystick mounted on the wheelchair helps maneuver it around.
- Another is the **touchpad controlled wheelchair**. Touchpads feel similar to what you may find on a computer for controlling its mouse cursor. Touchpads can be configured for the user so that touching a specific part of the touchpad relative to the center will move in that direction. One drawback of both these technologies is that it is only accessible to those with coordinated motor functions.[7]
- **Switch coordinated wheelchairs** are also available in the market. Switches can be mechanical momentary contact switches or based on proximity where no physical contact is required. Multiple switches can be used, one for each direction, three switches as in a head array or a single switch that is used with some scanning display.
- Another alternative is **the sip and puff mechanism wheelchair**, which are operated by sucking and blowing on a mouthpiece. They require quite a bit of practice by the user to get good at driving.
- **Eye movement activated and voice controlled wheelchairs** are also available. But the mechanism can be misled by rogue eye movements or voice commands. [7]

MATERIALS AND METHODS - TONGUE DRIVEN WHEELCHAIR

The alternative wheelchair system that will be discussed in this article is the tongue driven wheelchair system [TDS].[6] It is controlled via a prosthesis incorporated with touch sensors placed on the palate, and operated by the tongue movements. The prosthesis can be customised according to the dentulous state of the patient, if the patient is completely edentulous then the controller can be adapted to the complete denture prosthesis. And if the patient is partially edentulous then the controller can be incorporated into the Removable partial denture via clasp mechanism. In case of completely dentulous patients, the controller can be adapted onto a prosthesis adapted to the palatal aspect of maxilla via clasp retention mechanism.

The patient is advised to wear the prosthesis during the operation of wheelchair.

1. End-to-End Working Model of the prototype: The end-to-end working model of the tongue-controlled wheelchair involves various components seamlessly working together. The user's tongue movements are captured by the touch sensors placed in the upper jaw (figure 1). These touch sensors detect the tongue's position and send signals to the microcontroller, specifically the ESP32. The microcontroller processes these signals and determines the desired direction or action for the wheelchair. It then controls the DC motors, which are connected to the 3D printed wheels of the wheelchair (figure 2), through the L293D motor driver. By adjusting the motor speed and direction, the wheelchair moves according to the user's tongue movements. The microcontroller also interacts with other parts of the wheelchair, such as the chassis and chair, to ensure a holistic functioning system. The complete setup of the prototype is depicted in figure 3 (Figure 1 – touch sensors placed on the palatal prosthesis)

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(Figure 2 – 3D printer wheelchair with DC motor)

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(Figure 3 – complete prototype set up) 2. Microcontroller Used in this prototype and its Significance: The ESP32 microcontroller is selected for its suitability in IoT (Internet of Things) applications. It offers built-in Wi-Fi and Bluetooth connectivity, enabling wireless communication and control. The ESP32's ample processing power and memory make it capable of handling sensor inputs and effectively controlling the motors. Additionally, its abundant GPIO pins allow for seamless integration with various components of the wheelchair, including the touch sensors, motor driver, and other peripherals. By utilizing the ESP32 microcontroller, the tongue-controlled wheelchair can achieve efficient and reliable performance. 3. Sensors Used and their Significance: In the development of tongue-controlled wheelchairs, the choice of sensors plays a crucial role in achieving a wire-free setup. While touch sensors typically require wires to come out of the mouth, alternative sensor methods offer the possibility of a non-intrusive and comfortable solution. This document explores various alternative sensor approaches that eliminate the need for wires inside the mouth. Additionally, it provides reasons for utilizing touch sensors in cases where wires are necessary.

External Mounting:
Rather than placing sensors inside the mouth, an external mounting approach can be adopted. Touch sensors can be integrated into a custom-designed mouthpiece or attached to a wearable device positioned on the palate. This allows for close proximity to the tongue while routing wires externally, providing a wire-free experience for the user.

Other type of sensors available

- Inductive Coupling:
  Inductive coupling enables wireless power transfer. Touch sensors can be powered wirelessly using electromagnetic induction, with the power source located outside the mouth. Through a coil or magnetic field, the sensors receive power without the need for power wires. However, some form of wired communication may still be required for transmitting the touch data.

- Infrared (IR) Sensors:
  Infrared sensors can detect tongue movements without physical contact. Placed outside the mouth, these sensors capture the reflection or emission of infrared light from the tongue. The detected signals can be translated into control commands for the wheelchair, offering a wire-free and non-intrusive solution.

- Optical Sensors:
  Optical sensors, such as photodiodes or optical proximity sensors, analyze light changes to detect tongue movements. Positioned externally near the upper jaw, these sensors detect alterations in light when the tongue obstructs or reflects it. This wire-free method accurately captures tongue movements while maintaining user comfort.

- Magnetic Sensors:
  By utilizing magnetic sensors like Hall Effect or magneto resistive sensors, tongue movements can be detected through variations in the magnetic field. A small magnet placed on the tongue interacts with the externally positioned sensors, translating the changes into control commands. This approach eliminates the need for wires inside the mouth.

- Ultrasonic Sensors:
  Ultrasonic sensors measure the distance between the tongue and the sensor by emitting and analyzing reflected ultrasonic waves. These sensors, positioned

externally, allow for wire-free implementation. By accurately determining tongue position and movement, they enable precise control of the wheelchair.

Reason for Using Touch Sensors:
The decision to use touch sensors, despite the wires required, can be justified based on cost-effectiveness, simplicity, and user-friendliness. Touch sensors are readily available, cost-efficient, and provide immediate response. These factors make them suitable for projects with limited resources or tight timeframes, where a wire-free setup is not a critical requirement.

In the quest for a wire-free setup in tongue-controlled wheelchair projects, alternative sensor methods offer viable solutions. Through external mounting, inductive coupling, infrared, optical, magnetic, or ultrasonic sensors, it is possible to eliminate the need for wires inside the mouth. However, touch sensors remain a practical choice in scenarios where wires are inevitable, considering their accessibility, affordability, and ease of implementation.

The touch sensors, placed in the upper jaw, play a crucial role in capturing tongue movements. These touch sensors are preferred due to their simplicity, affordability, and ease of implementation. They detect the presence or absence of tongue contact, providing reliable input for controlling the wheelchair.
Touch sensors are often cost-effective, readily available, and offer simplified implementation. This makes them an accessible option, particularly for projects with budget constraints or those requiring quick prototyping.
Additionally, the wheelchair may incorporate other sensors relevant to the specific requirements of the application, such as distance sensors or obstacle detection sensors. These additional sensors enhance the overall functionality and safety of the wheelchair.

4. Implementation in Real Scenario and User Enable/Disable:
   In a real scenario, the tongue-controlled wheelchair would involve integrating the system into a commercially available wheelchair with a suitable chair for the user's comfort. The wheelchair's existing chassis provides the necessary structural support and maneuverability. The touch sensors would be strategically placed on the palate, allowing the user to control the wheelchair through tongue movements.
   To enable or disable the tongue-controlled functionality, a user-friendly interface can be incorporated into the wheelchair design. This interface may include buttons, switches, or touch-sensitive controls conveniently located within reach of the user. By engaging or disengaging this control mechanism, the user can activate or deactivate the tongue-controlled feature of the wheelchair.

Proper safety measures should be implemented to ensure the user's well-being. For example, an emergency stop button or lever can be included to immediately halt the wheelchair's movement in case of any unforeseen circumstances or emergencies. Additionally, the wheelchair can have manual control options, such as traditional joystick controls, allowing the user to switch between different control modes based on their preference or specific situation.

By integrating the tongue-controlled system into a real wheelchair, it becomes a practical and functional solution for individuals with limited mobility. The user can easily enable or disable the tongue-controlled feature as needed, ensuring a personalized and adaptable wheelchair experience while maintaining safety and convenience.

RESULTS

The prototype was adapted with four sensors denoting forward, backward, right and left movements. Several motion tests were done to check the efficiency of sensors in bringing about motion in the desired directions. The results obtained showed successful range of movements.

DISCUSSION

The use of evolving technology to improve the quality of life of individuals is being done at an accelerated rate in recent times. The results we have obtained from using sensors adapted on a palatal prosthesis have been encouraging. The basic movements of forward, reverse and right and left movements were appropriately followed in the model. As the model uses Bluetooth connection between the sensor and the wheelchair there is no clunky connective components.

Additionally, the wheelchair may be incorporated with other type of sensors (distance sensors or obstacle detection sensors) relevant to the specific requirements of the application. These additional sensors enhance the overall functionality and safety of the wheelchair.

This signifies the potential that similar technology can be utilized to make a full scale version adapted to a wheelchair that will successfully function in the intended manner. This could provide a new alternative version of a powered wheelchair.

CONCLUSION

The tongue drive wheelchair can be utilized by all people with disabilities to achieve the freedom to move around independently. This system has the potential to be more versatile in its applicability and offer more comfort during its usage. It is a compact system with a slight learning curve involved in adapting to its usage.

CONFLICTS OF INTEREST

There is no conflicts of interest

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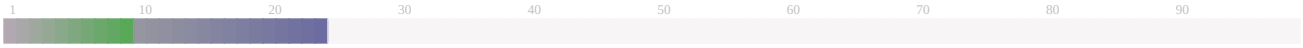

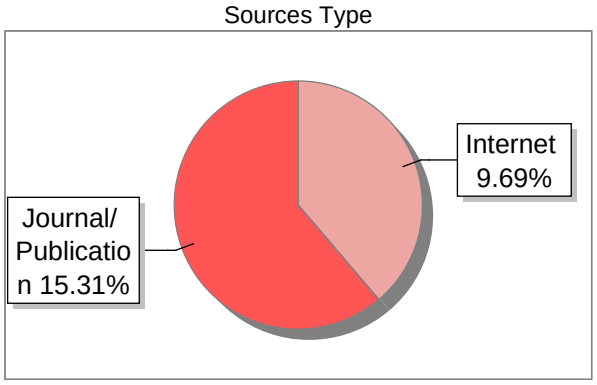

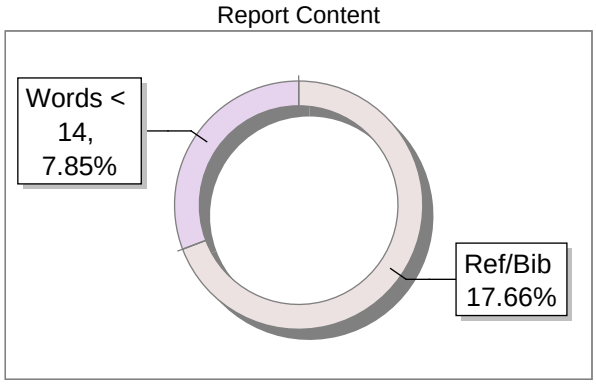

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EVALUATION OF THE ANTIBACTERIAL ACTIVITY OF VARIOUS CONCENTRATIONS OF RAISIN EXTRACT AGAINST STREPTOCOCCUS MUTANTS: AN IN VITRO STUDY

ABSTRACT

Background: Dental caries is one of the most common and costly diseases in the world. Although dental caries is rarely life threatening, it is a major problem for health service providers. *S. mutans* is considered as the pioneer organism in dental caries. Fruits like grapes and pomegranate have been found effective against *S. mutans.*

Objectives: To find out minimum inhibitory concentration of black raisins extract against S. mutans and to assess whether the black raisins extract has antibacterial efficacy on S. mutans.

Methods: In this in vitro study, compound isolatin of raisin extract was done using chloroform, hexane and methanol, prepared in Department of Pharmacology, Dayananda Sagar Institutions .Minimum inhibitory concentration of raisin extract was determined using optical density method. Evaluation of antibacterial activity was done using well diffusion method

Results: Minimum inhibitory concentration of raisin extract was observed at a concentration of 125 µg/well at which an inhibition rate of 48.65% was observed. Minimum zone of inhibition of 16±0.0mm was observed at a concentration of 2.5 µg of raisins extract.

Interpretation and conclusion: Raisins contain polyphenols, antioxidants, flavonoids and iron that may benefit overall human health. It has an MIC value of 125 µg/ml at which the rate of inhibition is 48.65%. The structural diversities and pronounced biological activities of compounds in raisins indicate that raisins are worthy of further studies that may lead to the identification of new functional constituents.

Keywords: raisin extract, Streptococcus mutants, antibacterial efficacy, dental caries

INTRODUCTION

Dental caries is one of the most common non communicable and costly diseases in the world. Although dental caries is rarely life threatening, it is a major problem for health service providers.[1] According to Global Oral Health Data Bank, prevalence of dental caries varies from 49% to 83% across different countries.[2]

An enhanced understanding of the role ofthe microorganisms in dental caries is needed to reduce the prevalence of caries. *S. mutans* is considered as the pioneer organism in dental caries. *S. mutans* play a key role in the etiology of dental caries because it can adhere to the enamel salivary pellicle and to other plaque bacteria.[3] Addition of antiplaque or antibacterial agents to dental health care products has been of value in controlling dental caries.

Various products like cholorhexidine, sodium fluoride, xylitol and triclosan have been found very effective in controlling *S. mutans* count.[4] Extracts containing polyphenols of plant origin gained more attention of researchers for their use against drug-resistant pathogens.[5] Anti-bacterials or antibiotics from these sources have been found to be more efficient with fewer side effects and less cost of production.[6]

Plant-based phenolic metabolites are beneficial to human health because of their potent antioxidation and wide range of pharmacologic properties such as antioxidant, anticancer, and platelet aggregation inhibition activities. It is important to stress more on natural products than artificial drugs. Going green has major benefits to patients and also environment.

Fruits like grape contain various nutrient elements, such as vitamins, minerals, carbohydrates, edible fibers and phytochemicals. Polyphenols are the most important phytochemicals in grape because they possess many biological activities and health-promoting benefits. Polyphenolics from grapes and red wines attracted the attention of scientists to define their chemical composition and their properties for human health. [7]

Black grape (*Vitis vinifera*) skin is a great source of phenolic compounds, which contains simple compounds (monomers) to complex tannin type substances (oligomers and polymers). The various classes of negatively charged polyphenols that have been identified in grapes, such as phenolic acids (benzoic, hydroxycinnamic acids), stilbene derivatives (resveratrol), flavanols (catechin,epicatechin), flavonols (kaempferol, myricetin), anthocyanin and many more.

These polyphenols boast many beneficial effects on human health such as inhibition of free radical damage, antibacterial, antifungal, increase cardiovascular health, anticarcinogenic and anti-inflammatory actions on human health.[7] Grape as a whole is generally underutilized and thrown away by the wine factory as waste products. Grape skins are rich sources of anthocyanins, hydroxycinnamic acids, flavanols and flavonol glycosides in which flavanols are mainly present in the seeds.[8]

Anthocyanins give black grapes their color. It is present in a huge amount as compared to other polyphenolic compounds. The higher amounts of dimers and trimers of epicatechin which possess a higher antibacterial activity than monomer ones.[9] Thus black grape is found to have both antifungal and antibacterial activities.[10]

Catechins, along with other polyphenols are highly negatively charged phytochemicals, that give the antifungal property to black grape. The phenolic compounds from different parts of grape have shown different antibacterial effects. antibacterial activity of fermented grape was either as effective as or significantly better than whole fruit grape extracts.[11]Various compounds in grape are being studied for their activity against *S. mutans.*

There is scarce literature reporting the antibacterial activity of raisins extract against *S. mutans.*

The purpose of this study was to assess antibacterial activity of chloroform soluble black graperaisins extract against *S. mutans*

METHODOLOGY

Study Design:

In vitro study

Study Setting:

The raisin extract was prepared in Department of pharmacology, Dayananda Sagar Institutions. The calculation minimum inhibitory concentration of raisin extract was done at Invivo Bioscience lab, Magadi road, Bangalore.

Materials used:

Black Grape (Vitis Viniferous)

Ethanol (99 %v/v)

Hexane (80% v/v)

S. mutans (25175) Ciprofloxacin (0.1 mg/mL)

Distilled Water

Soya bean Casein Digested agar plates

Compound isolation:

The dried and ground raisins (500 mg) were extracted with one litre of ethanol three times by maceration, for up to three days. The resultant extracts were combined and concentrated in vacuo at 40 degree celsius. The concentrated extract was suspended in90% ethanol (250 ml), and then partitioned with 250 ml of hexane three times to afford hexane soluble syrup on drying. Next, the aqueous methanol extract was partitioned with 250 ml of chloroform three times to give a chloroform soluble extract as per study by Zhu et al [12]

Estimation of minimum inhibitory concentration: [13]

It was done by mixing 90µl test compounds of different test concentration with 10µl Inoculum a n d was kept in 96 well plates. For Control, 90µl peptone broth without drug was used. The *S.mutans* treated plate was incubated at 37^0C for 24 to 48 hours and optical density at 590 nm was measured using a tecan plate reader. Minimum inhibitory concentration of grape extract giving 50% inhibition of optical density was compared with control.

15 After incubation 20µl Resazurin (1000µg/ml) was added to each well and incubated for 4hr to confirm the viability of culture. Evaluation of ANTIBACTERIAL activity by Well Diffusion Method: The antibacterial activity was determined by well diffusion technique. It was performed on soya bean casein digested agar plates. S. mutans (ATCC 25175) was used as test organism and Ciprofloxacin (100 µg/mL) was used as standard.14 Distilled water was used as a control. S. mutans (100µl) was inoculated on soya bean casein digested agar plates (90 mm). Raisins extract (25 µl), standard ciprofloxacin (25µl) and Control (25µl) for S. mutans were added to the 5mm well on agar plates. The treated plates with S.mutans were incubated at 370C for 24-48 hrs. The Minimum inhibitory concentration of raisin extract was determined by the ability of each substance to inhibit the growth of S. mutans around the 90 mm wells in soya bean casein digested agar plates. (Figure 1) SOYA BEAN CASEIN DIGESTED AGAR PLATESHOWING ZONE OF INHIBITION FIGURE 1

RESULTS

Various concentrations of raisins were used to find the minimum inhibitory concentration of the extract. At 15.62 µg/well concentration, 15.19 % inhibition was found for raisins extract. The concentration of raisins extract was gradually increased up to a concentration of 1000 µg/well at which the inhibition of 75.98 % was observed. Minimum inhibitory concentration of raisin extract was observed at a concentration of 125 µg/well at which an inhibition rate of 48.65 % was observed.

For ciprofloxacin, 50% inhibition or an MIC value was observed at a concentration of 0.5 µg/well.

Minimum zone of inhibition of 16±0.0 mm was observed at a concentration of 2.5 µg of raisins extract. There was no zone of inhibition found at a concentration of 1.5 µg of raisins extract. Minimum zone of inhibition of 25±0.0 mm was observed at a concentration of 2.5µg for ciprofloxacin.

DISCUSSION

The presence of anthocyanins, in a huge amount as compared to other polyphenolic compounds gives black grapes their colour. The amount of total polyphenols in the black grape varieties is higher as compared to that of green grape, due to the presence of the anthocyanins. The antibacterial property is also aided by the presence of polyphenols like oleanolic aldehyde, linoleic acid, linolenic acid, botulin, betulinic acid, 5-(hydroxymethyl)-2-furfural, rutin, b-sitosterol, and b- sitosterol glucoside were identified by comparing their physical and spectroscopic values. as an antibacterial agent, these polyphenols can penetrate the semi permeable cell membrane where they react with the cellular proteins. The intention of the current study was to check whether higher concentration gives better efficacy against *S mutans*. This study also evaluated the MIC of raisins extract collectively against *S. mutans*.

A study conducted by Cruz. J.F and Zhu. M [12] using the same method as the present study assessed the MIC of various compounds in raisins extract individually. The results of the study showed that various polyphenols in raisins showed different MIC values against *S. mutans*. The MIC values for different polyphenols were Oleanolic acid (625 µg/ml), Lineoleic acid (488 µg/ml), Rutin (250 µg/ml) and for 5 Hydroxymethyl-2- furfural (31 µg/ml). The results of the current study could not be compared with this study because current study compared the MIC value of raisins extract collectively.

A study was conducted by Yadav D, Kumar A and Mishra D[13] to find the antibacterial activity of black grape. The results of thier study showed that the extracts showed MIC of 260 µg /ml polyphenols against *S. aureus* and *E. aerogenes*. MIC of 540 µg/ml wasfound against *E.faecalis*. In this study the MIC value against *S. mutans* was not determined. Thus results of the current study could not be compared with this study.

In the present study we found an MIC value of 125 µg/ml against *S.mutans*. The zone of inhibition was determined by well diffusion technique using soya bean casein digested agar plates and it was found to be 16 mm after incubating it for 48 hours at 37 C. The results of the current study could not be compared with that of other studies as this is the first study of its kind which compared the MIC value of raisins extract collectively.

Limitations of the study:

Firstly, it was an in vitro study; the results cannot be extrapolated to in vivo situation. Secondly, in this study the MIC value for polyphenol components was determined collectively and further studies determining the MIC of individual polyphenol compound in the black raisin extract need to be conducted.

Further studies are recommended using Innovative technologies to obtain the pure black raisins extract and in vivo studies has to be conducted to find the efficacy of black raisins extract. Assessing the antibacterial efficacy against *S. mutans* is a surrogate end point but the true end point is the change in dental caries that has to be detected or find out using longitudinal studies.

Table1: Inhibitory activity of test compounds against test organism

Test Organisms	Test Compounds	Concentration per well	Zone of inhibition (mm)
Streptococcus mutans	**Control**	**-**	**-**
	Ciprofloxacin (Standard)	**2.5µg**	**25±0.0**
	Streptococcus mutans	**2.5mg**	**16±0.0**
		1.5mg	**-**

Table 2: Determination of Minimum Inhibitory concentration of Standard (Ciprofloxacin) against *S.mutans.*

Standard Conc. (µg/well)	*S.mutans*	
	OD	%Inhibition
0	0.62	0
0.125	0.51	17.42
0.25	0.45	26.94
0.5	0.31	50
1	0.24	60.81
2	0.18	71.13
4	0.14	77.14
8	0.09	85.48
MIC(µg/well)	**0.5 µg**	

Table 3: Determination of Minimum Inhibitory concentration of raisin extract against *S.mutans*

Sample Conc. (µg/well)	*S.mutans*	
	OD	%Inhibition
0	0.60	0.00
15.62	0.51	15.19
31.25	0.43	28.61
62.5	0.38	37.39
125	0.31	48.65
250	0.26	57.10
500	0.20	67.37
1000	0.15	75.98
MIC (µg/well)	**250µg**	

CONCLUSION

Raisins have been consumed for a long time and are commonly used in various food preparations. The studies have demonstrated an inverse association between intake of raisins and mortality from age related diseases such as coronary heart diseases. Anthocyanins, flavonoids and resveratrol are the major functional components that are responsible for most of biological activities of grape. The health benefits of grape are thought to arise mainly from bioactivities of their polyphenols

Raisins contain polyphenols, antioxidants, flavonoids and iron that may benefit overall human health. Black raisins are found to have antibacterial efficacy against *S.mutans* and also has several other health benefits. It has an MIC value of 125 µg/ml at which the rate of inhibition is 48.65%. Raisins are worthy of further studies that may lead to the identification of new functional constituents due to their distinctive structure and marked biological activities of the compunds present in them

structural diversities and pronounced biological activities of compounds in raisins indicate that Going green has a major benefit to the patients and also to environment thus the usage of raisins should be promoted in daily usage.

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CONFLICT OF INTEREST

There is no conflict of interest

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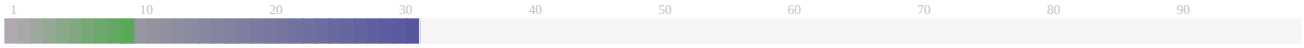

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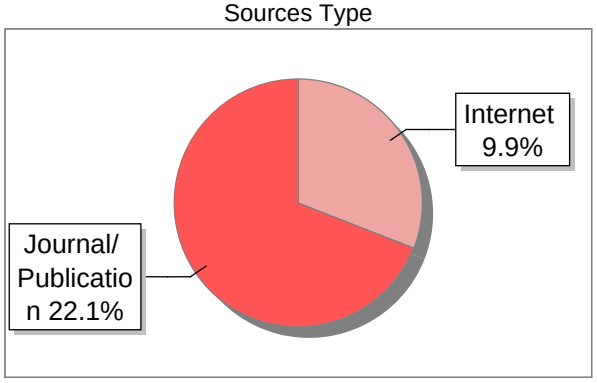

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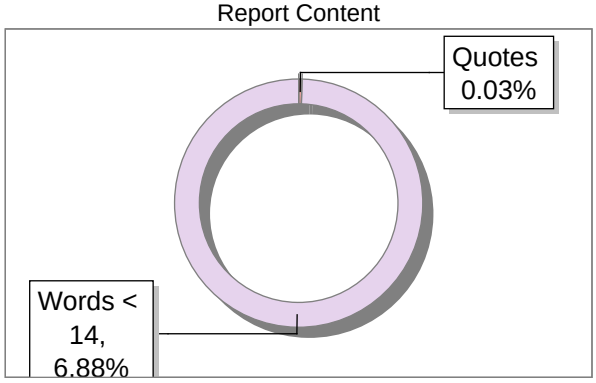

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4	moam.info	2	Internet Data
5	mdpi.com	2	Internet Data
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REVIEW ARTICLE

REVOLUTIONIZING ORAL CANCER DETECTION: FUSING THE POWER OF LIGHT AND AI FOR EARLY DIAGNOSIS

INTRODUCTION

Oral cancer ranks sixth globally in terms of cancer incidence. It is one of the most dreadful diseases affecting humans.[1] With a prolonged preclinical stage, oral squamous cell carcinoma (OSCC) is the most common form of oral cancer in terms of aetiology. [2] Early cancer detection, precise diagnosis, and highly efficient cancer therapy with minimal side effects are critical because they can significantly improve cancer patients' chances of survival and quality of life.[3]

Optical Coherence Tomography is noninvasive high resolution optical imaging technique. It relies on the interference of a local reference signal with a signal from the subject that is being investigated. [4] Due to its noninvasive, rapid, and three-dimensional imaging capabilities, optical coherence tomography (OCT) is gaining significant interest in the field of biomedical imaging. The sensitivity and imaging speed of the Fourier-domain OCT approach, which includes spectral-domain OCT (SD-OCT) and swept-source OCT (SS-OCT), have recently improved significantly in comparison to the time-domain OCT technique.[5] OCT has been widely used in numerous clinical applications, including oncology, gastroenterology, ophthalmology, dermatology, and dentistry.

Artificial intelligence (AI) has proven to be highly accurate and efficient in supporting biomedical imaging decision-making for individualized cancer treatment.[3] Artificial intelligence (AI) has the potential to significantly improve patient outcomes when it is included into clinical practice and research on cancers of the oral cavity.[6] AI is defined as a branch of computer science aiming to simulate intelligent human behaviour in machines. A programmed machine capable of learning and recognizing patterns and relationships between inputs and outputs is considered an AI system. Machine Learning (ML) and Deep Learning (DL) are the primary methods used to implement AI, with ML algorithms relying on structured, labelled data for predictions. Structured data, characterized by specific features, is processed by ML models to identify patterns, thus enhancing clinical decision-making across various

levels. ML methods, further categorized into supervised, unsupervised, and reinforcement learning, continuously update themselves, progressively improving analytical accuracy. DL, a subset of ML, specifically involves autonomously learning features and tasks from a training dataset. The term "deep" refers to the multiple layers of algorithms through which presented data passes during computation. A network of interconnected algorithms in DL is referred to as a neural network. In the context of cancer, DL and conventional machine learning, including rule-based learning, are employed to distinguish and detect cancer images from those of normal tissues and healthy controls. This interdisciplinary approach showcases the transformative impact of AI in enhancing healthcare outcomes.[7]

Mechanism of OCT

Optical coherence tomography basically uses a light source for imaging. A light beam can be transmitted, reflected, or absorbed when it strikes a tissue surface. Tissue-absorbing light is regarded as light that is emitted from the incident light. Tissue-resident chromophores, such as melanin and haemoglobin, oversee absorption and photochemical alterations, which are further influenced by the incident beam's wavelength. Up to a certain depth, light that passes through tissues is utilized to evaluate interior features since it can freely interact with underlying tissues. [1]

OCT and ultrasonography share imaging principles, measuring backscattered beams. However, they differ in penetration depth, resolution, and receiving mechanisms. Light velocity is higher, making time delay measurement impractical. OCT uses an interferometer to calculate light pathway difference.[7]

Primary principle of OCT is interferometry, which divides the produced white light into two equal beams that are at right angles to one another: the reference path beam and the sample path beam. The reference path beam is directed towards a mirror, while the sample path beam is directed towards tissues. The reflected light from both directions is combined at a beam splitter to create interference. The light-tissue interactions cause the sample path light to lose some intensity. When combined with the reference path beam, the difference in intensities produces an interference signal, which is recorded by a spectrophotometer.[1] (fig1)

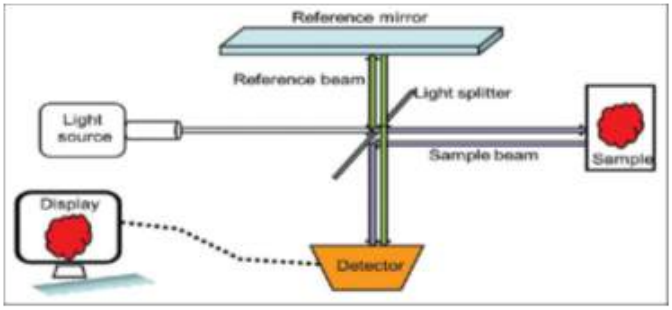


Fig1: Basic Principle of OCT [1]

Different Versions of OCT

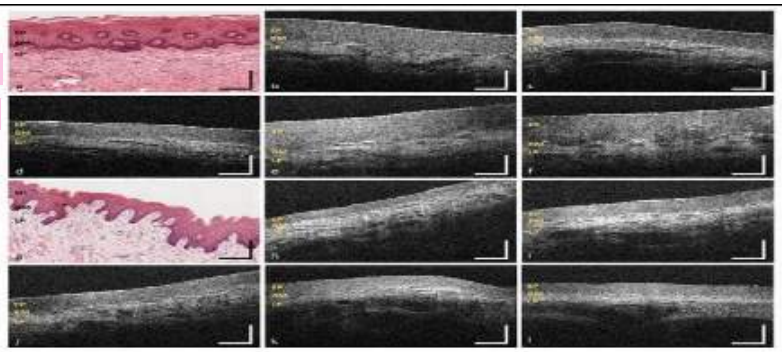
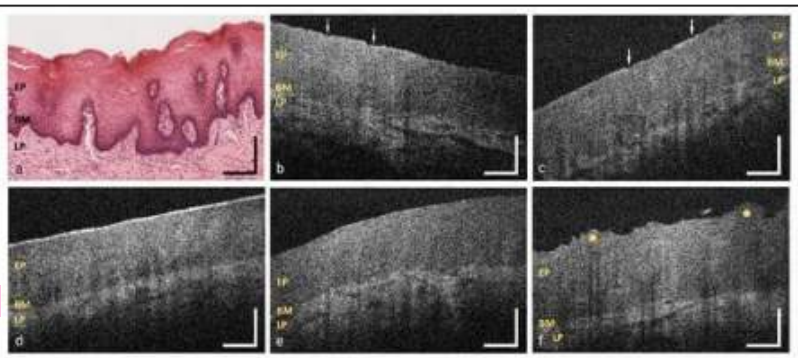
Depending on their reference arm optics, OCT devices can be classified as time-domain or frequency domain devices. Based on the receiving compartments and output characteristics, there are two types of frequency domain devices: spectral OCT and sweeping source OCT. The ultrahighspeed (kilohertz wavelength, center wavelength 1300 nm) laser beam used in swept source OCT improves the system's sensitivity, penetration depth, resolution, scanning rate(one second or less time imaging speed), which reduces acquisition time. The axial and transverse resolution of the swept source OCT are ascertained by the focal spot size and laser beam line width, respectively.[7]

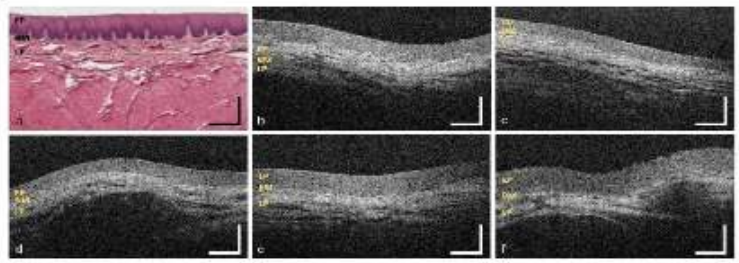
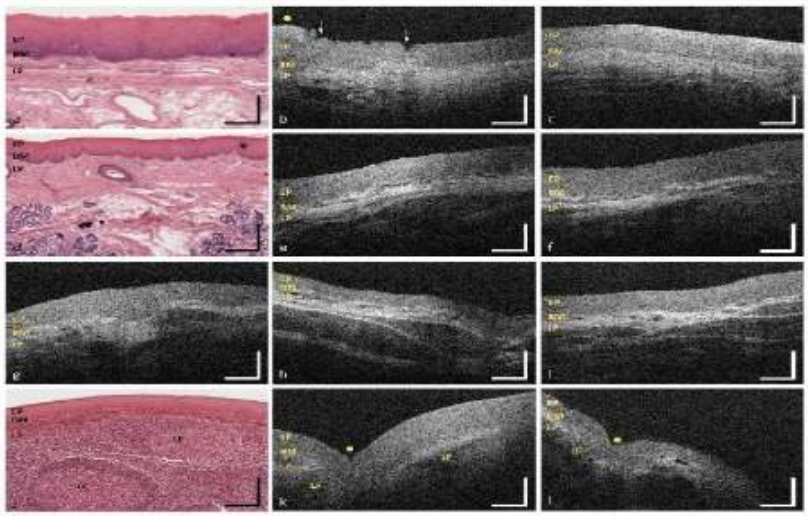
The first OCT type, time domain OCT (TD-OCT), acquires various optical path lengths (OPLs) by moving a reference reflector. Another common type of OCT is the spectral domain OCT (SD-OCT) or the Fourier domain OCT (FD-OCT). In SD-OCT, the OPL is determined at different wavelengths, and no moving reflection mirror is necessary. A SD-OCT system is setup with almost the same components as TD-OCT but with an additional grating, sensor array (usually a CC-array),or spectrometer.[8]

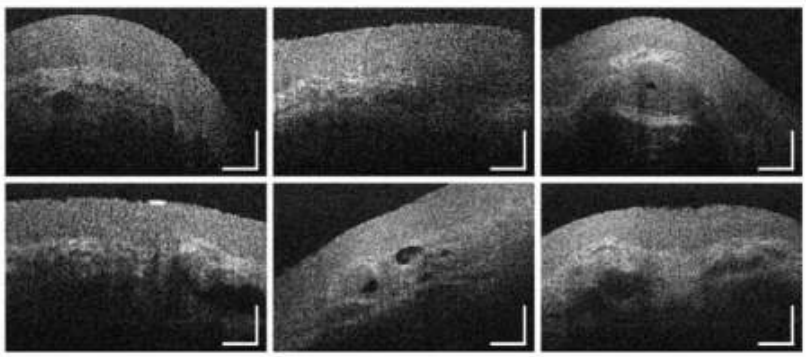
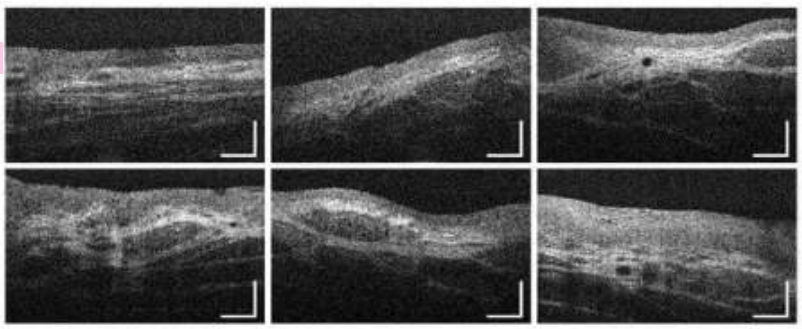
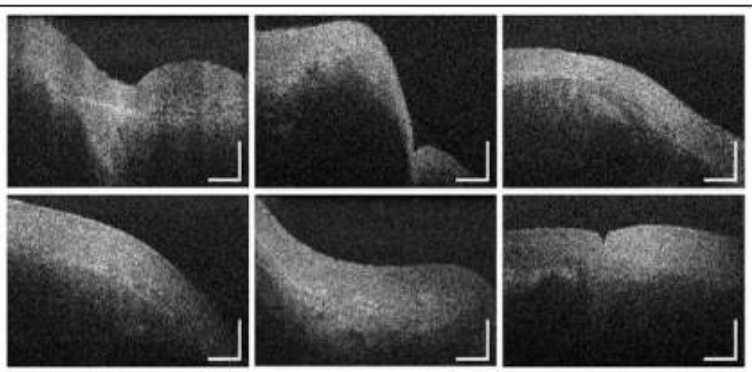
Normal Mucosa in OCT

A study conducted by Albrecht, et al. in 2020 on healthy human oral mucosa in OCT image [9] (table 1)

Normal Oral Mucosa	Characteristics in OCT	OCT and Histopathology Images

Labial and Alveolar Mucosa	The alveolar mucosa's epithelial surface is considered intact in 92.2% and 95.4% of measurements, with a homogeneous layer in 96.6% and a mean thickness of 142 ± 15 µm.	 OCT images of the labial mucosa (**b**–**f**) and the alveolar mucosa (**h**–**l**). The sample pictures represent the upper (MP1) (**b**,**c**) and the lower lip (MP3,MP4) (**d**–**f**) as well as the upper (MP2) (**h**,**i**) and lower alveolar region (MP5) (**j**–**l**). Exemplary HE stained histological cross sections depicting the labial and the alveolar mucosa (**a**,**g**) modified). EP: epithelium, BM: basement membrane, LP: lamina propria. Scale bars: 200 µmm.
Buccal Mucosa	OCT image analysis of buccal mucosa revealed surface alterations in 30.6% of cross sections, homogeneous epithelium in 74.6%, and intact basement membrane in 60.8%. Vascular supply was moderate in 67.7%, but further features were not detected due to fat tissue and limited imaging depth.	 OCT images of the buccal mucosa (**b**–**f**). The sample pictures represent the anterior (MP6) (**b**,**c**), the central (MP7) (**d**) and the posterior buccal region (MP8) (**e**,**f**). Exemplary HE stained histological cross sections depicting the buccal mucosa (**a**)). EP: epithelium, BM: basement membrane, LP: lamina propria; Arrows: epithelial surface alteration, Yellow dots: uneven surface profile. Scale bars: 200 µmm.

Sublingual Mucosa	OCT images from the ventral tongue and mouth floor showed intact epithelial surfaces, homogeneous structures, and extensive vascular supply due to large sublingual arteries and veins. 86.6% of sections were highly vascularized.	 OCT images of the ventral tongue (**b**,**c**) and the mouth floor (MP11) (**d**–**f**). The sample pictures represent the anterior (MP9) (**b**) and posterior sublingual region (MP10) (**c**). Exemplary HE stained histological cross sections depicting the sublingual mucosa (**a**) . EP: epithelium, BM: basement membrane, LP: lamina propria. Scale bars: 200 µmm.
Hard Palate	The hard palate exhibits multiple alterations in epithelial surface, with convex ridges (38.8%) matching transverse palatal folds. Over one-third of the epithelial layer (37.5%) is inhomogeneous, indicating a physiological adaptation to masticatory function. Female volunteers have lower values than males. The basement membrane is unsharp, and minor salivary glands appear in 15.0% of OCT cross sections.	 OCT images of the hard palate (MP12) (**b**,**c**), the soft palate (MP13) (**e**,**f**), the uvula (MP14) (**g**), the oropharynx (MP15) (**h**,**i**) and the palatine tonsil (MP16) (**k**,**l**). Exemplary HE stained histological cross sections depicting the hard palate (**a**), the soft palate (**d**) and the palatine tonsil (**j**). EP: epithelium, BM: basement membrane, LP: lamina propria, LF: lymphoid follicle; Arrows: epithelial alteration, Yellow dots: palatal ridges and tonsillar crypts. Scale bars: 200 µmm.

SoftPalate and Oropharynx	The soft palate, uvula, and oropharynx were examined for epithelial surface integrity, with a homogeneous epithelium. Vascularization by major vessels was high in most cases (56.1%), with a distinct vessel network in the lamina propria. Clusters of salivary glands were observed in 47.4%, confirming moistening of the alveolar region.	 Supplementary intensity-based OCT cross sections of the mucosal tissue of the soft palate (MP13), Scale bars: 200 μ mm.  Supplementary intensity-based OCT cross sections of the mucosal tissue of the oropharynx (MP15). Scale bars: 200 μ mm
Palatine Tonsils	The palatine tonsil was analyzed using OCT cross sections, revealing an intact epithelium (70.6%) and uneven surface profile (87.5%). Age-related changes were observed, with thickness lower in participants aged 25-45. The basement membrane was unsharp in 52.2%, with a	 Supplementary intensity-based OCT cross sections of the mucosal tissue of the palatine tonsil (MP16) Scale bars: 200 μ mm.

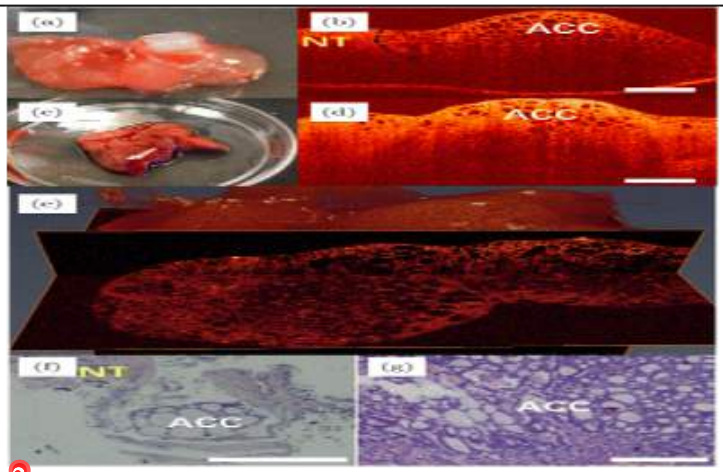
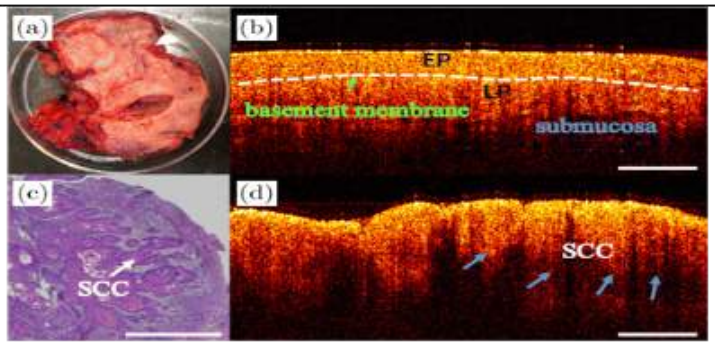
	moderate vascular supply in 60.3% of cases.	

