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The journal invites manuscripts from dental and other allied health sciences. It publishes manuscripts under categories of Original Research, Review and Case Reports.

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Chief Editor's Message

Dear Friends

With great pleasure I thank the new office bearers of IDA KOCHI for the year 2022 for entrusting me with the important responsibility for another year. As the editor of JIDAK, I am happy to announce the release of our first issue for 2022. All the previous issues are available @jidakochi.org.

Scientific articles are the face of any field and good quality journals are extremely helpful for the members of the association to keep themselves updated and become aware of new happenings in our field of dentistry.

Our issues are released with great efforts from our authors, reviewers and the Editorial team. We all have been working together for the benefit of all our members.

IDA KOCHI is one the most active branches in the state as well as our country. We have been able to reach these heights through active participation by all members. More and more participation from young active budding dentists is required to keep up the life of the branch.

Let's all take it as each and everyone's responsibility to actively participate in all the activities of our branch and help strengthen our branch.

Thanks and happy reading.

JAI HIND JAI IDA

Dr Vidhya Parameswaran
Chief Editor- JIDAK
IDA Kochi

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REVIEW ARTICLE

BONDING TO ZIRCONIA CERAMIC: A REVIEW

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ABSTRACT

Reliable bonding between resin composite cements and high strength ceramics is difficult to achieve because of their chemical inertness and lack of silica content that makes etching impossible. The purpose of this review is to classify and analyze the existing methods and materials suggested to improve the adhesion of zirconia to dental substrate by using composite resins, in order to explore current trends in surface conditioning methods with predictable results.

Keywords: Bonding, Ceramic, Material, Zirconia.

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INTRODUCTION

In present scenario, in order to improve aesthetical outcome of Fixed Partial Denture restorations dental researches are more directed towards metal-free prosthetic restorations, as these restorations allow to preserve soft tissue color more similar to the natural one than porcelain fused to metal restorations.[1] Many ceramics such as spinel, alumina, and ceramic reinforced with lithium disilicate, have been proposed for the construction of metal-free restorations.[2] Developments over the last 10 years in ceramic materials science for dental applications have led to a class of high strength materials (e.g., alumina and zirconia-based ceramics) that potentially provide better fracture resistance and long-term durability than traditional porcelain and other ceramic alternatives.[3] Raigrodski analyzed different all ceramic systems and concluded that reinforced ceramics can only be used to replace anterior teeth with single crown restorations or maximum with three units FPDs.[4] On the other hand, Zirconium dioxide restorations have a wider application field. Main advantage of Zirconia-ceramic FPDs is that these can be used in case of molars in contrary to other ceramic technologies which only allow the construction of structures that are resistant to chewing stresses on anterior teeth.[5]

DISCUSSION

Bonding is an adhesive technique in dentistry involving conditioning of enamel and/or dentin so as to create tags in the tooth structure for mechanical retention of restorative material.

A strong, durable resin bond provides:

1. high retention
2. improves marginal adaptation and prevents microleakage
3. increases fracture resistance of the restored tooth and the restoration.[6]

Bonding to zirconia ceramic: Adhesion methods and durability

Adhesive bonding techniques for zirconia[7]

1. Zirconia primers
2. MDP monomer based resin cements
3. Airborne particle abrasion
4. Tribochemical surface modification
5. Selective infiltration etching technique
6. Vapour phase deposition technique

Zirconia primers[8,9,10]

Organofunctional trialkoxysilane coupling agents (briefly silanes). Silanes form a large group of organic compounds that essentially contain a silicon (Si) atom or atoms. Organosilanes are either hydrophilic or hydrophobic. Silanes resemble orthoesters, and they can be bifunctional, ie, they have a dual reactivity. The organic functional part (eg, vinyl -CH=CH2, allyl -CH2CH=CH2, amino - NH2, isocyanato -N=C=O) can polymerize with an organic matrix. The alkoxy groups (eg, methoxy -O-CH3, ethoxy -O-CH2CH3) can react with an inorganic substrate, in both cases forming covalent bonds between the matrices.