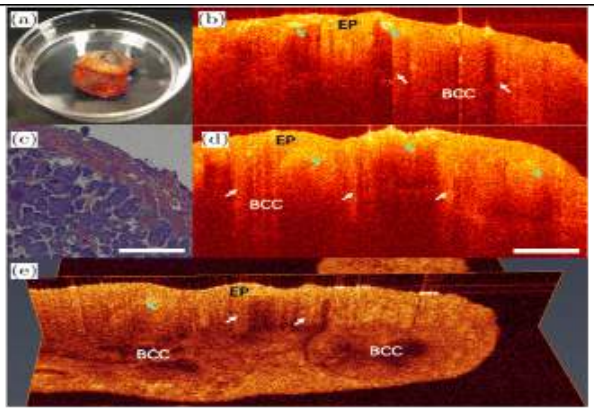
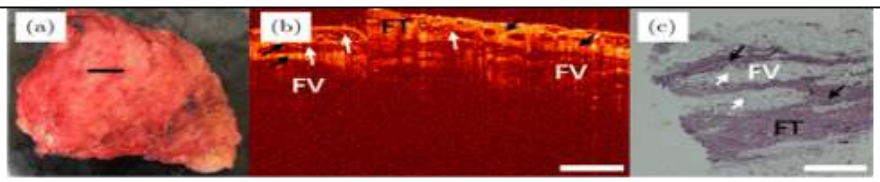
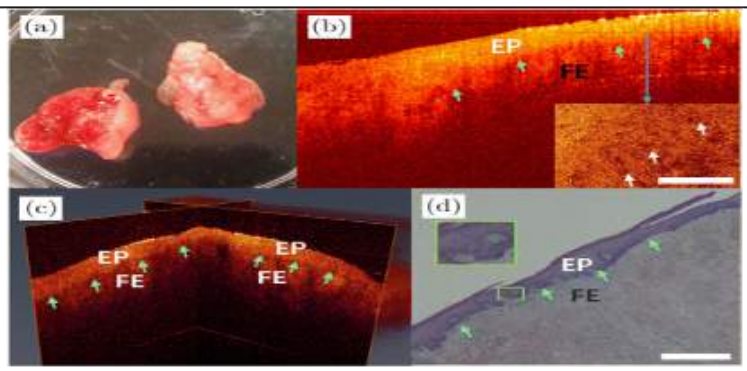
Table : 1: Normal Mucosa in OCT[9]

CANCER INDICATORS

OCT pictures can be used to identify neoplastic alterations in epithelial tissues, which are characterized by abnormal cells with larger nuclei. Expanded dysplastic cells, uneven stratification, basal hyperplasia, and an extended papilla core are significant histological indications of malignancy.On OCT Bscans, dysplastic cell s have a scattered speckle pattern.In order to distinguish between intact, premalignant, and cancerous tissues in the oral mucosa, researchers have looked for markers in the s ubepithelial tissue, basement membrane, and epithelial mucosa.Tumor invasion is indi cated by thickening of the basement membrane, which may also point to malignant alt erations.Both basement membrane integrity and epithelial thickness can be used as rel iable markers to distinguish between invasive cancer and normal or dysplastic tissues. Dysplastic transformation may result in fibroblast proliferation, modify collagen and other extracellular components, or affect the stroma.[7]

Oral Lesions	OCT, Histopathologic images

Adenoid cystic Carcinoma	 Images of adenoid cystic carcinoma. Panels (a) and (c) are photos, and panels (b) and (d) are the 2D OCT images of adenoid cystic carcinoma of the palate tissue from two patients, respectively. Panel (e) is the 3D OCT image of the adenoid cystic carcinoma. Panels (f) and (g) are their corresponding histopathological images. ACC: adenoid cystic carcinoma and NT: normal tissue.[10]
Squamous Cell Carcinoma	 OCT and the corresponding histology of SCC. (a) Photo of the excised tissue specimen. (b) and (d) The 2D OCT images of two different positions from the same specimen. Panel (b) shows normal oral mucosa, and panel (d) shows the SCC. (c) The corresponding histopathological image of SCC. SCC: squamous cell carcinoma, EP: epithelial layer and LP: lamina propria.[10]

Basal-Cell Carcinoma	 Images of the BCC. Photo [panel (a)] and 2D OCT images [panels (b) and (d)] of BCC removed from a patient, along with the corresponding histopathological image [panel (c)]. (e) The 3D OCT image. EP: epithelial tissue and BCC: basal cell carcinoma.[10]
Lipoma	 Images of lipoma. (a) Photo of the excised tissue specimen. (b) An OCT image of lipoma. (c) Its corresponding histopathological image. FT: fibrous tissue and FV: fat vesicle.[10]
Fibrous Epulis	 Images of fibrous epulis. (a) Photo of the excised tissue specimen. (b) The 2D OCT image and *en-face* OCT image from the dashed line of fibrous epulis. (c) The 3D OCT image and (d) its histopathological image. EP: epithelial tissue and FE: fibrous epulis.[10]

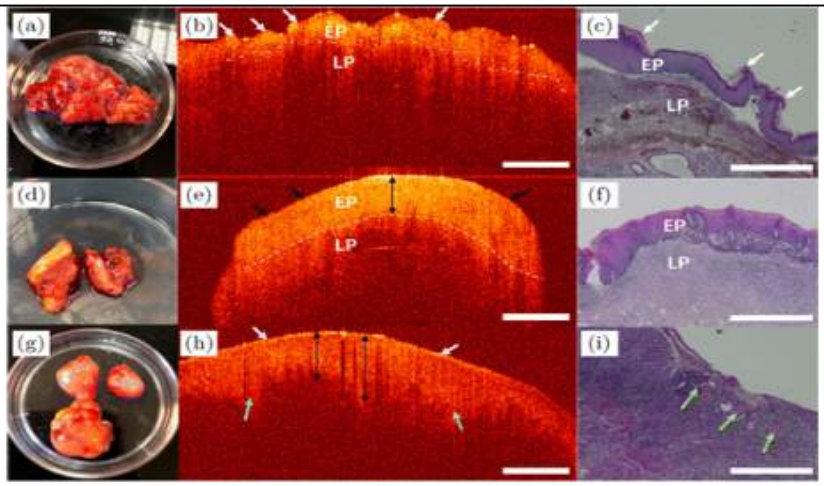
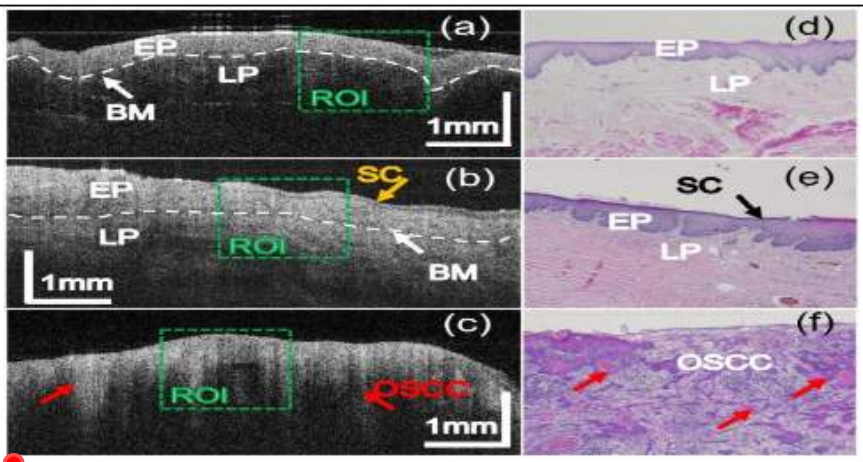
Leukoplakia	 OCT images and their histopathological images of leukoplakia. Panels (a) and (d) are photos, and panels (b) and (e) are the 2D OCT images of leukoplakia from two patients, respectively. Panel (g) is the photo and panel (h) is the 2D OCT image of leukoplakia canceration. Panels (c), (f) and (i) are the corresponding histopathological images of panels (a), (d) and (g), respectively. EP: epithelial layer and LP: lamina propria.[10]
Normal mucosa, Oral squamous cell carcinoma	 Morphological characteristics and statistical analysis of oral tissues. The representative OCT images of normal mucosa (**a**), LEH (**b**), and OSCC (**c**) and corresponding histopathological images (**d**–**f**). The ROI indicates 256 × 256 pixels.[2]

Table:2: OCT images of various lesions

INTEGRATION OF AI AND OCT

Oncological applications of OCT images have limitations such as limited penetration depth, scan volume, higher resolution, noise, and difficulty in image interpretation. Interpretation is operator-dependent, and there is no defined standard for interpretation. AI and machine learning algorithms can assist in interpreting OCT images, providing equal accessibility to automated professional diagnoses with high accuracy.[7]

Stages in integration of OCT to AI:

1. Data collection
2. Image processing
3. Establishment of AI models
4. Verification of AI models [11]

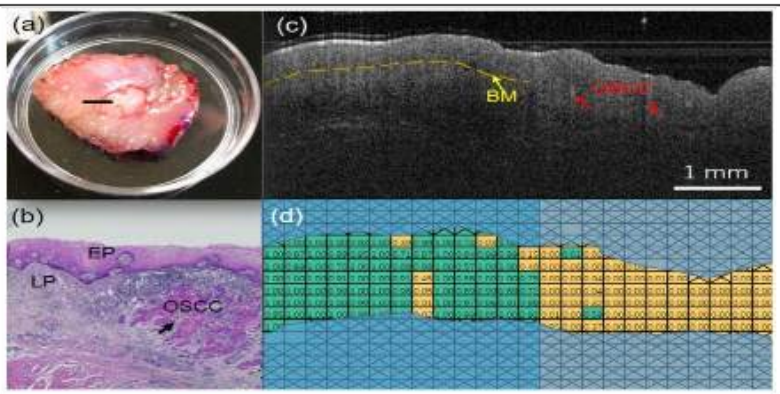
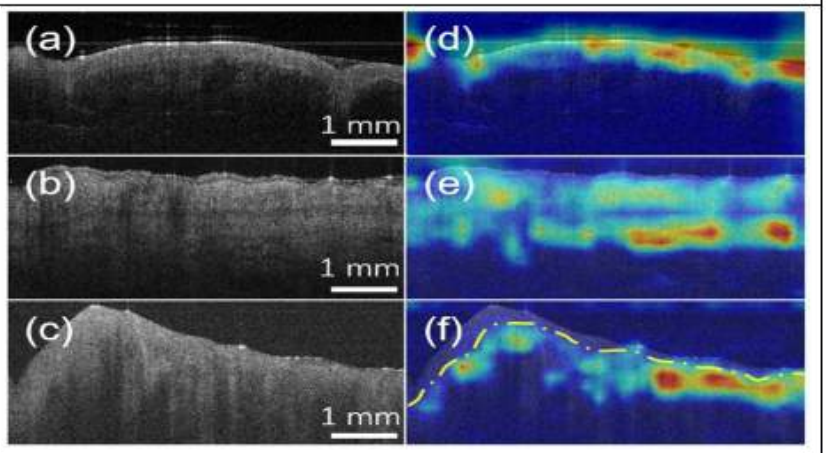
Artificial neural networks (ANN) are machine learning algorithms composed of neurons arranged in layers, with the deep learning convolution neural network being the most popular for analyzing visual figures. These networks can be trained by continuously introducing structured data and upgrading their operation ability.

Studies using various AI algorithms to interpret OCT images are given in the table:3

Name of the author	Year of the study	Objective of study	AI algorithm used	Outcome of the study
Pande P., Shrestha S., Park J., et al.[12]	2014	The objective of this study is to assess the feasibility of using image analysis algorithms for automated characterization and classification of OCT images in a hamster cheek pouch tumor model. Additionally, the study aims to evaluate the potential of OCT-based automated diagnosis of oral cancer.	Two algorithms were used : Algorithm 1- Algorithm for filtering A-lines in a B-scan. Algorithm 2- Algorithm for generating a binary mask corresponding to the epithelial region in a nonlayered B-scan.	The study presents a segmentation algorithm for identifying epithelial regions in OCT B-scans, achieving 80.6% sensitivity and classification accuracy, using random forest for robustness against noisy labels and overfitting.

Hwang DK,et al.[11]	2020	OCT macula cross-section scanning images from patients with diabetic macular edema (DME) to classify the disease.	AI models were developed using GGG16 and InceptionV3, with transfer learning applied.	The accuracy, sensitivity, and specificity of the models were 92.82%, 93.09%, 96.48%, 95.15%, and 89.63%, respectively.
James et al.[13]	2021	The aim of this study is to develop a decision tree using an OCT diagnostic system to accurately identify and differentiate between cancer/dysplastic lesions and non-dysplastic lesions in oral cancer screening.	A MATLAB based simple algorithm-score and an Artificial Neural Network-Support Vector Machine (ANN-SVM) based model was used.	The study uses a retrained convolutional neural network to classify three-dimensional OCT images of head and neck mucosa, identifying normal and abnormal tissues with 100% sensitivity and 70% specificity. The algorithm predicts the severity of oral squamous cell carcinoma (OSCC) lesions based on 172 oral sub-sites. The scores for dysplastic lesions differ significantly, with sensitivity of 93% and specificity of 74%.
Wei Yuan,.et.l[10]	2022	The aim of this study was to develop the automatic noninvasive OSCC diagnosis approach to identify the malignant tissues on Optical Coherence Tomography (OCT) images.	This study used Multi-Level Deep Residual Learning (MDRL) network	The MDRL system achieves the excellent diagnostic performance, with 91.2% sensitivity, 83.6% specificity, 87.5% accuracy, 85.3% PPV, and 90.2% NPV in image-level, with 0.92 AUC value. Besides, it also implements 100% sensitivity, 86.7% specificity, 93.1% accuracy, 87.5% PPV, and 100% NPV in the resected patch-level.
Yang, Z.; Pan, H.; Shang, J.;	2023	To evaluate deep-learning-based algorithms for OCT	Three CNNs(convolutional neural networks), including LeNet-5, VGG16, and	CNNs outperform machine-learning in detecting and diagnosing oral cancer, with accuracy of 92.52% and

Zhang, J.; Liang, Y.[2]		images to assist clinicians in oral cancer screening and diagnosis. .	ResNet18, and Machine learning	classification accuracy of up to 96.76%, demonstrating their logic and interpretability in OCT images.

Oral lesion	OCT image interpretation by AI
Oral squamous cell carcinoma	 OCT imaging and prediction results at the junction between normal mucosa and OSCC. (**a**) is a photograph of the excised tissue. (**b**) is the corresponding histopathological image with the normal region on the left and the cancerous region on the right. (**c**) is the OCT image at the black line of (**a**). (**d**) is the corresponding prediction visualization.[2]
Normal mucosa, Oral squamous cell carcinoma	

	Visualization on OCT images of oral tissues using Grad-CAM. (**a**–**c**) are representative OCT images of normal mucosa, LEH, and OSCC, respectively. (**d**–**f**) are the corresponding activation maps with unique feature aggregations, respectively.[2]

Table:3: Various studies conducted on integration of AI and OCT

ADVANTAGES IN INTEGRATIION OF OCT AND AI

1. Early Detection: AI can identify subtle changes in OCT scans that might be missed by human observers allowing it for early detection of diseases or abnormalities
2. Improved Accuracy: AI algorithms can analyze OCT images with a high degree of precision and accuracy.
3. Speed and Efficiency: AI can process OCT images much faster than humans, leading to quicker diagnosis and treatment decisions.
4. Quantitative Analysis : AI can perform quantitative analyses of OCT data, providing precise measurements and data that can be used for monitoring disease progression, treatment effectiveness, and research purposes.
5. Accessibility: As AI technology becomes more widespread it can potentially bring advanced diagnostic capabilities to regions with limited access to specialized healthcare professionals.
6. Enhanced Research Capabilities: The combination of OCT and AI can accelerate medical research by providing large datasets for studying diseases, drug responses, and treatment outcomes. This can lead to breakthroughs in understanding and treating various medical condition[2,7,11]

LIMITATIIONS OF INTEGRATION OF OCT AND AI

Limitations of AI such as the deskilling of physicians due to increased reliance on automation, the inability of AI programs to take a holistic approach to clinical encounters, the need for pre-existing strong datasets to train AI programs, and the inability to incorporate the ambiguity and variability inherent in clinical medicine. To facilitate the application of AI in oral cancer screening and diagnosis, it is necessary t o address the current obstacles, which include standardizing labeling, validating auto mated interpretations, and developing infrastructures. Additional research is required t o supply OCT imaging data for AI algorithms. [2,7]

CONCLUSION

AI shows good diagnostic performance with high sensitivity for oral cancer detection. Through the development of image acquisition devices and the grafting of various AI algorithms, the diagnostic accuracy is expected to increase. In the interpretation of OCT images of the oral mucosa and the differentiation of normal oral epithelium from precancerous and cancerous lesions, artificial intelligence algorithms have produced encouraging results. Even if it would take some time to integrate OCT and AI in a clinical context, the progressive evolution of AI algorithms for OCT image interpretation paves the path towards automation oral cancer screening by OCT.

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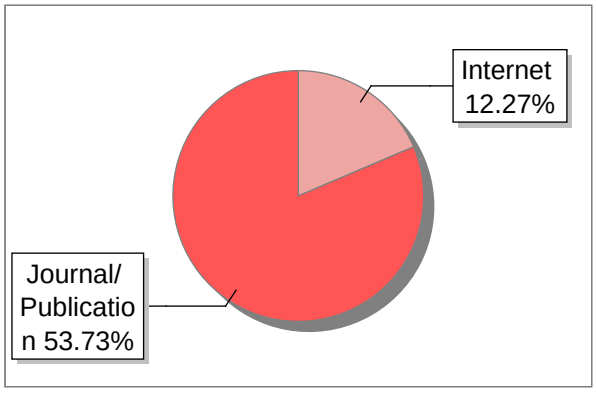

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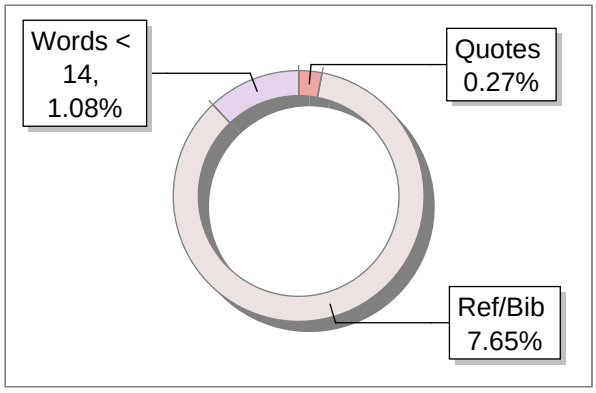

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108	Surface Tension Comparison of Four Common Root Canal Irrigants and Two New Irrig by Lucian-2006	<1	Publication
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INTRODUCTION

–The science fiction of today can be a reality tomorrow!

Research in medical and dental science have helped millions of people lead longer and healthier lives. We owe these improvements to decades of medical research as newer things are found, the older concepts may become obsolete and sometimes older concepts maybe rejuvenated by some researchers. This process creates myths and realities among the clinicians. Even in dentistry, there are myths and realities with regard to various aspects such as myths in diagnostic, disease process and even in treatment process.

Lesions of the pulp are often infectious and treatments involve several critical steps that are aimed to restrain infections of the root canal system in teeth. Originally, treatment methodologies in endodontics, like those in many other dental disciplines, evolved based on trial-and-error observations and only in recent decades have scientific methods been adopted to support clinical strategies. Yet, research reports focusing on issues relevant to the disease processes of the pulp and how they can be diagnosed and managed effectively are rare in the endodontic literature. An assessment of articles appearing in leading endodontic journals reveals that technical aspects of the testing of instruments and restorative materials, often by in vitro evaluations in extracted teeth, tend to be the dominating topics[1].

As a consequence, the advancement of biologically based knowledge significant to clinical endodontics has been slow.

In a critical review on contemporary issues in endodontics, observed: "The preoccupation of dentists with techniques has channelled dentistry (including endodontics) into a state of technical excellence that often is not accompanied by a biological awareness of the basic pathologic problems with which we are dealing or the biologic consequences of our therapy. The schism between clinicians and basic scientists is propagated by a tendency of each group to confer with themselves rather than with each other." The past 30 years have brought little change, and only modest amounts of the accumulated biological knowledge have found clinical application in the endodontic arena[2]. It is, therefore, not surprising that, in this field of dentistry, there are many contradictory views and opinions as to the proper management of

endodontic disorders. This library dissertation reviews and examines the background of some of the more significant issues that have been debated in the endodontic field in recent years and discusses controversies regarding the clinical management of the disease processes associated with the vital and the non-vital dental pulp.

REVIEW OF LITERATURE

1. The state of our scientific knowledge concerning inflammation and infection of pulp and periapical tissues is reviewed with respect to the correlation and lack of correlation of this body of scientific fact with present-day clinical practice. Caps in our knowledge are emphasized, and suggestions made as to possible paths of future research.[2]

2. Comparing some data on linear measurement of dye penetration following the cold lateral condensation of gutta-percha that were published between 1980 and 1990, a high level of variation has been found, although the experimental methods used in these studies were quite similar. In almost all studies evaluating various techniques, the cold lateral condensation technique has been used as a standard control for comparison. The reliability of these results is questionable. The problems with such studies were discussed. It seems that more research should be done on leakage study methodology, instead of continuing to evaluate the sealing ability of different materials and techniques by methods that may give little relevant information.[1]

3. The healing capacity of mechanically exposed and bacterially contaminated dental pulps was assessed in monkeys after capping with 2 commercial Ca(OH)2 containing compounds. Class V buccal cavity preparations resulting in pulpal exposure were prepared, left open to the oral cavity for 0, 1, 24 h or 7 days and employed as controls, or debrided, capped, restored with amalgam and left undisturbed for 5 weeks as treated exposures. Zero and 1 h untreated exposures presented damage from the mechanical trauma only, whereas 24 h and 7 day pulp wounds exhibited pronounced infiltrations of polymorphonuclear and mononuclear leukocytes. In addition, the 7 day exposures demonstrated several teeth with partial and total necrosis. Treated 0, 1 and 24 h exposures demonstrated wound healing, minimal pulp tissue inflammation, reorganization of soft tissue and formation of new hard tissue at the exposure site in 86 of 99 teeth. Treated 7 day exposures healed less frequently, showing signs of dentin bridging in 15 of 27 teeth. This study indicated that mechanically exposed and orally contaminated dental pulps in monkeys have a high capacity to resolve inflammation and initiate healing with new dentin formation at the exposure site when treated as described.[12]

4. The healthy pulp has good healing potential when it is exposed, although the exact repair mechanism is still undetermined, and it is not material-specific. Calcium hydroxide appears to promote the healing process and is the most widely accepted capping material. Paste-type calcium hydroxide formulations are more consistent in promoting healing of pulp exposures than cement forms where bacterial microleakage is eliminated. The prognosis for pulp capping with calcium hydroxide is good if the pulp has no pre-existing symptoms of pain, and the environment provided for it is suitable. This requires the absence of blood clots and bacterial contarnination. Where there are some symptoms of pain in a vital tooth, pretreatments with suitable materials improve the prognosis.[9]

5. There are many skeptics who condemn pulp capping but like to keep an eye on the research progress being made. Considerable literature emphasizes the negative aspects of vital pulp therapy and discourages its practice. Some clinicians and investigators continue to condemn pulp capping therapy for the same reasons reported in the literature 80 years ago despite the advances made in pulp biology. Clinicians are well aware of the immediate and long-term success rates after root canal therapy, but are less certain of the success of pulp capping. A number of nagging questions plague clinicians, when confronted with the choice of treatment. The research data on pulp capping is at times inadequate, confusing, misleading or even incorrect and diminishes the confidence of the practitioner in performing pulp capping.[11]

6. One hundred twenty-three pulp cappings had been performed by students in 1984 to 1987 (= 10-yr group) or in 1990 to 1992 (= 5-yr group) and were followed up in 1997. Teeth were checked for sensitivity (CO2/electrical pulp testing), percussion, and palpation; radiographs were taken to assess periapical status. In addition several other factors were determined that might have an influence on the success or failure rates, such as base material, type of restoration, site of exposure, etc. Results showed 44.5% failures (18.5% questionable and 37% successful cases) in the 5-yr group and 79.7% failing, 7.3% questionable, and 13% successful cases in the 10-yr group. As a factor of influence, the placement of a definitive restoration within the first 2 days after pulp exposure was found to contribute significantly to the survival rate of these teeth.[13]

7. Trans-dentinal stimulation of tertiary dentinogenesis has long been recognized, and has traditionally been ascribed to diffusion of irritant substances arising during injury and restorative treatment. Identification of bio-active components, especially growth factors including TGF-beta s, sequestered within dentin matrix provides a new explanation for cellular signaling during tertiary dentinogenesis. Both isolated dentin matrix components and pure growth factors (TGF-beta s) have been shown to signal cellular events leading to reactionary and reparative tertiary dentinogenesis. Careful consideration of the interplay between tissue injury and surgical and restorative material factors is required for optimum exploitation of the exquisite regenerative capacity of dentin-pulp for more biological approaches to clinical treatment of dental disease.[14]

8. An in vitro study investigated the resistance to static loading of endodontically treated teeth with uniform and nonuniform ferrule configurations. The results demonstrated that central incisors restored with cast dowel/core and crowns with a 2-mm uniform ferrule were more fracture resistant compared to central incisors with nonuniform (0.5 to 2 mm) ferrule heights. Both the 2-mm ferrule and nonuniform ferrule groups were more fracture resistant than the group that lacked a ferrule.[19]

9. A study was done to compare the dissolving potential of Dakin's solution with that of equivalent buffered and unbuffered sodium hypochlorite solutions on fresh and decayed tissues. In addition, the antimicrobial effect of Dakin's solution and equivalent unbuffered hypochlorite was tested. In contrast to earlier statements, the results of this study do not demonstrate any benefit from buffering sodium hypochlorite with sodium bicarbonate according to Dakin's method. An irrigation solution with less dissolving potential may be obtained by simply diluting stock solutions of NaOCl with water.[30]

10. A review of the relevant literature on chelating agents was done, presents an overview of the chemical and pharmacological properties of EDTA preparations and makes recommendations for their clinical use. Chelating agents were introduced into endodontics as an aid for the preparation of narrow and calcified root canals in 1957 by Nygaard-Østby. A liquid solution of

ethylenediaminetetraacetic acid (EDTA) was thought to chemically soften the root canal dentine and dissolve the smear layer, as well as to increase dentine permeability. Although the efficacy of EDTA preparations in softening root dentine has been debated, chelator preparations have regained popularity recently. Almost all manufacturers of nickel-titanium instruments recommend their use as a lubricant during rotary root canal preparation. Additionally, a final irrigation of the root canal with 15-17% EDTA solutions to dissolve the smear layer is recommended in many textbooks. [33]

11. Study was done to investigate in vitro the antimicrobial activity of 0.2%, 1%, and 2% chlorhexidine gluconate (CHX gel and CHX liquid), against endodontic pathogens and compare the results with the ones achieved by 0.5%, 1%, 2.5%, 4%, and 5.25% sodium hypochlorite (NaOCl). A broth dilution test was performed, and the timing for irrigants to kill microbial cells was recorded and statistically analyzed. Both 2.0% gel and liquid formulations eliminated Staphylococcus aureus and Candida albicans in 15 seconds, whereas the gel formulation killed Enterococcus faecalis in 1 minute. All tested irrigants eliminated Porphyromonas endodontalis, Porphyromonas gingivalis, and Prevotella intermedia in 15 seconds. The timing required for 1.0% and 2.0% CHX liquid to eliminate all microorganisms was the same required for 5.25% NaOCl. The antimicrobial action is related to type, concentration, and presentation form of the irrigants as well as the microbial susceptibility.[31]

12. The combination of sodium hypochlorite (NaOCl) and chlorhexidine (CHX) results in the formation of a precipitate. The aim of this study was to determine the minimum concentration of NaOCl required to form a precipitate with 2.0% CHX. This was accomplished with a serial dilution technique. X-ray photon spectroscopy (XPS) and time-of-flight secondary ion mass spectrometry (TOF-SIMS) were used to qualify and quantify the precipitate. A color change and precipitate were induced in 2.0% CHX by 0.023% and 0.19% NaOCl, respectively. Both XPS and TOF-SIMS showed the presence of para-chloroaniline in an amount directly related to the concentration of NaOCl used. Until this precipitate is studied further, its formation should be avoided by removing the NaOCl before placing CHX into the canal.[35]

13. Study was done to test the ability of a mixture of a tetracycline isomer, an acid, and a detergent (MTAD) to kill Enterococcus faecalis and compare its efficacy to that of sodium hypochlorite (NaOCl) and ethylene diamine tetraacetic acid (EDTA). The zones of inhibition and minimum inhibitory concentrations were measured for these solutions. Measurement of zones of inhibition and determination of the minimum inhibitory concentrations showed that MTAD is as effective as 5.25% NaOCl and significantly more effective than EDTA ($p < 0.0001$). Furthermore, MTAD is significantly more effective in killing E. faecalis than NaOCl when the solutions are diluted ($p < 0.0001$). Measurement of the minimum inhibitory concentrations demonstrated that although MTAD is still effective in killing E. faecalis at 200x dilution, NaOCl ceases to exert its antibacterial activity beyond 32x dilution. EDTA did not exhibit any antibacterial activity. Based on the results of this study, it seems that MTAD is an effective solution in eradicating E. faecalis.[37]

14. Antibiotics were first discovered in the late 1920s but were not routinely used clinically until the early 1940s during the Second World War. They can be used as an adjunct to endodontic treatment in a number of ways-systemically, prophylactically and locally. There are few real indications for the systemic use of antibiotics in conjunction with endodontic treatment. They are only needed when the body's efforts at fighting bacteria are failing. Use of antibiotics to prevent infection (antibiotic prophylaxis) may prevent some case of bacterial endocarditis. Therefore, prophylaxis is recommended for individuals in high-risk and moderate-risk categories. Another mode of application of antibiotics is local application as intracanal medicaments and root canal irrigants.[38]

15. The antibacterial effect of calcium hydroxide as a short-term intracanal dressing was clinically evaluated by applying the medicament for 10 minutes or 7 days in root canals of teeth with periapical lesions. The results showed that the 7-day dressing efficiently eliminated bacteria which survived biomechanical instrumentation of the canal, while the 10-minute application was ineffective.[43]

16. In the presence of endodontic gutta-percha cones, several species of bacteria were killed in vitro. Silver points, when compared with gutta-percha cones, were not or were considerably less effective against the target organism. Staphylococcus

aureus, in our assay system. Growth of bacteria in serum could be abolished by the mere presence of gutta-percha, especially when time was allowed for previous contact between the serum and the cones. It is concluded that gutta-percha cones possess a slowly acting, relatively weak, but, in our opinion, significant inherent antimicrobial property.[45]

17. A clinical study explored the influence of calcium hydroxide as an interappointment dressing on the healing of periapical lesions associated with pulpless teeth that had not been endodontically treated previously. This was achieved by comparing the prognosis after a two-visit root canal treatment with that following a one-visit treatment. From a microbiological perspective, one-visit root canal treatment created favourable environmental conditions for periapical repair similar to the two-visit therapy when calcium hydroxide was used as antimicrobial dressing. One-visit root canal treatment is an acceptable alternative to two-visit treatment for pulpless teeth associated with an endodontically induced lesion.[46]

18. Activated polymorphonuclear leukocytes (PMNs) release lysosomal enzymes and toxic oxygen-free radicals into their immediate environment. The persistent activation of PMNs by pulpotomy medicaments may contribute to the chronic inflammatory changes and root resorption seen in histologic sections. The authors examined the effects of pulpotomy medicaments commonly used in pediatric dentistry on PMN adherence, the earliest observable change in PMN behavior following activation, and perhaps 1 of the most crucial. The results showed that formocresol, eugenol, and calcium hydroxide caused lysis of PMNs at high concentrations, but activation of PMN adherence at low concentrations. By contrast, glutaraldehyde did not produce PMN lysis at high concentrations, nor did it cause activation of PMN adherence at low concentrations. These findings correspond to previous histologic studies which found that formocresol, eugenol, and calcium hydroxide, but not glutaraldehyde, can cause inflammatory destruction of pulpal tissues.[60]

19. Concern has been expressed about the safety of formocresol use in pediatric dentistry. Formaldehyde, a primary component in formocresol, is a hazardous substance and is considered a probable human carcinogen by the International

Agency for Research on Cancer, Health Canada, the Agency for Toxic Substances and Disease Registry in the U.S. Department of Health and Human Services, and the U.S. Environmental Protection Agency. Humans inhale and ingest formaldehyde daily, however, and produce formaldehyde during cellular metabolism. The human body is physiologically equipped to handle formaldehyde through multiple conversion pathways. The resultant single carbon atom released during metabolism is deposited in the "1-carbon pool," which, in turn, is used for the biosynthesis of macromolecules including DNA and RNA. Reevaluation of earlier research that examined potential health risks associated with formaldehyde exposure has shown that this research was based on flawed assumptions, which resulted in erroneous conclusions. The purpose of this review was to examine more recent research about formaldehyde metabolism, pharmacokinetics, and carcinogenicity. These results indicated that formaldehyde is probably not a potent human carcinogen under low exposure conditions. Extrapolation of these research results to pediatric dentistry suggests an inconsequential risk associated with formaldehyde use in pediatric pulp therapy.[64]

20. One of the major events involving inflammatory processes is the alteration of microcirculatory hemodynamics by inflammatory mediators released from tissue components. Using modern macrocirculatory techniques, 15 mu radioisotope labeled microspheres, 133Xe washout, laser Doppler flowmetry and double isotopes, 125 and 131I-albumin, and microcirculatory methods, intravital fluorescence microscopy with FITC labeled dextran, we have examined the effects of selected mediators, e.g. 5-hydroxytryptamine (5-HT), prostaglandin E2 (PG-E2), bradykinin (BK), substance P (SP), calcitonin gene related peptide (CGRP) and histamine on blood flow and vascular permeability in the pulp of experimental animals. Results of this study clearly show that there is a high structural/functional correlation in pulpal microcirculation in inflammation. As demonstrated in this presentation, the effects of inflammatory mediators on pulpal microcirculatory hemodynamics are complex.[66]

21. Male and female Fischer-344 rats were exposed to target concentrations of 0.5, 6, or 15 ppm formaldehyde by inhalation for 6 h/day for 5 days. Blood was removed by cardiac puncture within 1 h following termination of exposures and cultured in the presence of 5-bromodeoxyuridine (BrdU) (4 microM) for analyses of sister-chromatid exchange (SCE) and chromosome breakage. Formaldehyde did not

cause a statistically significant increase in either SCE frequency or in the number of metaphases displaying chromosome aberrations.[70]

22. There are three types of the root canal sealers commonly used in clinical applications. They are calcium hydroxide base (Sealapex), zinc oxide-eugenol base (Canals), and epoxy-resin base (AH Plus). Elutable substances and degradation products from root canal sealers may gain access to periodontal tissue in a number of ways. A study was done to evaluate the biologic effects of the root canal sealers on human oral cancer cell line (OC2). The tetrazolium bromide (MTT) assay was to evaluate the cell's survival rate. The DNA electrophoresis was used to evaluate the OC2 cell's DNA damage. The results demonstrated that the above root canal sealers' survival rates are in dose-dependent increase ($p < 0.05$). The toxicity of fresh mix group is higher than that of the mixed after 24h group. DNA fragmentation assay of sealer treated OC2 cells shows a smear layer pattern on the electrophoresis gel. There is no DNA damage found. The toxicity that regulated the cell death is not by the apoptic change of cells.[72]

23. A study was done to compare bacterial leakage using Streptococcus mutans and Enterococcus faecalis through gutta-percha and a thermoplastic synthetic polymer-based root filling (Resilon) using two filling techniques during a 30-day period. Teeth were decoronated, roots prepared to a length of 16 mm, and instrumented to ISO sizes 40 to 50. A total of 156 roots were randomly divided into 8 groups of 15 roots (groups 1-8) and 3 control groups (12 roots each). Roots were filled using lateral and vertical condensation techniques with gutta-percha and AH 26 sealer (groups 1 and 2) or with gutta-percha and Epiphany sealer (groups 3 and 4). Groups 5 and 6 were filled with Resilon and Epiphany sealer using the lateral or vertical condensation techniques. Resilon showed minimal leakage (group 8: one leakage; groups 5-7: each with two leakages), which was significantly less than gutta-percha, in which approximately 80% of specimens with either technique or sealer leaked. Kruskal-Wallis test showed statistical significance when all groups were compared ($p < 0.05$). Mann-Whitney U test compared the respective groups and found Resilon groups superior to gutta-percha groups ($p < 0.05$).[76]

24. A study compared the quality of obturation of high- and low-temperature thermoplasticized injectable gutta-percha techniques and standard lateral

condensation. A new model system was developed to more closely simulate the clinical environment. All obturations were performed in this same model which allowed direct comparisons between the different techniques. The resultant mass of gutta-percha was visually examined and graded for each obturation. Statistical analysis of the results indicated that both thermoplasticized injectable techniques were significantly better than lateral condensation. There was no significant difference between either of the thermoplastic obturation techniques.[81]

25. A study was done to evaluate the number of canals and isthmuses obturated after Cr, Er: YSGG laser treatment. Fifty-two canals were instrumented to a size 40 Profile 0.06 file combined with RC-Prep and sodium hypochlorite, or sterile water. The teeth were divided into 3 groups: (I) canals were flooded with 17% ethylenediaminetetraacetic acid for 3 minutes, (II) canals treated with the laser for 40 seconds, and (III) received no further treatment. Obturation was done with System B and Obtura III and AH Plus sealer. The specimens were rendered transparent and evaluated for the number of canals/isthmuses obturated. Under the conditions of this study, Cr, Er: YSGG treatment resulted in a statistically significant greater number of canals/isthmuses obturated ($P < .001$).[84]

26. A study was done to compare the microtensile bond strength (MTBS) between root canal and pulp chamber dentin with two bonding strategies (self-etching primer and total-etch technique). Bonding to pulp chamber dentin seems to be more predictable than to root canal dentin. In the former region, the total-etch technique may result in a higher bond strength.[90]

27. The ideal restoration of endodontically treated teeth (ETT) has been widely and controversially discussed in the literature. Prevention of healthy dental structure is essential to help mechanical stabilization of tooth-restoration integrity, increase the amount of suitable surfaces for adhesion and thus positively affect the long-term success. ETT are affected by a higher risk of biomechanical failure than vital teeth. With the development of adhesive systems, the need for post-core restorations is also reduced. Especially for restoration of excessively damaged ETT, endocrowns have been used as an alternative to the conventional post-core and fixed partial dentures. Compared to conventional methods, good aesthetics, better mechanical performance, and less cost and clinic time are the advantages of endocrowns.[96]

28. A study was done to compare healing after root-end resection with a root-end filling of mineral trioxide aggregate (MTA) or smoothing of the orthograde gutta-percha (GP) root filling. The results from this RCT emphasize the importance of placing a root-end filling after root-end resection. Teeth treated with MTA had significantly better healing (96%) than teeth treated by smoothing of the orthograde GP root filling only (52%).[102]

29. A study was done to determine the effect of 1- or 2-visit root canal treatment on the postoperative pain in the retreatment cases. Two-visit endodontic treatment with intracanal medication was found to be effective in reducing postoperative pain of previously symptomatic teeth and decreased the number of flare-ups in all retreatment cases.[115]

30. Evidence-based medicine (EBM) is defined as the conscientious, explicit and judicious use of current best evidence, combined with individual clinical expertise and patient preferences and values, in making decisions about the care of individual patients. In an effort to emphasize the importance of EBM in plastic surgery, ASPS and PRS have launched an initiative to improve the understanding of EBM concepts and provide tools for implementing EBM in practice. Through a series of special articles aimed at educating plastic surgeons, our hope is that readers will be compelled to learn more about EBM and incorporate its principles into their own practices. As the first of the series, this article provides a brief overview of the evolution, current application, and practice of EBM.[108]

CONTROVERSIES IN DIAGNOSIS

Establishing an accurate diagnosis is one of the most important and sometimes difficult situation for the clinician treating a patient with a traumatized tooth. This is in part a result of the limitations on the reliability and validity of the vitality measurements of the pulp. Controversy regarding the validity of these tests after trauma exists, and therefore the practitioner may become confused with respect to whether or not endodontic therapy is necessary.

According to Andreasen in 1981, a false-negative response may be obtained in the early stages of pulpal repair at the initial examination cannot be assumed to be healthy and continue to give a response over time.

According to Andreasen & Vestergaard Federsen, the development of pulpal necrosis may occur up to 3 months after concussion injuries, 1 year after subluxation and extrusion injuries, and as long as 2 years after lateral and intrusive luxation.

Oilman and Andreasen suggested that the ideal time period to wait in order to obtain a valid positive response from vitality testing is 1 to 6 weeks.

Recently, new studies have evaluated additional methods for vitality testing, such as laser Doppler flowmetry, which consists of the measurement of the pulpal blood flow and consequently the degree of pulp vitality.

However, the information concerning the unreliability of pulp vitality following trauma is still scarce[3]

Diagnosis of Pain

General Classification	Origin of Pain	Basic Quality of Pain
Local pathosis of extracranial structures	Craniofacial organs	Any
Referred pain from remote pathologic sites	Distant organs and structures	Aching, pressing
Intracranial pathosis	Brain and related structures	Any
Neurovascular	Blood vessels	Throbbing
Neuropathic	Sensory nervous system	Shooting, sharp, burning
Causalgic	Sympathetic nervous system	Burning
Muscular	Muscles	Deep aching, tight
Unclassifiable	Etiology as yet unknown	Any

Sinus pain

The sinuses themselves are relatively pain insensitive structures. Reynolds and Hutchins demonstrated that most so-called __sinus‘‘ pain actually arises from the nasal mucosa or from the stimulation of the nasal ostia. Conversely, various intranasal and sinus abnormalities, anatomic variations or subclinical inflammation, may present as primary headache disorders. Allergies may also cause boggy, edematous nasal mucosa. This may cause swelling of the turbinates, that may, in turn, block off the ostia of the maxillary sinuses. This has been implicated in causing referred symptoms to the teeth. Sicher pointed out that the superior alveolar nerves, supplying the maxillary molar and premolar teeth, pass along the thin wall of the sinuses. The canaliculi of the teeth often open toward the sinus, and pulpal nerves may be in direct contact with the inflamed mucoperiosteum of the sinus lining. Their direct irritation may cause dental symptoms. The reverse is also true. Inflammation or infection from the root of a tooth in contact with the sinus floor may cause sinusitis. This, in turn, will not resolve until the dental problem is corrected. Contrary to popular belief, infection and inflammation of the sinuses rarely cause facial pain or headache. Many headache patients with autonomic features will probably have tension-type headaches or migraines. Most authors feel that acute or chronic headache processes are not a result of overt paranasal sinus disease.

Angina Pectoris Vs Dental Pain

Severe pain of cardiac origin can be referred to the mandible and the maxillary region. The opposite pain reference has also been reported-pain from pulpalgia

referring down the homolateral neck, shoulder, and arms. That cardiac pain can be referred as far away as the jaws is fascinating. Yet remembering that dorsal root ganglion cells have been shown to branch in the periphery and that, in the rat at least, the dorsal root ganglion cell supplying the heart also supplies the arm helps to provide a probable explanation to this referred pain phenomenon. Angina pectoris is typically characterized by heaviness, tightness, or aching pain in the mid or the upper sternum. These symptoms may radiate upward from the epigastrium to the mandible—the left more frequently than the right.

Myocardial Pain

Myocardial infarct pain is similar to angina but is more pronounced, long-lasting, and does not resolve with rest. Severe pain in the left maxilla and mandible related to angina pectoris or myocardial infarction may occur without any other symptoms. Severe pain in the left maxilla and mandible related to angina pectoris or myocardial infarction may occur without any other symptoms. Bonica reported an incidence as high as 18% for the presentation of cardiac pain as jaw or tooth pain alone. The distribution of this cardiac pain may vary.

A careful history is important in diagnosing the referred oral pain of cardiac origin. Usually, the patient has a rather unusual story to tell, with a fairly severe pain that began rather suddenly in the left jaw and grew in intensity. The symptoms may sound very much like a pulpitis. The pain might even have moved from the mandible to the maxilla. The dentist must rule out dental pathosis quickly and efficiently. Radiographs and pulp testing of all of the teeth in the site of pain or rinsing with ice water will be equivocal. Analgesic block of the involved tooth or teeth will fail to relieve the pain. After localized dental or TMJ origins have been ruled out, referred pain from the chest must be considered.

Neurovascular Pains

This category of pain encompasses several of the primary headache disorders such as migraines, trigeminal autonomic cephalalgias, and simple intracranial vasodilation, as well as some headaches associated with pathological vascular disorders, such as temporal arteritis. The list includes only those headaches that have a higher likelihood of presenting in the dental office. In general, these headache types share the following

features. They all have primarily a deep, throbbing, pulsing, or pounding quality, occasionally sharp, and occasionally with an aching or burning background. The pain is exclusively or predominantly unilateral with pain-free or almost pain-free periods between attacks. The main difference between the different headache types lies in their temporal patterns and their associated symptoms.

The diagnosis of migraine can usually be made by history. Nonetheless, examination of the patient complaining of undiagnosed intermittent toothache or facial pain should include a thorough dental, TMJ, and muscle evaluation. Once obvious dental and joint pathology has been ruled out, and the qualitative and temporal pattern of the pain raises the possibility of dental or facial migraine, referral to an orofacial pain dentist should be made[4].

Reversible Vs Irreversible Pulpitis

Reversible pulpitis is a clinical diagnosis based on subjective and objective findings, indicating that the inflammation should resolve and the pulp return to normal. Signs of reversible pulpitis often include a normal periapical diagnosis but an increased response to cold that is non-lingering in nature (disappearing within seconds). The term lingering is often a confusing term to some, but it is used on an individual basis. If the patient response is equal in duration on all teeth, it would be non-lingering. If one tooth (or more) stands out above the rest of the teeth in terms of a variation or duration of symptoms, that is classified as lingering.

Reversible pulpitis is commonly related to recent restorations, root scaling, traumatic brushing techniques, incipient caries, and small infractions in the tooth crown. Patients who complain of symptoms related to sweets also are typically exhibiting a reversible pulpitis.

Irreversible pulpitis exhibits many forms and symptoms. Lingering painful thermal responses, particularly to cold, are the classic form of irreversible pulpitis. This pain is intensified by a stimulus but can be spontaneous. It is typically episodic in nature initially but may progress into a constant intense pain or toothache. The pulp is considered a deep tissue, it can be very difficult to isolate and pinpoint the exact tooth. Referred pain is common. Pulp testing needs to be thorough and methodical. Irreversible pulpitis, although commonly associated with its symptomatic form, also

presents in numerous other ways. Many times, an asymptomatic tooth may have an irreversible pulpitis. Lin and Langeland showed that when caries invaded the pulp space, bacteria were present, and a root canal filling is the appropriate treatment. The exception to this will be the young patient who still exhibits open apices or incomplete root development. Another form of irreversible pulpitis is hyperplastic pulpitis. Also referred to as a pulp polyp, this is a growth of pulp tissue from the pulp chamber that is usually covered with epithelium. This is typically seen again in a younger population and can be found in both primary and permanent dentition. Aerodontalgia or barodontalgia has often been referred to as an irreversible pulpitis.

Endo perio lesion

A controversy surrounding the treatment aspect of combined lesion is, which treatment should be done first. 3 schools of thought exist regarding this :

- Perform either the endo treatment first or the perio treatment depending up on the origin of the lesion.
- Start the endo treatment and continue till BMP. Place an intracanal medicament and perform the periodontal treatment. Wait till periodontal healing is observed and then complete the obturation.
- Perform the endo treatment prior to the periodontal treatment regardless of the disease.

The last philosophy is the most agreed upon treatment plan. However at times periodontal treatment is performed before an endo treatment.
For instance, an unexpected need may arise to perform a radicectomy during a periodontal surgery.
In such situations, the periodontal treatment is completed and the Endo treatment done at least within 2-3 weeks of the amputation[5].

CONTROVERSY- Endodontic therapy is contraindicated if the periapical area associated with a pulp less tooth involves one third of the root.

REALITY- the size of a periapical lesion has no relation to the size of the body to repair the lesion. Enormous lesion will heal completely following endodontic therapy by removing the source of irritant which lies within the canal, and thereafter completely filling the canal spaces.

CONTROVERSY-Endodontic therapy is contraindicated if the periapical lesion is an apical cyst.

REALITY- Bhaskar believes that over 42% of all periapical lesions are periapical cyst. It's quite obvious that when teeth involved with apical cyst are treated endodontically whether or not the cyst is enucleated, the periapical osseous defect will usually repair as readily as any other intrabony lesion.

CONTROVERSY- Endodontic therapy is contraindicated if the pulp involved tooth is badly broken down by caries.

REALITY- if the tooth is badly decayed, it must be evaluated on the basis of its usefulness. For example a severely involved molar tooth that has no opponent or maybe readily replaced by a bridge would not be a good candidate of endodontic therapy and restoration. A strategic tooth can be saved by a periodontic-endodontic therapy, restored with a post crown and serves as an excellent bridge abutment.

CONTROVERSY- Endodontic therapy is contraindicated because the involved tooth has torturous canal anatomy or very fine lumen.

REALITY- Although canal tortuosity contributes greatly to the problem of clinical endodontics, it does not render the treatment impossible. Most of these problems maybe solved with patience, perseverance, a lubricant such as EDTA and RC prep and fine sharp instruments. The extremely curved root maybe handled with ingenuity. This situation may call for decuspation or amputation of the root if the canal cannot be enlarged.

CONTROVERSY- Endodontic therapy is contraindicated because the involved tooth has advanced pulp recession.

REALITY-The surgical-length contra-angle bur allows the operator to reach into the tooth 13-14 mm, which is 4-5 mm further than one can advance with a standard-length contra-angle bur. By using the surgical length bur in the miniature contra-angle, one may extend the cut another 2-3 mm.

CONTROVERSY- Endodontic therapy is contraindicated because the involved tooth has an open flaring apex.

REALITY- The tooth with the open flaring apex maybe be endodontically treated, however and quite successfully. The first approach should be **apexification** procedure. Fortunately, this procedure leads to reawakening of root formation that ceases with premature pulpal death. Following the new growth, root canal therapy must be completed, however to obturate any tiny opening into the canal.

CONTROVERSY- Endodontic therapy is contraindicated because the involved tooth has a broken instrument in the canal.

REALITY- As the study of endodontic failures indicates, the number of failures from broken instrument is negligible. Indeed, the broken instrument itself may serves as an adequate root canal filling if it is locked into the dentin as it is twisted off. A broken instrument may also be bypassed and the canal obliterated beyond the instrument with softened gutta percha. If the instrument cannot be removed or bypassed, it maybe be necessary to fill the apex by retro filling.

CONTROVERSY- Endodontic therapy is contraindicated because the involved tooth has a procedural root perforation.

REALITY- It is a matter of degree or position of the perforation that determines whether the tooth can be saved. Perforation through the pulpal floor of premolar or a molar maybe frequently repaired. Perforation through the labial aspect of an anterior maybe repaired by using a surgical approach. Teeth with perforations on the lingual/palatal aspects preclude an attempt to salvage the damaged tooth.

CONTROVERSY-Endodontic therapy is contraindicated because the involved tooth has been perforated by internal resorption.

REALITY- The situation may be handled entirely as an internal problem, that is the metaplastic pulp causing the internal resorption maybe extirpated and the canal and the defect obliterated through the coronal approach. On the other hand, it maybe

necessary to approach the defect surgically and fill the defect with extra radicular filling technique rather than the usual intraradicaular approach. If the perforation from the internal resorption involves one root of a multirooted tooth, it is altogether possible to totally amputate the involved root and treat the other canals by endodontic means.

CONTROVERSY- Endodontic therapy is contraindicated because the involved tooth has external resorption present.

REALITY- External root resorption of the lateral walls of the root is not comparable in healing capacity to external root end resorption. Lateral root resorption is frequently related to traumatic injury of the suspensory apparatus of the tooth. Once this process has begun, and ankylosis between bone and tooth develops, it‘s difficult to interrupt. A successful result may be obtained when the perforating defect is in operable position. There appears to be no rule of thumb for prognosticating the outcome of this type of resorption.

CONTROVERSY- Endodontic therapy is contraindicated if the involved tooth is wholly of partially luxated.

REALITY- Traumatic luxation per se is certainly not a singular contraindication for root canal therapy. If the root of the wholly or partially luxated tooth hasn‘t ben fractured by trauma, replantation of tooth should be attempted.

CONTROVERSY-Endodontic therapy is contraindicated if the involved tooth has been treated previously and the endodontic treatment has failed.

RESULT- The previously treated pulpless tooth that ahs failed is far from a hopeless prognosis. Usually an error in treatment or diagnosis has been made which results in failure. By careful examination, the clinician must determine why the case has failed and if the cause is correctible, the clinician may correct the errors of omission or commission, which led to failure and therby turn a failure into success[4].

CONTROVERSIES IN VITAL PULP THERAPY

DISEASE OF THE PULP

Teeth may be exposed to a wide range of injuries that may put the vital functions of the pulp at risk. Some of the adverse influences are non-infectious injuries and disease processes produce defects in the tooth structure. Common examples include dental caries, attrition, erosion, abrasion, and various forms of fracture. Also, as a consequence of dental treatment procedures for managing caries and periodontal disease or to replace lost teeth, tooth substance is frequently lost. While injuries per se may interfere with the normal function of the pulp, they may also open up pathways to the pulp for a variety of noxious agents present in the oral cavity of which the resident microbiota are the most important and include trauma from accidents that interferes with the tissue's neuro-vascular supply. Normally, the hard-tissue barriers of the tooth, together with the capacity of the pulp to mount an appropriate inflammatory response, allow the tissue, similar to other connective tissues, to sustain injury and bacterial challenges. However, direct exposures to the oral environment are a threat to the pulp. Undeniably, the pulp has little self-healing capacity in such a situation because of lack of epithelia, which can bridge the defect and thereby offset deleterious effects of oral micro-organisms. Unless properly treated, even a minute pulpal exposure can provide oral microorganisms with the opportunity to cause a severe inflammatory lesion that eventually may result in complete breakdown of the tissue. Once the pulp has lost its vital functions, the potential for regeneration is slim in the adult tooth as microbes readily take over the pulpal space and multiply into large numbers. The ultimate consequence of this development is a chronic release of bacterial products that lead to peri-radicular inflammatory lesions and possibly also to undesirable systemic health effects. It is in this clinical context that endodontic therapies are carried out, sometimes to prevent but often in attempts to cure painful and non-painful clinical expressions of infections of the vital and the non-vital pulp[6].

DISEASE OF THE EXPOSED PULP

Nature Of The Controversy

The management of direct exposures of the pulp to the oral environment by caries or other forms of injury has intrigued the dental profession for hundreds of years. While

for a long time it was considered a hopeless task to save it from breakdown by a conservative pulp-capping or pulpotomy procedure, it became apparent, some 70-80 years ago, that pulpal healing is indeed possible. This occurred when it was discovered that wound treatment with calcium hydroxide in a water vehicle resulted in the repair of the exposure site The hard-tissue-repair response, although it does not occur consistently, has since been considered a desirable outcome, since it indicates healing of the pulp[7].

Despite the fact that pulpal healing and repair have been reported at a high rate in both experimental and clinical follow up studies, regardless of whether the tissue was injured by caries or accidental trauma, capping of the exposed pulp has remained a controversial treatment for the adult dentition. Disbelievers claim that the predictability of carrying out pulp-capping procedures successfully is inferior to the long-term success rate that endodontic therapy (pulpectomy and root filling) offers. Another compelling reason that has been put forth is that if treatment fails[8].

In the emergency situation, the dentist may also be challenged with the dilemma of having to identify the offending tooth among several candidate teeth. The subsequent endodontic treatment may furthermore become complex and more difficult to carry out than at the initial exposure, since the reparative phenomena, developing in the pulp during the healing phase, may result in a narrowing of the pulpal space. This is likely to have led many clinicians to uphold a skeptical attitude and to consider pulp capping a less-than-desirable therapeutic alternative[9]. Proponents of the treatment, on the other hand, allege that far too many pulps are extirpated that could have been saved by a conservative approach[10]. From a socio-economic point of view, procedures less invasive than pulpectomy are certainly desirable, since they are less tissue destructive and easier to carry out, thus saving effort, time, and money.

Between these two points of view are those who consider pulp capping appropriate only for exposures in healthy pulps occurring after accidental trauma. In particular, conservative treatment of exposures in young individuals is deemed suitable, since the pulp tissue volume in these individuals is large and rich in blood vessels and cells, making it apt to respond favorably to physical and microbiological challenges. Based on the analysis of a substantial number of clinical cases, Baume and Holz argued that direct capping with calcium hydroxide should not be used on pulps which have been

exposed by caries. Treatment should therefore be reserved only for teeth which display minimal signs of pulpitis. Such a clinical strategy is currently still advocated[8].

Potential Factors of Significance to Failure of Pulp Capping

Although often regarded as only one of many factors that can cause failure of pulp capping, there is ample evidence to suggest that the major threat to the pulp is of bacterial origin. A most convincing study in this context is that by, who compared the tissue response to direct exposures of the pulp, after leaving them unprotected to the oral cavity, in molars of germ-free and conventional rats. While the pulps in the conventional rats, as expected, became necrotic after a period of time and obviously infected, as indicated by the development of periapical abscesses, no such responses took place in the germ-free animals. On the contrary, pulp tissue in these animals remained healthy, and, at the exposure site, hard tissue repair developed despite the presence of debris of various origins in direct contact with the tissue. A most obvious inference of the latter study and similar observations is that pulpal wounds should heal if wound infection can be controlled. In other words, critical to the maintenance of pulpal health after capping should be the integrity of the wound site and whether it can be protected over the course of time from adverse influences of the oral microbiota. Calcium-hydroxide-mediated hard tissue repair is thought to provide such protective functions. Indeed, it has been reported that this hard tissue barrier can withstand microbial challenges if the surface restoration is lost[11].

In fact, it may become less than homogenous and may display porosities and defects, which can serve as pathways for microbial organisms to reach the pulp, should the integrity of the restoration margins or the entire restoration be lost[12].

This mechanism of lesion development and pulpal breakdown may be one important reason why pulps show a declining rate of survival over time following capping. a retrospective analysis was carried out of 510 pulps that were previously capped because of accidental exposure or exposure due to excavation of deep caries. While some pulps were lost soon after treatment, there was a successive decrease of pulpal survival over time. In a life table analysis, pulpal deaths amounted to 20% at 5 years, a rate that continued to increase until the end.

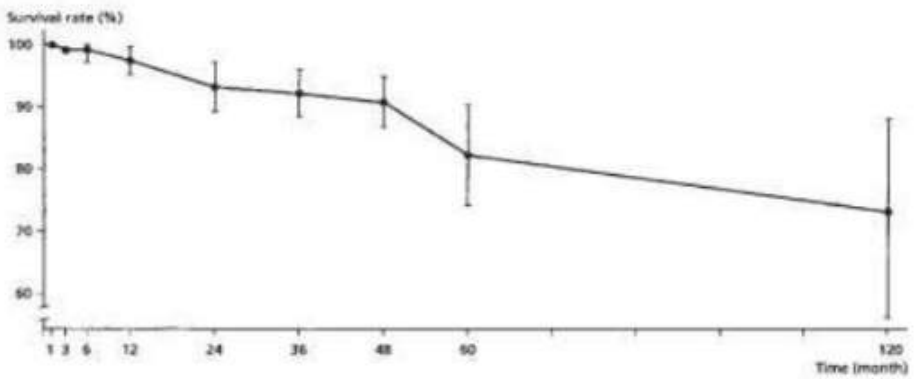


Figure 1. Graphic representation of the findings in the study by Hörsted *et al.* (1985). While the overall rate of pulpal survival was high, there was a decline over time. Bars indicate 95% confidence intervals.

In a similar retrospective analysis of pulp-capped carious exposures, the failure rate increased from 45% of treated cases at 5 years to 80% at 10 years—a daunting high rate of pulp-capping failure.

Some failures, especially those that occur soon after the completion of the treatment, may be due to reasons other than a leaky surface restoration. The previous injury and the associated bacterial exposure or both may have impaired the condition of the pulp to such an extent that it is unable to survive, regardless of treatment measure. It is most challenging for a clinician encountering a clinical exposure of the pulp to make such an assessment. This is particularly difficult when there has been caries penetration[13].

In the treatment of deep caries, clinicians run the risk of displacing infected dentin chips into the pulp tissue proper. This is a distinct possibility unless the last layer of carious dentin covering the pulp is very carefully removed. While non-infected dentin debris may become integrated into the hard tissue to generate molecules of significance for hard tissue induction, displaced infected debris may exacerbate the lesion or serve as a source of continual bacterial irritation of the tissue, or both. Consequently, the caries excavation procedure is potentially hazardous and could enhance the risk for an inflammatory breakdown of the pulp[14].

To circumvent this problem, Cvek has designed a procedure that has shown promise. The treatment, which he termed "partial pulpotomy", utilizes a pulp-cutting technique described by Granath and Hagman. The pulp tissue is atraumatically cut with an end cutting diamond at high speed and with copious irrigation. The wound surface is smoothed and completely debrided and cleaned prior to being capped. Limited case series of clinical follow-ups of treatments using such measures have shown that the five-year pulpal survival rate in young teeth with penetrating caries might be as high as 90%[15]. It should be noted, however, that no such data exist on more mature adult teeth. Claimed to be critically important for the outcome of a pulp-capping or partial pulpotomy procedure is the degree of pulpal bleeding upon mechanical exposure[11]. A profuse bleeding response that is difficult to stop is likely to indicate a more or less grave inflammatory involvement of the tissue. It may be equally important that unstoppable bleeding prevents proper management of the wound site and precludes its adequate closure by the capping agent. A blood coagulum may also be susceptible to wound infection. On the other hand, if the infection is controlled, the coagulum may serve as a matrix or mold for tissue re-organization[15].

DISEASE OF THE UNEXPOSED PULP

The inflamed pulp unexposed by caries or trauma always has the potential to be repaired. Although our diagnostic ability to differentiate a vital from a necrotic pulp is good, differentiating between reversibly and irreversibly inflamed pulp remains an educated guess at best.

Indirect pulp capping is finished by a permanent restoration in a one-step treatment, in the step-wise mode, various amounts of carious dentin are sealed off by a temporary restoration for a period of time. In anticipation of the remineralization of softened non-infected dentin over the pulp and recovery of any prevailing pulpal lesion with hard.

This latter mode of treatment has been severely criticized. By leaving caries behind to avoid pulp exposure, the clinician is unable to assess the depth of the caries lesion and the status of the pulp. Nygaard-Östby has drawn attention to the different scenarios that might exist in a case when caries has progressed to near the pulp tissue. On the one hand, an unbroken layer of primary dentin may separate the pulp from the caries lesion. In such an instance, the inflammatory involvement of the pulp is normally

small if present at all and thus is inconsequential. On the other hand, caries may have invaded reparative dentin and even advanced to the pulp tissue proper. Pulpal inflammation is then evident due to bacterial invasion of the tissue, a response which can progress to an abscess and partial necrosis. In both of these scenarios, leaving infected dentin permanently is not likely to change the preconditions for a successful outcome of a pulp preservation effort. Similarly, in the case of a healthy layer of remaining dentin, carious dentin in situ is of no benefit, and only impairs the prospect of a good restoration and a healthy pulp being retained in the long term. In a situation where bacteria have invaded the tissue, it remains to be shown that partial excavation of caries can actually suppress the infection. No such documentation is yet available tissue repair, a re-entry operation is carried out to complete excavation of remaining caries[7].

In this context, Jordan et al reported results from a follow-up of 24 molars which had signs of periapical involvement (small periapical lesion or widened apical periodontal space). These teeth had responded as vital to testing and had no history of spontaneous or prolonged pain. Of interest is that 11 teeth showed resolution of the periapical lesion and were judged clinically healthy at the final examination, from 10 months to 7 years following treatment. But 13 of the 24 treatments failed. Spontaneous recurrent pain occurred in 12 instances, and one tooth developed an acute swelling after 3 days[16].

For the reasons stated above, and the fact that convincing clinical data in support of the procedure have not surfaced over the years, indirect pulp capping as an attempt to preserve a functional and asymptomatic pulp tissue should be discouraged. Step-wise excavation, on the other hand, has the advantage that the clinician can evaluate, on reentry, whether vital pulpal conditions prevail and at the same time can check the integrity of the hard tissue covering the pulp. The method has been spurred by promising results in randomized clinical trials. In these studies, complete caries removal in one step was compared with the step-wise procedure as to the number of pulpal perforations. Significantly fewer pulpal exposures were recorded in primary and young permanent teeth. Notably, regardless of direct or stepwise excavation, the teeth with no pulpal exposure presented with normal clinical and radiographic conditions at the final clinical check-up. Björndal and Thylstrup confirmed these findings in an uncontrolled follow-up of step-wise treatments carried out by general

practitioners. Only 5 of 94 teeth with deep caries lesions, which the clinicians believed would result in pulp exposure if excavated in a single session, resulted in exposure. On the basis of these findings, it is reasonable to conclude that the procedure of excavating caries in a stepwise fashion may avoid inadvertent (iatrogenic) exposure of pulps. It is believed that by closing off the caries lesion from the oral environment for a period of time, acid-producing bacteria will be deprived of their nutritional supply. As a result, less acid will be generated, which in turn may allow for remineralization of softened but not infected dentin. Support for this potential comes from numerous reports of reduced microbial counts in caries lesions sealed off from the oral environment. In assessing the evidence in support of the stepwise excavation procedure, one has to take into consideration that, in the clinical follow-ups so far published, the cases were carefully selected. It is not unreasonable to assume that, in many of these instances, there was a favorable pulpal condition because of the absence of or limited bacterial invasion of the tissue, owing to a more or less intact layer of primary dentin. So far, there are no data to show that more pulps are actually being saved by such a measure in comparison with a direct capping procedure. Consequently, there is an obvious need to validate whether step-wise excavation is a worthwhile clinical procedure. Controlled prospective clinical trials with due consideration of relevant clinical parameters are therefore called for[17].

CONTROVERSIES IN ACCESS CAVITY PREPARATION

Modern clinicians must factor the unique and dramatically higher biting force of the molar tooth when designing the endodontic portion of the endo-endorestorativeprosthodontic (EERP) continuum. The occlusal forces created by the attachment position of the elevator muscles to the mandible generate occlusal forces that vary dramatically throughout the dentition, with light biting force in the front of the mouth to increasingly heavier forces at the back of the mouth. In physics, the mandible with its hinged access (the temporomandibular joint) is classified as a moment arm. The closer to the hinge, the higher the moment, or force, applied. The ability of the incisor to splay forward when loaded occlusally also comes into play when evaluating tooth stresses during occlusal loading. However, the molar absorbs a more vertical force and, therefore, a significantly higher net compressive force. When these 2 factors are combined (moment arm and splay), the overall compressive forces on the molar create a situation that requires a different set of rules for the calculation of ferrule, post and core design, resistance to fracturing, and (of utmost importance) endodontic access and removal of radicular dentin during endodontic shaping[18].

There are also different forces. The incisor must withstand milder, but more oblique, shearing forces. Most of the in vitro and in vivo research of post and core design has been conducted on maxillary incisor teeth, and attempting to extrapolate these findings to the molar tooth is not feasible. Placing a post in a round, husky maxillary anterior root and subjecting it to mild shearing force has little relevance to placing a post in a delicate, ovoid root in a mandibular molar and subjecting it to heavy compressive force.

Endodontic accesses are traditionally conservative to the occlusal/incisal tooth structure. However, with the changes that occur in restorative dentistry, this technique is unnecessarily restrictive for the operator and potentially damaging to the more critical cervical area of the tooth[19].

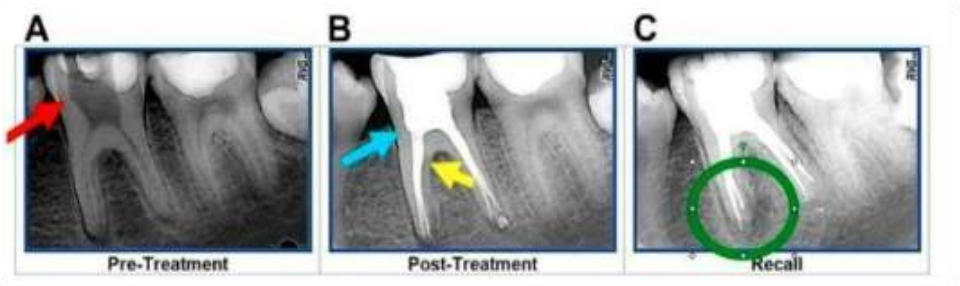


Figure A- First access using fissure burs and with the type of dentin removal that is the standard today.

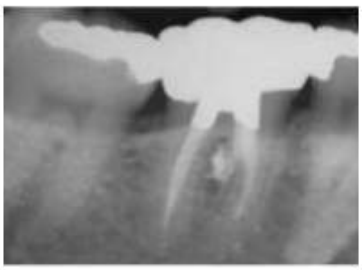
Figure B- The tooth was then re-accessed by an internationally recognized endodontist. This model for generous removal of peri-cervical dentin is common in many specialty practices.

Figure C- Eighteen months later, the lesion on the mesial root continues to enlarge. The wholesale loss of Peri Cervical Dentin has reduced the value of this tooth to the point that, when the tooth becomes symptomatic, extraction and replacement with an implant is a better option[18].

LOOK, GROOM, AND FOLLOW: SHAPING VERSUS MACHINING

Why are Gates Glidden (GG) burs so problematic?

Since the introduction of rotary files, GG burs have been used more aggressively and with more reliance on larger sizes (4, 5 and 6) to reduce binding and fracture of rotary files. Gates burs have always been considered safe because they do not end cut and are self-centering. There is a significant problem here, which is cervical self-centering. Because the shank of the GG is so thin, it is difficult to steer the GG away from high-risk anatomy. As the GG straightens the coronal or high curve, it can shortcut across a fluting or furcation and weaken or even create strip perforations



Why are round burs so destructive?

The traditional method of initiating endodontic access is predicated on mental models that do not represent the day-to-day clinical reality presented to the clinician. Round bur technique rely on tactile feedback as the round bur drops into the chamber. If the pulp chamber is sufficiently large, then a round bur can truly drop into the pulp chamber.

The case shown here is more representative of the cases typically presenting for endodontic treatment. Trying to drop a round bur into the scant or nonexistent chamber is not going to lead to the desired outcome.

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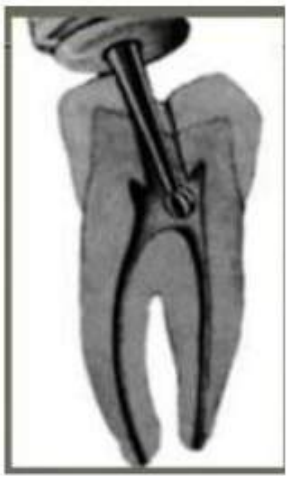


Instead, the size of the burs relative to the chambers, the omnidirectional cutting blades (which side cut aggressively), and chatter common with this bur design are much more likely to lead to the kinds of outcomes seen in

Eighteen months follow-up- Despite generous access opening and aggressive canal enlargement, the lesion on the mesial root continues to grow.

Why is complete deroofing so dangerous?

When the authors first began to maintain a soffit, which is a small piece of roof around the entire coronal portion of the pulp chamber, it seemed sloppy and contradicted the compulsive nature of traditional dentistry that has made complete deroofing a mark of a thorough clinician. The pulp seemed difficult to remove under the tiny eve and the removal of sealer and gutta percha was equally difficult. It just seemed wrong. Cleanup is easier and the authors take pride in this important advance in minimally invasive access. It is a perfect example of banked tooth structure. However, it is the attempts at removing the soffit that are far more damaging to the surrounding PCD.

The idea that a round bur can be dropped below this soffit and drawn coronally to unroof the chamber is predicated on large pulp chambers and exceptional hand skills. Clinically, it is impossible. Attempting to remove the pulp chamber roof does not accomplish any real endodontic objective, and invariably gouges the walls that are responsible for long-term survival of the tooth.

The primary reason to maintain the soffit is to avoid the collateral damage that usually occurs, namely the gouging of the lateral walls. Research will certainly need to be done to validate the strength attributes of the roof strut or soffit. However, in the absence of a compelling reason to remove dentin, our default position should always be conservative. This 360 soffit or roof-wall interface can also be compared with the metal ring that stabilizes a wooden barrel. Inference to the second moment of inertia in structural engineering deserves analysis.

In practice, it is impossible to cut flat walls in 3 dimensions with a round instrument. The chamber is not unroofed in some areas, leaving pulpal and necrotic debris with no specific subsequent step to address the debris, yet the walls are overextended and gouged in other areas. Further, the internal radius of curvature at many of the pulp chamber line angles is simply too small for all but the smallest of round burs.

In the final analysis, round burs point cut in an endodontic access application, whereas what is needed is planning. What is needed is a new set of mental models

based on vision, and a new set of instruments reflective of the task at hand and the desired shaping outcomes. The new vision-based mental model is Look, Groom, Follow.

The new burs are all round-ended tapered

It is appropriate to provide updated cavosurface outlines and cross-sectional illustrations for initial access for the maxillary and mandibular molars

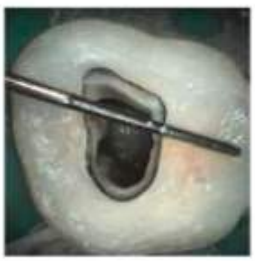
Cavosurface And Cross-Sectional Illustrations For Maxillary Molar Access

Traditional textbooks devote considerable length and effort on drawing access outline forms that are done on restoration-free, caries-free teeth. When in doubt, a larger outline form through the restorative should be cut, but only to the level at which dentin is encountered. Then, the access should be vision based, cuing from the colour map and the presence of any PTRs that can be identified. This method is a stepped access, in which an intentionally over-enlarged access is made through the cavosurface of a restored tooth (typically a crowned tooth) to the level at which dentin is encountered, then the access steps in to the size of the pulp chamber outline. The occlusal view drawing shows an inner outline of maxillary molars.

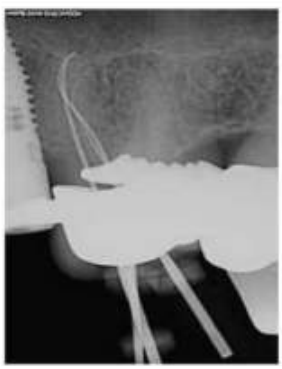
An access extension or modification that is frequently needed is the fluting or notching of the mesial wall in the area of the MB2. This requirement is due to the pattern of calcification that often places the angle of entry to the MB2 at an untenable

distal angle. This notching can be performed in dentin with a BUC-1 ultrasonic tip, and, if need be, extended into restorative using an LAAxxess nipple-tipped diamond. This case shows a preliminary access with a slight amount of fluting. A closeup shows the finished fluting in the prepared case, and the overall sizes of the access through the porcelain fused to metal (PFM) (crown) and the dentin

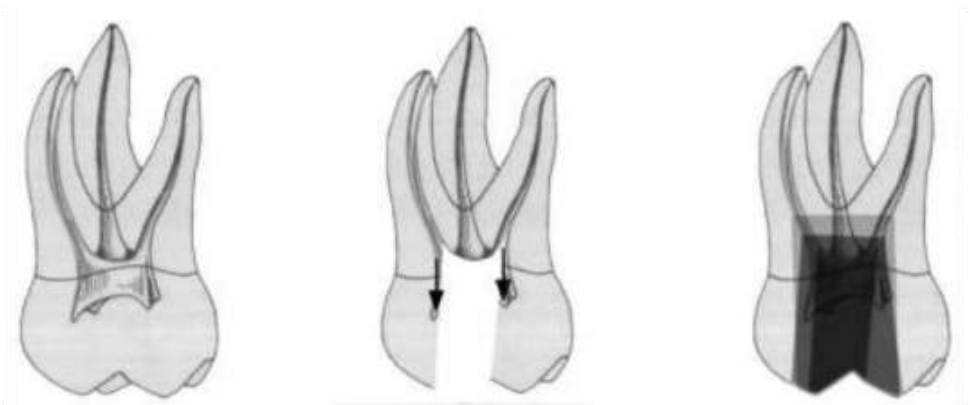


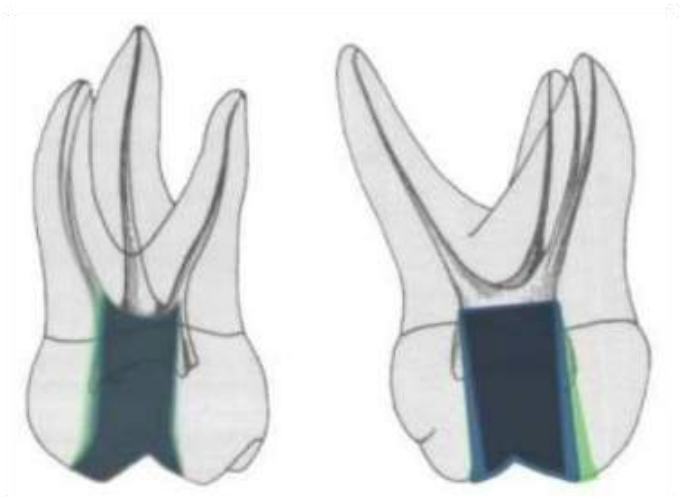
A frequent criticism of the techniques demonstrated here is that these more precise shapes preclude the discovery of coronal points of negotiation (PONs), and deep anatomy, and preclude the development of condensation hydraulics. The authors have not found this to be the case. In this case with an apparent confluent MB/MB2, precurved files were introduced with intent on the palatal aspect of the MB2, which often contains a deep split. The wire radiograph shows the 2 larger files, 1 in the MB orifice and 1 in the MB2 orifice joining, and a smaller file, also in the MB2. The completed case is shown as




The first 2 buccal views show a large pulp chamber, and a raw Clark/Khademi (CK)-style access with small soffits of chamber roof left to be debrided later. The next buccal view is an overlay of the CK-style access, a more traditional occlusally divergent access, and an access taken from a recent text showing fairly parallel walls, but grossly overextended cervically. The second set of overlays shows the CK-style access with blue and green extensions, with cavosurface finish lines appropriate for a bonded substrate with a bonded restorative, which are described later.



The mesial view shows the various extensions, again emphasizing the directions to extend as opposed to exact amounts and locations. The extension is not balanced equally between buccal and palatal, but favors the buccal.



Restorative materials should almost always be sacrificed before tooth structure. More occlusal tooth structure should be sacrificed for more cervical tooth structure. The key pericerivcal tooth structure should remain as untouched as possible. Final cavosurface outline extension at the finish appointment (which may be the start appointment on a 1-step case) hinges on the existing restorative, and the restorative plan. If abundant highly bondable substrate such as etchable porcelain or always be sacrificed before tooth structure. More occlusal tooth structure should be sacrificed for more cervical tooth structure. The key pericerivcal tooth structure should remain as untouched as possible. Final cavosurface outline extension at the finish appointment (which may be the start appointment on a 1-step case) hinges on the existing restorative, and the restorative plan. If abundant highly bondable substrate such as etchable porcelain or enamel is available, and a bondable restorative material such as a heavily filled composite resin is planned, the cavosurface should be Cala Lillied, or generously beveled on those areas. If the bondability of the substrate is of low, or a bond cannot be established between the substrate and restorative material, a butt joint or 70 to 90 interface at the cavosurface should be the objective. On multiple visit cases in which an unbonded temporary restoration is placed, the cavosurface should be maintained at 70 to 90 until the completion visit.

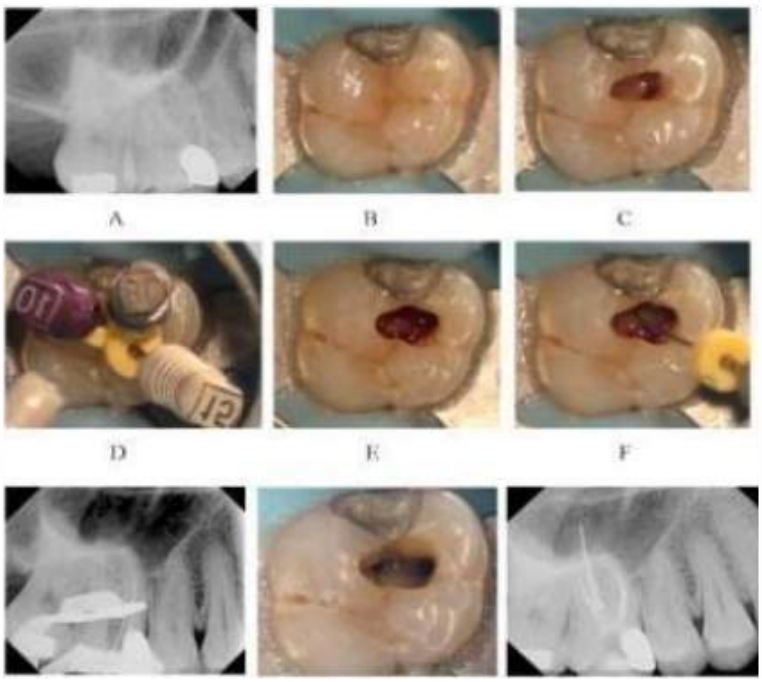
Cavosurface And Cross-Sectional Illustrations For Mandibular Molar Access

These illustrations are consistent with the style of access demonstrated in the maxillary molar section earlier (generously flared and flattened when appropriate in the coronal third of the tooth, then conservative in the middle and apical portion of the coronal portion of the tooth). The first step in contemporary molar access in the noncrowned tooth is flattening. It is a step that is ignored or overdone in most practices[18].

Controversies regarding conventional and conservative access cavity preparation

Recently, variously-sized access cavity designs have been described and compared, including the traditional endodontic cavity, the conservative endodontic cavity, and the so called –ninja‖ endodontic cavity. The controversy should not be whether to completely de-roof or partially de-roof a pulp chamber, or whether to cut a ninja-type access cavity to any given orifice; rather, the answer to this debate should

be based on the reality of –do what you can, with what you got, where you are.‖ Ultimately, the size of the access cavity is most influenced by anatomical knowledge, experience, and the technologies and methods utilized to shape, 3D clean, and fill root canal systems.



Traditionally-sized access cavities only reduce tooth stiffness by 5%, whereas cutting an MOD preparation decreases tooth stiffness by more than 60%. Yet, it is appreciated that it is the cumulative loss of tooth structure that increases the possibility of radicular fracture. Tooth survival following endodontic treatment is most dependent on full coverage, as teeth without full coronal coverage are extracted 6 times more frequently (Figure 6). In one large epidemiological study, initial endodontic treatment was performed by general dentists and endodontists in 1,462,936 teeth. Overall, 97% of these teeth were retained in the oral cavity for at least 8 years, while analysis of the 3% extracted teeth revealed that 85% had no full coronal coverage. Further, ongoing debate continues regarding whether to preserve, partially remove, or eliminate any given triangle of dentin. Yet, eliminating triangles of dentin allows the coronal aspect of any given canal to be intentionally relocated away from an external root concavity and toward the greatest bulk of dentin. Histological evidence demonstrates that removing triangles of dentin results in more

radicularly centered final preparations, which in turn, make teeth more fracture resistant.8 Experienced dentists appreciate that, in the instance of full coronal coverage, the buccal and lingual aspects of a circumferential ferrule are far superior at resisting vertical and lateral occlusal loading as compared to the mesial and distal aspect of the same ferrule[20]

CONTROVERSIES IN WORKING LENGTH DETERMINATION

One of the major controversies in root canal treatment is the apical end point of the working length. It is a paradigm in modern endodontics that instrumentation beyond the apical foramen should be avoided because it is so often associated with a reduced success. Most clinicians prefer to end the biomechanical instrumentation at the apical constriction (narrowest point in the canal at approximately the dentin–cemental junction), where the contact between root canal filling material and the apical tissues is minimal. In addition, many dentists practice apical patency with small files in order to maintain communication with the apical tissues and prevent canal blockage and ledging coronal to the determined end point.

Stein and Corcoran discussed the possibility of unintentional over-instrumentation when radiographs alone were used for working length determination. They reported that the position of a file placed for working length determination appeared radiographically 0.7 mm shorter than its actual position. The results of another investigation suggest that a working length that ends radiographically 0 to 2 mm short of the radiographic apex does not guarantee that instrumentation beyond the apical foramen will be avoided in premolars and molars. The authors conclude that radiographic measurements should be combined with electronic working length determination using modern apex locators to better help identify the apical end point of root canal preparation and avoid over-instrumentation[21].

Weine (1982) stated that, in general, a point located 1 mm coronal to the apex is close to the area of the cemento-dentine junction (CDJ). He said that in the evaluation of the exact point where the canal preparation should end, 1 mm short of the radiographic apex is probably acceptable. Another study which identified a smaller diameter or `apical constriction' as the point where the canal preparation should end and where the deposition of calcified tissue is most desirable. In the case of a periapical radiolucency with radiographic signs of apical resorption, the preparation should be shortened by an additional 0.5 mm from the radiographic apex[22].

Weine (1982) suggested instrumentation and obturation to the CDJ, which he believed was located at the same level as the apical constriction (Figs 1 and 2). Nguyen indicated the CDJ as the limit of the preparation.

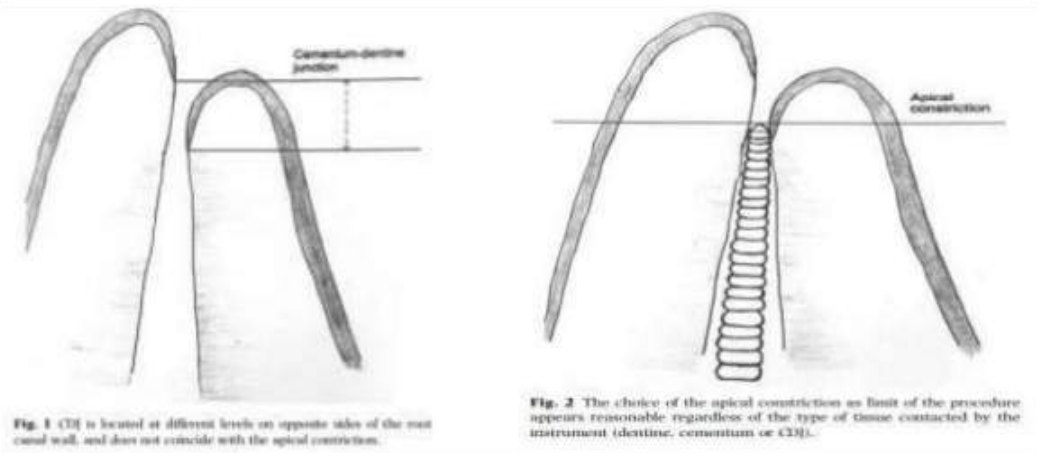


Fig. 1 CDJ is located at different levels on opposite sides of the root canal wall, and does not coincide with the apical constriction.