Generally, silanes may or may not contain reactive groups. A reactive group can also be -chloride (-Cl). There can be a propylene link (-CH2CH2CH2-) between Si and the organic functionality, especially when the silane is used for metal pretreatment. Silanes may be monofunctional or bisfunctional, Trisfunctional silanes with three Si atoms also exist. Silanes, hybrid organic-inorganic compounds, can function as mediators and promote adhesion between dissimilar, inorganic and organic, matrices through dual reactivity.

They are called primers, coupling agents, or sizes, depending on their function and substrates. They can also be used as filler surface treatment agents and able to act as coupling agents in the interface between organic-inorganic substances, silanes must first be hydrolyzed (activated) and condensed. At about pH 4 (for organotrialkoxysilanes), the rate of condensation between silanol groups of monomeric silane molecules to larger oligomers is at the minimum, and the silane solutions have the highest stability. Acetic acid is often used for the pH adjustment. The hydrolysis time varies depending on the silane concentration, solution, and temperature, but usually 0.5 to 2.0 hours is enough.

During the condensation reaction, silane molecules react with each other, forming dimmers followed by condensation to form siloxane oligomers. Also, hydrogen bonding between the siloxane monomers and oligomers occurs in the solution. Silane oligomers react with each other, forming branched hydrophobic siloxane bonds, -Si-O-Si-, and with an inorganic matrix (eg, silica, metal oxides that contain hydroxyl-OH groups) they can form -Si-O-M- bonds (M = metal).

According to the latest theories, there will be a film, a hydrophobic and branched polysiloxane layer that may also contain free hydrogen-bonded oligomers. Also, free water molecules can appear in the film. If the substrate is silica (quartz, Si02) or silicate, only a siloxane layer; -Si-O-Si-, will be formed. The branched siloxane layer (film) thickness is dependent on the concentration of the silane solutions. lf the substrate is aluminum, -Si-O-;AI- bonds seem to have poor hydrolytic stability. The silane most commonly applied in dental laboratories and chairside is a monofunctional methacryloxypropyltrimethoxysilane. Usually dilute, often less than 2 wt% in water-ethanol solution, with its pH of 4 to 5, adjusted with acetic acid, being prehydrolyzed. MPS is used to optimize and promote the adhesion, through chemical and physical coupling, between metal-composite, ceramic-composite, and composite-composite.

- **Silanes are applied in:**

1. Polar aqueous alcohol solutions (eg, ethanol, isopropanol) and in ethyl acetate
2. Nonpolar solutions (eg, n-pentane, n-hexane) have also been investigated

The silanes used in dentistry are usually in 90% to 95% ethanol or isopropanol solutions, but more dilute alcohol solutions, about 20% or even 40% to 50%, are also used. Acetone-ethanol mixture is also known.

MDP monomer based resin cements[11,12,13]

Organophosphate monomers have an organofunctional par t , most often a methacrylate group.The phosphate monomers also contain phosphoric acid groups that can develop the bond with the metal oxides in the substrate. The application of MDP-containing silane/cement system (Clearfil Esthetic Cement) attained the best overall results. The adhesive potential of 10-MDP to densely sintered zirconia may depend on the presence of a passive coating of zirconium oxide on the ceramic surface. Chemical reactions involving the hydroxyl groups of the layer and the phosphate ester monomers of the MDP may occur at the interfacial level. Moreover, the functional monomer has been rated as relatively hydrolysis stable, due to the presence of a long carbonyl chain.

Conventional silanes are not as effective on zirconia as on silica- based ceramics. Nonetheless, the silane molecule (3-MPS) mixed with 10-MDP in the coupling solution (Clearfil Ceramic Primer) may have promoted the bonding mechanism, improving surface wettability and forming cross-linkages with methacrylate groups as well as siloxane bonds with the Oh groups of the ceramic substrate. Such a reaction may be promoted and sustained by the acidity of the substrate treated with the coupling solution. A relatively strong poly-molecular layer may be responsible of the ceramic-resin cement bond.

Like silanes, organophosphate monomers have an organofunctional part, most often a methacr ylate group that can be co-polymerized with the monomers of a composite resin system. The phosphate monomers also contain phosphoric acid groups that can develop the bond with the metal oxides in the substrate. The other monomers in Zirconium Phosphide, such as the carboxylic acid monomer, are cooperating in the development of the bond.

Airborne particle abrasion[14,15]

Air-particle abrasion is a prerequisite for achieving sufficient bond strength between the resins and high-strength ceramics that are reinforced either with alumina or zirconia. The air abrasion systems rely on air-particle abrasion with different particle sizes ranging from 30 to 250μm. The abrasive process removes loose contaminated layers and the roughened surface provides some degree of mechanical interlocking or 'keying' with the adhesive. While these mechanisms explain some of the general characteristics of adhesion to roughened surfaces, it may also introduce physico-chemical changes that affect surface energy and wettability. Such conditioning systems could be applied either at the laboratory or chairside, using large or small size particles. However, there is limited knowledge as to whether micromechanical retention using large or small particle size increase resin bond to high-strength ceramics of different microstructures and chemical compositions.

A high and reliable resin bond to alumina and zirconia ceramics was also achieved with airborne particle abrasion and by using a phosphate monomer (MDP) containing resin composite luting cement. Air-abrasion seems to be a prerequisite to achieve high and durable bond strengths to zirconia ceramics. This method can significantly improve resin-zirconia ceramic bond strength and its durability by increasing surface roughness, cleaning and activating the ceramic surfacewhen combined with adhesive monomer- containing primers such as 4-methacryloxyethyl - trimellitate - anhydride(4-META) or 10-methacryloxydecyl-dihydrogenphosphate (MDP). However, air-abrasion might compromise the mechanical strength of ceramic itself by initiating surface defects. Therefore, reducing the pressure during air-abrasion or omitting air abrasion completely might be recommended in combination with new ceramic primers in order to improve the bonding durability and reduce the negative influence of high-pressure air-abrasion on the mechanical properties of zirconia ceramic.

Tribochemical surface modification[16,17,18]

Modern surface conditioning methods require airborne particle abrasion of the surface before bonding in order to achieve high bond strength. One such system is silica coating. In this technique, the surfaces are air- abraded with aluminum oxide particles modified with silisic acid. The blasting pressure results in the embedding of silica particles on the ceramic surface, rendering the silica- modified surface chemically more reactive to the resin through silane coupling agents. Silane molecules, after being hydrolized to silanol, can form polysiloxane network or hyroxyl groups cover the silica surface. Monomeric ends of the silane molecules react with the methacrylate groups of the adhesive resins by free radical polymerization process.

Application of a silica coat on ceramics with high crystalline (low silica) content.

This technology was initially developed for metals to increase bonding to resins. The silica coating systems include:

- Rocatec and Cojet from ESPE (Germany) and
- the Silicoater MD from Heraeus Kulzer (Germany).

Cojet is an in-office silica coating system that uses 30-µm silica-modified Al_2O_3 particles (Cojet-Sand) blasted to the surface, followed by the application of a silane agent (ESPE-Sil). These silica coating systems have showed adequate bond strength values. COJET Sand is a specially developed sand for coating all conventional dental materials intraorally such as, for example, metal, ceramic and composite surfaces. In addition to providing microretentive roughening, silicatized COJET Sand allows a ceramic-type coating of the surface of the material. Combined with ESPE SIL, the surface silicatized by COJET Sand provides the foundation for the adhesive bond. Because of its fine particle size (30 µm), the abrasion rate is much lower than with conventional abrasives. Even fine crown edges can therefore be treated without damage.

Mechanism of Adhesion

The coating step during repair work is performed by sandblasting with silicatized COJET coating sand. Blasting causes the ceramic coating to be tribochemically anchored. Tribochemistry means the creation of a chemical bond by the use of mechanical energy. This energy can be supplied by rubbing, grinding or blasting. If corundum particles, modified by silica, with a mean particle size of 30 µm strike the surface to be silicatized with great energy, very high temperatures are produced by the energy of impact (triboplasma). During this process, components of the blasting abrasive are incorporated into the metal down to a depth of 15 µm. Since this effect is limited to microscopically small areas of the surface, no temperature increase over the entire metal frame can be observed.