Fig. 2 The choice of the apical constriction as limit of the procedure appears reasonable regardless of the type of tissue contacted by the instrument (dentine, cementum or CDJ).

Ingle, based on Kuttler's study, stated that the narrowest diameter of the apical foramen was located at the CDJ (Figs 1 and 2), which was usually found about 0.5 mm from the external surface of the root. Limiting the instrumentation to 0.5 mm from the radiographic terminus of the root would certainly maintain the minimum and ideal apical opening. The overextension of instrumentation and the displacement of toxic products from the root canal into the periapical tissue would be avoided. This author also recommended obturation at 0.5 mm from the radiographic apex and stated that obturating up to the radiographic terminus of the root actually results in an overfilling[23,24].

Frank et al. (1988) suggested an apical stop located between 0.5 mm and 1 mm from the apex. The stop represents the apical limit of the instrumentation and keeps the obturation material inside the canal during condensation. With regard to the problem of accessory canals, these authors stated that too much importance has been given to these canals, as if they were crucial elements in obtaining success or failure. In fact their importance is relatively little if the main canal is properly prepared and filled. Their obturation happens by chance and does not have clinical significance.

Guldener (1985) suggested choosing a working length which corresponds to the tooth length less 0.5 mm for cases with a necrotic pulp. In cases of vital pulp extirpation, he recommended an additional reduction of 0.5 mm, 1 mm short of the tooth length. Taylor (1988) pointed out a narrower spot at the apical level called `Minor Diameter' which he believed to correspond histologically to the CDJ[25].

Langeland, however, advocated termination of instrumentation and obturation at the apical constriction. He demonstrated histologically that the pulp in the apical portion of the root canal, in the lateral canals and in the apical ramifications remains vital and often uninflamed, even in the presence of a radiolucency. Finally, despite necrosis and bacteria establishing themselves in the periapical lesion, the instrumentation and obturation should remain at the apical constriction. He also stated that the most frustrating clinical aspect is that no exact distance from the radiographic apex could be given, because the distance from the radiographic apex to the apical constriction varies widely from root to root. Histologically, he demonstrated that the CDJ ± being highly irregular (e.g. 3 mm higher on one wall than on the opposite wall) ± did not at all coincide with the apical constriction. Consequently, he refused to accept any distances from the radiographic apex as an accurate indicator for the termination of the endodontic debridement and obturation. Contrary statements in the literature, although calculated from large numbers of measurements, are based on averages and oversimplifications which cannot give accurate clinical direction. This is a situation where the use of averages adds to the confusion rather than giving a solution to the problem. Furthermore the CDJ is a histopathological structure which cannot be found clinically and thus cannot be instrumented or obturated. His firm clinical advice is: Carefully study a good quality radiograph in a viewing device blocking out all extraneous light, have the knowledge of the variations of root canal anatomy foremost in your mind, use your tactile sense to locate the apical constriction, observe if blood or other tissue fluids appear on the instrument tip, or anywhere on a paper cone, indicating that you are in the periapical tissue. This is an inaccurate art, based on precise science. Finally, put it all together using common sense: instrumentation beyond the foraminal constriction causes an unnecessary enlargement of the pulpal wound, contaminants from the canal will interfere with the wound healing and medicaments and/or materials will cause tissue destruction, inflammation, and a foreign body reaction in the periapical tissue'.Regardless of a vital or necrotic pulp, however, he suggests termination of the obturation at the apical constriction, that is short of the apex, radiographic or anatomic, which will result in the smallest possible wound and optimal healing. This decision is based on anatomical and histological material[26].

Pecchioni (1983) stated that during instrumentation it is better not to go nearer than 0.5±1 mm from the radiographic apex. Even regarding the distance where the obturation should end. He affirmed that it must, in any event, end at 0.5 mm from the radiographic apex. However he continued while it is very serious and damaging to go beyond this limit with instrumentation, it is less serious to slightly overfill the apex, since the common sealers are generally tolerated and easily resorbable'. Thus: we feel comfortable saying that in necrotic cases an overfill does not represent a contraindication. In fact, while treating vital teeth alteration of the apical pulp stump must be avoided, in necrotic cases leaving necrotic or infected debris, or an empty space in the last part of the root canal must be avoided'. Langeland, by contrast, stated that all endodontic sealers are irritant and resorbable[27]. The above authors seem to agree that instrumentation and subsequent canal obturation should be confined to the root canal space, coronal to and at some varying distance from the radiographic apex.

Table 1 *Recommended limit of instrumentation and obturation*

Authors	Ideal limit	Practical limit	Modifications in 'necrotic cases'	Materials beyond the foramen	Lateral canals and apical ramifications
Weine (1982)	CDJ (apical constriction)	1 mm from the apex	Additional 0.5 mm shorter (1.5 mm total from the apex	—	Rarely cause failure
Nguyen (1985)	CDJ	—	—	—	—
Ingle (1983)	CDJ (apical constriction)	0.5 mm from the apex	—	—	—
Frank et al. (1988)	—	0.5–1 mm (apical stop)	—	—	Their obturation casual and not clinically relevant
Guldener (1985)	—	1 mm from the apex	0.5 mm longer (0.5 mm from the apex)	—	—
Taylor (1988)	Apical constriction (minor diameter)	—	—	—	—
Pecchioni (1983)	—	0.5–1 mm from the apex	Overfilling accepted	Slight overfilling not relevant	—
Seltzer et al. (1968, 1969)	—	Instrumentation and obturation 'short'	—	Not accepted	—
Langeland (1967)	Apical constriction	Apical constriction	No difference in limit of procedure	Not intended	Not intended material in lateral canals
Schilder (1967, 1976, 1987)	—	Radiographic terminus of the canal	No difference in limit of procedure	Not relevant	Obturation desired

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This chapter aims to clarify the problems described on the basis of strict scientific criteria. These will include (i) statistical/longitudinal studies, (ii) anatomical evidence, and (iii) histopathological/microbiological evidence.

Statistical/longitudinal studies

Since 1956 many statistical studies on the results of endodontic treatment have been published. From these studies a correlation between clinical variables and success rate can be made. One of the most investigated aspects is success rate related to the radiographic level of the endodontic obturation.

In a study on 1007 endodontically treated teeth, 1770 canals, Swartz et al. (1983) evaluated several variables and came to the conclusion, among others, that overfilled canals were four times more likely to fail than canals filled short of the radiographical apex'. Marin (1989) conducted a retrospective analysis on the clinical radiological results of a sample of 1200 roots treated over a period of 5 years. The purpose was to determine whether a significant statistical relationship existed between the level of the root canal filling and the success rate. He concluded that cases with fillings at 0.5 and 1 mm from the radiological apex appear to have a significantly superior clinical prognosis. In cases where the filling reaches or goes beyond the radiological apex, there is a considerable decrease in the number of complete repairs and a consequent increase in incomplete repairs and failures. The importance of staying inside the root canal with the obturation and avoiding extruding material into the periapical tissues in order to obtain a higher success rate has also been stressed more recently found that in roots with necrotic pulps and periapical lesions the best prognosis was obtained when the filling reached within 2 mm of the apex (94%). By contrast, in cases with excess root filling the success rate decreased to 76%; in cases of excess root filling during retreatment of previously filled roots the success rate decreased to 50%.

Smith et al. had a 86.95% success rate when the position of the root filling was within 2 mm of the radiographic apex. In cases with `long' obturation the success rate was reduced to 75%. Friedman et al. (1995) found that in the presence of extruded sealer the success rate was 56.7% against 81.9% in the absence of extrusion. Contrary to the studies undertaken by endodontic specialists which reported success rates of 91±94%, epidemiological studies of large population groups showed uncertain and failure rates of about 50% of endodontic procedures performed by generalists. OÈ desjoÈ et al. found that 24.5% of the endodontically treated roots demonstrated periapical lesions. Buckley & SpaÊngberg found 31.3% of root-filled teeth with periapical lesions, and 42.9% of overfills had periapical disease. These studies agreed that inadequate canal

obturation and overfilling were strongly associated with the presence of periapical disease. It is clear that all studies confirm the practice of staying short of the apex with a proper obturation to obtain the highest success rate[25].

Anatomical evidence

The anatomical complexity of the root canal system has been well known since the beginning of this century. Preiswerk stated that he was the first to describe the presence of an anastomosing canal system. Subsequently Hess undertook a further study of the anatomical complexity of the root canal system. Kuttler made an impressive number of measurements on the apical part of the canal. Very seldom does a root canal end at the radiographic apex. Much more frequently the foramen ends at a location short of the apex. This was reconfirmed in a recent study by Gutierrez & Aguayo, who examined 140 extracted permanent teeth with a scanning electron microscope. All the root canals were found to deviate from the long axis of their roots. The number of foramina ranged from 1 to 6. The openings always ended short of the apices by 0.20±3.80 mm[24].

This represents a problem for the endodontist, because this phenomenon is recognizable on the radiograph only when the foramen ends on the mesial or distal aspect of the root. When the foramen ends on the buccal or lingual aspect it is not possible to recognize it radiographically. Thus, over-instrumentation of the root canal must be a common and unnoticed occurrence, unless the operator is diligently examining the tip of the instrument for blood. Cases of endodontic failure where the canal appeared to be filled short of the apex radiographically were in fact obturated beyond the foramen. Apicectomies and successive histological sections demonstrated that the obturation material protruded into the periodontal ligament from a foramen ending several millimetres short of the apex on the buccal aspect[25].

Frequently the main canal in the apical third divides into several branches, each ending on the external root surface with a distinct foramen. Lateral canals can also be present at any level along the root, and it is evident that the tip of a file cannot suddenly make a 908 turn to instrument these spaces. From all these considerations it may be concluded that the best place to end the preparation procedure is at the apical constriction which is usually located at a distance between 1 and 2 mm from the radiographic apex, keeping in mind that in particular cases the foramen could be

found several millimetres short of the apex (Ricucci et al. 1990, 1991, Gutierrez & Aguayo 1995). However, apart from those exceptions where the experience and expertise of the operator will allow recognition of anatomical variations, instrumenting at an average distance of between 1 and 2 mm from the apex will prevent over instrumentation, leaving the pulp tissue contained in the apical part of the canal and the ramifications undisturbed.

Langeland (1996), based on anatomical/histopathological studies, refused to settle for any particular length from the apex. The radiographic apex with all its radiographic inaccuracies is the `constant' against which the everchanging distance from the anatomical apical constriction must be measured. This has to be inaccurate, as confirmed by Gutierrez & Aguayo[26].

Histopathological/microbiological evidence

The first scientific basis for modern clinical endodontology was established by Davis. This author, on the basis of Hess's study, was the first to suggest that careful treatment of the apical tissue was a requirement for success in endodontics. His conclusion was not based on histological observation, but since then many histological studies based on biopsies of the apex with the surrounding periapical tissues or on extractions of teeth performed at varying periods of time following the endodontic treatment have confirmed his observation. All these studies agreed that, in vital pulp treatment, partial pulpectomy was preferred to total pulp removal. The first histological studies on pulp wound healing were made by Hatton et al. and by Blayney but the series were too small and data about diagnosis, procedures, observation periods and results were insufficient.

Subsequently Nygaard-Ostby performed clinical/histopathological studies on 20 human teeth. On some of them pulpectomy was performed; in the others a partial pulpectomy was performed using a blunted Hedstroem file. The distance from the apex was checked radiographically. Observation periods ranged from one month to several years. Despite limitations in the number of cases and a number of uncontrolled variables such as diagnosis, medicaments and filling materials, Nygaard Ostby stated: `To leave the apical and foraminal part of the pulp tissue and to retain its vitality will play a decisive role for the success in the treatment of the vital pulp'. Also: `In cases where the pulp is vital before treatment, no matter whether the

diagnosis be clinically intact pulp, acute or chronic pulpitis, partial extirpation seems to give the most favourable prognosis. By appropriate treatment, in the majority of cases, the vitality of the residual pulp may be conserved, the result being a normal apical periodontal ligament and fibrous connective tissue in the apical portion of the root canal[28].

Histological results after pulpectomy in 17 teeth with previous vital pulps. In 15 of these a pulpectomy was performed, with the wound surface between 1.5 and 6 mm from the radiological apex. Although a number of uncontrolled variables were present, they recorded histological success in 10 out of the 15 cases.

Partial pulpectomies in 12 contralateral tooth pairs were perfromed. Half the canals were obturated with calcium hydroxide mixed with saline, the other half with chloropercha and gutta-percha, according to the Nygaard-Ostby technique. The teeth were extracted after observation periods of 4 to 29 weeks. They classified 12 of the 23 partial pulpectomies as successful and 4 as more or less successful. They concluded that optimal results `would appear to be obtained' with a residual apical pulp 1±2 mm long.

They concluded that, in cases of vital pulp extirpation, optimum results, in terms of tissue repair, were obtained when root canals were instrumented and filled short of the apices of the teeth. They emphasized that when obturation materials are forced into the periapical tissues they cause the inflammatory response to persist. The foreign materials act as continuing irritants. Over-all the best results are obtained when the apical pulp stump retains its vitality and no foreign material is impinged on the pulp or periapical tissues. Substantial agreement exists among many researchers that partial pulpectomy is preferable to total pulpectomy in vital pulp treatment. The same agreement is not registered in the treatment of `necrotic cases'. A very strict distinction between the vital pulp condition and necrotic pulp condition has always been made by clinicians. It seems a very common cliche that, when a pulp appears clinically necrotic (i.e. it does not respond to sensitivity tests), it is generally considered to be necrotic in its entirety, including the apical pulp and the tissue contained in lateral canals and in apical ramifications. This is a basic conceptual error on which, subsequently, inappropriate therapeutic options have been based. In fact progression of the pulp necrosis as the result of caries is a slow process. The invasion

of bacteria into necrotic pulp tissue occurs in irregular `pockets', deeper in some areas, adjacent to vital pulp tissue on the same level as the orifice[25].

The involvement of lateral canals

It has already been stated that it is incorrectly presumed that when a pulp appears to be `clinically necrotic' it is considered entirely necrotic, including the pulp tissue in the lateral canals and apical ramifications. Langeland demonstrated that the histological condition of the tissue contained in lateral canals reflects the condition of the pulp in the main canal, from which they emerge: when a lateral canal is present in an area where healthy pulp tissue is present in the main canal, healthy pulp tissue will be found throughout the lateral canal; when a lateral canal is present in an area where there is an inflammation in the main canal, there will be an inflammation in the adjacent area of the lateral canal; and when a lateral canal is present in an area where there is necrosis in the main canal, there will be necrotic tissue in the adjacent part of the lateral canal[26]. This will be followed by a transition zone of necrosis/neutrophilic leucocytes, and then vital and inflamed tissue connected to a periodontal lesion. In other words, during disintegration of the main canal pulp the tissue in the lateral canals and in the apical ramifications remains vital as far as the tissue in the main canal, but is partially necrotic when necrosis reaches the level of the pulpal entrance of lateral canals and apical ramifications. The inflammatory reaction of the tissue contained in the lateral canal will become weaker closer to the periodontal ligament. Circulation from the periodontal ligament is mainly responsible for the maintenance of this tissue vitality. The explanation for lateral lesion formation in the presence of an inflamed but vital pulp tissue is the same as for periapical lesion formation. The accumulated disintegration products of the coronal pulp, bacterial disintegration products and their toxins are transferred through functioning veins and diffuse into the periodontal tissue. The subsequent evolution of this situation will depend on time; necrosis may finally reach the periodontal ligament. Practical consequences resulting from these observations are the following: it is impossible to instrument lateral canals and apical ramifications. Material which radiographically appears in the lateral canals are forced into the tissue. When lateral canals appear `filled', it is evidence that a sufficient amount of sealer has been pushed into them to make them appear radiodense[25].

In summary, the root canal should be prepared and obturated to a point as close to the apical foramen as possible yet still within sound tooth structure. The objective of determining the WL is to enable the root canal to be prepared as close to the apical constriction as possible.

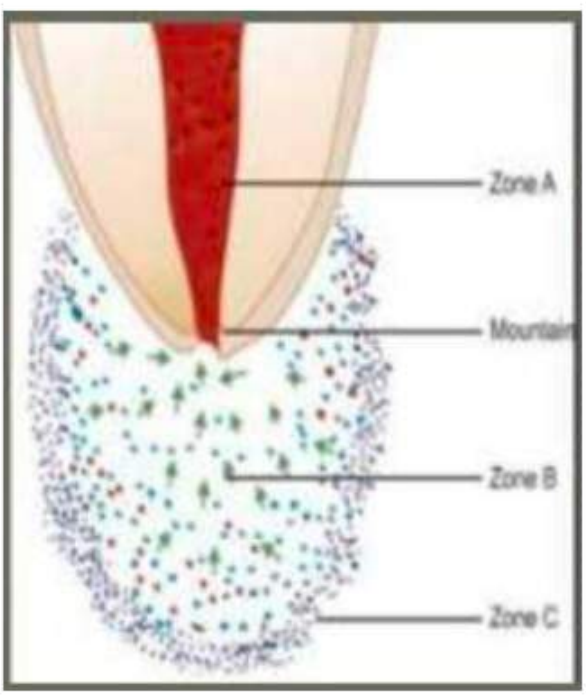
CONTROVERSIES IN CLEANING AND SHAPING

Location of micro-organisms

It is in the expanding phase that micro-organisms may invade the periapical tissue compartment. However, once the lesion has entered a more established form, it is believed that bacteria are eliminated from the soft tissue lesion.

Careful microscopic examinations have failed to identify micro-organisms in inflammatory periapical lesions associated with necrotic pulps in more than occasional instances (Nair, 1987).

Kronfield explained that the granuloma does not provide a favorable environment for the survival of the bacteria. He employed the FISH concept so as to explain the tissue reaction in and around the granulomatous area.



Numerous publications have reported the presence of micro-organisms in seemingly quiescent periapical inflammatory tissue lesions (Sundqvist and Reuterwing, 1980), and these findings question the validity of the concept of the sterile apical granuloma. Studies have confirmed that during the development of these lesions, several

microorganisms, normally residents of the infected pulp space, will be found in the abscessed tissue (van Winkelhoff et al, 1985).

Immunohistochemical markers have provided good evidence for the presence of both Actinomyces israelii and Proprionibacterium propionicum in confirmed well-organized but treatment-resistant periapical tissue lesions (Sundqvist and Reuterwing, 1980; Borssén and Sundqvist, 1981)

Although the debate has been heated at times, the concept of the sterile peri-radicular granuloma must still be regarded as valid

The main targets for treatment are the organism located within the confines of the root canal space, and one can conclude that rarely is there a need for systemic use of antimicrobials to remedy treatment failures[29].

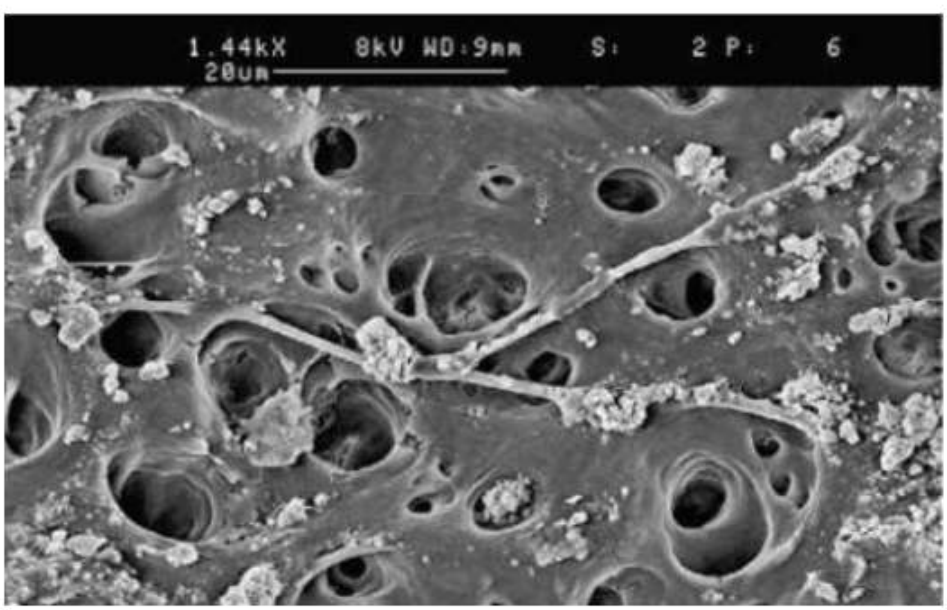
IRRIGATING SOLUTIONS

Sodium Hypochlorite

Sodium hypochlorite (NaOCl) is the most popular irrigating solution. NaOCl ionizes in water into Na1 and the hypochlorite ion, OCl, establishing an equilibrium with hypochlorous acid (HOCl). At acidic and neutral pH, chlorine exists predominantly as HOCl, whereas at high pH of 9 and above, OCl predominates.Hypochlorous acid is responsible for the antibacterial activity; the OCl ion is less effective than the undissolved HOCl. Hypochloric acid disrupts several vital functions of the microbial cell, resulting in cell death.NaOCl is commonly used in concentrations between 0.5% and 6%. It is a potent antimicrobial agent, killing most bacteria instantly on direct contact. It also effectively dissolves pulpal remnants and collagen, the main organic components of dentin. Hypochlorite is the only root-canal irrigant of those in general use that dissolves necrotic and vital organic tissue. It is difficult to imagine successful irrigation of the root canal without hypochlorite. Although hypochlorite alone does not remove the smear layer, it affects the organic part of the smear layer, making its complete removal possible by subsequent irrigation with EDTA or citric acid (CA). It is used as an unbuffered solution at pH 11 in the various concentrations mentioned earlier, or buffered with bicarbonate buffer (pH 9.0), usually as a 0.5% (Dakin solution) or 1% solution. However, buffering does not seem to have any major effect on the properties of NaOCl, contrary to earlier belief [30,31].

There is considerable variation in the literature regarding the antibacterial effect of NaOCl. In some articles hypochlorite is reported to kill the target microorganisms in seconds, even at low concentrations, although other reports have published considerably longer times for the killing of the same species. Haapasalo and colleagues showed that the presence of dentin caused marked delays in the killing of Enterococcus faecalis by 1% NaOCl. Many of the earlier studies were performed in the presence of an unknown amount of organic matter (eg, nutrient broth) or without controlling the pH of the culture, both of which affect the result. When the confounding factors are eliminated, it has been shown that NaOCl kills the target microorganisms rapidly even at low concentrations of less than 0.1%.

However, in vivo the presence of organic matter (inflammatory exudate, tissue remnants, microbial biomass) consumes NaOCl and weakens its effect. Therefore, continuous irrigation and time are important factors for the effectiveness of hypochlorite. Bystro¨ m and Sundqvist studied the irrigation of root canals that were necrotic and contained a mixture of anaerobic bacteria[32].



These investigators showed that using Desired functions of irrigating solutions Washing action (helps remove debris) Reduce instrument friction during preparation (lubricant) Facilitate dentin removal (lubricant) ,Dissolve inorganic tissue (dentin)

Penetrate to canal periphery Dissolve organic matter (dentin collagen, pulp tissue, biofilm) Kill bacteria and yeasts (also in biofilm) Do not irritate or damage vital periapical tissue, no caustic or cytotoxic effects Do not weaken tooth structure Irrigation in Endodontics. 0.5% or 5% NaOCl, with or without EDTA for irrigation, resulted in considerable reduction of bacterial counts in the canal when compared with irrigation with saline. However, it was difficult to render the canals completely free from bacteria, even after repeated sessions. Siqueira and colleagues reported similar results using root canals infected with E faecalis. Both studies failed to show a significant difference in the antibacterial efficacy between the low and high concentrations of NaOCl. Contrary to these results, Clegg and colleagues,in an ex vivo biofilm study, demonstrated a strong difference in the effectiveness against biofilm bacteria by 6% and 3% NaOCl, the higher concentration being more effective[29].

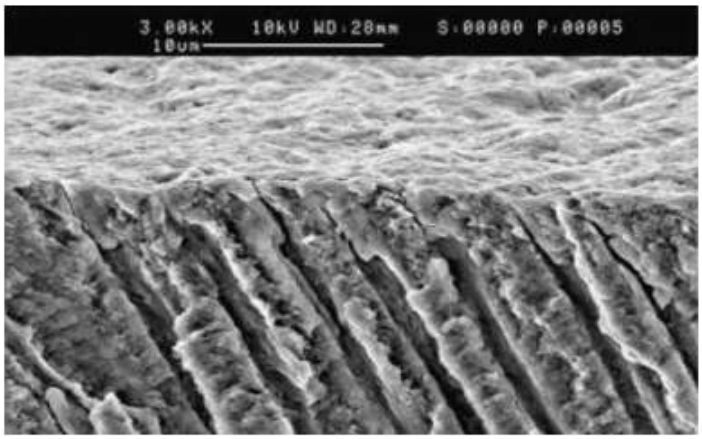
The weaknesses of NaOCl include the unpleasant taste, toxicity, and its inability to remove the smear layer by itself, as it dissolves only organic material. The limited antimicrobial effectiveness of NaOCl in vivo is also disappointing. The poorer in vivo performance compared with in vitro is probably caused by problems in penetration to the most peripheral parts of the root-canal system such as fins, anastomoses, apical canal, lateral canals, and dentin canals. Also, the presence of inactivating substances such as exudate from the periapical area, pulp tissue, dentin collagen, and microbial biomass counteract the effectiveness of NaOCl. Recently, it has been shown by in vitro studies that long-term exposure of dentin to a high concentration sodium hypochlorite can have a detrimental effect on dentin elasticity and flexural strength. Although there are no clinical data on this phenomenon, it raises the question of whether hypochlorite in some situations may increase the risk of vertical root fracture. Bystroem and Sundqvist studied root canals naturally infected, mainly with a mixture of anaerobic bacteria, and showed that although 0.5% NaOCl, with or without EDTA, improved the antibacterial efficiency of preparations compared with saline irrigation, all canals were not bacteria free even after several appointments. No significant difference in antibacterial efficiency in vivo between 0.5 and 5% NaOCl solutions was found in the study. Siqueira et al. using E. faecalis-infected root canals demonstrated the superior antibacterial affect against root canal bacteria of

hypochlorite in comparison with physiological saline. However, no difference was detected between 1, 2.5, and 5% NaOCl solutions[32].

In summary, sodium hypochlorite is the most important irrigating solution and the only one capable of dissolving organic tissue, including biofilm and the organic part of the smear layer. It should be used throughout the instrumentation phase. Hence there is no gold standard of concentration of NaOCl used in irrigation of root canals.

EDTA

Complete cleaning of the root-canal system requires the use of irrigants that dissolve organic and inorganic material. As hypochlorite is active only against the former, other substances must be used to complete the removal of the smear layer and dentin debris. EDTA and CA effectively dissolve inorganic material, including hydroxyapatite. They have little or no effect on organic tissue and alone they do not have antibacterial activity, despite some conflicting reports on EDTA. EDTA is most commonly used as a 17% neutralized solution (disodium EDTA, pH 7), but a few reports have indicated that solutions with lower concentrations (eg, 10%, 5%, and even 1%) remove the smear layer equally well after NaOCl irrigation. Considering the high cost of EDTA, it may be worthwhile to consider using diluted EDTA. EDTA is used for 2 to 3 minutes at the end of instrumentation and after NaOCl irrigation. Removal of the smear layer by EDTA or CA improves the antibacterial effect of locally used disinfecting agents in deeper layers of dentin. EDTA is manufactured as liquids and gels. Although there are no comparative studies about the effectiveness of liquid and gel products to demineralize dentin, it is possible that the small volume of the root canal (only a few microliters) contributes to a rapid saturation of the chemical and thereby loss of effectiveness. In such situations, the use of liquid products and continuous irrigation should be recommended, the canal-wall dentin and should probably be avoided[33].

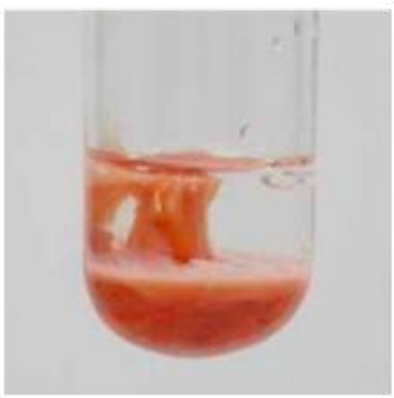


Chlorhexidine Digluconate

Chlorhexidine digluconate (CHX) is widely used in disinfection in dentistry because of its good antimicrobial activity. It has gained considerable popularity in endodontics as an undesired characteristics of sodium hypochlorite (ie, bad smell and strong irritation to periapical tissues). However, CHX has no tissue-dissolving capability and therefore it cannot replace sodium hypochlorite. CHX permeates the microbial cell wall or outer membrane and attacks the bacterial cytoplasmic or inner membrane or the yeast plasma membrane. In high concentrations, CHX causes coagulation of intracellular components. One of the reasons for the popularity of CHX is its substantivity (ie, continued antimicrobial effect), because CHX binds to hard tissue and remains antimicrobial. However, similar to other endodontic disinfecting agents, the activity of CHX depends on the pH and is also greatly reduced in the presence of organic matter[34].

Several studies have compared the antibacterial effect of NaOCl and 2% CHX against intracanal infection and have shown little or no difference between their antimicrobial effectiveness. Although bacteria may be killed by CHX, the biofilm and other organic debris are not removed by it. Residual organic tissue may have a negative effect on the quality of the seal by the permanent root filling, necessitating the use of NaOCl during instrumentation. However, CHX does not cause erosion of dentin like NaOCl does as the final rinse after EDTA, and therefore 2% CHX may be a good choice for maximized antibacterial effect at the end of the chemo-mechanical preparation. Most

of the research on the use of CHX in endodontics is carried out using in vitro and ex vivo models and gram-positive test organisms, mostly E faecalis. It is therefore possible that the studies have given an over-positive picture of the usefulness of CHX as an antimicrobial agent in endodontics. More research is needed to identify the optimal irrigation regimen for various types of endodontic treatments. CHX is marketed as a water-based solution and as a gel. Some studies have indicated that the CHX gel has a slightly better performance than the CHX liquid but the reasons for possible differences are not known[35].However, CHX and NaOCl are not soluble in each other; a brownish-orange precipitate is formed when they are mixed.



Interactions Between Irrigating Solutions Hypochlorite and EDTA are the 2 most commonly used irrigating solutions. As they have different characteristics and tasks, it has been tempting to use them as a mixture. However, EDTA instantaneously reduces the amount of chlorine when mixed with sodium hypochlorite, resulting in the loss of NaOCl activity. Thus, these solutions should not be mixed. CHX has no tissue dissolving activity and there have been efforts to combine CHX with hypochlorite for added benefits from the 2 solutions. The characteristics of the precipitate and the liquid phase have not been thoroughly examined, but the precipitate prevents the clinical use of the mixture. Atomic absorption spectrophotometry has indicated that the precipitate contains iron, which may be the reason for the orange development. Presence of parachloroaniline, which may have mutagenic potential, has also been demonstrated in the precipitate. Mixing CHX and EDTA immediately produces a white precipitate[36].

Although the properties of the mixture and the cleared supernatant have not been thoroughly studied, it seems that the ability of EDTA to remove the smear layer is reduced. Many clinicians mix NaOCl with hydrogen peroxide for root-canal irrigation. Despite more vigorous bubbling, the effectiveness of the mixture has not been shown to be better than that of NaOCl alone. However, combining hydrogen peroxide with CHX in an ex vivo model resulted in a considerable increase in the antibacterial activity of the mixture compared with the components alone in an infected dentin block. However, there are no data concerning the use or effectiveness of the mixture in clinical use[32].

Bio Pure MTAD

Bio Pure (Dentsply, Tulsa Dental, Tulsa, OK, USA) otherwise known as MTAD, is a relatively new root canal irrigant which was introduced by Torabinejad et aL in 2003. This solution is a mixture of 3% doxycycline, 4.25% citric acid and a detergent (0.5% Polysorbate Several studoes have evaluated the effectiveness of MTAD for disinfection of root canals. Torabinejad et ul. have shown that MTAD is able to remove the smear layerǁ‘ and is effective against E. faecalis. Shabahang et al showed that a combination of 1.3% NaOCl as a root canal irrigant and MTAD as a final rinse was more effective than 5.25% NaOCl in disinfecting root canals. However, Tay et aL‘ found that when MTAD is applied to 1.3% NaOC1-irrigated dentine, its antimicrobial substantivity is reduced. They attributed this phenomenon to the

oxidation of MTAD by NaOCl in a manner similar to the peroxidation of tetracycline by reactive oxygen species. In another study, MTAD was significantly very effective against E. faecalis. Baumgartner showed that the infected root canal system was consistently disinfected when a combination of 5.25% NaOC1/15% EDTA was used[37] .However, the combination of 1.3% NaOCl/BioPure MTAD left nearly 50% of the canals contaminated with E.faecalis. Krause et aL revealed that, in the agar diffusion model, NaOCl produced less dilution of bacteria than MTAD or doxycycline. Ghoddusi et al evaluated the effect of MTAD as a final irrigant on bacterial leakage of the root canal, and its interaction with two conventional root canal sealers (AH-Plus or Rickert). According to their findings, it took longer for bacteria to penetrate when either EDTA or MTAD was used for smear layer removal. Furthermore, the root canals obturated with AH-Plus showed significantly longer duration of resistance to bacterial penetration than canals obturated with rickert. Davis et al showed that, using the agar diffusion method, BioPure MTAD produced significantly more zones of microbial inhibition than 5.25% NaOCl, 2% CHX, and Dermacyn (Oculus Innovative Sciences, Petaluma, CA). Newberry et al determined in vitro the antimicrobial effect of MTAD as a final irrigant on eight strains of E. faecalis and to measure the minimum inhibitory concentration (MIC) and the minimum lethal concentration (MLC) of MTAD. After irrigating with 1.3% NaOC1, the root canal and the external surfaces were exposed to MTAD for 5 minutes. The results showed that this treatment regiment was effective in completely heating the growth in seven of eight strains of E.faecalis. The MIC/MLC tests showed that MTAD inhibited most strains of E.faecalis growth when diluted 1:8192 times and killed most strains of E. faecalis when diluted 1:512 times. Recently, Shahnbag et al showed that although the addition of chlorhexidine did not negatively impact on the efficacy of MTAD, the substitution of this antimicrobial agent for doxycycline significantly reduced the efficacy of the solution[38].

Tetra clean

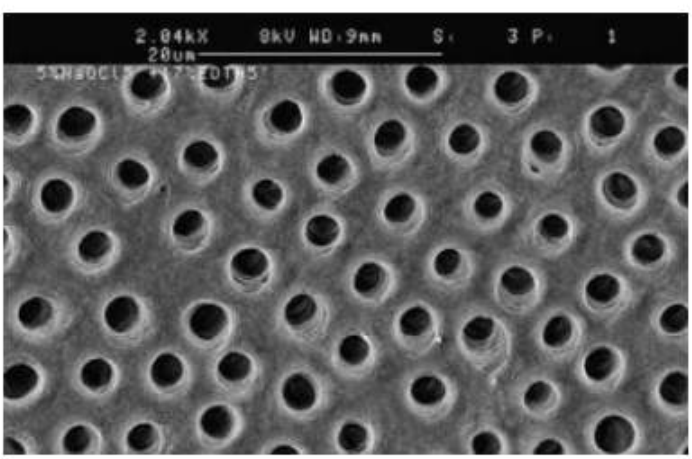
Tetraclean, like MTAD, is a mixture of an antibiotic, an acid and a detergent. However, the concentration of antibiotic (50mg/ml doxycycline) and the type of detergent (polypropylene glycol) are different from those of MTAD. Giardino et al compared the surface tension of EDTA 17%, Cetrexidin, Smear Clear, Sodium hypochlorite 5.25%, with the surface tension of MTAD and Tetraclean. Their

findings demonstrated that sodium hypochlorite 5.25%, and EDTA 17% had the highest surface tension, whereas those of Cetrexidin and Tetraclean have shown the lowest surface tension values. In another study, they compared the antimicrobial efficacy of 5.25% NaOC1, BioPure MTAD, and Tetraclean against E. faecalis biofilm generated on cellulose nitrate membrane filters. Results showed that only 5.25% NaOCl could disintegrate and remove the biofilm at every time; however, treatment with Tetraclean caused a high degree of biofilm disintegration in every considered time intervals as compared with MTAD[38].

CHALLENGES OF IRRIGATION

Smear Layer

Removal of the smear layer is straight forward and predictable when the correct irrigants are used. Relying on EDTA alone or other irrigants with activity against the inorganic matter only, however, results in incomplete removal of the layer. Therefore, use of hypochlorite during instrumentation cannot be omitted.

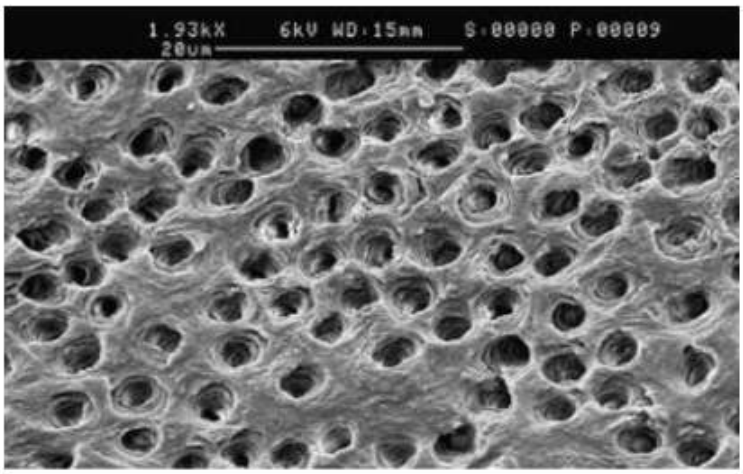


The smear layer is created only on areas touched by the instruments. Delivery of irrigants to these areas is usually unproblematic, with the possible exception of the most apical canal, depending on canal morphology and the techniques/equipment used for irrigation. However, careless irrigation, with needles introduced only to the coronal and middle parts of the root canal, is likely to result in incomplete removal of the smear layer in the apical root canal[32].

Dentin Erosion

One of the goals of endodontic treatment is to protect the tooth structure so that the physical procedures and chemical treatments do not cause weakening of the dentin/ root. Erosion of dentin has not been studied much; however, there is a general consensus that dentin erosion may be harmful and should be avoided. A few studies have shown that long-term exposure to high concentrations of hypochlorite can lead to considerable reduction in the flexural strength and elastic modus of dentin. These studies have been performed in vitro using dentin blocks, which may allow artificially deep penetration of hypochlorite into dentin. However, even short-term irrigation with hypochlorite after EDTA at the end of chemo-mechanical preparation causes strong erosion of the canal-wall surface dentin and maximum time duration is 1-2 minutes.

Although it is not known for sure whether surface erosion is a negative issue or if, for example, it could improve dentin bonding for posts, it is the authors‘ opinion that hypochlorite irrigation after demineralization agents should be avoided. Instead, chlorhexidine irrigation could be used for additional disinfection at the end of the treatment[32].



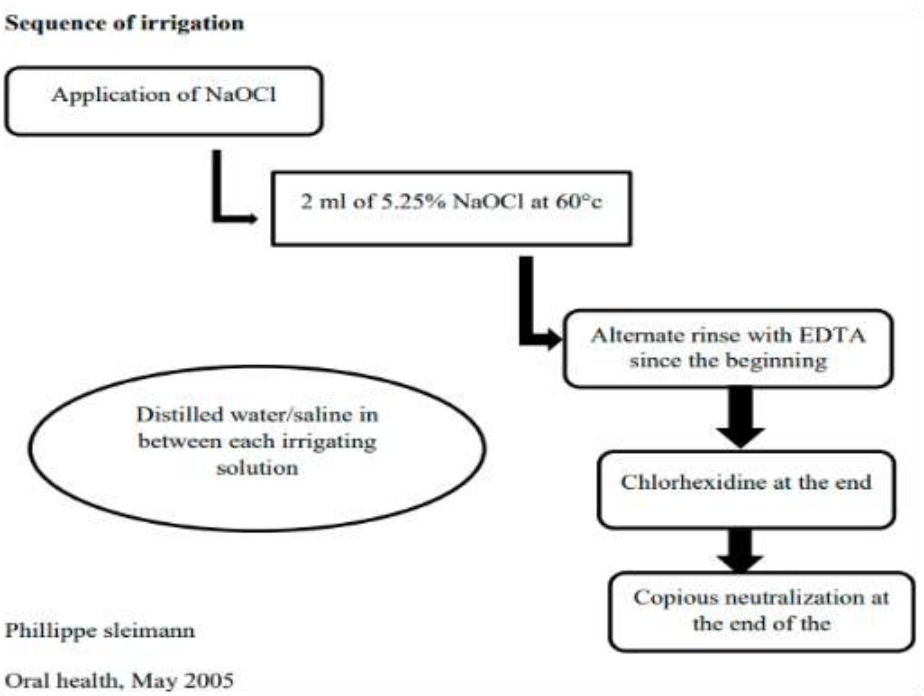
Cleaning of Un-instrumented Parts of the Root-canal System

Irrigation is most feasible in the instrumented areas because the irrigation needle can follow the smooth path created by the instruments. Cleaning and removing of necrotic tissue, debris, and biofilms from untouched areas rely completely on chemical means,

and sufficient use of sodium hypochlorite is the key factor in obtaining the desired results in these areas. A recent study showed that untouched areas, in particular anastomoses between canals, are frequently packed with debris during instrumentation. Visibility in micro-CT scans indicates that the debris also contain a considerable proportion of inorganic material. Although at present it is not known how these debris can best be removed (if at all), it is likely that physical agitation (eg, ultrasound) and the use of demineralizing agents are needed in addition to hypochlorite[39].

Safety versus Effectiveness in the Apical Root Canal

Irrigation must maintain a balance between 2 important goals: safety and effectiveness. This point is particularly true with the most important irrigant, sodium hypochlorite, but other irrigants can also cause pain and other problems if they gain access to the periapical tissues. Effectiveness is often jeopardized in the apical root canal by restricting anatomy and valid safety concerns. However, the eradication of the microbes in the apical canal should be of key importance to the success of endodontic treatment. Sufficient exchange of hypochlorite and other irrigants in this area while keeping the apical pressure of the solutions minimal is the obvious goal of irrigation of the apical root canal. A better understanding of fluid dynamics and the development of new needle designs and equipment for irrigant delivery are the 2 important areas to deal with in the challenges of irrigating the most apical part of the canal[32]



Agitation devices

New agitation devices that rely on various mechanisms of irrigant transfer like the EndoVac system, EndoActivator, sonic agitation etc appear to have resulted in improved canal cleanliness when compared with conventional syringe needle irrigation.