The surfaces modified in this way are conditioned in the next step - silanization. Silanization with ESPE SIL first allows a chemical bond between the ceramic bonding agent layer and the opaquer or any other commercial methacrylated monomer system. The anchoring thus produced corresponds in broad outlines to the chemical binding of silanized fillers in the composite. The silane used in ESPE SIL is distinguished by two different polar ends on the molecule. The alkoxy groups of the silanol unit, (RO)3Si group on the left side will form a chemical bond with the silicatized surface. The methacrylate groups (right side of the silane) can then be copolymerized with the monomers of the resin. In this way, a chemical bond is achieved between metal frame and resin.

Vapour phase deposition technique[19,20]

It is a unique deposition technique whereby chloro-silane is combined with water vapor to form a more reactive, SixOy-functionalized surface.The process utilizes a molecular vapor deposition (MVD) tool, developed specifically to deposit conformal, thin films to serve as hydrophobic, hydrophilic, biocompatible, protective, ordering, or otherwise reactive coatings.This flexible system allows deposition of numerous materials from simple liquid precursors. Examples of materials include fluoropolymers for hydrophobicity, silanes for polymer and metal adhesion or hydrophillicity, and PEG-based coatings for biocompatibility.

Deposition conditions and precursor chemistry can also be modified to produce a range of surface characteristics. This process is a very simple and fast method for producing thin, high quality, conformal coatings of almost any organic material with a boiling point below 150°C. As the silicon tetrachloride (SiCl4) and water vapor react with the substrate surface, active hydroxyl groups are formed on the surface subsequently forming a silicon oxide layer on the substrate surface. This treatment serves as a primer step for subsequent reactions with organo-silanes, used as adhesion promoters in conventional resin bonding applications. It is thus hypothesized that the chloro-silane pretreatment process will allow for conventional silanation and resin bonding techniques to be a viable option for high strength ceramics.

Selective infiltration etching technique[21,22,23]

Additional structural changes occur on the grain level, which tends to mature and grow in size when g iven sufficient t ime and temperature. Grain growth and cubic grain formation were observed when zirconia was heated to 1450°C for 2 hours. When heated for 30 minutes at relatively lower temperatures (700-900°C), the surface of zirconia was reported to undergo a thermal aging process, especially in the presence of water vapor. On a microscopic level, thermal aging resulted in the creation of surface elevations, grain pullout and detachment, and increased grain boundary thickness. During thermal etching of zirconia at a temperature of 1350°C for 12 minutes, surface elevations, rippled grain surfaces, and vertical grooves at grain boundaries were reported using atomic force microscopy.

These observations were related to the tetragonal monoclinic transformation of zirconia crystals at the surface grains, which can accommodate the accompanying increase in volume, a state determined by grain boundaries and surface energies. However, deeper grains are restrained and constrained by the bulk of the materials and, thus, become strained. This thermo-dynamic behavior indicates that the structure the surface grains could be manipulated by controlling both temperature and heating time.

Heat-induced maturation (HIM) is a new method which results in stressing the grain boundary regions by 2 short thermal cycles. But it does not provide sufficient energy to allow for grain growth or cubic grain formation. The zirconia is heated to 750°C for 2 minutes, cooled t 650°C for 1 minute, reheated to 750°C for an additional 1 minuet state, and then cooled to room temperature. After this heat treatment, grain boundaries become prestressed and can be more easily infiltrated by other materials.

When heated to a temperature range between 700°C and 810°C for 1 minute, small dopants, as silica or titanium, were able to diffuse at grain boundary regions in fully sintered zirconia materials. Controlled diffusion of dopants or secondary phases along the grain boundary interfaces is enhanced for small grain-sized zirconia, which has bigger grain boundary surface area.