Despite the plethora of in vitro studies, no well-controlled study is available. In addition, no evidence-based study is available to date that attempts to correlate the clinical efficacy of these devices with improved treatment outcomes.

Thus, the question of whether these devices are really necessary remains unresolved[32].

Lasers in irrigation

60

In vitro studies have shown that both CO2 and Xr:YAG lasers possess potent antimicrobial activity, however comparative studies in simulated infected root canals have shown that the effect is either equal to, or weaker than the action of NaOCl irrigation. Hence, it still is a controversy if lasers are an effective way to clean the root canal and more evidence is required[32].

CONTROVERSIES IN INTRACANAL MEDICAMENTS

Calcium Hydroxide

The development and progression of an endodontically induced apical periodontitis are clearly associated with the presence of microorganisms in the root canal system[40]. Thus, conventional root canal treatment aims primarily at eliminating these bacteria as completely as possible. The root canal was cleaned and shaped, ideally to the apical constriction[41] under sufficient irrigation with a potent solution, e.g. sodium hypochlorite. In addition, an interappointment antimicrobial dressing was generally advocated to prevent recovery and multiplication of microorganisms remaining even after careful instrumentation and debridement of the root canal space[42] a popular medicament is calcium hydroxide. Clinically, microbiological samples from initially infected root canals substantiated the potential of calcium hydroxide to eliminate or reduce the total number of cultivable bacteria in the root canal system when the medicament was placed in the root canal for at least one week[43].

Due to the inaccuracy of the sampling method itself, however, there is a risk of obtaining false negative bacterial samples. Thus, it can be speculated that in some teeth periapical healing occurred even when bacteria were left in inaccessible areas of the root canal system, e.g. in the dentinal tubules, following complete instrumentation and placement of an antimicrobial medicament. This may be one reason for the recent controversy about the necessity of an antimicrobial intracanal dressing[42]. It has been reported that calcium hydroxide has the potential to kill bacteria left in inaccessible areas of the root canal system and therefore favours the healing process of periapical lesions[42]. Others have recommended for practical reasons that endodontic treatment should be completed in a single visit (one-visit treatment) without any intracanal dressing[44].

It is argued that bacteria surviving in the root canal system after root canal preparation are entombed by obturating the root canal and perish as a result of lack of substrate[44]. These microorganisms may no longer interfere with the periapical healing process. Likewise, some root canal sealers and gutta-percha cones elicit in vitro an antibacterial activity that may contribute to the elimination of intracanal microorganisms[45]. The present prospective clinical study was initiated to explore the influence of calcium hydroxide applied as an interappointment intracanal dressing on

the healing process of periapical lesions associated with pulpless teeth. For this purpose the prognosis after a two-visit root canal treatment was compared with that following a one-visit treatment.

In conclusion, the promising prognosis of both treatment approaches substantiated the hypothesis that from a microbiological view one-visit root canal treatment with guttapercha cones and a calcium hydroxide-containing sealer created favourable environmental conditions for periapical healing. Thus, one visit root canal treatment is an alternative to two-visit treatment with calcium hydroxide as an interappointment dressing for pulpless teeth associated with endodontically induced lesions[46].

Antibacterial Activity

Calcium hydroxide exerts antibacterial effects in the root canal system as long as a high pH is maintained. An in vivo study showed that root canals treated with Ca(OH)2 had fewer bacteria than did those dressed with camphorated phenol or camphorated mono chlorophenol. Another study reported Ca(OH)2 to be effective in preventing the growth of microorganisms but to a limited extent when compared to camphorated chlorophenol, stressing the necessity of direct contact to achieve the optimum antibacterial effect. It was shown that a 7-day application of a Ca(OH)2 medicament was sufficient to reduce canal bacteria to a level that gave a negative culture. It has also been shown that an aqueous Ca(OH)2 paste and a silicone oil-based Ca(OH)2 paste are effective in the elimination of Enterococcus faecalis in dentinal tubules. Estrela et al demonstrated that both the direct exposure test and the agar diffusion test are useful in establishing the antimicrobial spectrum of Ca(OH)2 and in developing improved infection control protocols. A complete antimicrobial effect was observed after 48 h with both tests, irrespective of the Ca(OH)2 paste vehicle. Another study showed that Ca(OH)2 decreased the numbers of E. faecalis at all depths within dentinal tubules up to 24 h and that less viscous preparations of Ca(OH)2 were more effective in the elimination of E. faecalis from dentinal tubules than were viscous preparations. In a study to evaluate the effect of electrophoretically activated Ca(OH)2 on bacterial viability in dentinal tubules, Lin et al. reported that treatment with electrophoresis was significantly more effective than pure Ca(OH)2 up to depths of 200 to 500 µm. Specimens treated with electrophoretically activated Ca(OH)2 revealed no viable bacteria in dentinal tubules to a depth of 500µm from the

root canal space within 7 days. E. faecalis cells in the exponential growth phase have been shown to be the most sensitive to Ca(OH)2 and are killed within 3s to 10mins.

By contrast, several studies have attested to the ineffectiveness of Ca(OH)2 in eliminating bacterial cells. Two studies revealed that Ca(OH)2 had no antibacterial effect as a paste or as the commercial preparation Pulpdent when used against Streptococcus sanguis. It was also shown that a Ca(OH)2 paste (Calasept; Speiko, Darmstadt, Germany) failed to eliminate, even superficially, E. faecalis in dentinal tubules.21 Safavi et al. indicated that E. faecium remained viable in dentinal tubules after relatively extended periods of Ca(OH)2 /saline mixture treatment. Another study demonstrated that Ca(OH)2 could take up to 10 days to disinfect dentinal tubules infected by facultative bacteria[41].

Siqueira demonstrated that, after 1 week of contact, Ca(OH)2 mixed with saline was ineffective in eliminating E. faecalis and E. faecium inside dentinal tubules. Estrela et al. found that Ca(OH)2 in infected dentinal tubules had no antimicrobial effect on S. faecalis, S. aureus, Bacillus subtilis, Pseudomonas aeruginosa, or on the bacterial mixture used throughout the experiment. It has been revealed that the viability of E. faecalis in infected root dentine was not affected by Ca(OH)2 . In a systematic review to assess the antibacterial efficacy of Ca(OH)2 , Sathorn et al. showed that Ca(OH)2 had limited effectiveness in eliminating bacteria from human root canal when assessed by culture techniques. In a polymerase chain reaction (PCR) study to evaluate the effect of root canal filling with or without prior Ca(OH)2 or 2% chlorhexidine (CHX) on the persistence of bacterial DNA in infected dentinal tubules, Cook et al. showed that 2% CHX treatment followed by canal filling was more effective in removing the DNA of E. faecalis than placement of Ca(OH)2 or immediate canal filling. Furthermore, in failed root canal treatments, a 2% CHX gel was a more effective intracanal medicament than Ca(OH)2 paste against E. faecalis. Krithika datta et al indicated that 2% CHX gel alone was more effective against E. faecalis than was Ca(OH)2 . Another study found that a polymeric chlorhexidine-controlled release device was significantly more effective in reducing intra-dentinal bacteria than was Ca(OH)2.

Combination Of Ca(OH)2 And Chlorhexidine

Chlorhexidine (CHX) is a cationic biguanide whose optimal antimicrobial activity is achieved within a pH range of 5.5 to 7.0. Therefore, it is likely that alkalinizing the pH by adding Ca(OH)2 to CHX will lead to precipitation of CHX molecules, thereby decreasing its effectiveness. It has been demonstrated that the alkalinity of Ca(OH)2 when mixed with CHX remains unchanged. Therefore, the usefulness of mixing Ca(OH)2 with CHX remains unclear and controversial. When used as an intracanal medicament, CHX was more effective than Ca(OH)2 in eliminating E. faecalis from inside dentinal tubules. One report revealed that all of the chlorhexidine formulations studied, including a CHX/ Ca(OH)2 50:50 mix, were effective in eliminating E. faecalis from dentinal tubules, with a 1% CHX gel working better than the other preparations. These findings were corroborated by two other studies in bovine dentine and and human dentine.

Haenni et al. found no additive antibacterial effect by mixing Ca(OH)2 powder with 0.5% CHX. They indicated that CHX had a reduced antibacterial action. However, Ca(OH)2 did not lose its antibacterial properties in such a mixture. An in vitro study showed that 2% CHX gel was the most effective agent against E. faecalis inside dentinal tubules, followed by a Ca(OH)2 /2% CHX mixture, whereas Ca(OH)2 alone was totally ineffective, even after 30 days. The 2% CHX gel was also significantly more effective than the Ca(OH)2 /2% CHX mixture against C. albicans at 7 days, although there was no significant difference at 15 and 30 days. Ca(OH)2 alone was completely ineffective against C. albicans. In an in vivo study using primary teeth, Onçag et al. showed that a 1% CHX-gluconate gel, both with and without Ca(OH)2 , was more effective against E. faecalis than Ca(OH)2 alone over a 48-hour period.

Another study showed that that 2% CHX-gluconate was significantly more effective against E. faecalis than Ca(OH)2 used alone or a mixture of the two. Although this was also confirmed by Lin et al., a study by Evans et al. using bovine dentine concluded that 2% CHX with Ca(OH)2 was more effective than Ca(OH)2 in water. An animal study demonstrated that teeth dressed with CHX for 4 weeks had reduced inflammatory reactions in the periodontium (both apically and marginally) and less root resorption. Waltimo et al. reported that 0.5% CHX-acetate was more effective at

killing C. albicans than was saturated Ca(OH)2, whereas Ca(OH)2 combined with CHX was more effective than Ca(OH)2 used alone[47].

Ledermix

Ledermix is a glucocorticosteroid-antibiotic compound. Ledermix paste was developed by Schroeder and Triadan in 1960, and was released for sale in Europe by Lederle Pharmaceuticals in 1962. The primary interest of Schroeder and Triadan in development of Ledermix paste was based on the use of corticosteroid to control pain and inflammation. The sole reason for adding the antibiotic component to Ledermix was to compensate for what was perceived to be a possible corticoid-induced reduction in the host immune response. The two therapeutic components of Ledermix (i.e., triamcinolone and demeclocycline) are capable of diffusing through dentinal tubules and cementum to reach the periodontal and periapical tissues. Abbott et al showed that dentinal tubules were the major supply route of the active components to the peri-radcular tissues, while the apical foramen was not as significant as a supply route[48]. Various factors can affect the supply of the active components to the periradicular tissues-these include the presence or absence of the smear layer, the presence or absence of cementum, and the presence of other materials within the canal, for example, calcium hydroxide.

Bryson et a1 showed that the Ledermix Paste treated roots had statistically significantly more healing and less resorption than the roots treated with Ca(OH)2. Root filing with Ledermix Paste also resulted in significantly less loss in root mass due to resorption compared to those roots filled with Ca(OH)2. Chen et a1. found that corticosteroid and tetracycline, as anti-inflammatory and anti-resorptive agents, shut down or minimised the inflammatory reaction including clastic-cells mediated resorption, thus promoted more favourable healing than the positive control group which had no intracanal medicaments. Furthermore, they forecasted that in severe traumatic injuries, where a large surface area of periodontal inflammation is expected, removing the pulp and placing corticosteroids into the canal at the emergency visit would become a standard protocol. Trope found no significant difference in the flareup rate among the three intracanal medicaments (Formocresol, Ledermix, and calcium hydroxide). Ehrmann et al found that painful teeth with acute apical periodontitis that had been dressed with Ledermix paste gave rise to less pain than

that experienced by patients who had a dressing of calcium hydroxide or no dressing at all[49].

Kim et al. investigated the effects of Ledermix paste as an intracanal medcament on discolouration of mature teeth. Results demonstrated that after 12 weeks, sunlight exposure had caused dark grey-brown staining of the teeth in the Ledermix groups, but this did not occur when the teeth were kept in the dark. More severe staining was noted when Ledermix paste filled the pulp chamber than when the paste was restricted to below the CEJ. They suggested that if placement of the Ledermix restricted to below the gingival margin, such effects could be minimised. In another study, they investigated the effects of Ledermix paste as an intracanal medicament on discolouration of immature teeth. After 12 weeks, sunlight exposure had caused dark grey-brown staining in the Ledermix groups but this did not occur when the teeth were kept in the dark. More severe staining was noted when Ledermix paste filled the pulp chamber than when the paste was restricted to below the CEJ and when teeth were exposed to sunlight. When compared to the results of a similar study using mature teeth, the results were similar but the immature teeth were more severely stained than the mature teeth. The Ca(OH)2, paste caused an increase in lightness and yellowness in immature teeth[50].

Triple Antibiotic Paste

The infection of the root canal system is considered to be a polymicrobial infection, consisting of both aerobic and anaerobic bacterial. Because of the complexity of the root canal infection, it is unlikely that any single antibiotic could result in effective sterilisation of the canal. More likely a combination would be needed to address the diverse flora encountered. A combination of antibiotics would also decrease the likelihood of the development of resistant bacterial strains. The combination that appears to be most promising consists of metronidazole, ciprofloxacin, and minocycline. Sato et al showed that no bacteria were recovered from the infected dentine of the root canal wall 24h after application of the triple antibiotic paste, except in one case in which a few bacteria were recovered. Hoshino et al investigated the antibacterial effect of a mixture of ciprofloxacin, metronidazole and minocycline, with and without the addition of rifampicin, on bacteria taken from infected dentine of root canal walls.

They found that alone, none of the drugs resulted in complete elimination of bacteria. However, in combination, these drugs were able to consistently sterilize all samples. Iwaya et al reported a necrotic immature mandibular second premolar with periapical involvement and sinus tract. Instead of the standard root canal treatment protocol and apexification, antimicrobial agents (metronidazole and ciprofloxacin) were used in the canal, after which the canal was left empty. Radiographic examination showed the start of apical closure five months after the completion of the antimicrobial protocol. Thickening of the canal wall and complete apical closure was confirmed 30 months after the treatment, indicating the revascularization potential of a young permanent tooth pulp into a bacteria-free root canal space. Takushige et al evaluated the efficacy of poly-antibiotic paste consisted of ciprofloxacin, metronidazole and minocycline, on the clinical outcome of so-called _Lesion Sterilization and Tissue Repair (LSTR)' therapy in primary teeth with peri-radcular lesions. Results showed that in all cases, clinical symptoms such as gingival swelling, sinus tracts, induced dull pain, spontaneous dull pain, and pain on biting disappeared after treatment, although in four cases clinical signs and symptoms were finally resolved only after retreatment using the same procedures. Thus, gingival abscesses and fistulae, if present, disappeared after a few day[50]

CONTROVERSIES IN FORMOCRESOL

Formocresol has been used in dentistry since 100 years and for deciduous teeth pulpotomy since 80 years. The reparative, biologic approach to pediatrics pulp therapy is either devitalization approach of formocresol pulpotomy or pulpectomy. Formocresol was introduced to treat non-vital permanent teeth in the United States by Buckley in 1904 [51]. In 1930, Sweet introduced the formocresol pulpotomy technique. Formocresol has subsequently become a popular pulpotomy medicament for primary teeth. Initially, the technique involved five visits. Sweet reduced the number of visits over the years, because of economic and behaviour management considerations[51]. Doyle et al used a two-visit procedure in their comparison study of formocresol and calcium hydroxide. Within a few years, Spedding et al. and Redig reported the results of a 5-min formocresol protocol, and since that time, complete mummification has been abandoned by the profession[52,53,54] .

By 1960, a single visit procedure was advocated [55]. Studies have shown formocresol therapy to have a success rate between 70% and 90%. Histologic results have been variable in contrast to the high clinical success rate. Formocresol is still considered a gold standard by which all new modalities are compared[56].

Mechanism of action

Formocresol acts through the aldehyde group of formaldehyde, forming bonds with the side groups of the amino acids of both the bacterial proteins and those of the remaining pulp tissue. It is therefore both a bactericidal and devitalizing agent. It kills off and converts bacteria and pulp tissue into inert compounds.Its function is to fasten the live pulps, maintaining them inert and facilitating the conservation of deciduous tooth until their physiologic fall. It has a potent antibacterial action that justifies its use in long curative in endodontic treatment[57].

With formocresol as the pulptomy medicament, a zone of fixation usually is evident where the pulp is in direct contact with the medicament. Coagulation necrosis of the tissue occurs at the amputation site and is supported by the fact that true coagulation necrosis is produced by poisons such as phenol, formaldehyde or mercuric chloride, which denatures the protein of the cells[58]. It has also been shown that formocresol inactivates the oxidative enzymes in the pulp tissue adjacent to the amputation site. It

may also have some effect on hyaluronidase action. Therefore, the protein-binding properties and the inhibition of the enzymes that can break the pulp tissue down together result in 'fixation' of the pulp tissue by formocresol and render it inert and resistant to enzymatic breakdown[57]. Farther away, where the concentration of formocresol is decreased, there is a zone of poor cellular definition and necrosis. Apical to this is a zone of chronic inflammation, which blends into normal tissue[52]. In contrast, Berger reported complete loss of vitality with fibrous granulation tissue in the apical third of the root canal[59].

In a study to know the effect of formocresol on polymorphonuclear cells (PMNs), the lysis of PMNs was observed with high concentrations of formocresol. An interesting finding with low concentrations of formocresol was the significant stimulation of PMN adherence. The authors postulate that stimulation of PMNs by pulpotomy medicaments may contribute to the chronic inflammatory changes seen with their use. Initial stimulation followed by depressions is a well-known response of PMNs following activation by various stimuli. Same activation-deactivation phenomenon was observed clearly with formocresol[60].

Internal resorption may also result in teeth treated with formocresol might be due to the severe damage to the residual tissue, also destroying its capacity to reabsorb. This may be attributed to inflammation of the residual pulp. On the other hand, pulpotomy treatment with formocresol in monkeys has been associated with the formation of reparative dentin. Human studies have not reported the finding of reparative dentin in association with the formocresol pulpotomy. This might be possibly due to the production of reparative dentine on light stimulation like any type of trauma, including formocresol of the pulpal tissue of monkeys[61].

Pharmacokinetics of formaldehyde

Formaldehyde exposure occurs daily as it is present in air, water and food. The World Health Organization (WHO) has estimated daily consumption of formaldehyde to be approximately 1.5-14 mg/day (mean, 7.8 mg/day) [62] . Assuming a contribution of 9.4 mg/day from food, 1 mg/day from inhalation and 0.15 mg/day from water, an adult takes in 10.55 mg of formaldehyde per day [63]. The estimated formaldehyde dose associated with 1 pulpotomy procedure, assuming a 1:5 dilution of formocresol placed on a no. 4 cotton pellet that has been squeezed dry, is approximately 0.02-0.10

mg. Hileman has shown that endogenous levels of metabolically produced formaldehyde range from approximately 3-12 ng/g tissue. This formaldehyde is produced by amino acid metabolism, oxidative demethylation, and purine and pyrimidine metabolism. Exogenous formaldehyde is taken up into the human body via ingestion, inhalation and dermal exposure. Inhaled formaldehyde appears to be readily absorbed by the upper respiratory tract, but it is not distributed throughout the body because it is rapidly metabolized. Ingested formaldehyde is readily absorbed by the gastrointestinal tract and exhibits little subacute toxicity after oral exposure. Exogenous formaldehyde has a biologic half-life of 1-1.5 minutes and is quickly cleared from human plasma[65].

Histological studies demonstrate the true biological damage after formocresol treatment. Physiologically, with the vascular damage, the balance between osmotic pressure and hydrostatic pressure is disrupted in tissue. As a result, there is absorption of inflammatory fluid insult by pulp tissue and decrease in the osmotic pressure. So hemostatic balance is re-established. When this occurs, the constricted pulp cavity must dissipate the pressure changes. If this does not occur, pressure necrosis of the pulp occurs. In addition, lymphatic and venous vascular flow from the coronal pulp must dissipate this excess inflammatory fluid. This excess is distributed apically and to regional vascular vessels. Therefore, the local insult results in systemic distribution [66].

Pharmacokinetics of cresol

The second active ingredient in formocresol, cresol, has received little attention in investigations of formocresol efficacy. Cresol has poor solubility, so it is assumed that it does not enter systemic circulation. Cresol is highly lipophilic and has been shown to completely destroy cellular integrity. This would allow deeper tissue fixation by the formaldehyde component of formocresol. No data exist regarding cresol metabolism or elimination in humans or other mammals, and about environmental sources of cresol to which humans might be exposed. Benzyl alcohol is a by-product of tricresol oxidation.

Benzyl alcohol is oxidized rapidly to benzoic acid, conjugated with glycine in the liver, and excreted as hippuric acid. It has no carcinogenic or mutagenic potential, and the allowable daily intake, as established by WHO is 5 mg/kg [67].

Concerns about formocresol

Concerns about the safety of formocresol have been appearing in the dental and medical literature for more than 20 years. Formaldehyde, a primary component in formocresol, is a hazardous substance. National Institute for Occupational Safety and Health in USA states if formaldehyde exposure occurs at a concentration of 20 ppb (parts per billion) or higher, it is instantly dangerous to health and life.

Studies on formocresol therapy have put the clinical success rate between 70% and 90%. But variable histologic results were also reported in contrast to the clinical success rate. Instead of preserving vital pulpal tissue, chronic inflammation and necrotic tissue were found. Another problem with formocresol is its systemic distribution from the pulpotomy site. Pruhs et al. found a relationship between primary teeth treated with formocresol and enamel defects in the permanent successors. The allergenic and mutagenic properties of formaldehyde have been demonstrated in animal models, but not in humans. Cysts have also been found to be associated with the pulpotomized teeth[68]

Mutagenicity, genotoxicity and cytotoxicity

Exposure of cells to formaldehyde leads to the formation of DPX (DNA-protein cross-links). The most common types of DNA damage induced by formaldehyde are clastogenic lesions, including sister chromatid exchanges (SCEs), micronuclei and chromosomal aberrations, and deletions. It has been proposed that formaldehyde could induce the development of DPX at distant sites, but no convincing evidence has been obtained from in vivo experimental studies.

The recent research by Heck and Casanova showed the development of DPX in nasal tissues and upper respiratory tract associated with high dose exposure of formaldhehyde. DPX does not persist in tissues for more than few hours and undergoes spontaneous hydrolysis or active repair by proteolytic degradation of crosslinked proteins. So role of DPX in formaldehyde-induced carcinogenesis is again questionable [69].

Cytogenetic studies of lymphocytes from rodents following formaldehyde inhalation with exposures ranging from 0.5-1.5 ppm for 6 h/day for 5 days failed to detect either chromosomal aberrations or SCEs at any of the formaldehyde concentrations In vitro

experiments with a Chinese hamster cell line found that DPX and SCE, as a result of formaldehyde exposure, were associated with cytotoxicity, not mutation. In addition, no mutagenesis occurred in cultured human lymphocytes below a formaldehyde threshold of 5 µg/mL in the culture medium.

In one of the dental studies that do not support formaldehyde is a mutagenic, Zarzar et al. performed formocresol pulpotomy on 20 children by using Buckley's original formula. Blood samples were collected from each child immediately before and 24 hours after the pulpotomy. No statistically significant differences were found between the two groups in terms of chromosomal aberrations, chromatid breaks or chromatid gaps. Also, Zarzar et al. concluded that formocresol is not mutagenic[70].

Ribeiro et al. reported two studies that assessed the mutagenic potential of formocresol. With a mouse lymphoma cell line, cultured human fibroblasts and a series of formocresol dilutions similar to clinical doses, these authors found that formocresol did not produce detectable DNA damage and should not be considered genotoxic[71].

The investigations of root canal sealers that contain formaldehyde and produce cytotoxicity are not comparable with formocresol pulpotomy studies. Because large quantities of formaldehyde are produced from sealers than pulpotomy, large quantities of sealers are used. Root canal sealer remains in root canal and forms part of restoration and may lead to further release of formaldehyde[72].

It is summarized that DPX development demonstrated only after a prolonged exposure to formaldehyde at specific contact sites such as nasopharynx. A minute quantity used in pulpotomy for few minutes that will produce distant site genotoxicity is not evidence-based.

Carcinogenicity

In 2004, International Agency for Research on Cancer (IARC) reclassified formaldehyde as a known carcinogen from human probable carcinogen, but according to them, it is an agent that can increase the risk of cancer at some doses. They do not undertake the dose response analyses and possible threshold. The possibility that inhaled or ingested formaldehyde might induce cancer at sites distant from the respiratory or gastrointestinal tracts has been investigated in numerous long-term

toxicity studies performed in rodents. Experimental and epidemiologic research do not support the theory that inhaled or ingested formaldehyde might induce distant site toxicity.

The facts are that formaldehyde occurs naturally throughout the body, there are multiple pathways for detoxification, and only microgram quantities of formaldehyde are applied to pulp tissues during pulpotomy procedures for mere minutes. Considering these facts, exposure of children to the formaldehyde component of formocresol during a pulpotomy is insignificant and inconsequential [72].

Formocresol versus glutaraldehyde

In recent years, glutaraldehyde has been proposed as an alternative to formocresol based on its superior fixative properties, self-limiting penetration, low antigenicity, low toxicity and elimination of cresol. It is a colorless solution that has a mild odour and a boiling point of 183°C to 187°C, is soluble in water, and produces mild acidity on contamination. Glutaraldehyde is a chemically bifunctional reagent, which forms strong intra- and intermolecular protein bonds, leading to superior fixation by crosslinkage. Glutaraldehyde produces a zone of tissue fixation where it is in direct contact with the pulp, while apical to this is a zone of normal tissue with few inflammatory cells. It has been observed that inadequate fixation leaves a deficient barrier to sub-base irritation, resulting in internal resorption. Penetration into the surrounding peri-apical tissue is limited primarily by protein cross-linkage formation. Thus, systemic distribution of glutaraldehyde is limited. Glutaraldehyde is less necrotic, dystrophic, cytotoxic and antigenic, is a better bactericide, and fixes the tissue instantly[73].

Prakash et al. concluded that glutaraldehyde is better fixative and less toxic agent than formocresol. In this study, they compared the clinical and radiological effects of formocresol and glutaraldehyde pulpotomies in various exposed vital human primary molars. The 2% glutaraldehyde compound was promising when compared to ferric sulfate and formocresol in an in vivo study. The only limitations of glutaraldehyde are instability due to short shelf-life and it has to be freshly prepared. In this study, the clinical and radiographic success of formocresol, glutaraldehyde and ferric sulfate were compared as a pulpotomy medicament in primary molars at 3-month intervals

over 1 year. Internal resorption was found in all the medicaments. Clinical success was higher than the radiological success.

One study failed to justify recommendation of 2% buffered glutaraldehyde solution as a substitute to formocresol as failure was observed within 6 months of treatment and failure rate was increased even after and up to 25 months. Internal resorption and external resorption were listed as failures. Resorption rate of pulpotomized teeth was similar to that of other teeth.

Long-term (36 months) success rates of four different glutaraldehyde preparations (2%-buffered and unbuffered, 5%-buffered and unbuffered) as a pulpotomy agent in pulp exposed primary molars were evaluated. The 5% buffered solution group showed highest success rate, whereas 5% unbuffered solution showed the lowest, but as such there was no significant difference found among the four groups. The canal obliteration was noted in 22 treated teeth. The relative high failure rate in this longterm follow-up indicates that clinicians should be cautious before extensively using glutaraldehyde as pulpotomy agent.

Formocresol vs electrosurgery pulpotomy

Another form of non-chemical devitalization developed is electrosurgical pulpotomy. It is a method of cutting and coagulating soft tissues by means of high-frequency radio waves passing through the tissue cells. The advantages of electrosurgical pulpotomy are similar. The self-limiting, pulpal penetration is only a few cell layers deep. There is good visualization and homeostasis without chemical coagulation or systemic involvement. It is less time-consuming than the formocresol approach. Electrocautery carbonizes and heat denatures pulp and bacterial contamination. It may not be suitable if apical root resorption has occurred. Remarkably, Mack and Dean reported a very high success rate with the technique.

Studies show that there is no significant difference between clinical and radiographic success rates for electrosurgical and formocresol pulpotomies. [72],[73] But electrosurgery is considered as sensitive technique. Oztas et al. reported that formocresol pulpotomy technique is histopathologically superior to electrosurgery pulpotomy technique, as they found presence of inflammation, fibrosis, necrosis and resorption. On the other hand, El-Meligy et al. showed that teeth treated by

electrosurgery pulpotomy exhibited less histopathological reaction than formocresol pulpotomy.

Electrosurgery pulpotomy with either mechanical coronal pulp removal or electrical coronal pulp removal induces formation of reparative dentin. This is in the form of bridging at the pulpal amputation sites or along the canal walls. It indicates the present healthy vital pulp efforts to heal the area of insult. This technique also increases the fibroblastic activity at the middle and apical portions of roots with early resorption, as pulp tissue tries to renew itself with proliferation of fibroblasts. On the basis of the use of electrosurgical current intensity, there is a chance of periapical or furcal involvement. Ruemping et al. used low intensity current for electrosurgical pulpotomy during their research so there was no peri-apical or furcal involvement.

Formocresol vs laser surgery

The carbon dioxide laser has wide applications in oral and general surgery procedures involving soft tissue. The laser emits an infrared beam at a wavelength of 10.6 m, has an affinity for water, and is capable of producing well-localized cautery to soft tissue. Tissue is removed by ablation through conversion of the laser beam to heat. Based on these characteristics the carbon dioxide laser appears to have promise as an alternative for pulpotomy therapy.

A study conducted to evaluate the response of the human primary pulp to the carbon dioxide laser and formocresol for vital pulp therapy showed that there were no significant differences between the formocresol and laser groups with respect to symptomatic, clinical or radiographic findings. The histologic observations in this study revealed three interesting effects. First, the laser treatment was at least as effective in minimizing post-treatment inflammation as the formocresol treatment. Second, there was no statistically significant recovery from inflammation between the 28- and 90-day observation period in either the laser or formocresol group. Third, there was a strong and statistically significant inverse correlation between the energy used during the respective laser pulpotomies and the degree of inflammation observed at 28 days.

The histological response of dental pulp after different types of laser irradiation was evaluated in some studies. The results revealed that laser irradiation caused carbonization, necrosis and infiltration of inflammation cells, edema and hemorrhage in the pulp tissue.

The pulp can predictably heal itself when the temperature does not raise more than 5.5 o C above physiological baseline. The higher energy created a thicker char layer over the remaining pulp, which in some way had a favorable effect in reducing the initial inflammatory response in residual pulp.

Formocresol versus calcium hydroxide

Calcium hydroxide was the first agent used in pulpotomies that demonstrated any capacity to induce regeneration of dentin. The high pH of calcium hydroxide wounds the pulp in a manner that permits the intrinsic reparative cascade to begin. Unfortunately, the stimulus evoked by this compound is delicately balanced between one of repair and resorption. The study by Magnusson demonstrated how often the balance is tilted toward the destructive pathway.

Schröder emphasized on the importance of avoiding a blood clot between the amputation site and calcium hydroxide for clinical success. Calcium hydroxide adequately controls pulpal hemorrhage, to permit good contact between medicament and pulpal tissue. This seems to be important in the prevention of internal resorption, post-pulpotomy.

A study conducted to compare the clinical and radiological outcomes following single-visit vital pulp therapy techniques, using two different materials, formocresol and calcium hydroxide in cariously exposed primary molar teeth. This investigation confirms the clinical efficacy of a one-fifth dilution of Buckley's formocresol as an agent in pulp treatment of cariously exposed, vital primary molar teeth. However, calcium hydroxide in its pure, powder form is a clinically acceptable alternative when combined with strict selection criteria for this method of restorative care. There was a statistically insignificant difference in successful clinical and radiological outcome between the two treatment groups. Markovic et al. reported the presence of a dentine bridge above the pulp amputation site radiographically in 47% of pulpotomized teeth using calcium hydroxide. Heilig et al. was performed calcium hydroxide pulpotomy

in 17 carious primary molars using alternative method of hemorrhage control i.e., aluminum chloride. This study suggests that the aluminum chloride-calcium hydroxide pulpotomy may be a viable alternative to formocresol pulpotomies in the primary dentition. Although these findings encourage continued research, including a long-term follow-up, a histologic study is indicated.

Formocresol versus mineral trioxide aggregate

Mineral trioxide aggregate (MTA) is a fine hydrophilic powder developed by Mahmoud Torabinejad in Loma Linda University. It consists of tricalcium silicate, tricalcium aluminate, tricalcium oxide, silicate oxide and bismuth oxide. The US Food and Drug Administration approved MTA in 1998 as a therapeutic endodontic material for humans. Torabinejad et al., Bates et al. and Fischer et al. evaluated the sealing ability of MTA in root canals. MTA is currently being used in pulp therapy and has been shown to provide an enhanced seal over the vital pulp and is nonresorbable. Furthermore, MTA has superior biocompatibility and is less cytotoxic than other materials currently used in pulp therapy.

Previous studies showed that MTA stimulated the release of cytokines and production of interleukin and induced hard tissue formation. Schmitt et al. reported that Tulsa Dental provides MTA as ProRoot. The material can be placed in the tooth with the Tulsa carrier, an amalgam carrier, Messing gun or a hand instrument. Advantage of MTA is that it needed less time for procedures. Some of the main disadvantages are discoloration, costs and accessibility, which may block worldwide distribution of MTA where formocresol is relatively inexpensive and have global accessibility. MTA has also shown to revascularize and promote dentin-like tissue formation in several clinical situations.A histological study to know the effects of gray and white MTA on amputated pulp tissue, along with formocresol as a gold standard suggests that it preserves and regenerates both hard and soft tissues. The nearly normal pulp architecture was found to be intact and continuous odontoblastic layer was seen. While cases treated with white MTA showed dentine bridge formation along with inflammatory cells and areas of partial necrosis, more clinical and radiographic failures were seen with white MTA. The minor difference in composition between gray and white groups accounts for the differences in pulpotomy success rates. The gray MTA contains tetracalcium aluminoferrite while it is absent in white MTA. The

clinical success of formocresol is attributed to its bactericidal characters even though it shows poorly calcified secondary dentin bridging along with complete necrosis and inflammatory cells.

The normal consequence of pulp treatment is internal resorption. It was seen in both formocresol and MTA groups but no explanation for MTA was given as this consequence is not seen in MTA cases[74].

CONTROVERSIES IN OBTURATION

Some of the most controversial aspects of root canal treatment that have been debated for decades are where to terminate apically, cleaning. shaping and obturation procedures. Many of the investigators of the late 19th Century and early 20th Century debated these issues prolifically. using science as the basis for their clinical directives. In some respects, many of these scientifically-based dictates have been abandoned in favorable. of clinical techniques that provide aesthetic radiographic views but do not necessarily support tissue regeneration at the root apex following obturation.

Working length determination guidelines often cite the cementodentinal junction or apical constriction as the ideal position for terminating canal cleaning and shaping procedures and the position to which the filling material should be placed for clarification purposes, the CDJ is a histological. not a clinical. position in the root canal system. Secondly, the CDJ is not always the most constricted portion of the canal in the apical third of the root Thirdly, the distance from the apical foramen to the canal constriction depends on a multitude of factors such as increased cemental deposition or radicular resorption. Both processes are strongly influenced by age, trauma, orthodontic movement. periradicular pathology, or periodontal disease. Especially in periodontal disease states, the CDJ location has no predictable anatomic appearance or location due to resorptive processes or cementa1 depositions that may extend well into the root canal. Therefore, the foramen and CDJ position on the root can be highly variable and can exist anywhere from the direct radiographic apex up to 3 mm coronal to the radiographic apex depending on a particular root morphology (Fig 2) These potential anatomic variations have had a major impact on the precise region or location for determining the working length and termination of root canal cleaning, shaping and obturation. These clinical concerns, along with the integrity of the periradicular tissues have formed the basis for success in prognostic studies that have identified that the optimal result is to end root canal procedures inside the radiographic apex (approximating the CDJ). When cleaning, shaping and obturation are significantly shorter than this (> 2 mm). the success rates drop. When longer than this, especially with filling materials beyond the radiographic apex, an even poorer result is noted[75].

From a realistic viewpoint. however, it is often impossible to know exactly where the apical foramen and apical constriction are located until after the canal has been obturated.

Apical Position of The Obturation Material Historically

Gutta-percha has been the material of choice as a solid core filling material for canal obturation It demonstrates minimal toxicity. minimal tissue irritability and is the least allergenic material available when retained within the canal system. In cases of inadvertent gutta-percha cone overextension into the periradicular tissues. it is well tolerated, as long as the canal is clean and sealed Gutta-percha. however. has been shown to produce an intense localised tissue response in subcutaneous tissues when placed in fine particle form or to stimulate cellular inflammatory factors in macrophages. This potential may impact on some popular obturation techniques Many of the more contemporary obturation techniques advocate canal obturation to within 0.5 mm of the radiographic apex, to the radiographic apex, or beyond, which is confirmed by the presence of a "puff" of filling material. This puff, whilst thought to consist only of root canal sealer. can also be gutta-percha that has been thermoplasticize. Recently, the impact of sealers on cellular elements found in the periradicular tissues has been investigated and the presence of these materials may be responsible for apoptotic changes (programmed cell death) to a greater or lesser extent depending on the type of sealer. In this regard, the question can be asked "Could this process be responsible for the development of periradicular lesions long after the apparent treatment presents as successful'" Whilst empiric observations support a high degree of initial clinical success with techniques that tolerate or encourage the placement of sealer beyond the root end, no long-term prognostic studies have supported this position for the termination of root canal procedures Furthermore, canals with filling material beyond the confines of the root canal system tend to cause more postoperative discomfort. Whilst filling the entire root canal system is the major goal of canal obturation. the apical termination of the root canal filling material has been controversial. If a major goal of the root canal procedure is to create an environment conducive to the regeneration of cementum over the apical foramen, the periodontium that enters the apical foramen in teeth with vital. yet compromised. pulps should not be challenged with the extrusion of root canal filling materials beyond the end of the canal (Fig. 2). This concept has been scientifically

valid for many years and is supported by numerous retrospective studies and reviews, Even in those cases with periradicular radiolucencies. filling beyond the confines of the canal is less desirable, although filling the root canal as close as possible to its terminus is desirable Contemporary endodontic practices and long-term evaluative studies favour and support obturation within the confines of the root canal system in all cases in an attempt to prevent further challenge to the already compromised and challenged periradicular tissues. Recently-advocated obturation techniques supporting the use of resin-based and bonded materials have not had the same extensive evaluation that gutta-percha, when in contact with the periradicular tissues has had[76]

Root canal treatment of maxillary first molar using the Epiphany Soft Resin Obturating System vertical heated compaction (above) represents a 4-month followup assessment. The patient is symptom free and there appears to be some initial resolution of the radiolucency on the mesiobuccal root.

Contemporary Materials For Root Canal Obturation:

The development of contemporary resin-based materials for bonding within the root canal as the root filling has posed some interesting possibilities. questions and challenges. The prime developments to date have been the tandem of Epiphany soft resin. a dual-cured dental resin composite sealer containing a mixture of BisGMA, ethoxylated BisGMA UDMA and hydrophilic difunctional methacrylates. calcium hydroxide. barium sulfate. barium glass and silica fillers, and Resilon'". a hard resin that is a thermoplastic synthetic polymer of polyester called polycaprolactone. Fuithermore. Resilon contains a bio-active glass component along with bismuth oxychloride and barium sulfate) The Resilon ' material is available in cones that are ISO-sized .02 .04 and .06 taper, as well as in accessory sizes. Pellets of the material are also available for softening and delivery via injectable systems Clinically, the materials are used with a primer after the smear layer has been removed. The

resulting obturation within the canal. being a combination of the soft resin sealer and hard core polycaprolactone. is referred to as Resilon"' Epiphany ' sealer monoblock, as it is claimed to seal from dentinal wall to dentinal wall in circumference. Furthermore, the movement of the material into the patent dentinal tubules of the smear layer-free dentine is claimed. The material has excellent flow characteristics during compaction in the root canal via either a cold lateral compaction or warm vertical compaction technique. In the latter scenario. as with guttapercha and sealer, the extrusion of the filling material beyond the root end, especially following over-instrumentation or patency filing is a strong possibility. This then creates a similar challenge to the healing and preferentially the regeneration of the periradicular tissues as does guttapercha and sealer. One study compared Resilon with gutta-percha in terms of the melting point, specific heat capacity, enthalpy change with melting, and heat transfer. It was found that there was no difference in the melting point temperatures for the two materials, but Resilon had a significantly greater specific heat capacity and endothermic enthalpy change. There was a significant difference in the heat transfer test in the temperature increase between gutta-percha and Resilon within 3 mm of the heat source, with gutta-percha having a greater temperature change. They concluded that Resilon may not be thermoplasticized the same as gutta-percha because there is a higher specific heat, higher enthalpy change with melting, and less heat transfer. Moreover. a multitude of questions arise regarding many aspects of these materials. because to date the published literature provides little detail regarding the clinical manipulation of the material or the ultimate tissue responses to the materials or their components Granted that many clinicians. primarily endodontists. have been using the material in their practices. the need for evidence-based information or at least expanded details on the scientific basis for how this material works is imperative Furthermore, long-term to form sealer tags that enhance both the seal of the root canal and the strength of the root[77].

N2 Sargenti paste

It relies heavily on formaldehyde containing paste and indicated undesirable properties.Cases of incomplete seal and apical fenestration formation were formed.On February 1993, the FDA advisory panel confirmed the N2"s that safety and effectiveness remain unproven[83]

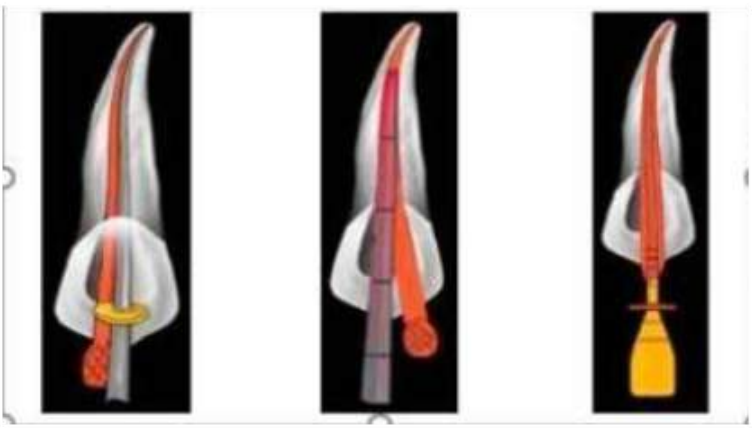
Contemporary Core Filling Materials

Gutta-percha is the standard material of choice as a solid core filling material for canal obturation. It demonstrates minimal toxicity and minimal tissue irritability, is the least allergenic material available when retained within the canal system,and in cases of inadvertent gutta-percha cone overextension into the periradicular tissues, is well tolerated provided the canal is clean and sealed. Chemical solvents have been used for almost 100 years to soften gutta-percha, with methods ranging from merely dipping the gutta-percha cones into the solvent for one second for better canal adaptation, to creating a completely softened paste of gutta-percha with the solvent. Solvents used have included chloroform, halothane, rectified white turpentine, and eucalyptol. Periradicular tissues may be irritated if the solvent is expressed beyond the canal or significant amounts of softened gutta-percha are inadvertently placed into the periradicular tissues. Failure to allow for dissipation of chemical solvents, if volatile, or the removal of excess solvent with alcohol can result in significant shrinkage and possible loss of the apical seal. The use of chemical solvents has been both praised and questioned, but with the advent of thermoplasticized gutta-percha, the need to consider the use of solvents at any time must be questioned. The use of solvents, however, may still be considered for a number of challenges the clinician may face in daily practice, such as the custom fitting of master cones in irregular apical preparations or following apexification[78].