A novel surface treatment method developed by the authors, selective infiltration etching(SIE), uses principles of heat-induced maturation and grain boundary diffusion to transform the relatively smooth non retentive surface of Y-TZP into a highly retentive surface. In combination with heat induced maturation, which is used to prestress the grain boundary regions, these regions could be further widened by applying a thin layer of an infiltration glass over the surface of treated zirconia. In the semiliquid state, the molten glass infiltrates selectively between the boundaries of the surface grains and exerts surface tension and capillary forces, allowing rearrangement movements of the surface grains, and results in the creation of 3-dimensional network of inter grain porosity. This surface treatment is selective because it involves only the surface grains in contact with the infration glass. Thus, the operator can control the area of the zirconia that needs to be treated.

Other Methods[24]

- Plasma spraying technique.
- Fusing glass (porcelain) pearls to the zirconia surface.
- Nobel bond.

Plasma Spraying Technique[24]

The plasma spraying techniques may give improved bonding values even though its bonding energy still remains unknown. Plasma is a partially ionized gas containing ions, electrons, atoms, and neutral species. To enable the gas to be ionized in a controlled and qualitative manner, the process is carried out under vacuum conditions. A high frequency generator-which can be in the kilohertz, Megahertz, or microwave range is then used to ionize the gas into plasma. The plasma-spray technique may give a good bond even if the bonding energy is still hard to explain. This technique has been widely tested together with various materials in various situations. In most cases it seems to improve the bond strength to several materials, explained by covalent bonds.

Fusing glass (porcelain) pearls to the zirconia surface[25,26]

Another way to establish a firm bond between the zirconia surface and the resin luting material could be by fusing glass (porcelain) pearls to the zirconia surface. This treatment should, however, be done with caution in order not to jeopardize either the crown build up or the fit of the reconstruction to the tooth. However, two pre-requisites must be fulfilled with this technique.

1. It should not interfere with the crown fusing and should be incorporated in that scheme to avoid additional fusing.
2. It must not create an increase in thickness over approximately 5 μm.

Low fusing porcelains (or glasses) attached by electrostatic bonds mainly depend on contact area and different isoelectric points on the material. This is noted to be 8.2 (pH) for zirconia but for most glasses lower, around 3.5. Together with van der Waals interaction the electrostatic forces contribute to the attachment of the glass pearls. Bond strength values were increased by a factor of 10. These pearls can be successfully silanized prior to cementation and with this one, even higher bond strength values obtained.

Nobel Bond[27,28]

Recently, a new approach for modifying zirconia surfaces (tentatively named NobelBond; Nobel Biocare AB, Goteborg, Sweden) was introduced. The new modified ceramic surface, currently not commercially available, is purported to have a unique adhesive surface replete with intricate microporosities. The modified zirconia surface does not require further post manufacture surface treatment, being ready for adhesive cementation as is. It has been suggested that the combination of the zirconia mechanical properties with the new adhesive surface would be advantageous for the fabrication of RBFPD frameworks.

The modified zirconia surface has abundant and intricate microporosities, ranging from 27.3 to 69.9 μm in breadth and 19.9 to 46.9 μm in depth. Therefore, the resin cement penetrates into the microporosities, providing mechanical interlocking for micromechanical retention. The modified surface is produced by coating a presintered or a fully sintered and milled zirconia framework with slurry containing zirconia ceramic powder and a pore former. Then the slurry-coated ceramic is sintered while the pore former burns off, leaving a porous surface. The porosities of the surface can be modified by using different sizes of pore formers or repeating the coating process. The modified surface showed increased bond strengths compared to airborne-particle abraded or intact zirconia surfaces. In addition, because of the intricate surface, no special monomer, such as 10-methacryloyloxydecyl dihydrogen phosphate (MDP), is necessary for bonding to this high-strength ceramic. Therefore, the use of conventional bis-GMA resin cements is possible.

Zirconia Bond with Veneering Ceramic[29,30]

Clinical failures of veneered Y-TZP frameworks due to chipping of the veneering ceramic are reported to be 13.0% after an observation period of three years) and 15.2% after five years). Sufficient bond strength between the veneering ceramic and the substructure is therefore a concern for the long term clinical success of zirconia restorations.

Bond strength is determined by a host of factors:

1. Strength of the chemical bonds
2. Mechanical interlocking
3. Type and concentration of defects at the interface
4. Wetting properties
5. Degree of compressive stress in the veneering layer due to a difference in the coefficients of thermal expansion between zirconia and the veneering ceramic

On enhancing bond strength, sandblasting is a popular means used to achieve this purpose by increasing surface roughness and providing undercuts. However, sandblasting also initiates phase transition, thus affecting mechanical strength and most probably, the bonding capacity of the material.

For veneering zirconia, silicate ceramics are used. Silica coating of zirconia, therefore, may be considered to enhance bond strength. Due to the high kinetic energy of the particles at the impact, silica is fused to the substrate surface. Depending on the bond strength of the silica layer to zirconia, the bond strength of the veneering ceramic might also be enhanced.

SUMMARY AND CONCLUSION

The original roughness produced by the milling during fabrication is not sufficient to promote adhesion and it seems important to mention that not only cleaning, but roughening and activating the surface are important to achieve durable resin bond to densely sintered zirconia ceramic. It has been demonstrated that, besides increasing surface roughness of y-TZP ceramics, air abrasion also leads to the transformation from tetragonal to monoclinic phase. Tribochemical silica coating has also been recommended on zirconia as a roughening procedure and presents good immediate results especially when combined to silanes, associating the micromechanical with the chemical retention via siloxane bonds. When focussing on the topographical modification of zirconia, however, similar surface roughness can be created with Al2O3 airborne-particle abrasion and silica coating methods.

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REVIEW ARTICLE

MOLAR INCISOR HYPOMINERALISATION - A LITERATURE REVIEW

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ABSTRACT

Molar incisor hypomineralisation (MIH) is a common developmental dental condition that presents in childhood. This defect usually involves one to four permanent first molars and permanent incisors. The affected teeth are more prone to caries and post-eruptive enamel breakdown, therefore, it is believed that this condition might be responsible for a substantial proportion of childhood caries since the condition has high prevalence. However, the possibility of a genetic component in the development of MIH cannot be excluded. Management of MIH always pose a big problem to the clinicians, as well as for the child due to severe sensitivity caused by the defective enamel.

Keywords: Incisors, Management, Molar, Resin Infiltraion, Veneers

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INTRODUCTION

Developmental defects of teeth are caused by complex interactions between genetic andenvironmental factors during tooth development.[1] Enamel is a unique hard tissue which does not undergo remodelling like bone and as a result the structure of enamel is affected during its formation permanently.[2] In recent years, site specific hypoplastic enamel disorders such as molar incisor hypomineralization (MIH) and hypomineralized second primary molars (HSPMs) have become serious concerns in pediatric dentistry.[3] The term molar-incisor hypomineralisation (MIH) was first introduced in 2001 by Weerheijm et al.[4] MIH was defined as 'hypomineralisation of systemic origin, presenting as demarcated, qualitative defects of enamel of one to four first permanent molars (FPMs) frequently associated with affected incisors.[5]

MIH is a hypomineralized defect of one to four first permanent molars and it occasionally involves permanent incisors. It is characterized by demarcated opacities with variable coloration, from white, cream, yellow to brown. The location is usually asymmetrical.[4] Consequently, these teeth may be very sensitive, undergo posteruptive tissue breakdown and be predisposed to caries. Associated opacities on anterior teeth are less likely to have functional problems but may result in cosmetic and psychosocial issues.[6]