Gutta-percha Cones

The composition of gutta-percha cones is approximately 19% to 22% Balata and 59% to 75% zinc oxide, with remainder a combination of various waxes, colouring agents, antioxidants, and metallic salts.The specific percentages for components varies by manufacturer, with resulting variations in the brittleness, stiffness, tensile strength, and radiopacity of the individual cones attributable primarily to the percentages of gutta-percha and zinc oxide. The antimicrobial activity of gutta-percha is also primarily due to the zinc oxide. In particular, for techniques that use vertical compaction of heat-softened gutta-percha, both the non-standardized and more tapered cones have become quite acceptable[79].

Custom cones can also be developed for canals with irregular or large apical anatomy, Over time, numerous methods have been advocated for obturating the prepared root canal system, each with their own claims of ease, efficiency, or superiority. Most contemporary techniques still rely on gutta-percha and sealer to achieve their goal. Four basic techniques exist for the obturation of the root canal system with guttapercha and sealer: (1) the cold compaction of gutta-percha; (2) the compaction of heat-softened gutta-percha with cold instruments until it has cooled; (3) the compaction of gutta-percha that has been thermoplasticized, injected into the system, and compacted with cold instruments; and (4) the compaction of gutta-percha that has been placed in the canal and softened through the continuous wave technique (Calamus). A multitude of variations on these four basic themes exists. For injectable thermoplastic obturation techniques, gutta-percha may come in either pellet forms or in cannulae.

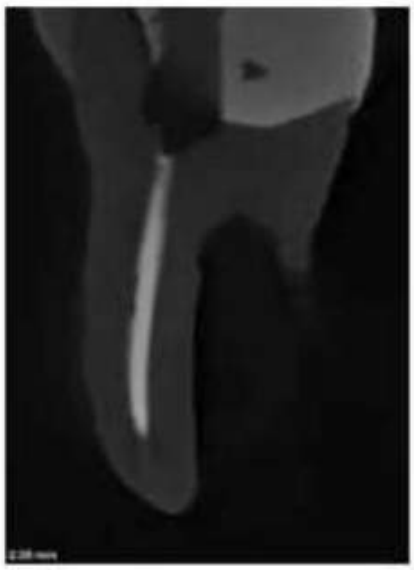


No single technique has proven to have statistically significant superiority when considering both in vitro and in vivo studies, as the success of all techniques is highly dependent on the cleaning and shaping of the canals and the clinician‟s expertise in the use of a particular technique. While many have advocated the use of the lateral compaction technique or a single cone fill (monocone) to achieve a quality apical seal, the technique in itself does not necessarily favor the filling of canal irregularities. Recognizing this, use of a softened gutta-percha technique with heat or chemical softening is required to achieve a thorough obturation. In addition, while filling the entire root canal system is the major goal of canal obturation, a major controversy exists as to what constitutes the apical termination of the root canal

filling material. Working length determination guidelines often cite the cemento dentinal junction or apical constriction as the ideal position for terminating canal cleaning and shaping procedures and placing the filling material. However, the cemento-dentinal junction is a histologic and not a clinical position in the root canal system and, in addition, the cemento-dentinal junction is not always the most constricted portion of the canal (yellow arrows) in the apical portion of the root[80].

Contemporary practices of obturation favour material softening; even this does not guarantee that an impervious seal of the root canal system will be established. Also, with softened gutta-percha obturation techniques there has been a greater incidence of material extrusion beyond the confines of the canal. While softening of gutta-percha may be viewed as routinely desirable, the selective use of this technique solely or in combination with a solid core of gutta-percha must be at the discretion of the competent clinician when anatomy dictates this approach.

Recent research conducted at Nova Southeast University using micro CT scanning technology has shown the effectiveness of scanning for imagery and the greater precision observed compared to standard radiographs. In one example, a mesiobuccal canal was filled using GT® Series X™ obturator and the mesiolingual canal was filled using a single cone technique (ActiV GP). It appeared from one angle that all canals were equally filled. However, closer examination subsequent to filling showed voids using the single cone technique throughout the length of the root filled using this technique[81].



The single cone technique did not produce a monoblock obturation.

The gutta-percha from the GT obturator flowed into the canal isthmus and filled it.

Controversies in obturation of lateral canals

The complexity of the canal anatomy makes it very difficult to efficiently clean, completely disinfect and obturate all ramifications (lateral and accessory canals, deltas, isthmuses) often observed especially at the apical third of the roots. It is well known that in necrotic pulps, these irregularities can harbour infected tissue that could lead to periodontal destruction. The clinical significance of the obturation of these ramifications is at least a matter of discussion. There has been no convincing evidence that obturation of these canals or isthmuses would have an impact on treatment outcome. Despite the controversy, sealing fins and ramifications with a material that possesses antibacterial activity could be beneficial, prolonging the suppression of microbial activity through the action of the root canal filling material[82]. Since the introduction of lasers in endodontics during the early 1970s, there have been several studies regarding the application of this technology as an aid to improve not only the cleansing and disinfection but also the sealing of the root canal system. Treatment of the radicular dentinal walls with the laser has been shown to promote cleaner surfaces when compared with a combination of sodium hypochlorite and ethylenediaminetetraacetic acid (EDTA), which might result in better adaptation of the filling material to the root canal walls. Thus, the application of the Cr, Er: YSGG laser has been shown to provide superior cleanliness of the canals when compared with instrumentation alone[83].

The necessity for the complete obturation of the root canal system and its ramifications seems to be, at the very least, controversial. Sabeti et al., for instance, have reported no difference in healing of apical periodontitis when root canals in dogs were left without obturation after cleaning and shaping procedures, questioning the importance of this phase of the endodontic therapy. According to the authors, –In theory, if we can sterilize the canal and prevent coronal leakage, then a filling should not be necessary‖. However, others have reported the importance of the obturation with thermoplasticized gutta-percha and sealer for the successful outcome of the endodontic therapy. Despite the controversy, one could speculate that filling the main canal and its ramifications with gutta-percha and a sealer with antibacterial properties might be beneficial. Even though the disinfection of the canal system seems to be the most significant factor in root canal therapy, the importance of the obturation should not be overlooked when attempting to maintain the root canal space free of

contamination, increasing the chances of long-term clinical success. Laser devices still need further development, especially when using the technology to clean and shape curved and calcified canals. Zipping and ledging have been frequently reported in the literature which could create difficulties for an adequate obturation. Some canals that received the laser application demonstrated irregularities in the outer walls toward the ‒safe zone‖. However, the irregularities did not influence the quality of the obturation. However, the search for new ways to improve root canal therapy seems to be a reasonable task, and the laser might be a useful instrument in this quest. It can be concluded that treatment with Er, Cr: YSGG laser after mechanical instrumentation allows obturation of a greater number of root canal ramifications by gutta-percha and/or sealer.

Other researchers have shown the importance of combining therapies such as rotary instrumentation using larger apical sizes with the use of calcium hydroxide to reduce the numbers of bacteria in root canals and increase long-term success. In a recent metaanalysis of studies done over the last three decades on optimal obturation length, the results demonstrated that obturating materials extruding beyond the radiographic apex correlated with a decreased prognosis for repair. When faced with the possibility of inadvertent over-instrumentation into neurovascular anatomy, the research provides a substantial number of appropriate caveats.

When Is The Canal Ready To Obturate?

Radicular space obturation is ideally accomplished after cleaning and shaping has been completed to an optimum size. Although there is no universal agreement on what constitutes an optimal size, it seems that the canal(s) should be dry, with no ‒‖weeping‖‖ of fluids into the radicular space. The tooth should ideally be asymptomatic, although those completely instrumented, yet with mild symptoms or even significant symptoms, have been shown to become asymptomatic upon obturation. There are also reports showing the importance of obturating canals following negative bacterial cultures. Sjogren et al found that upon a 5-year recall, 94% of cases exhibiting negative cultures were found to be successful, whereas only 68% of those filled with positive cultures were successful[84].

Influence of Post Space Preparation on Obturation

In order to provide better retention for a core build-up after root canal treatment, it is often necessary to include one or more posts (dowels) The length of the space created to accommodate a post and its time of preparation (immediately following obturation or at a later time) are of concern, as they can affect the quality and the durability of the canal seal. A study by Bourgeois and Lemon in 1981 related that using a hot plugger when making a post space was favorable. A follow-up study by Dickey et al. suggested that if Peeso reamers or chloroform and K-files were used, gutta-percha removal should be delayed by 1 week to allow for setting of the sealer.

The classic literature dealing with the timing of post space preparation has differed regarding its importance. Mattison et al. showed that timing did not matter. More recently, studies have shown conflicting results, as one study with immediate post space preparation gave better results to minimize coronal leakage, while another study showed no difference between immediate and delayed preparation. Another study addressed post spaces made in canals obturated by different filling techniques, including silver points, lateral compaction, warm/vertical compaction, Ultrafil or Obtura and found no significant differences in amounts of leakage. Another issue with respect to post space preparation is that of minimal obturation length (or maximum post space depth). Goodacre and Spolnik recommend post length of at least the same or more as the height of the crown and that 4 to 5 mm of gutta-percha remains apical to the post to maintain an adequate seal. Abramovitz et al. more recently showed that less than 4 to 5 mm of gutta-percha provides an unreliable seal.

Some concern has been expressed about ThermaFil carriers and their potential impedance when creating a post space. Ravanshad and Torebinejad compared metal core ThermaFil obturations notched to fracture 5 to 6 mm from the apex to lateral and vertical compaction obturations with respect to coronal leakage. They found that the ThermaFil group had the highest degree of coronal dye penetration. When comparing ThermaFil plastic and metal carrier obturations following the manufacturer‟s instructions regarding post space preparation, there was very little differences in apical leakage according to Mattison.Another study compared the effects of immediate versus delayed post space preparation on the apical seal using AH Plus sealer and vertical compaction.

Post space depths were all done to allow 4 mm of apical gutta-percha to remain. Teeth in which the post space preparation was delayed for 1 week had significantly more apical leakage than those with immediate post space preparation. Perhaps more convincing evidence of the importance of leaving a minimum amount of apical seal are the findings of Kvist et al. in a clinical study of root canal failures. They found that cases involving post placement had a significantly higher percentage of failures related to apical fillings with less than 3 mm of length[85].

CONTROVERSIES IN POST ENDODONTIC RESTORATION

The restoration of endodontically treated teeth has long been a controversial topic, often approached empirically and based on assumptions rather than scientific evidence. The loss of tooth vitality is not accompanied by significant change in tissue moisture or collagen structure, while endodontic therapy, and, in particular, the use of irrigants such as sodium hypochlorite and chelators, proved to soften dentin[86].

The most important changes in tooth bio- mechanics is attributed to the loss of tissue either at radicular or coronal levels, which points out the importance of a highly conservative approach during endodontic and restorative procedures[87].

Micromorphology of the adhesive interface

A well-structured resin-dentin interdiffusion zone was observed at the interface with radicular dentin using either total-etch or self-etch adhesives; however, this hybrid layer was more uniform when a total-etch system was used. Ferrari et alevaluated the structural characteristics of resin-radicular dentin inter- faces and concluded that the hybrid layer thickness and resin tag density diminished from the coronal to the apical third of a root. In vivo confocal and SEM (scanning electron microscope) microscopy demonstrated that the penetration of adhesives inside radicular dentin proved to be complete in only one- third of extracted teeth in the apical third and in two-thirds of the samples in the middle and coronal thirds and evaluated the micromorphology of failed adhesive inter-faces and found that the failure always occurred between either the hybrid layer and bonding resin or the bonding resin and com- posite resin cement, with higher proportions of interfacial defects at the hybrid layer after long periods of clinical service. These findings demonstrate the limited stability of the hybrid-layer interface[88].

Another in vitro study confirmed the higher occurrence of debonding at the top of the hybrid layer, with either SEM or confocal microscopy. It was also shown that the adhesive interface demonstrates a wellorganized structure with hybrid layer and resin-tag formation where good adhesion is present, whereas a poorly structured interface is visible in most debonded areas[89].

Bond strength and adhesive interface with pulpal-floor and radicular dentin

Adhesion to pulpal-floor dentin measured by microtensile bond strength test proved to be inferior to adhesion to coronal dentin with either a prime-and-bond system (15.6 versus 29.9 MPa) or 2-step self-etch adhesive (22.5 versus 36.0 MPa).Lopes et al [113] have also shown that adhesion to pulpal chamber dentin was more reliable than to root-canal dentin. These findings might be explained by the difference in the collagen cross-linking structure at the different dentin locations. The total-etch technique also appeared to produce [68] higher bond strength values than the self-etching approach. In fact, it was shown that selfetching primers should not be combined with chemical or dual-cured cements, due to the remaining acidic components of the primer[90]. Endodontic irrigants such as chloroform, halothane, hydrogen peroxide, and sodium hypochlorite (NaOCl) reduce bond strength to dentin, while chlorexidine did not affect adhesion.60,61 .The influence of sodium hypochlorite treatment on dentin bond strength might vary with the adhesive used. In addition, the use of NaOCl proved to influence the resin tag morphology; with treatment, resin tags presented a cylindrical, solid shape instead of a hollow, tapered appearance.

Fiber posts provided better bond strength values than ceramic posts. When the tensile force required to dislodge a translucent fiber post cemented by either light-curing adhesive-cement system or dual-curing system was tested, the light-curing system resulted in slightly inferior bond strength values but provided a better adaptation than the dual- curing system.64 When comparing them in a push-out test, the bond strength of fiber post to radicular dentin cemented with either a luting (unfilled or low filler content) or restorative composite resin, [102] higher values were obtained with the restorative composite resins [91].

Bond strength and interface between posts and luting/core composite resin

Following a pull-out test, adhesively cemented carbon-fiber posts presented bond strength values of 25 MPa between post and luting cement. A finite element analysis of the same study configuration did also show that stresses accumulate at the post-cement interface and in the cement bulk itself, lowering stresses in radicular dentin due to [70] the use of a post material of low elasticity modulus. Boschian Pest et al found similar adhesion values between fiber post and cement for unfilled, low-filled (luting), and highly filled (restorative) materials following a push-out test. In a pull-

out test, sandblasting used to create microretentions lowered the bond strength between carbon posts and luting composite resin due to alumina particles impinging carbon fibers[92]. In another invitro study there was no difference in tensile bond strength between composite resin core and sand- blasted or serrated carbon fiber posts. The use of serrated posts appears to be a more reliable approach to increase stability of the post inside the canal[93].

When testing the interface between composite resin cores and smooth fiber or serrated stainless steel posts, higher tensile strength values were obtained with the metal posts, due to the primary influence of macro-mechanical retention. For adhesion between partially stabilized zirconium oxide posts and pressed glass ceramic or composite resin core materials, the use of tribochemical silicoating provided the best retention[94].

The Ferrule Effect

The –ferrule effect‖ is important to long-term success when a post is used. A ferrule is defined as a vertical band of tooth structure at the gingival aspect of a crown preparation. It adds some retention, but primarily provides resistance form and enhances longevity. Stankiewicz and Wilson published a good review of the topic in 2002. A ferrule with 1 mm of vertical height has been shown to double the resistance to fracture versus teeth restored without a ferrule. Other studies have shown maximum beneficial effects from a ferrule with 1.5 to 2 mm of vertical tooth structure.A study by al- Hazaimeh and Gutteridge reported no difference in fracture resistance with or without a 2-mm ferrule using prefabricated posts and resin cement. Clinical benefits achieved by omitting the ferrule preparation includes minimize periodontal effect or trauma of extending the finishing line gingivally. The importance of ferrule is not clear with recent advancements like bonded titanium posts and fiber reinforced composite posts with adhesive resin cements that could provide internal bracing of the root that substitutes for the ferrule effect.

The debate about which post material can sustain higher failure loads (thus longer clinical service) and express more favourable failure modes (thus allow re-restoration) is also still unsolved in literature. However, the fracture patterns were more favourable when a ferrule was present. The majority of the fractures in the teeth without a ferrule were non-restorable. A study by Saupe et al. (57) also reports no

difference in fracture resistance of teeth with bonded posts with or without a ferrule. In some cases, particularly with anterior teeth, it is necessary to perform crown lengthening or orthodontic eruption of a tooth to provide an adequate ferrule.

To crown or not to crown [23]

It should be emphasised that there is no consensus regarding the preferred type of final restoration for endodontic treated teeth. Although the overwhelming majority of the literature supports the need for full coverage restorations of most endodontic treated teeth, and a strong association between the success of endodontic treated teeth and crowned teeth has been shown.

Alternatives have been suggested like complex amalgam restorations, overlays or composite restorations. More recently partial restorations like indirect onlays have been suggested as a restoration that preserves more sound tooth structure than does a full coverage crown while at the same time provides cuspal coverage to protect weakened cusps. The need for crowning a tooth is directly related to its mechanical weakening due to previous restorations, decay and/or endodontic access cavity preparation. No significant biochemical change, indicating that endodontic treated teeth are more brittle, has been demonstrated.

It is now accepted that cuspal deflection and thickness of the residual walls and cusps are the key factors. For this reason, the use of alternative restorations should be considered for certain clinical presentations, due to their ability to preserve thick residual walls better than do crowns. Alternatives include gold crowns and more recently, minimal preparation composite crowns with a 0.5 mm chamfer finish line, bonded with resin cements. Similarly, cuspal coverage direct or indirect composite restorations have been advocated for use in molar teeth so as to eliminate the need for axial wall destruction. [127] [23]

With the improved wear characteristics the newer composites are showing this type of restoration may be an option, particularly in teeth of poorer prognosis, as currently there is sparse long-term information on the longevity of cusp-replacing composite restorations.

It can be stated that the restoration of nonvital teeth has evolved from a completely empirical approach to bio- mechanically driven concepts, the conservation of tissue and adhesion being the most relevant elements for improved long-term success[95].

Endocrowns vs conventional crowns

The true breakthrough in the restoration of endodontically treated teeth was the introduction of adhesion, propelled by the development of effective dentin adhesives. The chief advantage of adhesive restorations is that macro retentive elements are no longer mandatary as long as enough surface is available. With this approach, the insertion of radicular posts has become the exception rather than the rule when applying conventional restorative techniques. In fact, minimally invasive preparations, with maximal tissue conservation, are now considered „the gold standard" for restoring ETT . By following this rationale, endocrowns are applied as a prosthetic option in restoration of endodontically treated incisors, premolars and molars with excessive tissue loss. Pissis was the forerunner of the endocrown technique and has described it as the „mono-block porcelain technique". In 1999, the endocrown was described for the first time by Bindle and Mörmann as adhesive endodontic crowns and characterized as total porcelain crowns fixed to endodontically treated posterior teeth. These crowns would be anchored to the internal portion of the pulp chamber and on the cavity margins, so macro-mechanical retention is provided by the pulpal walls, and micromechanical retention is obtained by the use of adhesive cementation. This method is particularly indicated in cases in which there is excessive loss of tissue of the crown, interproximal space is limited and traditional rehabilitation with post and crown is not possible because of inadequate ceramic thickness. Compared to conventional crowns, endocrowns are easy to apply and require a short clinical time. Low cost, short preparation time, ease of application, minimal chair time and aesthetic properties are the advantages of endocrowns. In addition, endocrowns are also an alternative in teeth with short or atresic clinical crowns, calcified, curved or short root canals that make post application impossible. In a study of 3D Finite Element Analysis of molars restored with endocrowns and posts during masticatory simulation, teeth restored by endocrowns were potentially more resistant to failure than those with fiber reinforced posts [96].

CONTROVERSIES IN ENDODONTIC SURGERY

Apical surgery belongs to the field of endodontic surgery that also includes incision and drainage, closure of perforations, and root or tooth resections. The objective of apical surgery is to surgically maintain a tooth that has an endodontic lesion which cannot be resolved by conventional endodontic retreatment. This goal should be achieved by root-end resection, root-end cavity preparation, and a bacteria-tight closure of the root-canal system at the cut root end with a retrograde filling. In addition, the periapical pathological tissue should be completely debrided by curettage in order to remove any extra-radicular infection, foreign body material, or cystic tissue. Apical surgery has greatly benefited from continuing development and introduction of new diagnostic tools, surgical instruments and materials, making this method of tooth maintenance more predictable. Success rates approaching 90% or above have been documented in several clinical studies[97].

The introduction of cone beam computed tomography (CBCT), also called digital volume tomography (DVT), has had an enormous impact in dentistry, and particularly in surgical fields of dentistry. Whereas conventional computed tomography (CT) provides sliced-image data, CBCT captures a cylindrical volume of data in one acquisition and thus offers distinct advantages over conventional radiography. These advantages include increased accuracy, higher resolution, scan-time reduction, and dose reduction (Cotton et al., 2007). CBCT greatly aids in assessment prior to apical surgery[98].

A study compared CBCT with intraoral periapical radiography in the diagnosis of periapical pathology. In 32 (=70%!) of 46 cases, additional relevant information was obtained with CBCT, including presence and size of apical lesions or presence of an apico-marginal communication. Another study compared CBCT with intraoral periapical radiography (PA) in posterior maxillary teeth referred for apical surgery. CBCT showed significantly more lesions (34%, $p < 0.001$) than PA. Additional findings were seen more frequently with CBCT than PA, including missed canals, presence of apico-marginal communication, expansion of lesions into the maxillary sinus, and sinus membrane thickening. The study clearly showed the limitations of PA compared to CBCT for preoperative diagnosis of posterior maxillary teeth scheduled to undergo apical surgery. Hence, the use of CBCT has been recommended

for presurgical planning, and in particular for planning of apical surgery in multirooted teeth[99].

A surgical approach is more conservative than a non-surgical treatment for certain cases. A common example is a tooth with acceptable endodontics and a new post and crown restoration, but a persistent or enlarging periapical lesion. Breaking or disassembling the crown, removing the post and retreating the canals would be more dramatic, more time consuming, more costly and less predictable than a root-end microsurgical approach[100].

A more critical and difficult issue is the presence of dentinal cracks. The use of an (rigid) endoscope appears to be useful for the detection of dentinal cracks (or of other microstructures) at the cut root face (von Arx et al., 2002, 2003a,b; Slaton et al., 2003). However, the clinical relevance of dentinal cracks observed at the resected root surface has not yet been clarified (Morgan and Marshall, 1999). A recent in vitro study has found that the presence of cracks originating from the root canal negatively influences the seal of root-end filling materials, and is probably of major clinical importance (de Bruyne and de Moor, 2008). The use of ultrasonic tips is one of the alternatives. Although, as they work with vibration and by contacting the root canal walls, there is still a risk of formation of cracks on the surface of the cavity which may lead to apical leakage in the long term. In the recent years, besides ultrasonic tips, lasers are also used in retrograde cavity preparation[100].

After the careful check of the resection plane, a retrocavity is prepared into the rootend. This retrocavity should have a depth of 3 mm and should follow the original path of the root canal. The cavity should also include an isthmus or accessory canal, if present. While the conventional technique of root-end cavity preparation, i.e., the use of a small round bur or of an inverted cone bur in an angled micro-handpiece, was problematic with regard to direction and depth of the retrocavity, the development of sonic- or ultrasonic driven microtips (retrotips) was a major breakthrough in apical surgery, and has considerably simplified the technique of root-end cavity preparation. Elimination or minimisation of the bevel angle is one of the most important benefits of microsurgery. With the traditional rotary bur, the steep angle of 45-60 degrees was recommended. However, there is no biological justification of a steep bevel angle. It was strictly done for better access and visibility. It causes large removal of the buccal

bone along with the root area. Furthermore, bevelling frequently misses the lingually positioned apex, causes elongation canal and reduction of the root diameter, thereby weakening it[101].

For root-end filling, a variety of materials have been propagated in the past. Almost every material that was introduced in operative and restorative dentistry as a temporary (SuperEBA, IRM, Cavit, etc.) or permanent (gold, amalgam, resin composite, glass ionomere cement, compomere, etc.) restoration material was sooner or later also utilized in apical surgery. However, mineral trioxide aggregate (MTA) appears to have become the gold standard for a root-end filling material. All clinical comparative studies published to date have reported higher success rates for MTA than for the competitor material although the differences were not found to be significant (probably due to the number of treated cases). Although MTA is an expensive material and the clinician has to become familiar with its handling, it has major advantages, including excellent biocompatibility, ideal adherence to the cavity walls and low solubility (Poggio et al., 2007), and cementogenesis at the cut root face, with deposition of new cementum onto the exposed dentin and MTA surfaces. The most recently published randomized clinical trial compared MTA to smoothing of the existing orthograde gutta–percha (GP) root filling. Teeth treated with MTA demonstrated a significantly ($p < 0.001$) better healing (96%) than teeth treated with the smoothening procedure only (52%). The results emphasize the importance of placing a root-end filling after apical resection[102].

With regard to the outcome of apical surgery, inconsistent success rates ranging from 44% to 90% were reported prior to the introduction of microsurgical techniques. However, recent studies have shown that the treatment outcome of apical surgery has considerably improved, and the success rates have approached or exceeded 90%. This tendency of consistently high healing rates after apical (micro-)surgery has been substantiated by several clinical studies. Another important issue to consider in the healing outcome of apical surgery is the difficulties and challenges of combined endoperio lesions, in particular the absence of the buccal bone plate with a completely exposed buccal root surface. Only a few clinical studies have compared the healing outcomes in apical surgery of teeth with intact and with missing buccal bone. A 5-year success rates associated with molar apical surgery in consideration of the width of the buccal __bone cuff‘‘ prior to wound closure. Teeth with a width of 3 mm or

greater of cuff had a healing rate of 76%, whereas teeth with no buccal bone cuff had a significantly lower healing rate of 46% ($p < 0.0001$)[103]. Another study reported a successful outcome of 77.5% in apicoectomized teeth with combined endodontic–periodontal lesions, compared to a successful outcome of 95.2% in teeth with isolated endodontic lesions. Teeth with an apico-marginal communication undergoing apical surgery may benefit from further advances and refinement of regenerative techniques[104].

Endodontic Treatment Vs Implant Surgery

One of the major issues confronting the contemporary dental clinician is the treatment decision between extracting a tooth with placement of a dental implant or preserving the natural tooth by root canal treatment. A recent systematic review comparing the two of the most common treatment options – root canals and dental implants – found virtually equal success, or survival rates, between both treatments. Since the comparative analysis uncovered no significant differences in the success rates between the two options, the researchers emphasize that treatment decisions must be based on factors other than outcome, such as case complexity or the patient's individual health and preferences. He recommended treatment must be safe, mindful of the patient's wishes, and should aim at preserving the natural tooth when possible,‖ said Dr. Goldstein. However, despite this similarity, the authors conclude that the priority should always be to preserve the natural tooth before extracting and replacing with an implant[105].

CONTROVERSIES IN SUCCESS Vs FAILURE OF ROOT CANAL TREATMENT SUCCESS VERSUS FAILURE

The highest failure rate (16.6%) was in endodontic retreatment cases. Symptomatic cases were twice as likely to fail as were asymptomatic cases (10.6% versus 5.0%). A Japanese study followed one-visit cases for as long as 40 months and reported an 86% success rate. Oliet again found no statistical significance between his two groups. The majority of the postgraduate directors of endodontics also felt that the chance of successful healing was equal for either type of therapy. The original investigators in this field, Fox et al., Wolch, Soltanoff, and Ether et al., were convinced that singlevisit root canal therapy could be just as successful as multiple-visit therapy[106].

SINGLE VISIT VS MULTIPLE VISIT

Single- versus multiple-visit root canal treatment has been the subject of longstanding debate in the endodontic community. In fact, the attempt to complete root canal treatment in one visit has been documented since the end of the nineteenth century, yet we have not come to a definitive conclusion. Some of the unresolved issues include differences in clinical outcomes, inadequate microbiological control and pain. This controversy can be investigated more systematically with the aid of an evidence-based approach[107]. When clinicians are faced with choices of which treatment should be offered to patients, the central issues that should be considered are effectiveness, complications, cost and probably patient/operator satisfaction. It has been established that the current best available evidence has failed to demonstrate a difference in therapeutic efficacy (healing rates) between these two treatment regimens in teeth with necrotic pulps and apical periodontitis[108]. Complications of these two treatment approaches, though, have not yet been studied systematically.

Pain and swelling are often indicators of an existing disease process associated with an offending tooth. Endodontic treatment aims to reverse the disease process and thereby eliminate the associated signs and symptoms. When the treatment itself appears to initiate the onset of pain and/or swelling, the result can be very distressing to both the patient and the operator. Patients might even consider postoperative pain and flare-up as a benchmark against which the clinician‘s skills are measured. Prevalence of postoperative pain or flare-up is, therefore, one of the influencing

factors when making a clinical decision. Obviously, the treatment with the lower prevalence of postoperative pain is usually the treatment of choice as long as effectiveness and cost are not compromised. Even though postoperative pain in endodontics is not a particularly good outcome measure because it tends to be transient, it has been widely used as an argument either for or against single-visit root canal treatment. A majority of endodontists in the United States 25 years ago believed that there would be more pain if treatment was completed in one appointment. Clinical decision making, however, should be based on the best clinical evidence rather than consensus[109].

Apical periodontitis present

Two studies were available in this category; one prospective cohort (Ng et al. 2004) and one retrospective cohort[110]. Prevalence of postoperative pain was significantly higher in single visit root canal treatment in (P-value < 0.001)[111].The odds of postoperative pain occurring in association with single-visit root canal treatment were 2.8 times that of multiple-visit treatment (odds ratio = 2.8; 95% CI: 1.7–4.7). Eleazer & Eleazer reported opposite results using flare-up rate as an outcome measure. Prevalence of flare-up was significantly higher in a multiple-visit approach[110].

Apical periodontitis absent

Three studies were available in this group; two randomized controlled trials[112] and one prospective cohort study[113]. Postoperative pain was not significantly different between single- and multiple visit root canal treatment in these studies (P-value = 0.23, 0.16 and >0.9 Mann–Whitney U-test, Pearson uncorrected chi-square and Fisher exact test, respectively)[114].

Retreatment cases

Only one study was available in this category, which was a randomized controlled trial[115]. Prevalence of flare-up was significantly higher with a single-visit approach (Pvalue = 0.05; Fisher exact test). The odds of flare-up occurring in single-visit root canal retreatment were 4.9 times that of multiple-visit treatment (odds ratio = 4.9; 95% CI: 1.1–19). The study showed a significant disadvantage of single-visit retreatment in terms of the frequency of flare-up. However, the P-value just reached a significant level (P-value = 0.05).

Compelling evidence indicating a significantly different prevalence of postoperative pain/flare-up of either single- or multiple-visit root canal treatment is lacking. The low level of agreement amongst studies reflects the widely varying measures of pain severity, differences in treatment protocols and patient selection, as well as variability in treatment effects[114].

CONCLUSION

The scientific review presented here suggests that, if many of the different opinions prevailing in the endodontic field are to be resolved, there is considerable room for properly designed clinical studies. The most apparent gap in the published literature is the lack of randomized clinical trials, systematic reviews and meta-analysis which are needed to resolve issues that relate to proper management of pulpal and periodontal wounds, proper medication, and number of appointments for treatment of infected root canals.

Endodontic practice has to be depended on the combination of research work and clinical experience.

There is more than enough scientific literature available about endodontics which may create confusion for practitioners in managing cases. It is quite challenging for the clinician to select the best knowledge and technique to treat his/her patient. Finally it depends on multiple factors such as genetics, age, ethnicity, gender, body and psychological constitution, presence of systemic/debilitating diseases and attitude of patients along with the knowledge and skill of the clinician to bring about the best outcome of the treatment

Hence, clinician with profound knowledge about the disease dynamics, proper skill using proper techniques and studying the human as a whole is very important to get the best result.

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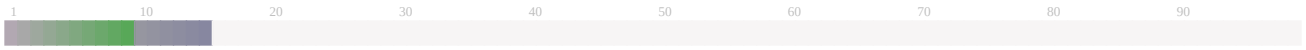

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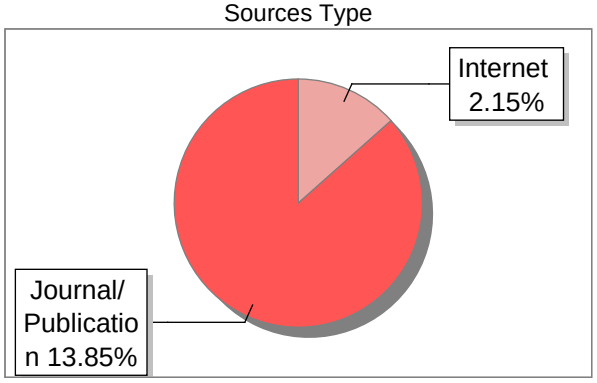

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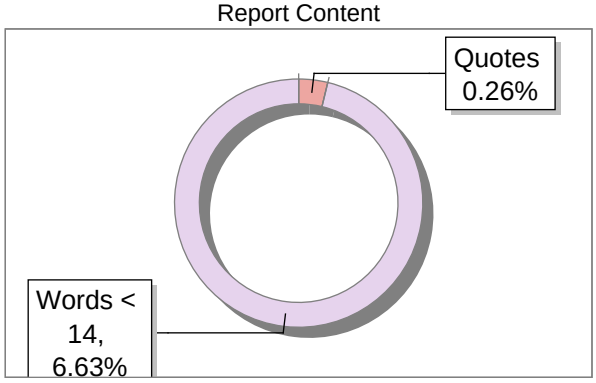

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Comparative evaluation of microleakage in class II cavities restored with snow plow technique using flowable or preheated packable bulk fill composite resin as gingival increment, by dye extraction method – an in vitro study

Abstract:

Context

One of the undesirable characteristics of dental composite resin is the polymerization shrinkage and the associated microleakage leading to failure.

Aim

To comparatively evaluate microleakage in class II cavities restored with snow plow technique using either preheated packable or flowable bulk fill composite resin.

Materials and methods

Fifty sound first molars were selected. Class II mesio occlusal box preparations were made. The test specimens were randomly divided into two groups. Group 1: Tetric N Flow bulk fill and Tetric N Ceram bulk fill co-cured in snow plow technique. Group 2: Tetric N Ceram bulk fill preheated to 60°C and Tetric N Ceram bulk fill co-cured in snow plow technique. Restored teeth were processed for dye extraction.

Statistical Analysis:

Mann-Whitney U test was applied to compare the microleakage between the groups.

Results

Results indicate that specimens in group 2 showed lower microleakage (median 0.041750) when compared to specimens in group 1 (median 0.059400).

Conclusion

The results imply that the preheated packable bulk fill composite resin showed less microleakage as compared to flowable composite while restoring class II cavities by the snow plow technique.

Keywords: Bulk fill, Dye extraction, Microleakage, Preheating, Snow plow

Introduction

Marginal adaptation and flow of dental composite resin remain a challenge while restoring deep class II preparations. To overcome this, the snow plow technique was introduced, in which a less viscous material is applied as gingival increment, overlayed by a more viscous material and co-cured.[1] Another method is by preheating packable composite resin, which ensures increased flow, a higher degree of polymerization and fewer marginal gaps.[2] This study was undertaken to evaluate microleakage in class II cavities restored with packable bulk fill composite resin with either preheated packable or flowable bulk fill composite resin as an initial increment in the snowplow technique.

Clinical relevance of the study – The use of preheated bulk fill composite resins and the snow plow technique of placement has the potential to improve flow and marginal adaptation thereby minimizing microleakage.

Methodology

50 human extracted mandibular molars were selected for this study with the following criteria.

Inclusion criteria – intact, non-carious, permanent mandibular molars.

Exclusion criteria – teeth with pre-existing caries, restoration, cracks, fractures, non-carious lesions like attrition, abrasion. All the selected teeth were cleaned and stored in 0.5% chloramine T solution (Pure-lab, Chem industry, India) for 48 hours, and then washed and transferred to distilled water. Standardized class II mesio occlusal box preparations were made with the following dimensions - 3mm buccolingually and 2mm mesiodistally. The gingival seat of the proximal box was placed 1 mm coronal to the cementoenamel junction. The specimens were then randomly divided into two groups of 25 teeth in each group for restorations. Samples of each group were mounted in contact with each other. Tofflemire matrix band and retainer were adapted to establish contact and to prevent gingival overhang of the restoration. The prepared cavity surfaces were etched with 37 % phosphoric acid (Eco-Etch, Ivoclar Vivadent: Schaan, Liechtenstein) for 15 s, rinsed and dried. Tetric N bond adhesive (Ivoclar Vivadent: Schaan, Liechtenstein) was applied to the

etched surface, gently air-dried, and light cured for 20 seconds.

In group 1, the flowable composite resin Tetric N flow (Ivoclar Vivadent: Schaan, Liechtenstein) was placed as the gingival increment and overlayed with packable bulk fill composite resin Tetric N Ceram (Ivoclar Vivadent: Schaan, Liechtenstein) in 4mm thickness. It was compacted such that the flowable composite resin was displaced into a thin layer. This was co-cured for 20 seconds, known as the snow plow technique. The rest of the preparation was restored with Tetric N Ceram bulk fill composite resin and light cured.

In group 2, Tetric N Ceram packable bulk fill composite resin was placed in the composite warmer (Endoking Dental resin composite heater, Endoking, India) and heated to 60°C. This preheated material was injected into the cavity as the gingival increment and overlayed with Tetric N Ceram packable bulk fill composite resin at room temperature in 4mm thickness and compacted together. This was co-cured for 20 seconds, known as the snow plow technique. The rest of the preparation was restored with Tetric N Ceram packable bulk fill

composite resin and light cured. All restorations were finished and polished.

The samples were then stored in artificial saliva (ICPA Health products, India) at 37°celsius for 24 hours. Just prior to subjecting the test specimens for dye extraction, they were subjected to thermocycling in a thermocycling unit (GSC Global Thermal cycling chamber, India) in a water bath at 5^0C and 55^0C, with a resting time of 30 seconds each, for 500 cycles. For microleakage assessment, the root apices of all the teeth were completely covered and sealed with sticky wax and nail varnish (Disguise Cosmetics, India) was coated onto the crown and root surfaces of the teeth entirely except for 1-2 mm around the margins of restorations. Specimens were then immersed in 2% methylene blue dye (Labogens, India) for 24 hours. After 24 hours, the specimens were rinsed under tap water to remove the traces of the dye. The nail varnish coating was removed using polishing discs (NMD Nexus Medodent, India).

The specimens were placed in vials containing 3 ml of 65 wt % nitric acid (Schwabe, India) for 72 hours. After 72 hours the vials were centrifuged (REMI R 8

laboratory centrifuge, India) at 5,000 rpm for 5 mins. The supernatant from the vials was transferred to cuvettes to be placed in the spectrophotometer. The dye absorbance value was measured in a UV-visible spectrophotometer (UV-1700 PharmaSpec UV vis Spectrometer, India) at 550nm.

Results

The results of the spectrophotometer indicated the dye absorbance of methylene blue at the resin-tooth interface due to microleakage around the restoration. SPSS (Statistical Package for Social Sciences) version 21. (IBM corporation: New York, USA) was used to perform the statistical analysis. A non-parametric test (Mann-Whitney U test) was applied as data showed a non-normal distribution. The level of significance was set at 5%. As shown in Table 1, the median microleakage score in teeth restored with group I was 0.059400 (IQR 0.0137), and group II was 0.041750 (IQR 0.0104). Mann-Whitney U test showed a statistically significant difference between the groups (p=0.001). Graphical representation of the results is depicted in Figure 1.

The results indicated that group II restored with pre-heated packable bulk fill composite resin (60^0 C) and packable bulk fill composite resin co-cured in snow plow technique showed lower microleakage as compared to group I restored with flowable bulk fill and packable bulk fill composite resin in snow plow technique.

Discussion

Placement of dental composite resin restoration requires adequate isolation, predictable adhesion protocol, material selection and appropriate placement technique, all of which can directly impact the outcome of the procedure.

Unlike amalgam, composite resin cannot be easily condensed into the cavity but has to be sculpted to all the regions of the prepared cavity, which in turn affects the proper adaptation of material to the preparation. [3] In addition to that, the cervical proximal margins in class II restorations are often considered challenging, as bonding is often less predictable due to insufficient or inaccessible enamel margins for bonding.[4] This

difficulty in obtaining intimate cavity adaptation will lead to incomplete marginal sealing and microleakage.[5]

There are several other factors that may lead to the increased risk of failure at the gingival margins of deep class II composite resin restorations, such as the exposure of the cavity surfaces to saliva, gingival crevicular fluid or blood and inadequate light penetration to the gingival margin.[6]

One of the most undesirable characteristics of composite resin is the polymerization shrinkage resulting in gap formation and microleakage.[7]

Microleakage has been defined as, "The clinically undetectable passage of bacteria, fluids, molecules or ions between cavity walls & the restorative material applied to it".[8] This may lead to sensitivity, secondary caries, pupal pathosis and restoration failure.[9] There have been a lot of studies done over the years on various methods to minimize the microleakage in composite resin restorations.

Snow plow technique is a new technique in which a less viscous material is applied as gingival increment, overlayed by packable composite resin and co-cured.

Subsequently, the remainder of the preparation is restored using packable composite resin. By ensuring that the flowable material is "pushed" into a highly thinned layer, the negative effects of polymerization shrinkage of a relatively thick layer of flowable, is reduced.[10] An in vitro study by Chuang et al, reported significantly lower microleakage with the snow plow technique using flowable and packable composite resins.[11]

However, in this study, the use of bulk-fill composite resins in the snow plow technique has the added benefit of reduced polymerization shrinkage owing to the incorporation of isofillers and novel photoinitiator ivocerin that improved the depth of cure. Tetric N-Ceram is has shown to exhibit good esthetic properties, easy handling and its clinical longevity. Tetric N-Ceram Bulk Fill and Tetric N-Flow Bulk Fill both contain "ivocerin" as the photoinitiator which is highly photoreactive and provides for increased depth of cure of up to 4mm.[12] It also contains a patented "shrinkage stress reliever" with a low modulus of elasticity(10GPa) that effectively reduces the stress during

polymerization.

The other method employed in the current study is the preheating of composite resins. The warming method is designed to produce a "flowable" viscosity in a packable composite resin. This can be attributed to the thermal energy produced due to preheating that causes the monomers within the resin matrix to move further apart by readily sliding over each other. various studies have shown that preheating composite resins reduces their viscosity and improves the flow, allowing for better adaptation.[13] Studies have also shown an improvement in physical properties, such as a higher degree of conversion and lower polymerization shrinkage.[14,15]

A systematic review by Lopes et al concluded that the preheating of composite resins is safe for clinical use and that there may be some benefit in enhancing the marginal seal without negatively affecting other properties.[16]

The average composite resin preheating temperature found in the literature is 54°C to 68°C, considered a safe temperature range without causing damage to the pulp

tissue.[17,18] Hence in this study, dental composite resin was preheated to 60°C. The temperature of the preheated material does not remain the same throughout the restorative procedure. Studies have demonstrated almost a 50% rapid drop in temperature of the material within 2 minutes of its removal from the heating device.[19]

A pulp temperature rise of more than 5.5°C is considered potentially damaging to the human pulp tissue and the adequate remaining dentin thickness is an important factor that provides a thermal barrier against any harmful stimuli.[20]

After completing the restorations, the specimens were subjected to thermocycling. Thermocycling is an invitro process of subjecting the specimens to extremes of temperature to simulate oral conditions.

To assess the sealing efficiency of the restorative material & microleakage, the specimens were immersed in 2% methylene blue dye for dye extraction because it is economical, and the particle size of this dye is less than the internal diameter of dentinal tubules (1-4 μm) and can show dentin permeability. In the dye extraction

method, teeth are dissolved in acids that release all dye from the interface and the optical density of the solution is measured by adsorbing light via a spectrophotometer. The dye extraction method presents a benefit over the fluid filtration technique, as filtration values tend to diminish over time, as the water penetrates all irregularities until a plateau is reached.[20]

In the present study, results showed microleakage scores in teeth restored with group I with a median of 0.059400 (IQR 0.0137) and in group II with a median of 0.041750 (IQR 0.0104). Group II showed lower microleakage than group I and the results were statistically significant ($P<0.05$). The results indicate that group II comprising teeth restored with pre-heated packable bulk fill composite resin (to 60^0 C) and packable bulk fill composite resin co-cured in snow plow technique showed lower microleakage when compared to group I with teeth restored with flowable composite resin and packable bulk fill composite resin co-cured in snow plow technique.

This can be attributed to the snow plow technique that allows the less viscous material to flow into the

preparation and allows for better marginal adaptation, thereby reducing the microleakage. Also, preheating of the dental composite resin lowers viscosity and thereby improves adaptation along with an improvement of physical properties, such as lower polymerization shrinkage and a higher degree of monomer conversion.

Conclusion

Within the limitations of the present study, it can be concluded that,

- Class II restorations in both the groups, placed in snow plow technique, using flowable bulk fill and preheated packable bulk fill composite resin, exhibited some amount of microleakage.
- Among the two experimental groups, group II samples restored in snow plow technique with pre-heated (60^0 C) packable bulk fill composite resin exhibited lesser microleakage values (Median of 0.041750) than the group I samples (Median of 0.059400). The difference between the two groups was statistically significant.
- The results imply that the preheated packable bulk

fill composite resin as gingival increment in the snow plow technique has shown better marginal adaptation. Thus, reducing microleakage as compared to flowable composite resin, while restoring class II cavities by snow plow technique.

However, further long-term in vitro and in vivo studies are required with the snow plow technique using other bulk fill and packable materials, in much deeper class II cavities and varying preheating temperatures, before we extrapolate the results to clinical situations.

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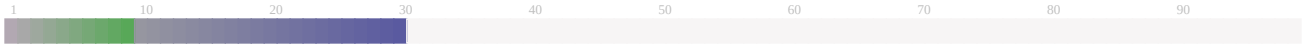

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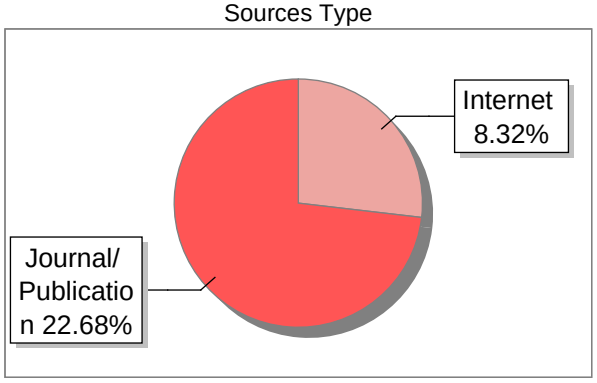

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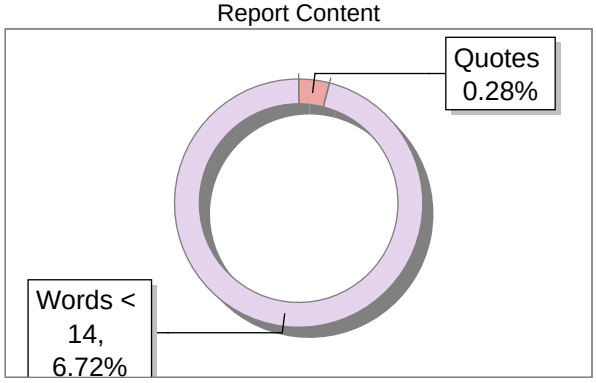

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Comparative evaluation of microleakage in class II cavities restored with snow plow technique using flowable or preheated packable bulk fill composite resin as gingival increment, by dye extraction method – an in vitro study

Abstract:

Context

One of the undesirable characteristics of dental composite resin is the polymerization shrinkage and the associated microleakage leading to failure.

Aim

To comparatively evaluate microleakage in class II cavities restored with snow plow technique using flowable or preheated packable bulk fill composite resin as gingival increment.

Materials and methods

Fifty sound first molars were selected. Class II mesio occlusal box preparations were made. The test specimens were randomly divided into two groups. Group 1: Tetric N Flow bulk fill and Tetric N Ceram bulk fill co-cured in snow plow technique. Group 2: Tetric N Ceram bulk fill preheated to 60°C and Tetric N Ceram bulk fill co-cured in snow plow technique. Restored teeth were processed for dye extraction.

Statistical Analysis:

Mann-Whitney U test was applied to compare the microleakage between the groups.

Results

Results indicate that specimens in group 2 showed lower microleakage (median 0.041750) when compared to specimens in group 1 (median 0.059400).

Conclusion

The results imply that the preheated packable bulk fill composite resin as gingival increment showed less microleakage as compared to flowable composite while restoring class II cavities by the snow plow technique.

Keywords: Bulk fill, Dye extraction, Microleakage, Preheating, Snow plow

Introduction

Marginal adaptation and flow of dental composite resin remain a challenge while restoring deep class II preparations. To overcome this, the snow plow technique was introduced, in which a less viscous material is applied as gingival increment, overlayed by a more viscous material and co-cured.[1] Another method is by preheating packable composite resin, which ensures increased flow, a higher degree of polymerization and fewer marginal gaps.[2] This study was undertaken to evaluate microleakage in class II cavities restored with packable bulk fill composite resin with either flowable or preheated packable bulk fill composite resin as gingival increment in the snowplow technique.

Methodology

50 extracted mandibular molars free of caries, cracks, decay and restorations were selected for this study. All the selected teeth were cleaned and stored in 0.5% chloramine T solution for 48 hours, and then washed and transferred to 0.9% saline solution. Standardized

class II mesio occlusal box preparations were made with the following dimensions - 3mm buccolingually and 2mm mesiodistally. The gingival seat of the proximal box was placed 1 mm coronal to the cementoenamel junction. The samples were randomly assigned into two groups of 25 teeth in each group for restorations. Samples of each group were mounted in contact with each other. Tofflemire matrix band and retainer were adapted to establish contact and to prevent gingival overhang of the restoration. The prepared cavity surfaces were etched with 37 % phosphoric acid for 15 s, rinsed and dried. Tetric N bond adhesive was applied to the etched surface, gently air-dried, and cured for 20 seconds.

In group 1, Tetric N flow (flowable composite resin) was placed as the gingival increment and overlayed with Tetric N Ceram (packable bulk fill composite resin) in 4mm thickness. It was compacted such that the flowable composite resin was displaced into a thin layer. This was co-cured for 20 seconds, known as the snow plow technique. The rest of the preparation was filled with Tetric N Ceram bulk fill composite resin and

light cured.

In group 2, Tetric N Ceram (packable bulk fill) composite resin was placed in the composite warmer and heated to 60°C. This preheated material was injected into the cavity as the gingival increment and overlayed with Tetric N Ceram (packable bulk fill) composite resin at room temperature in 4mm thickness and compacted together. This was co-cured for 20 seconds, known as the snow plow technique. The rest of the cavity was filled with Tetric N Ceram (packable bulk fill) composite resin and light cured. All restorations were finished and polished.

The samples were then stored in distilled water for 24 hours at 37 °C and then subjected to thermocycling using a thermocycling apparatus in a water bath at 5^0C and 55^0C, with a dwell time of 30 seconds each, for 500 cycles. For microleakage assessment, the radicular apices of teeth were sealed with sticky wax and the root and crown surfaces of the teeth were completely covered with nail varnish except for 1-2 mm around the margins of restorations. Specimens were then immersed in 2% methylene blue dye for 24 hours. After 24 hours,

the samples were washed under tap water to remove the traces of the dye. The nail varnish was removed using polishing discs.

The teeth were placed in test tubes containing 3 ml of 65 wt % nitric acid for 3 days. Test tubes were centrifuged at 5,000 rpm for 5 mins. The supernatant from each sample was transferred to cuvettes. The dye absorbance was measured in a UV-visible spectrophotometer at 550nm.

Results

The results of the spectrophotometer indicated the dye absorbance of methylene blue at the resin-tooth interface due to microleakage around the restoration. SPSS (Statistical Package for Social Sciences) version 21. (IBM corporation: NY, USA) was used to perform the statistical analysis. A non-parametric test (Mann-Whitney U test) was applied as data showed a non-normal distribution. The level of significance was set at 5%. The median microleakage score in teeth restored with group I was 0.059400 (IQR 0.0137), and group II was 0.041750 (IQR 0.0104). Mann-Whitney U test showed a statistically significant difference between the

groups (p=0.001).

The results indicated that group II restored with pre-heated packable bulk fill composite resin (60^0 C) and packable bulk fill composite resin co-cured in snow plow technique showed lower microleakage as compared to group I restored with flowable bulk fill and packable bulk fill composite resin in snow plow technique.

Discussion

Placement of dental composite resin restoration requires adequate isolation, predictable adhesion protocol, material selection and appropriate placement technique, all of which can directly impact the outcome of the procedure.

Unlike amalgam, composite resin cannot be easily condensed into the cavity but has to be sculpted to all the regions of the prepared cavity, which in turn affects the proper adaptation of material to the preparation.[13, 4] In addition to that, the cervical proximal margins in class II restorations are often considered challenging, as bonding is often less predictable due to insufficient or

inaccessible enamel margins for bonding.[3] This difficulty in obtaining intimate cavity adaptation will lead to incomplete marginal sealing and microleakage.[5] [13] Several other factors may contribute to the increased risk of failure at the gingival margins of deep class II composite resin restorations, such as the exposure of the cavity surfaces to saliva, gingival crevicular fluid or blood and inadequate light penetration to the gingival margin.[6]

One of the most undesirable characteristics of composite resin is the polymerization shrinkage resulting in gap formation and microleakage.[7,8, 13,]

Microleakage has been defined as, "The clinically undetectable passage of bacteria, fluids, molecules or ions between cavity walls & the restorative material applied to it".[9] This may lead to sensitivity, secondary caries, pupal pathosis and restoration failure.[3] There have been a lot of studies done over the years on various methods to reduce the microleakage in class II composite restorations.

Snow plow technique is a new technique in which a less viscous material is applied as gingival increment,

overlayed by packable composite resin and co-cured. Subsequently, the rest of the preparation is restored with packable composite resin.[10] By ensuring that the flowable material is "pushed" into a highly thinned layer, the negative effects of polymerization shrinkage of a relatively thick layer of flowable, is reduced. An in vitro study by Chuang et al, reported significantly lower microleakage with the snow plow technique using flowable and packable composite resins.[11]

However, in this study, the use of bulk-fill composite resins in the snow plow technique has the added benefit of reduced polymerization shrinkage owing to the incorporation of isofillers and novel photoinitiator ivocerin that improved the depth of cure. Tetric N-Ceram is characterized by its excellent esthetic properties and easy handling as well as its clinical longevity. Tetric N-Ceram Bulk Fill and Tetric N-Flow Bulk Fill both contain "ivocerin" as the photoinitiator which is highly photoreactive and provides for increased depth of cure of up to 4mm.[12] It also contains a patented "shrinkage stress reliever" with a low modulus of elasticity(10GPa) that effectively reduces

the stress during polymerization.

The other method employed in the current study is the preheating of composite resins. The warming method is designed to produce a "flowable" viscosity in a packable composite resin. The theoretical basis for this behavior is that thermal energy forces the composite monomers or oligomers further apart, allowing them to slide by each other more readily. Studies have shown that heating resin composites lowers viscosity and thereby improves adaptation.[13] Studies have also shown an improvement in physical properties, such as a higher degree of conversion and lower polymerization shrinkage.[14,15]

A systematic review by Lopes et al concluded that the preheating of composite resins is safe for clinical use and that there may be some benefit in enhancing the marginal seal without negatively affecting other properties.[16]

The average composite resin preheating temperature found in the literature is 54°C to 68°C, considered a safe temperature range without causing damage to the pulp tissue.[17,18] Hence in this study, dental composite resin

was preheated to 60°C. The temperature of the heated material placed into the cavity is not the same throughout as there is a rapid dropping of temperature of approximately 50% in 2 min counted after removing the material from the heating device.[19]

A pulp temperature rise of 5.5 °C is considered as the potential damaging threshold for human pulp tissue and the adequate remaining dentin thickness still appears to be one of the most important factors for the protection of the pulp since dentin acts as a thermal barrier against harmful stimuli.[20]

After completing the restorations, the specimens were subjected to thermocycling. Thermocycling is an invitro process of subjecting the specimens to extremes of temperature to simulate oral conditions.

To assess the sealing efficiency of restorative material & microleakage, 2% methylene blue dye was chosen for dye extraction because it is simple and economical, the particle size of this dye is less than the internal diameter of dentinal tubules (1-4 µm) and can show dentin permeability. In the dye extraction method, teeth are dissolved in acids that release all dye from the interface

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This can be attributed to the snow plow technique that allows the less viscous material to flow into the preparation and allows for better marginal adaptation,

thereby reducing the microleakage. Also, preheating of the dental composite resin lowers viscosity and thereby improves adaptation along with an improvement of physical properties, such as a higher degree of conversion and lower polymerization shrinkage.

Conclusion

Within the limitations of the present study, it can be concluded that,

- Class II restorations in both the groups, placed in snow plow technique, using flowable bulk fill and preheated packable bulk fill composite resin, exhibited some amount of microleakage.
- Among the two experimental groups, group II samples restored in snow plow technique with pre-heated (60^0 C) packable bulk fill composite resin exhibited lesser microleakage values (Median of 0.041750) than the group I samples (Median of 0.059400). The difference between the two groups was statistically significant.
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snow plow technique has shown better marginal adaptation. Thus, reducing microleakage as compared to flowable composite resin, while restoring class II cavities by snow plow technique.

However, further long-term in vitro and in vivo studies are required with the snow plow technique using other bulk fill and packable materials, in much deeper class II cavities and varying preheating temperatures, before we extrapolate the results to clinical situations.

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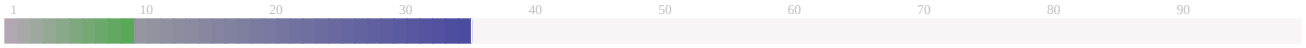

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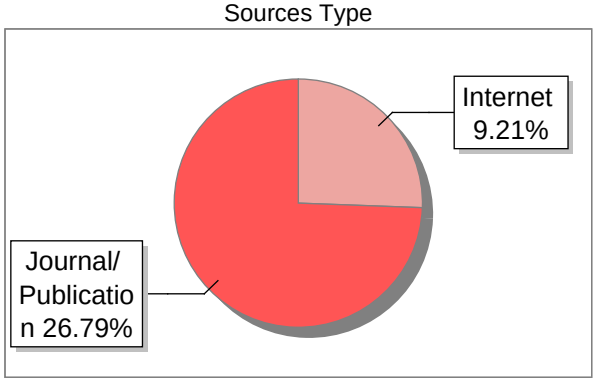

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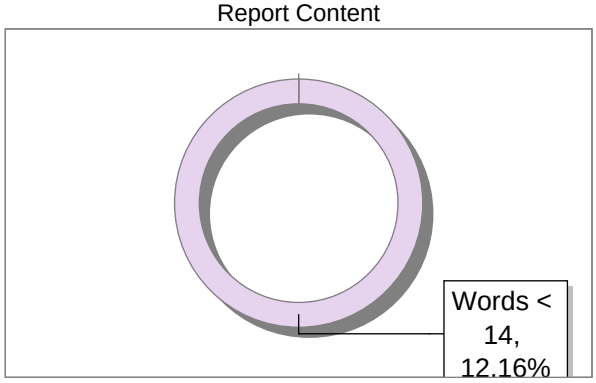

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BACKGROUND

Gingival hyperpigmentation is a significant concern for many patients, presenting challenges for periodontists due to the aesthetic issues associated with dark gums. Approximately 15% of Europeans experience oral pigmentation, with the prevalence rising to 80% in the Asian population. [1] Healthy gingiva can range in color from pale pink to deep bluish-purple, with variations largely influenced by factors such as melanogenesis intensity, keratinization, epithelial thickness, and vascularity. [2] While gingival hyperpigmentation is physiological and does not cause systemic issues, it often becomes an aesthetic concern, especially in individuals with a high lip line or gummy smile. [3,4]

Various techniques have been developed to address gingival hyperpigmentation, including surgical, electrosurgical, rotary, cryosurgical, free gingival grafts, and laser treatments. [5,6] Scalpel surgery is noted for its simplicity, effectiveness, and cost-efficiency. The rotary technique is also relatively easy and safe, allowing for repeat procedures if residual pigmentation remains. The electrosurgical technique works by using electrical energy to disrupt melanin cells in the treatment area. More recently, lasers have gained recognition for their effectiveness in removing melanin pigmentation by ablating epithelial tissues; this process requires the presence of melanin within the laser's penetration range, which absorbs light energy and converts it into heat through photo-thermolysis. [7]

Gingival re-pigmentation can occur post-treatment due to the migration of melanocytes from adjacent areas. This study aimed to evaluate and compare the clinical efficacy of scalpel, rotary, electrocautery, and laser techniques for gingival depigmentation by measuring the reduction in the Dummet Oral Pigmentation Index (DOPI) score from baseline to six months. Additionally, the study assessed pain perception using the Visual Analog Scale and gathered patient preferences regarding their overall treatment experiences.

METHODS

The clinical study received approval from the Research and Ethics Committee and is registered with the Clinical Trials Registry - India (CTRI) [Registration number: CTRI/2017/09/009873].

It utilized a randomized, double-blind (for both patients and evaluators), split-mouth design, with each quadrant of the mouth receiving a different depigmentation technique. Quadrant allocation was determined through random drawing using Microsoft Excel. A total of 51 patients were screened for inclusion and exclusion criteria related to gingival pigmentation, measured using the Dummet Oral Pigmentation Index (DOPI) [8] scoring system. Ultimately, 20 patients (13 females and 7 males, ages 20-35) with a DOPI score of 2 or higher were included. Exclusion criteria included systemic diseases contraindicating periodontal surgery, untreated periodontal or pulpal diseases, dentinal hypersensitivity, pathological hyperpigmentation, chronic smokers, and pregnant or lactating women. A thorough intraoral examination and detailed medical history were conducted to rule out pathological gingival hyperpigmentation.

The primary outcome of the study was the clinical efficacy of the four depigmentation techniques, measured by changes in DOPI scores. Secondary outcomes included postoperative pain assessed through the Visual Analog Scale and patient preferences regarding their overall experiences. To ensure double blinding, clinical settings, operating areas, and instruments were standardized. All procedures were performed by a single trained clinician in a separate room from where evaluations for DOPI scores (at baseline and six months) and pain (at 24 hours and one week) took place. Randomization was coded alphanumerically to maintain blinding, and a statistician analysed coded data to conceal treatment identities.

CLINICAL PROCEDURE

Electro surgery: After adequate anesthesia, BONART ART-E1 Elextrosurgery unit (J02887), Bionart Medical Technology Inc were used for gingival depigmentation. Needle and loop electrodes were used with light brushing strokes and the tip was kept in motion throughout. Prolonged repeated application of electrode to the tissues was avoided to prevent undesired tissue destruction (Figure 1). Patients from all the groups

were instructed to avoid eating hot, hard and spicy food for the first 24 h following the procedure. Antibiotics amoxicillin 500 mg thrice daily for 5 days and to start using 0.2% chlorhexidine gluconate mouth wash from next day, 12th hourly for 1 week.

Diode Laser: After obtaining adequate anesthesia, laser assisted depigmentation was performed using Indium Gallium Arsenide Phosphorous Diode Laser (InGaAsP, Epic™10, Biolase, USA) with strict adherence to safety measures according to manufacturer's instructions. Parameters such as energy output, and pulse duration, were determined prior to the initiation of the procedure. The InGaAsP diode laser (940nm) was set at 2 to 4 W power and tissue ablation was performed with short light paint brush strokes in a horizontal direction to remove the epithelial lining and expose connective tissue bed in a contact, continuous wave mode (Figure 2).

Rotary: After obtaining adequate anesthesia, Gingival depigmentation was carried out using high speed hand piece with a large size flame shaped diamond bur in feather, light brushing strokes supplemented with continuous saline irrigation to remove the pigmented layer and expose smooth and uniform connective tissue bed. Small sized burs were avoided as it has a tendency to make small pits in the area to be corrected. Care was taken to see that all remnants of the pigment layer are removed and the surgical area was covered with a periodontal dressing for a period of 1 week (Figure 3).

Scalpel technique: After obtaining adequate anesthesia, partial thickness flap was raised using bard parker blade number 11/15 from marginal gingiva to mucogingival junction to excise pigmented epithelium completely and connective tissue bed was exposed. The exposed connective tissue was carefully examined and any remaining tissue tags was removed using surgical scissors. Bleeding was controlled using a pressure pack and once hemostasis was achieved, the surgical site was covered by periodontal dressing for a period of 1 week (Figure 4).

Clinical Assessment Dummett oral pigmentation index [8] (DOPI): Based on DOPI scores the intensity of pigmentation was measured at baseline and 6 months postoperatively. 0 = pink tissue (no clinical pigmentation); 1 = mild light brown tissue (mild clinical pigmentation); 2 = medium brown or mixed brown and pink tissue (moderate clinical pigmentation); or 3 = deep brown/ blue–black tissue (heavy clinical pigmentation).

Evaluation of pain response [9,10]**:**

From all the four groups were asked to define the level of pain and discomfort experienced with respective treatment mode by using the Visual Analog Scale (VAS). Pain was assessed on a 10cm horizontal, continuous interval scale with the left endpoint marked 'no pain' and the right endpoint marked 'severe pain'. The patients were asked to mark to according to the level of pain. Scores were calculated as follows: 0 = no pain; 0.1 to 3.0 cm = slight pain; 3.1 to 6.0 cm = moderate pain; 6.1 to 10 cm = severe pain. Pain levels were evaluated at 24 hours and 1 week post-operatively. Each patient was given a separate single assessment sheet for all three time periods so that the patients are not encouraged to refer to the previous VAS markings.

Evaluation of clinical outcome of depigmentation: [13]

Subjects from all the four groups were followed up at a regular interval, for a period of six months. Clinical examination to check for any signs of re-pigmentation was done according to Dummett-Gupta Oral Pigmentation Index scoring criteria given by Dummett C.O. in 1964.

Patient perception of the treatment.

At the day1 and 6 months' postoperative visit patients were asked about comfort during treatment and opinion regarding the overall esthetic outcome respectively. Accordingly, patients were asked to identify the preferred modality.

Statistical analysis

Data analyses were performed using statistical software. To test the statistical significance of difference of quantitative variables, one-way analysis of variance (ANOVA) test with the necessary Bonferroni correction for multiple comparisons was performed. Paired t test was used to test the statistical significance of difference between the baseline and 6-month parameters. P <0.005 was considered statistically significant. All the hypotheses were formulated using two-tailed alternatives against each null hypothesis.

Results

Visual analogue scale score:

The mean VAS scores obtained at 24 h and one week postoperatively for all the four groups (Cautery, Laser, Rotary and scalpel) are presented in table 1. The intragroup comparison of VAS scores of 24 h and one-week post op was made using paired t test and the results found that at1week postoperatively, there was a significant drop in the VAS for all four groups ($P < 0.001$), which was statistically significant. P values as obtained by ANOVA with Bonferroni's correction for multiple comparisons at the day 1 postoperative visit are represented in table 2. The results of intergroup comparison suggested that the laser treated group displayed least amount of pain, followed by cautery, rotary and then scalpel. Difference was statistically significant for cautery v/s scalpel, laser v/s rotary and laser v/s scalpel.

Table 1 Visual Analogue Score (Intra group comparison at 24 h and one-week post op)

Comparison of Clinical pigmentation at baseline and 6 Months

The intra group comparison for changes in area of pigmentation from baseline to 6 months postoperatively was done by paired t test. Mean values for intragroup comparison were calculated and the difference was found to be statistically significant ($P<0.0001$*) for all the four groups (Table 3). The intergroup comparison of effectiveness of depigmentation was as follows Laser ≥ Cautery ≥ Rotary ≥ Scalpel, however difference was not statistically significant ($P \geq 0.05$). Figure 5 depicts the comparison of clinical pigmentation at baseline and 6 months.

Preference of Treatment Procedure

Patients were asked rate each treatment modality of depigmentation in terms of amount of pain and overall esthetic outcome at the end of 6 months. A significantly higher number of patients preferred laser first (40%), followed by rotary (25%) surgical stripping (20%) and cautery (15%).

Discussion

The present study evaluated and compared four gingival depigmentation techniques: surgical stripping, rotary, electrocautery, and diode laser. Clinical outcomes were assessed based on pain perception at 24 hours and one week postoperatively using Visual Analog Scale (VAS) scores, changes in the Dummet Oral Pigmentation Index (DOPI) scores from baseline to six months, and patient preferences based on overall experience.

VAS results indicated that the laser treatment resulted in the least pain, followed by electrocautery, scalpel, and rotary methods. The minimal pain experienced in the laser group is attributed to its disruption of the Na+-K+ pump and the ablation of nerve endings due to protein coagulum formation. [11] Electrocautery also creates a protein coagulum, acting as a biological dressing that reduces pain. In contrast, surgical stripping and rotary procedures leave raw, bleeding surfaces with exposed nerve endings, leading to increased postoperative pain. These findings are consistent with previous studies, showing that lasers provide analgesic benefits that enhance patient acceptance compared to traditional methods. [13]

One-week post-treatment, healing was satisfactory in all groups, except for a slight delay in the electrocautery group. Scalpel and rotary techniques expose the connective tissue bed and depend on tactile sensation, allowing for minimized tissue penetration and wound size. Diode lasers (810 nm GaAlAs and 980 nm InGaAsP) penetrate deeply due to low water absorption, effectively targeting hemoglobin and pigmented tissue, which promotes faster healing. [12,14] These lasers enable controlled cutting with limited necrosis, whereas electrocautery risks damage to surrounding tissues, potentially leading to delayed healing. [9] The findings align with previous studies by Shalu Chandna et al. and Bhusari et al. [15, 16]

After six months, 10% of the laser-treated quadrants showed mild clinical re-pigmentation (DOPI score of 1), compared to 15% in the electrocautery group, 25% in the rotary group, and 30% in the scalpel group, all considered aesthetically acceptable.

The findings of the present study are in comparison with by previous studies by MB Murthy et al. [17] Overall, at Laser and electrocautery group displayed minimal gingival re-pigmentation compared to scalpel and rotary technique. This can be explained by their ability to thermally damage the melanocytes. [18] On the other hand, though surgical stripping or rotary method offers no risk of thermal damage to the underlying structures, they are associated with higher rates of gingival re-pigmentation owing to incomplete removal of hyper pigmented tissue. [19]

Patient ratings indicated a preference for the laser technique, which was favored for minimal pain, shorter operating time, and less bleeding. Electrocautery, while providing good aesthetic outcomes, had drawbacks such as unpleasant odors and delayed healing. The split-mouth design of the study reduced variability and required fewer subjects compared to parallel group designs. [20] Overall, the study concluded that laser depigmentation is the most effective method, although further long-term studies with larger sample sizes and additional clinical parameters are necessary to validate these findings.

Conclusion

Despite the limitations of this study, laser treatment emerged as the most effective modality, offering optimal aesthetics, minimal postoperative re-pigmentation, and higher patient acceptance compared to electrocautery, scalpel, and rotary techniques. However, further large-scale multicentric studies with larger sample sizes are necessary to validate these findings.

Figure legends:

Figure 1: CONSORT flow diagram

Figure 2- Electrocautery depigmentation a) preoperative view b) intra-operative c)immediate post-operative d) one-week post-operative e) six-month post-operative image.

Figure 3- Laser depigmentation a) preoperative view b) intra-operative c) immediate Postoperative d) one-week post-operative e) six-month post-operative image.

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Figure 5- Scalpel depigmentation a) preoperative view b) intra-operative c) immediate Postoperative d) one-week post-operative e) six-month post-operative image.

List of abbreviations:

1. VAS: Visual analogue scale
2. DOPI: Dummet Oral Pigmentation Index
3. InGaAsP: Indium Gallium Arsenide Phosphorous Diode Laser

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Consent for publication: The patients were informed that the intraoral images of the surgical area would be utilized for scientific communications, while maintaining the confidentiality of the patient (these points were included in the informed consent).

Availability of data and material: The datasets generated and analysed during the current study is available from the corresponding author on reasonable request.

Funding: Authors did not receive funds for the study.

Acknowledgments: Not Applicable

Conflicts of interest: There are no conflicts of interest

TABLES

	Cautery		Laser		Rotary		Scalpel	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
24 h post op	3.38	1.880649	3.45	1.234376	5.35	2.084403	5.95	2.089447
1week post op	0	0	0	0	0	0	0	0
P value	P<0.0001*		P<0.0001*		P<0.0001*		P<0.0001*	

*Denotes significant difference

Table 2 Visual Analogue Scale (Inter group comparison at 24 h)

Cautery VS Laser	Cautery VS Rotary	Cautery VS Scalpel	Laser VS Rotary	Laser VS Scalpel	Rotary VS Scalpel
P ≥ 0.05	P ≥ 0.05	P<0.0001*	P<0.0001*	P<0.0001*	P ≥ 0.05

*Denotes significant difference

Table 3 Dummett oral pigmentation index (Intra group comparison at baseline and 6 months' post op)

	Cautery		Laser		Rotary		Scalpel	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Baseline	2.55	0.51	2.6	0.50	2.65	0.48	2.7	0.47
6 months	0.15	0.36	0.1	0.30	0.25	0.44	0.35	0.48
P value	P<0.0001*		P<0.0001*		P<0.0001*		P<0.0001*	

*Denotes significant difference

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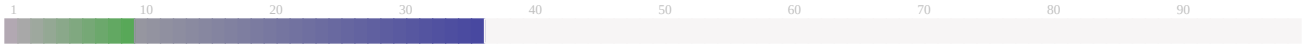

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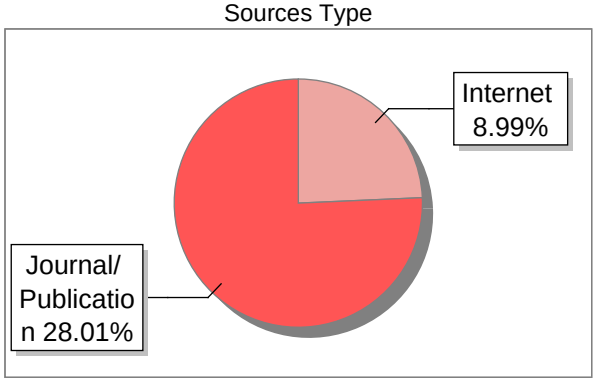

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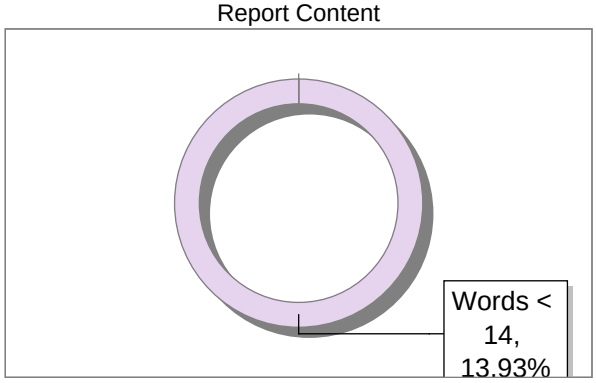

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BACKGROUND

Gingival hyperpigmentation is a significant concern for many patients, presenting challenges for periodontists due to the aesthetic issues associated with dark gums. Approximately 15% of Europeans experience oral pigmentation, with the prevalence rising to 80% in the Asian population. [1] Healthy gingiva can range in color from pale pink to deep bluish-purple, with variations largely influenced by factors such as melanogenesis intensity, keratinization, epithelial thickness, and vascularity. [2] While gingival hyperpigmentation is physiological and does not cause systemic issues, it often becomes an aesthetic concern, especially in individuals with a high lip line or gummy smile. [3,4]

Various techniques have been developed to address gingival hyperpigmentation, including surgical, electrosurgical, rotary, cryosurgical, free gingival grafts, and laser treatments. [5,6] Scalpel surgery is noted for its simplicity, effectiveness, and cost-efficiency. The rotary technique is also relatively easy and safe, allowing for repeat procedures if residual pigmentation remains. The electrosurgical technique works by using electrical energy to disrupt melanin cells in the treatment area. More recently, lasers have gained recognition for their effectiveness in removing melanin pigmentation by ablating epithelial tissues; this process requires the presence of melanin within the laser's penetration range, which absorbs light energy and converts it into heat through photo-thermolysis. [7]

Gingival re-pigmentation can occur post-treatment due to the migration of melanocytes from adjacent areas. This study aimed to evaluate and compare the clinical efficacy of scalpel, rotary, electrocautery, and laser techniques for gingival depigmentation by measuring the reduction in the Dummet Oral Pigmentation Index (DOPI) score from baseline to six months. Additionally, the study assessed pain perception using the Visual Analog Scale and gathered patient preferences regarding their overall treatment experiences.

METHODS

The clinical study received approval from the Research and Ethics Committee and is registered with the Clinical Trials Registry - India (CTRI) [Registration number: CTRI/2017/09/009873].

It utilized a randomized, double-blind (for both patients and evaluators), split-mouth design, with each quadrant of the mouth receiving a different depigmentation technique. Quadrant allocation was determined through random drawing using Microsoft Excel. A total of 51

patients were screened for inclusion and exclusion criteria related to gingival pigmentation, measured using the Dummet Oral Pigmentation Index (DOPI) [8] scoring system. Ultimately, 20 patients (13 females and 7 males, ages 20-35) with a DOPI score of 2 or higher were included. Exclusion criteria included systemic diseases contraindicating periodontal surgery, untreated periodontal or pulpal diseases, dentinal hypersensitivity, pathological hyperpigmentation, chronic smokers, and pregnant or lactating women. A thorough intraoral examination and detailed medical history were conducted to rule out pathological gingival hyperpigmentation.

The primary outcome of the study was the clinical efficacy of the four depigmentation techniques, measured by changes in DOPI scores. Secondary outcomes included postoperative pain assessed through the Visual Analog Scale and patient preferences regarding their overall experiences. To ensure double blinding, clinical settings, operating areas, and instruments were standardized. All procedures were performed by a single trained clinician in a separate room from where evaluations for DOPI scores (at baseline and six months) and pain (at 24 hours and one week) took place. Randomization was coded alphanumerically to maintain blinding, and a statistician analysed coded data to conceal treatment identities.

CLINICAL PROCEDURE

Electro surgery: After adequate anesthesia, BONART ART-E1 Elextrosurgery unit (J02887), Bionart Medical Technology Inc were used for gingival depigmentation. Needle and loop electrodes were used with light brushing strokes and the tip was kept in motion throughout. Prolonged repeated application of electrode to the tissues was avoided to prevent undesired tissue destruction (Figure 1). Patients from all the groups were instructed to avoid eating hot, hard and spicy food for the first 24 h following the procedure. Antibiotics amoxicillin 500 mg thrice daily for 5 days and to start using 0.2% chlorhexidine gluconate mouth wash from next day, 12th hourly for 1 week.

Diode Laser: After obtaining adequate anesthesia, laser assisted depigmentation was performed using Indium Gallium Arsenide Phosphorous Diode Laser (InGaAsP, Epic™10, Biolase, USA) with strict adherence to safety measures according to manufacturer's instructions. Parameters such as energy output, and pulse duration, were determined prior to the initiation of the procedure. The InGaAsP diode laser (940nm) was set at 2 to 4 W power and tissue ablation was performed with short light paint brush strokes in a horizontal direction to remove the epithelial lining and expose connective tissue bed in a contact, continuous wave mode (Figure 2).

Rotary: After obtaining adequate anesthesia, Gingival depigmentation was carried out using high speed hand piece with a large size flame shaped diamond bur in feather, light brushing strokes supplemented with continuous saline irrigation to remove the pigmented layer and expose smooth and uniform connective tissue bed. Small sized burs were avoided as it has a tendency to make small pits in the area to be corrected. Care was taken to see that all remnants of the pigment layer are removed and the surgical area was covered with a periodontal dressing for a period of 1 week (Figure 3).

Scalpel technique: After obtaining adequate anesthesia, partial thickness flap was raised using bard parker blade number 11/15 from marginal gingiva to mucogingival junction to excise pigmented epithelium completely and connective tissue bed was exposed. The exposed connective tissue was carefully examined and any remaining tissue tags was removed using surgical scissors. Bleeding was controlled using a pressure pack and once hemostasis was achieved, the surgical site was covered by periodontal dressing for a period of 1 week (Figure 4).

Clinical Assessment Dummett oral pigmentation index [8] (DOPI): Based on DOPI scores the intensity of pigmentation was measured at baseline and 6 months postoperatively. 0 = pink tissue (no clinical pigmentation); 1 = mild light brown tissue (mild clinical pigmentation); 2 = medium brown or mixed brown and pink tissue (moderate clinical pigmentation); or 3 = deep brown/ blue–black tissue (heavy clinical pigmentation).

Evaluation of pain response [9,10]:

From all the four groups were asked to define the level of pain and discomfort experienced with respective treatment mode by using the Visual Analog Scale (VAS). Pain was assessed on a 10cm horizontal, continuous interval scale with the left endpoint marked 'no pain' and the right endpoint marked 'severe pain'. The patients were asked to mark to according to the level of pain. Scores were calculated as follows: 0 = no pain; 0.1 to 3.0 cm = slight pain; 3.1 to 6.0 cm = moderate pain; 6.1 to 10 cm = severe pain. Pain levels were evaluated at 24 hours and 1 week post-operatively. Each patient was given a separate single assessment sheet for all three time periods so that the patients are not encouraged to refer to the previous VAS markings.

Evaluation of clinical outcome of depigmentation: [13]

Subjects from all the four groups were followed up at a regular interval, for a period of six months. Clinical examination to check for any signs of re-pigmentation was done according to Dummett-Gupta Oral Pigmentation Index scoring criteria given by Dummett C.O. in 1964.

Patient perception of the treatment.

At the day1 and 6 months' postoperative visit patients were asked about comfort during treatment and opinion regarding the overall esthetic outcome respectively. Accordingly, patients were asked to identify the preferred modality.

Statistical analysis

Data analyses were performed using statistical software. To test the statistical significance of difference of quantitative variables, one-way analysis of variance (ANOVA) test with the necessary Bonferroni correction for multiple comparisons was performed. Paired t test was used to test the statistical significance of difference between the baseline and 6-month parameters. P <0.005 was considered statistically significant. All the hypotheses were formulated using two-tailed alternatives against each null hypothesis.

RESULTS

Visual analogue scale score

The mean VAS scores obtained at 24 h and one week postoperatively for all the four groups (Cautery, Laser, Rotary and scalpel) are presented in table 1. The intragroup comparison of VAS scores of 24 h and one-week post op was made using paired t test and the results found that at1week postoperatively, there was a significant drop in the VAS for all four groups (P < 0.001), which was statistically significant. P values as obtained by ANOVA with Bonferroni's correction for multiple comparisons at the day 1 postoperative visit are represented in table 2. The results of intergroup comparison suggested that the laser treated group displayed least amount of pain, followed by cautery, rotary and then scalpel. Difference was statistically significant for cautery v/s scalpel, laser v/s rotary and laser v/s scalpel.

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Patients were asked rate each treatment modality of depigmentation in terms of amount of pain and overall esthetic outcome at the end of 6 months. A significantly higher number of patients preferred laser first (40%), followed by rotary (25%) surgical stripping (20%) and cautery (15%).

Discussion

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The present study evaluated and compared four gingival depigmentation techniques: surgical stripping, rotary, electrocautery, and diode laser. Clinical outcomes were assessed based on pain perception at 24 hours and one week postoperatively using Visual Analog Scale (VAS) scores, changes in the Dummet Oral Pigmentation Index (DOPI) scores from baseline to six months, and patient preferences based on overall experience.

VAS results indicated that the laser treatment resulted in the least pain, followed by electrocautery, scalpel, and rotary methods. The minimal pain experienced in the laser group is attributed to its disruption of the Na+-K+ pump and the ablation of nerve endings due to protein coagulum formation. [11] Electrocautery also creates a protein coagulum, acting as a biological dressing that reduces pain. In contrast, surgical stripping and rotary procedures leave raw, bleeding surfaces with exposed nerve endings, leading to increased postoperative pain. These findings are consistent with previous studies, showing that lasers provide analgesic benefits that enhance patient acceptance compared to traditional methods. [13]

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Conclusion

Despite the limitations of this study, laser treatment emerged as the most effective modality, offering optimal aesthetics, minimal postoperative re-pigmentation, and higher patient acceptance compared to electrocautery, scalpel, and rotary techniques. However, further large-scale multicentric studies with larger sample sizes are necessary to validate these findings.