Prevalence of MIH

The prevalence of MIH has been shown to range from 2.8% to 44% in different studies.[7] Among studies with more than 1000 subjects, the prevalence of MIH ranges from 2.8% to 21%. Overall, the prevalence of MIH varies by country, region and age group studied.[8] The worldwide prevalence is worryingly high (14.2%) and varies considerably from 0.5% in India to 40.2% in Brazil.[9] Weerheijm and Mejare reported a prevalence rate ranging from 3.6% to 25% after carrying out studies in European countries.[10] Later, a systematic review by Jalevik showed a wide variation in the prevalence of MIH between 2.4% and 40.2%. A non systematic online search and screening in the PubMed data base using the terms: European Academy of Pediatric Dentistry (EAPD); MIH; after the year 2003 showed prevalence of MIH ranging from 3.5% to 40.2%.[1]

Aetiology

MIH is a qualitative defect in enamel classified as hypomineralised type that follows the natural incremental lines of enamel formation, from cusp tip to cementoenamel junction.[1] MIH was initially described as an idiopathic defect but the causative mechanism of MIH is still unclear.[5] Most studies suggest that a combination of factors may affect ameloblasts, resulting in abnormal enamel formation leading to MIH.[11] The clinical presentation of localised and asymmetrical lesions suggests a systemic origin with the disruption in the amelogenesis process most probably occurring in the early maturation stage or even earlier at the late secretory phase.[12] Molar incisor hypomineralisation has no hypoplastic defects as there is no discernable reduction in enamel thickness. Any reduction in enamel thickness seen clinically is indicative of posteruption disintegration of enamel.[1]

The condition seems to be multifactorial and systemic factors such as acute or chronic illnesses or exposure to environmental pollutants during the last gestational trimester and first three years of life have been suggested as causative or contributing factors.[5] The number of affected teeth was associated with the time when the potential systemic disturbance occurred; children with prenatal, perinatal and postnatal problems showing more affected teeth in increasing order.[13] Multiple possible causes have been suggested in the literature, for instance, respiratory tract infections, perinatal complications, dioxins, oxygen starvation, low birth weight, calcium and phosphate metabolic disorders, frequent childhood diseases, use of antibiotics and prolonged breast feeding.[12]

Laboratory Findings

Hypomineralised enamel appears to have reduced hardness and elasticity, increased porosity, a higher protein content and an altered carbon:carbonate ratio. The relative abundance of serum albumin in yellow/brown hypomineralised enamel has also been reported as a notable finding and a potential inhibitor of enamel crystal growth.[14] Despite these laboratory investigations, questions remain about the depth and degree of defective enamel and the corresponding clinical presentation.[15] Furthermore, the scope of this

in vitro research is limited to extracted human molars, as anterior teeth are unlikely to be removed for clinical reasons.[6]

Molar Incisor Hypomineralisation and Dentin Pulp Complex [1,16,17]

After evaluation of various mineral content in hypomineralized tissue and comparing it with normal dentin it was found that Ca:P ratio of dentin below hypomineralised was almost identical to that of normal enamel, but when the Ca:C ratio was assessed, it was found to be low in dentin with an elevated level of C. The levels of O and P in dentin of normal teeth were found to be higher, but in hypomineralised teeth, dentin showed higher levels of N. Patients with MIH affected teeth suffer from dentine sensitivity to various thermal, mechanical and osmochemical stimuli due to the porous nature of enamel sometimes, exposing the dentin. This can favour ingress of bacterial contaminants thereby resulting in chronic inflammation of the pulp leading to a variety of morphological and cytochemical neuronal changes, with an over expressed dentin sensitivity.

Clinical Features [1,18,19,20]

Cervical enamel in most of cases is sound with no evidence of defective structure but if we see at a more occlusal level, the defect is confined to the inner enamel while the outer enamel does not appear to be affected. In the occlusal region, the hypomineralisation is more evident eventually spreading to the entire thickness of the enamel. The defects usually did not involve the cusp tips; the involvement of margin caused reduction in the height. An indicator of the severity of MIH affected teeth is the actual organic content of its enamel whereas brown enamel, the most severe form of MIH, has the highest protein content (15-21-fold greater), whilst the protein content of white/opaque and yellow enamel are both markedly higher (eight-fold greater) than sound enamel.