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List of abbreviations:

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P value	P<0.0001*		P<0.0001*		P<0.0001*		P<0.0001*	

*Denotes significant difference

Table 2 Visual Analogue Scale (Inter group comparison at 24 h)

Cautery VS Laser	Cautery VS Rotary	Cautery VS Scalpel	Laser VS Rotary	Laser VS Scalpel	Rotary VS Scalpel
P ≥ 0.05	P ≥ 0.05	P<0.0001*	P<0.0001*	P<0.0001*	P ≥ 0.05

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Table 3 Dummett oral pigmentation index (Intra group comparison at baseline and 6 months' post op)

*Denotes significant difference

	Cautery		Laser		Rotary		Scalpel	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Baseline	2.55	0.51	2.6	0.50	2.65	0.48	2.7	0.47
6 months	0.15	0.36	0.1	0.30	0.25	0.44	0.35	0.48
P value	P<0.0001*		P<0.0001*		P<0.0001*		P<0.0001*	

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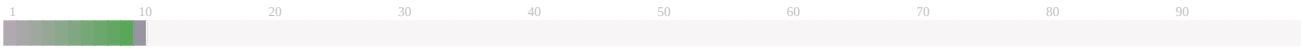

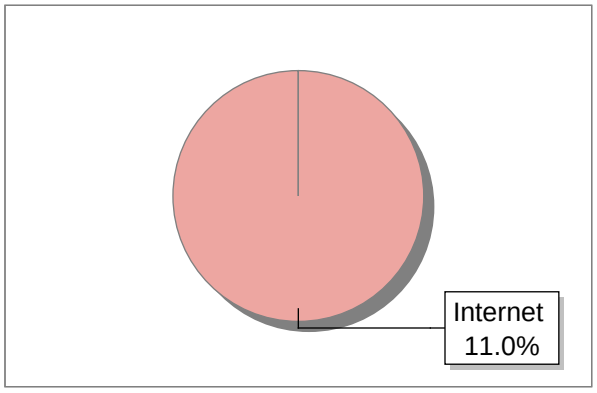

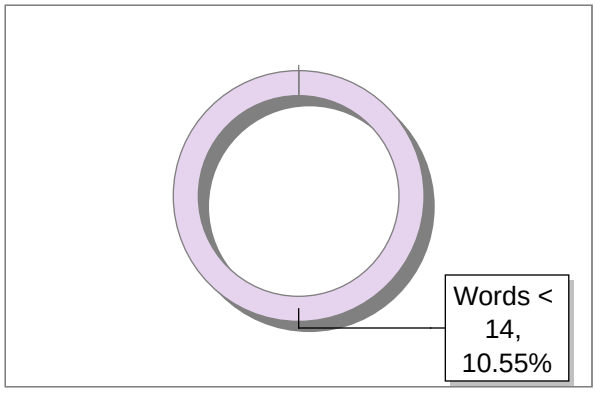

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Abstract:

Background

Regenerative endodontics are biologically based procedures to replace damaged structures, including dentin and root structures, as well as cells of the pulp-dentin complex. Success of these regenerative procedures depends on the survival of the stem cells. Antibiotic pastes used for microbial elimination are not used at high concentration because of its potential toxicity to the stem cells.Also, their usage at lower concentration raises many concerns. Phytomedicines because of their good efficacy and lesser adverse effects have been used extensively. Carnosic acid is one such phytomedicine which has proven to have a good effect against degenerative diseases because of their good regenerative potential. Moreover, studies have shown carnosic acid having better disinfection capacity than triple antibiotic pastes (TAP) as intracanal medicament. However, its regenerative potential in endodontics is yet to be known. Therefore, this study aims to investigate the cytotoxicity on the SCAPs of carnosic acid on permanent human teeth in comparison with triple antibiotic paste.

Aim and objective

To evaluate and compare the cytotoxic effect of carnosic acid on stem cells from the apical papilla (SCAPs) of permanent human teeth

Methodology

Stem cells removed from immature teeth were cultivated. After cultivation and third cell passage, modified TAP (metronidazole, ciprofloxacin, and clindamycin) and carnosic acid were placed in cell culture medium. After 1 and 3 days, cell viability in the culture medium was assessed using MTT method ([4,5-dimethylthiazol-2-yl]-2,5-diphenyltetrazolium bromide) and ELISA (Enzyme-linked immunosorbent assay).

Results

Carnosic acid has shown higher absorbance value and hence is less cytotoxic to stem cells than mTAP.

Conclusion

Within the limitations of the current study, it can be concluded that Carnosic acid has a lower cytotoxic effect on the SCAPs than mTAP. Hence, its use as ICM in regenerative endodontics looks promising. However, further clinical studies are required.

Keywords

Carnosic acid, intracanal medicaments, modified triple antibiotic paste, regeneration, stem cells

Key Messages:

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Text

Introduction:

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Regenerative endodontics is biologically based procedure intended to replace damaged structures, including dentin and root structures, as well as cells of the pulp-dentin complex and was first introduced by Dr Nygaard Ostby in 1961.[1] Three components of regenerative endodontics include stem cells, scaffold and growth factors.[2] The goals of this procedure comprises symptom elimination and healing, increasing root length and thickness and positive response to vitality testing.[2] Given that the reduction of microbial load in regenerative endodontics is achieved by proper irrigation and dressing, the selection of a proper material might be a critical factor for attaining effective canal disinfection, and the balance between the antimicrobial effect of chemicals and their inertness to stem cells.[3] Calcium hydroxide has been routinely used as intracanal dressing in the regenerative procedure.[4] Due to the polymicrobial nature of the root canal niche, antibiotic paste combinations were tried.[4]

Triple antibiotic paste consisted of metronidazole, minocycline and ciprofloxacin.[1] But the presence of minocycline poses the risk of staining and discoloration of the tooth.[5] Cefaclor, clarithromycin, clindamycin, amoxicillin and other antibiotics have been tried to overcome the problem of discoloration.[5] But, allergic potential, host immune resistance and concentration dependent survival of stem cells continued to be some of the challenges.The cytotoxic effect of TAP on primary pulp stem cells of deciduous teeth has also been reported. Also, there are concerns about the destructive effect of mTAP on the stem cells from the apical papilla (SCAPs) of immature permanent teeth.[4]

Hence, other phytochemicals such as carnosic acid obtained from the leaves of rosemary plant (Salvia rosmarinus) leaves which have both antimicrobial and antioxidant properties as suggested by Neito *et al*.[6] This material has shown good regenerative potential and low tissue toxicity as suggested by Mirza *et al*.[7]

However, there are not many studies comparing the cytotoxicity of carnosic acid and TAP on long term usage as ICM in regenerative procedures. Therefore, this study was designed to assess and compare the cytotoxicity of modified Triple antibiotic paste (mTAP) and Carnosic acid (CA) on Stem

cells of apical papilla (SCAPs) of extracted intact human mandibular third molars.

Subjects and Methods:

SAMPLE SELECTION

After obtaining informed consent from the patients, four healthy immature third molars with open apex (more than 1.5 mm diameter) extracted for orthodontic purpose in the age group of 17-21 years with no history of systemic diseases were extracted to obtain SCAPs. Teeth with caries, previous restoration, endodontic treatment, periapical pathosis and fully developed roots were excluded. Two to five days before tooth extraction, the patients underwent dental prophylaxis, and on the day of extraction, the patients received tooth prophylaxis as well. Before and after anaesthetic injection, patients were asked to rinse their mouth with 0.2% chlorhexidine mouthwash for 30 seconds.

HARVESTING OF SCAPs AND CULTURE

Teeth were extracted with sterile instruments and were immediately placed in sterile phosphate buffered saline (PBS) (™ Media). SCAPs were then isolated from the apical papilla tissue of incompletely developed tooth using sterile tweezers and placed in a digestive solution containing trypsin. It was made sure to change the cell culture medium every two days.Cell passage was performed after cell density in cell colonies reached about 80-70%. Third passage cells were used to assess the cytotoxicity of the drugs. Flow cytometric analysis was performed in the third passage to evaluate the nature of SCAPs and the expression of surface markers.

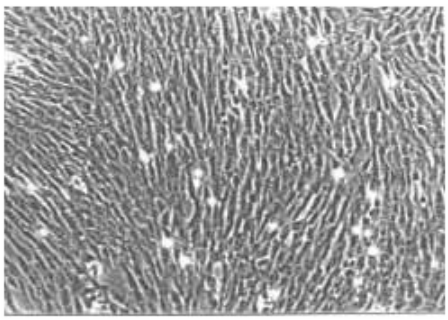

Fig 1- Cell density

PREPARATION OF ANTIBIOTICS

Antibiotic combination consisted of metronidazole (400 mg), ciprofloxacin (500 mg) and clindamycin (500 mg). Enteric coating of these medicines were removed and then crushed with the help of a clean mortar and pestle. Each antibiotic was weighed by a digital scale with an accuracy of 0.000g. Then 50 µg/ml of each medication was prepared and equal proportions of each medication in the prepared concentration was mixed for mTAP. >91% CA (Alpspure Lifesciences Private Ltd) was the other agent used. Solvent used for antibiotics was the cell culture medium. The prepared medications were added to cell culture plates. 24 and 72 hours later, cell viability in the culture medium was evaluated using the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide (MTT) method.

Group I : SCAPs exposed to a combination of mTAP over a period of 24 and 72 hours

Group II : SCAPs exposed to CA over a period of 24 and 72 hours

DATA ANALYSIS

Sample size of 60 was established pertaining to 60 wells in the microtiter plate. Absorbance value of each well for both the groups was measured through ELISA reader (Rayto, RT-2100C).

Statistical analysis was done using SPSS statistical software (version 26.0 IBM Corp.). Statistical tests such as Levene's test for equality of variances and independent t test for equality of means was calculated. The significance level in all tests was kept <0.05.

RESULTS

Group	N	Max (24 hrs)	Min (24 hrs)	Mean	Std. Deviation	p value
CA	60	0.05761	0.04736	0.05249	0.005124	<0.000001
TAP	60	0.04572	0.03802	0.04187	0.003851	

Group	N	Max (48 hrs)	Min (48hrs)	Mean	Std. Deviation	p value
CA	60	0.06043	0.05020	0.05532	0.005116	<0.000001
TAP	60	0.04653	0.03918	0.04286	0.003671	

Table 1 - Absorbance values of CA and TAP group at 24 and 48 hours interval

Absorbance values of the carnosic acid group are higher than the mTAP group both at 24 hours and 48 hours. Hence, CA is less cytotoxic on stem cells of apical papilla tha mTAP as an intracanal medicament.

Fig 2 - Graphical representation of results

DISCUSSION

Restoration of tissue continuity by exactly similar tissues without loss of original architecture & function is known as regeneration.[8] Regenerative endodontics aims at regenerating dentin and pulp like tissue.[2] Teeth with necrotic pulp and immature apex, which do not require post/core were indicated for the procedure.[1] Following proper irrigation protocol and disinfection strategy is very crucial; incomplete eradication of the bacterial load results in the change in stem cells phenotypic expression from dentinogenic to osteogenic type.[9]

Calcium hydroxide intracanal medication upregulates phosphorylated extracellular signal related kinases only at low conc. At higher concentrations, it has shown to affect SCAPs attachment. Different antibiotic combinations have also been tried and tested and have given quite promising results. But the development of resistant bacterial strains, allergic reactions and damage to DNA of SCs is quite concerning and points to look forward towards an alternative.[4]

Carnosic acid looks to be one such alternative in this field. A study by Loussouarn *et al* showed the antioxidant property of carnosic acid is due to the polyphenols present in it.[10] 4 phenolic hydrogen(-OH) inhibits the lipid peroxidation, fosters cell proliferation, mitosis and differentiation resulting in upregulation of the signalling pathway. The antimicrobial action is by interaction with the cell membrane resulting in leakage of cellular components. They interact with the cell membrane, causing change in the genetic material and nutrients, altering the transport of electrons, leakage of cellular components and change in fatty acid. In addition, it also produces an interaction with the membrane of proteins resulting in loss of membrane functionality and its structure.[10] Crozier *et al* reported CA to have anti-allergic potential. It inhibits allergen-induced phase responses including Ca^{2+} mobilization, ROS production and subsequent degranulation and late responses by modulation of tyrosine kinase Syk and downstream effectors TAK1 (Ser412) and Akt (Ser473) as well as NFκB signaling.[11] A study by Mirza *et al* property of carnosic acid to transcript cytoprotective genes.[7] According to

Zampini *et al*. it has a lower minimum inhibitory concentration (MIC) and is effective against multidrug resistant bacteria by acting as an effective pump modulator.[12]

The pluripotency of CA is through the upregulation of the KEGG pathway as described by Ferdousi *et al*. PDGFRB and ROCK1 upregulation is responsible for angiogenic growth and MAPK & IKBKB pathway being responsible for its ability for neo-neuronal growth.[13]

Dessai *et al* reported carnosic acid as an intracanal medicament performs better than triple antibiotic paste and calcium hydroxide to eradicate Enterococcus faecalis from root canal pointing towards its better antimicrobial efficacy.[14] The concentration responsible for antimicrobial action of CA is as low as 6.25-12.5 µM as reported by Othman *et al*.[15]

Mirza *et al* stated that Carnosic acid exerts a neuroprotective role that may serve to strategize novel therapeutic approaches for debilitating neurodegenerative disorders by regeneration.[7] Also, Lou *et al* reported rosemary to have the potential to stimulate hepatocyte proliferation leading to liver regeneration.[16]

The results obtained in this study shows a higher absorbance value for carnosic acid both at 24 hours and at 48 hours interval which is 0.05249 and 0.05532 respectively. Whereas, mTAP shows absorbance value of 0.04187 and 0.04286 at 24 and 48 hours respectively. This suggests the lower cytotoxic levels in the CA group and higher percentage of cell survival and is statistically significant. The reasons associated are the good antimicrobial efficacy at a lower concentration. This low concentration helped in stem cell survival, attachment, differentiation and proliferation. It is pluripotent in nature. Antibiotics have shown detrimental effects on stem cells, whereas carnosic acid has helped in the survival of those SCs.

CONCLUSION

Within the limitations of the current study, it can be concluded that Carnosic acid has a lower cytotoxic effect on the SCAPs than mTAP. Hence, its use as ICM in regenerative endodontics looks promising. However, further clinical studies are required.

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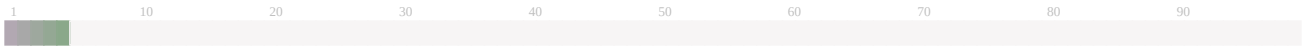

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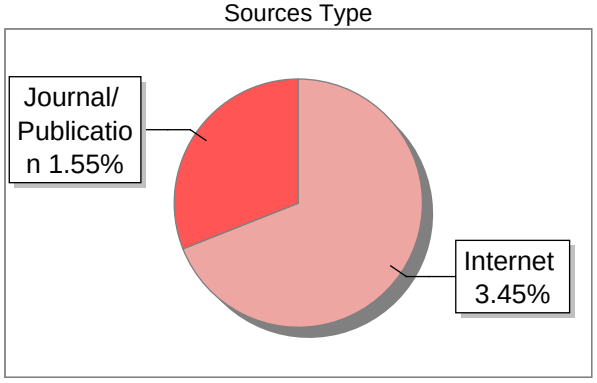

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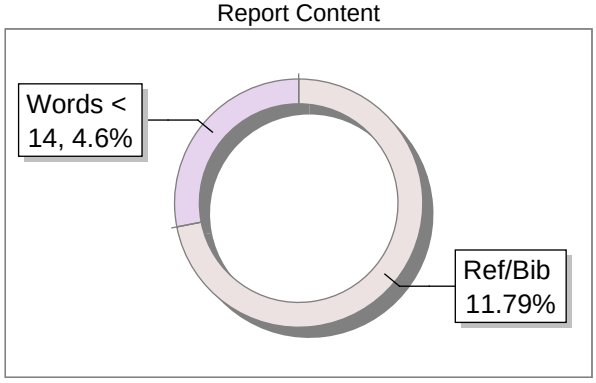

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Treatment of Skeletal Class II malocclusion with Obstructive Sleep Apnoea Using Orthodontic-Surgical Approach

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Abstract:

In the treatment of skeletal class 2 retrognathic mandible, the airway should be considered for the progress and outcome of the treatment, here we present a case of 30 year old male patient with class II skeletal base with maxillary and mandibular dentoalveolar protrusion, with crowding in the maxillary and mandibular arch, increased maxillary mandibular plane angle and increased lower anterior facial height, he had convex profile with potentially incompetent lips .He had nocturnal choking, difficulty in breathing while lying down and snoring suggestive of obstructive sleep apnoea. Bilateral saggital split osteotomy (BSSO) advancement of 8mm and genioplasty of 4mm was done. The post operative orthodontic treatment included settling the bite, monitoring the relapse, and managing the dental space for futu

Keywords: Obstructive sleep apnoea(OSA); Class 2 malocclusion; hyperdivergent facial type

INTRODUCTION

Approximately 14.6% of Indians have class II malocclusion. This circumstance be brought on by a mandibular deficiency or maxillary excess. The dentoalveolar position in growing patients may change if functional appliances are used and cause remodeling of the condyles. In Class II adults with skeletal deformities, Orthodontic camouflage or surgical-orthodontic treatment are the standard methods for treating malocclusion. On the other hand, dental compensation is utilized in orthodontic camouflage therapy to conceal the skeletal disparity. Additionally, the skeletal deformity is corrected with jaw osteotomies that rotate counterclockwise and orthodontic detailing in the surgical-orthodontic option.

Because surgical-orthodontic therapy promotes greater advancement of the mandible and chin and less retraction of the upper teeth, it is more successful in preserving the upper lip profile. As a result, patients with a more severe sagittal jawbone discrepancy—particularly those with mandible retrusion—typically undergo it. Notwithstanding the issues with oral function and appearance, patients with retrusive mandibles—particularly those with profiles resembling birds—need to have their airway health taken into account. When an airway is narrow, a lateral cephalometric film evaluation is necessary.

When the airway is significantly constricted, the AHI Index and polysomnography (PSG) could be necessary to identify if obstructive sleep apnea (OSA) is present.

A case report demonstrated the correction of skeletal Class II malocclusion with retrusive mandible.

CASE REPORT

A male patient named Paged 30 years came to the department with chief complaint of forwardly placed upper front teeth, reduced chin size & difficultyin breathing while lying down,nocturnal choking & snoring Familial malocclusion History:-His father has similar dental problems. He is internally motivated with positive attitude towards orthodontic treatment. On physical examination , he is moderately built with 168 cms in height weighs 64 kgs withmesomorphic body type.Patient had history of restless sleep ,Nocturnal choking & Witnessed apnea during sleep. Patient has undergone Sleep Studywith Somno Touch Resp.

CLINICAL EXAMINATION

Extraoral Examination

There was no evidence of facial asymmetry in the frontal view. The individual had obvious lip incompetence accompanied by a prominent show of upper teeth. His upper

dental midline was aligned with facial midline,mesocephalic head , mesoproscopic face , potentially incompetent lips ,consonant smile , incisorexposure on smile 7mm width ,no gingival exposure on smiling and a mesorrhine nose.

In profile view, Convex facial profile , vertical FMPA , Increased lower facial height ,Straight nasal dorsum ,Average nasolabial angle , Negative lipstep , Deep mentolabial sulcus , Receeding chin ,double chin appearance.

Intraoral Examination

Because teeth 35, 36, and 46 were missing, the molar relationship could not be established. The canine relationship and buccal segment were Class II on the right, end on left side with a deep bite and increased overjet (the overjet measured 9mm, while the overbite measured 6mm) . 15, 18, 26, 32, 36, 42, and 46 of his teeth were teeth 16 and 47 are mesially tilted. A palatal cross bite on tooth 27 was noted. His lower dental arch was ovoid and symmetric, while his upper arch was tapered and symmetric. Overall, there was satisfactory periodontal health. His missing teeth caused spacing in his lower and upper arch.

SUMMARY OF RESPIRATORY ANALYSIS

Increased Respiratory Effort-Related Arousals (RERA): The individual experiences a higher frequency of Respiratory Effort-Related Arousals, indicating disruptions in sleep due to respiratory events.

Desaturation to 85%: Oxygen saturation levels drop to 85%, suggesting significant episodes of oxygen desaturation during sleep. This is a critical concern as it may lead to hypoxemia.

Snoring: The presence of snoring indicates potential airway obstruction or restriction during sleep, contributing to respiratory disturbances.

Radiographic findings

PERMANENT DENTITION,MISSING 36,35,46 RC treated 17 Restored 26

Cephalometric Findings

1. The patient exhibits a Class II skeletal jaw base.
2. An increased mandibular plane angle is observed, measuring at -42 degrees on average, compared to the normal average of 28 degrees.
3. A vertical growth pattern is evident in the patient's facial structure.
4. There is an increased lower anterior facial height.
5. The patient presents with a divergent jaw bas

6. Proclination of the upper incisors to the sella-nasion (SN) plane is observed.
7. Both the upper and lower pharyngeal airways are reduced in size.
8. The upper pharynx measures at -14 mm (normal range: 15-20 mm).
9. The lower pharynx measures at -6 mm (normal range: 11-14 mm).
10. A decrease in mandibular corpus size by 6 mm is noted.
11. The patient exhibits an obtuse chin-throat angle

Sagittal Relation:

1. The patient exhibits a skeletal Class II jaw base.

2. The ANB angle is 7°, indicating a significant discrepancy between the maxilla and mandible positions.
3. The mandibular plane angle is 42°, suggesting a particular orientation of the jaw structures.
4. Points A and B on the FH plane are 16 mm apart.
5. The Wits appraisal measures 5 mm, indicating the degree of maxillary and mandibular discrepancy.
6. The facial angle is 76°, suggesting a retrusive lower jaw.
7. The AB Plane Angle is -11°, further indicating a retrusive lower jaw.
8. Schwarz analysis reveals a maxilla to mandible ratio of 2.14:2.86, signifying an increased maxilla and decreased mandible.
9. Maxillary size is decreased by 2.6 mm, and mandible size is decreased by 5 mm.

Vertical Relation:

10. The patient exhibits a vertical growth pattern, with the maxilla and mandible diverging anteriorly.
11. SN-GO-GN angle is 45°, indicating a vertical growth pattern.
12. FMA is 42°, contributing to the vertical growth pattern

13. The Jaraback Ratio is 61%, confirming a vertical growth pattern.
14. Y Axis N-S-GN is 80°, and Y Axis FH-S-GN is 74°.
15. Upper and lower gonial angles are 45° and 90°, respectively.
16. Basal plane angle is 43°.
17. The J Angle is 85°.
18. N-ANS measures 46 mm, indicating a decreased middle third of the face by 5 mm.
19. U1 to NF shows extruded incisors by 3 mm.
20. U6 – NF reveals extruded upper molars by 2 mm and intruded lower molars by 2 mm.

Soft Tissue Relation:

21. The patient has an average nasolabial angle.
22. A deep mentolabial sulcus is observed.
23. Upper lip thickness is 14 mm, with a basic upper lip thickness of 17 mm.
24. Lip strain is 3 mm.
25. Lower lip thickness is 14 mm, and lower lip length is 54 mm.

26. The soft tissue profile angle is 148°, indicative of a Class II soft tissue profile.
27. The total soft tissue profile angle is 124°, confirming a Class II profile.
28. The soft tissue facial angle is 79°, consistent with a Class II soft tissue profile.

Diagnosis:

29. Skeletally, the patient exhibits a Class II maxilla-mandibular relation with soft tissues matching.
30. A vertical growth pattern and increased lower anterior facial height.
31. Decreased mandibular corpus size is noted.
32. Divergent jaw bases are observed.
33. Dentally, there is a Class II incisor and canine relation, proclined upper incisors and lower incisors, and lower anterior crowding.
34. Increased overjet and overbite are evident.
35. Soft tissue features include a convex facial profile, average nasolabial angle, reduced chin thickness, protruded and incompetent lips, obtuse chin throat angle, double chin appearance, and a deep mentolabial sulcus.

PROBLEM LIST

Class II maxillo mandibular relation with convex facial profile,vertical growth pattern,incompetent & protruded lips d,ecreased upper & lower pharyngeal airway ,double chin appearance ,class II incisor & class II canine relation ,missing -46,36,35 , increased overjet & overbite and crowding in relation to upper & lower anteriors and proclined upper incisors.

AIMS AND OBJECTIVES OF TREATMENT

1. To correct skeletal class II base
2. To correct recessive mandible
3. To correct proclined upper and lower anteriors
4. To achieve ideal overjet and over bite
5. To prosthetic rehablitate -35
6. Achieve class I molar canine and incisor relation
7. To achieve a pleasing soft tissue profile
8. To achieve **ideal dimension of pharyngeal airway.**

TREATMENT PROGRESS

Levelling ,Aligning & Arch coordination-Upper :014 niti ,016 niti,018 niti,17x25 niti,19x25 niti,19x25 s.s

- Lower: 014 niti ,016 niti,018 niti,17x25 niti,19x25 niti,19x25 s.s and 018 AJW

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2.SURGICAL PHASE: • Surgical correction of class-2 by BSSO advancement surgery & Rotational genioplasty

POST SURGICAL CEPHALOMETRIC INTERPRETATION

The post surgical orthodontic treatment skeletal relationship of the patient remained unchanged.The MxMd plane angle changed

VARIABLE	PRETREATMENT	POST-SURGICAL
SNA	77	79
SNB	70	75
ANB	7	4
Wits appraisal	5mm	7mm
Upper incisor to SN	103 (proclined)	102
Lower incisor to mandibular plane angle	97(proclined)	100
Interincisal angle	111(proclined)	110
Maxillary mandibular planes angle	43(vertical growth)	44
Upper anterior face height	46mm	51mm
Lower anterior face height	75 mm	77 mm
Jarabak ratio	61.5	60
Lower incisor to APog line	+10 mm(protruded)	9 mm
Lower lip to Ricketts E Plane	+4 mm	4 mm

3.POST SURGICAL ORTHODONTICS

• Implant assisted Protraction of 47,48,37,38 during post surgical orthodontics to achieve bilateral class 1 molar relation

• Settling posterior occlusion. Prosthetic rehabilitation of 35 using FPD or implant. Retention- lingual fixed Retainer, removable retainer.

DISCUSSION

A large percentage of orthodontic patients have skeletal class II malocclusion. The only options for adults with skeletal class II are surgery or camouflage. Even though the primary reason these patients visit is for cosmetic purposes, a deficient mandible, which is an underlying craniofacial abnormality, frequently acts as a significant risk factor for sleep apnea or breathing disorders during sleep. The likelihood that airway issues will arise in the future and the impact of treatment on the airway should be taken into account when planning the treatment strategy.

The Sleep Questionnaire (FOSQ) is a screening tool used for diagnosis of sleep disorders related to breathing. This self-report measure was initially described by Weaver et al. to evaluate the effects of excessive sleep disorders on a variety of daily routine activities, including general activity level, attentiveness, general productivity, social behavior, and physical intimacy. hyperdiverse facial type with a profile resembling a bird's face. In neonates, congenital micrognathia frequently results in respiratory emergencies. Even though our patient's mandibular retrusion wasn't too severe, we still wanted to take care of his airway. For treating OSA, CPAP therapy is considered the gold standard. In carefully chosen patients, oral appliances such as mandibular advancement devices (MADs) can be used. In addition, candidate cases may be given consideration for soft tissue surgical procedures such as

adenotonsillectomy, nasal, palatal, and tongue surgeries. Specifically, maxillomandibular advancement (MMA) was the primary skeletal correction. Given the patient's profile and primary complaint, OGS is regarded as the primary treatment strategy in this case. Mandibular advancement was taken into consideration because it could enhance his airway volume and facial profile at the same time. The patient's airway space widened significantly overall. Stability during surgery is influenced by the direction of movement, the kind of fixation, the kind of surgical technique, and muscle adaptation. Proffit et al. state that when a patient has rigid internal fixation and their anterior facial height is maintained or increased, the maxilla tends to move upward, which keeps the mandible stable as it moves forward following surgery.

On the other hand, the anterior facial height was lowered during surgery. Within the following surgery, themaxilla rotated in a clockwise direction, and the mandible moved backward and the chin underwent significant remodeling. form. It showed significant surface remodeling and a mild surgical relapse. Patients with Class II malocclusion experience relapses of OGS in advancements greater than 10 mm. Furthermore, the surgery may be the cause of the relapse. According to certain research, the OGS correction of MPA is associated with elongation of the suprahyoid muscle and extension of the pterygomasseteric sling in patients with skeletal Class II malocclusion and high MPA. This may also increase the risk of surgical recurrence. The maxilla was impactioned and rotated counterclockwise as a result of the surgery. These modifications were comparable.

According to Proffit et al.'s findings, the posterior portion of the maxilla remained stable vertically during the first six weeks following the superior repositioning of the maxilla, while the maxilla's anterior portion may move downward. As a result, we presume that while recovering from surgery, even though an auxiliary appliance when theanterior incisor was not utilized, theintrusion was kept up by the continuous arch wire methodology. This condition's explanation could be that the bite force made an effort to keep the upper occlusal plane stationary level while the maxilla rotated clockwise to relapse. It is possible to conduct additional research in this area. In summary, the patient's initial status, could be the cause of the relapse pattern involving hyperdivergent craniofacial morphology and a smaller TMJ form. Another possible explanation is the fixation technique, the surgical design (more mandible advancement), and muscle acclimatization. The misaligned TMJ could pose a threat factor for

MMC's CCWR. When the craniofacial type first appeared, the VME, high MPA, and

Significant AP disparity was present at the same time. Antegonial notching is frequently discussed in relation to mandibular development and Development is one of the seven morphological markers used to forecast growth pattern of the mandible. According to Bjork and Skieller, the mandibular rotation that occurs during growth in reverse has an apex below the gonial angle, which results in a long face by increasing in concavity at the antegonial notch or a facial type that is hyperdivergent, similar to what we saw in our patient.
Greater lower back pain is correlated with a deep antegonial notch in the mandible border.
steeper MPA and AFH that match the patient's initial demonstration. A steeper MPA condition and lower AFH should have resulted in an AOB, however this didn't happen in the anterior region of the maxilla, lower and upper incisors, and the anteromedulla, resulting in VME with a gummy smile.

Overall, there is still room for improvement in a few areas, like the obvious notching at mandibular margin, a typical sagittal osteotomy side effect progression of the jaw. This might have happened as a result of the deep malposition of the lingual proximal segment or antegonial notch split, thin mandible, or poor surgical technique. This can be handled even more by another procedure involving lipofilling or bone grafts. An additional factor is that the lip posture was sagging at the bilateral cheilion, providing the patient with a frowny expression whenever he wasn't smiling. The muscle traction may have been the cause of this. During the mandibular advancement, the depressor anguli oris muscle, which originates from the external oblique line, may change in length and rotation in a counterclockwise direction.
The hyperactive state of the perioral muscle may cause a frowny expression on one's face. One could inject type A botulinum toxin to relax these muscles. Consulting with a plastic surgeon can help to alleviate this issue.
surgeon.

CONCLUSION

Because a retrusive mandible frequently causes airway problems, the airway condition needs to be taken into consideration for patients with skeletal Class II who have a retrognathic mandible in addition to esthetic and functional goals. Additionally, CBCT or an X-ray can be used to confirm the condylar anatomy and assess the likelihood of a relapse following Class II surgical-orthodontic treatment. It may be necessary to overcorrect mandibular advancement in order to make up for the airway patency and skeletal relapse.

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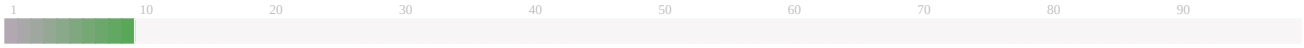

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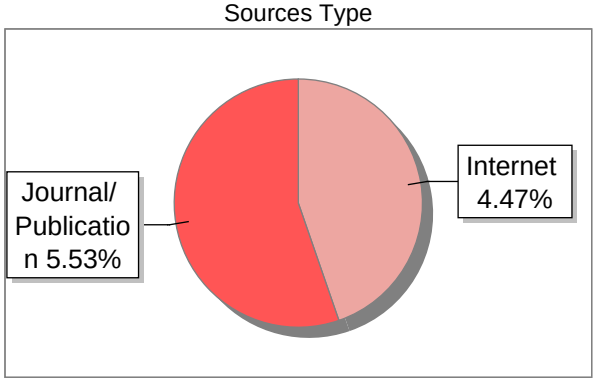

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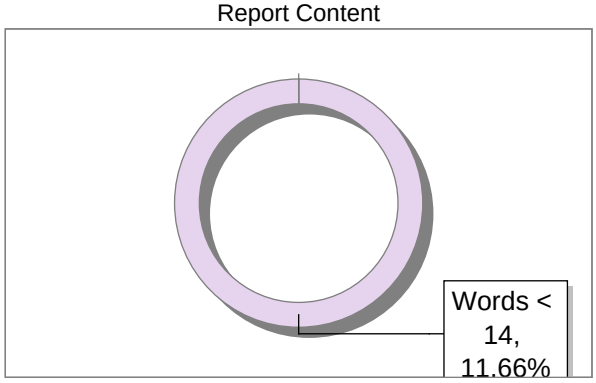

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INTRODUCTION

Advances in technology have greatly influenced the field of dentistry in recent times. The advent of nanotechnology is one such advance that has helped improve the properties of dental materials when incorporated into them. Since dental materials are placed within the oral cavity and are constantly in contact with saliva and water, exposed to temperature changes, masticatory forces and acidic substances consumed by the patient, wearing away of the material has always been a concern. There has thus, always been an interest in developing dental materials with improved lifespan in the oral cavity. Nanotechnology has helped greatly in moving towards achieving this. Various nanomaterials have been incorporated into dental materials to enhance their properties. Graphene is one such nanomaterial and its derivatives have attracted great attention, owing to their excellent physicochemical property, morphology, biocompatibility, multi-differentiation activity, and antimicrobial activity[1]. It is a carbon based nanomaterial consisting of two-dimensional sheets that are made up of sp^2 hybridized carbon atoms bonded together in hexagonal structures[2] .

BACKGROUND:

Graphene was first isolated in 2004 by Novoselov et al.[3], and it consists of two-dimensional sheets that are made up of sp^2 hybridized carbon atoms bonded together in hexagonal structures. It has unique structural, chemical and thermal properties which has led to its utilisation in various fields like biomedical, electronics, energy production, bimolecular sensors etc.

Graphene nanomaterial is available as ultrathin graphite, few layer graphene, graphene oxide[Go], reduced graphene oxide[rGo] and graphene nanosheets.[4] Graphene derivatives are widely applied in the dental fields of restorative materials, adhesives, cements, primers and many more because of properties such as biocompatibility, anti-microbial efficiency and excellent physico-mechanical properties. Pristine graphene - that is graphene in its original, pure, unoxidized form - enjoys superior properties to its oxidized counterpart, but pristine graphene isn't easy to come by and its lack of abundance has held back the development of graphene-based functional devices.[5]

As per literature, there are more than 2,942 studies related to graphene-based materials for dental applications[1]. This emerging research in regard to graphene seems promising and hence has prompted this review of literature with an intent towards evidence based application of graphene in dentistry.

Method of collecting data

Review is facilitated by literature search through online and offline modes, that provided us with 26 relevant publications in regard to graphene and its applications.

PROPERTIES OF GRAPHENE

BIOCOMPATABILITY

When used in dental materials, graphene is in constant contact with the oral tissues and saliva. It is thus essential for the material to be bio-compatible. Researchers have studied its biocompatibility in various studies. They have found various factors to be involved in determining its biocompatibility. Up to date, the affected factors involved concentrations, surface functionalization, and so on. Some researchers showed that the toxicity of Graphene oxide to fibroblast cells was minimal when the concentration of Graphene oxide was lower than 20 µg/ml. whereas, the cytotoxicity of graphene oxide increased when the concentration was up to 50 µg/ml.[6]

Wang et al. investigated the cytotoxicity of graphene oxide in mice and the results demonstrated a dose-dependent toxic behaviour *in vivo.* The cytotoxicity of graphene oxide increased when the concentration was increased.[7] When the concentrations of Graphene Oxide were 0.1 and 0.2 mg, there was no toxicity detected. With the increase concentration to 0.4 mg, chronic toxicity was observed in mice.[7]

Diana et al. investigated the cytotoxicity of GO, nitrogen-doped graphene (N-Gr), and thermally reduced Graphene Oxide (TRGO) on human dental follicle stem cells and analysed the involved specific mechanism. The result showed the lowest cytotoxicity of GO and the highest cytotoxicity of TRGO.[8]

ANTI-BACTERIAL PROPERTY

The anti-bacterial property of graphene has gained interest as it can lead to help achieve infection control when added into dental materials. The antibacterial effect of graphene-based materials was first discovered by Huet al.[9] A complete understanding of the anti-bacterial property of graphene is yet to be completely understood. Many researchers have proposed different theories. Physical damage is induced by blade like graphene materials piercing through the microbial cellular membrane causing leakage of intracellular substance leading to cell death. [10]

Wrapping and photo thermal ablation mechanism could also provoke bacterial cell damage by enclosing the bacterial cells, providing an unique flexible barrier to isolate bacteria growth medium, inhibiting bacteria proliferation, and decreasing microbial metabolic activity and cell viability.[2]

Chemical effect is primary oxidative stress mediated with production of ROS [reactive oxygen species] as excessive intracellular ROS accumulation could cause intracellular protein inactivation, lipid peroxidation, and dysfunction of the mitochondria, which lead to gradual disintegration of cell membrane and eventual cell death.[11]

APPLICATIONS IN DENTISTRY

Graphene added to PMMA

Polymethyl methacrylate resin has been used in dentistry from many decades for fabricating denture bases due to advantages, such as easy manufacturing process, low cost, low modulus of elasticity, easy repair, and good aesthetics. However, the limitations of PMMA [polymethyl methacrylate] such as low mechanical properties, large polymerization shrinkage, and the poor inhibition of biofilm formation reduce the life-span of the material.[12.] In recent studies, researchers have tried the addition of graphene oxide into polymethyl methacrylate for improving the mechanical and antibacterial properties of PMMA.

Because of the mechanical effect of graphene on PMMA, Azevedo et al. has achieved the definitive maxillary full-arch rehabilitation by incorporating Graphene oxide into the PMMA resin. Review after 8 months revealed satisfactory mechanical and aesthetic outcome, indicating that the addition of GO [graphene oxide] to PMMA resin would be a good choice for prosthetic rehabilitation.[13]

Bacali et al. reported on PMMA with graphene-silver nanoparticles (Gr-Ag), and the mechanical properties, hydrophilic abilities, and the morphology of the composites were further evaluated. The results showed that the compression parameters, bending, and tensile strength of the Gr-Ag fillers were significantly higher than the pure PMMA group, indicating that the addition of Gr-Ag improved the mechanical properties of PMMA resin.[14] Moreover, Bacali and his co-workers also assessed the antibacterial properties of Gr-Ag–modified PMMA, and the results confirmed that Gr-Ag–modified groups showed higher inhibition effect in all Gram-negative strain, *Staphylococcus aureus*, *E. coli*, and *Streptococcus mutans*.[14]

Use of graphene in restorative dentistry

It is always desirable for restorative materials to have a prolonged life in the oral cavity. The added advantage of anti-bacterial property of graphene can help in infection control.

Graphene when added to GIC has shown to cause a significant improvement in its mechanical and biologic properties. Fluoride graphene [FG] when prepared by hydrothermal reaction of graphene oxide and mechanically blend with glass ionomer could produce a GICs/FG composites matrix, which could significantly enhance the mechanical, tribological, and antibacterial properties of glass ionomer.[15]

Graphene has been used in various types of dental resins to strengthen bonding and adhesive strength in restorative dentistry. However, if the site it not properly sealed, bacteria can easily access the cured dental tissues through cavities at the tooth restoration interface.[2] In addition, adhering materials onto dentin is challenging since dentin has higher water content compared to enamel and is less mineralized . Graphene nanoplatelets have been studied for antimicrobial and antibiofilm properties and combined with polymer materials to act as better dental adhesive . From the study, the graphene nanoplates inhibited the growth of *S. mutans* bacteria *in vitro* and demonstrated good mechanical performance without decreasing adhesive strength.[16]

Application of graphene in implants

Titanium implants have in recent times become a popular choice of prosthesis to replace missing teeth. Titanium has been shown to have good osseointegration property. At the hard tissue interface, osteogenic properties of implant material are essential for osseointegration while at the soft tissue interface, to ensure a tight epithelial seal preventing bacterial invasion is obligatory . Failure of implants can happen due to poor osseointegration and peri-implantitis of titanium and its alloys.[17]

Therefore, many surface modifications by graphene-based materials have been used to improve the bioactivities of titanium and its alloys. [18] Gu et al. successfully constructed single-layer graphene sheets on the titanium substrates by PMMA-mediated method.[19]The studies conducted showed that graphene sheets exhibited superior adhesion and proliferation properties of human gingival fibroblasts (hGFs), human adipose-derived stem cells (hASCs), and human BMMSCs (Bone Marrow Mesenchymal Stem Cells) compared with the control.[20]

When graphene is coated on titanium substrate, the hydrophobic character of graphene film exerted self-cleaning effect on its surfaces decreasing the adhesion of microorganism including *S. sanguinis* and *S. mutans*.[21]

Additionally, compared to titanium alone, graphene possesses osteogenic property enhancing the expression of osteogenic related genes RUNX2 [Runt-Related Transcription Factor 2, COL-I[CONSTANS-like 1], and ALP[aluerin like protease], boosting osteocalcin gene and protein expression, and consequently increasing the deposition of mineralized matrix [2]

Tissue Engineering

Tissue engineering is being widely used in repairing and regenerating the defects caused by tumours, traumas, infections etc. Scaffolds provide a platform for the attachment, proliferation, and differentiation of different stem cells in the tissue engineering. Many researchers proved that graphene-based materials were suitable for fabricating or coating for scaffolds in the tissue engineering.

A pioneering study demonstrated that graphene and Graphene Oxide can accelerate MSC [mesenchymal stem cell] osteogenic differentiation to different degrees due to π–π stacking, hydrogen bonding, and electrostatic interactions with proteins , which may be the underlying mechanism supporting the coating application.[22]

Teeth whitening

Hydrogen peroxide is a commonly used material for in-office teeth whitening procedures. Though it has proven to be an effective bleaching agent, use of excessive amounts of

hydrogen peroxide is associated with side effects such as teeth sensitivity and gingival irritation.

Su et al have therefore resorted to combining graphene oxide with hydrogen peroxide to improve the efficiency of the process and reduce the potential side effects.[23] The CoTPP [Cobalt-TetraPhenylPorPhyrin]- rGO [reduced Graphene Oxide] nanocomposite can be used as a catalyst to produce more reactions between the staining molecules and H_2O_2, which accelerate the bleaching process.[23] In summary, graphene-based materials are a promising catalyst for tooth whitening application with proper types and concentrations.

Drug delivery

Localised drug delivery systems have garnered the interest of many practitioners as they provide the opportunity to deliver the desired quantity of drug to the site of interest. They also allow the controlled release of the drug. This has led few researchers to look into graphene as an avenue to function as a drug delivery system.

Graphene Nanosheet structure with high surface area and good water dispersibility is a promising candidate for drug carriers toward specific organs[24]. La et al. reported that GO is an efficient carrier for the delivery of therapeutic proteins.[25] They applied GO-Ti [graphene oxide-titanium] implants as carriers to deliver BMP-2 [bone morphogenetic protein 2] for bone regeneration and successfully demonstrated that ionized GO can deliver proteins by binding through electrostatic interactions. Furthermore, they used a GO-Ti substrate for BMP-2 delivery as an osteoinductive and SP as a stem cell recruitment agent for in situ bone regeneration and reported that GO has the potential to sustain the release of BMP-2[25]

Trusek et al. found that GO had the potential in acting as a drug carrier especially in the therapy of dental inflammation[26]

CONCLUSION

Graphene-based nanoparticles are considered a topic of great interest in the field of dentistry. They have shown to be of great benefit in improving upon the performance of various dental materials. Additionally, graphene nanoparticles have been found to have adequate initial biocompatibility in the mouth when it comes to bone and tissue engineering. Addition of graphene has been considered in case of dental cements, adhesives, resins and as bio coatings to implants.

Although graphene has been shown to display relatively good biocompatible qualities in various dental applications from *in vitro* tests, there is still a lack of long-term cytotoxicity studies of graphene nanoparticles in the body, as well as a lack of understanding as to how easily they can be excreted from the body. Various factors such as particle size and concentration have shown to influence the cytotoxicity of graphene. There is thus a need for standardization of biocompatibility requirements for dental applications is also needed with long-term *in vitro* and *in vivo* studies to see the long term health effects.