These microstructural changes in hypomineralised enamel improve the understanding of some of the problems associated with the clinical management of these teeth like the frequent occurrence of enamel fractures and inadequate retention of adhesive materials, both of which are recognized as significant clinical challenges.

Clinical Problems in MIH [5,20]

- The hypomineralized enamel will be softly porous and has a discolored chalky appearance
- Demarcated white/yellow/brown opacities usually limited to incisal or cuspal one third, rarely involving cervical one third. Defects that are <1 mm are not reportedunder MIH
- In molars, posteruptive enamel breakdown is common due to occlusal loading
- Rapid caries progression- because of the porous and friable enamel structure
- Adhesion of restoration material is poor
- Anesthetic difficulties: A combination of hypersensitivity and rapidly progressing caries causes chronic inflammation of the pulp, preventing effective local anesthesia
- Dental fear and anxiety can lead to behavioral management problems
- Esthetic problems in anterior teeth.
- Tooth Loss
- Occasional eruption difficulties of molars due to enamel roughness
- Negative impact on the child's school performance due to the absence from school
- Financial concerns for families

Diagnosis[6,21,22]

Determining a definitive diagnosis of MIH can be challenging, particularly in younger children in whom permanent teeth are still erupting, as the full distribution of any enamel defects will not yet be evident. So, the ideal time to diagnose MIH is as soon as it is clinically apparent either in primary or permanent dentition. The examination should be performed on clean wet teeth. The clinical presentation of MIH depends on its severity and can range from white-creamy opacities, yellow-brown opacities, post-eruptive enamel breakdown to atypical caries located on at least one FPM(first permanent molar) with or without incisor involvement. The lesions should be larger than 1 mm to be recorded as MIH. Mathu-Muju and Wright had classified

MIH into three severity levels:

- Mild MIH: the demarcated opacities located at non-stress bearing areas, no caries associated with the affected enamel, no hypersensitivity and incisor involvement is usually mild if present
- Moderate MIH: the demarcated opacities present on molars and incisors, the post-eruptive enamel breakdown limited to one or two surfaces without cuspal involvement, atypical restorations can be needed and normal dental sensitivity
- Severe MIH: post-eruptive enamel breakdown, crown destruction, caries associated with affected enamel, history of dental sensitivity and aesthetic concerns.

Differential Diagnosis

Conditions which can present with hypomineralised lesions and should be distinguished from MIH include:

- Fluorosis
- Traumatic Hypomineralisation
- White Spot Lesion
- Enamel Hypoplasia
- Amelogenesis Imperfecta[6]

Fluorosis[23]

Clinial picture of fluorosis is present as diffuse, linear, patchy or confluent white opacities without a clear boundary. The severity can range from barely perceptible striations in the enamel to gross disfiguration with almost complete loss of the external part of the enamel. It affects teeth in a symmetrical, bilateral pattern unlike MIH which is asymmetrical. but fluorosis affected teeth are caries-resistant while in MIH they are caries-prone.

Traumatic Hypomineralisation[20]

This is associated with a history of dental trauma to the primary predecessor tooth. Periapical infection of the primary tooth can disturb mineralisation of the underlying tooth germ. It has a wide variety of clinical presentations differing in shape, outline, localisation and colour. It is often limited to one tooth and asymmetrical.

White Spot Lesion5

This is the earliest clinical sign of caries. The lesions appear chalkier, matt or more opaque than the adjacent sound enamel. They can be distinguished from MIH because they occur in areas of plaque stagnation, such as the cervical margin of the tooth.

Enamel Hypoplasia[5]

This is a quantitative defect resulting reduced enamel thickness but in this case borders of hypoplastic enamel lesions are mostly regular and smooth, indicating developmental and pre-eruptive lack of enamel. The margins in MIH with post-eruptive enamel breakdown are sharp and irregular due to post-eruptive shearing of weakened enamel.

Amelogenesis Imperfecta[1]

This is a genetic condition which results in enamel that is hypoplastic, hypomature, or hypomineralised. In this condition, all teeth in both dentitions are affected and a familial history is often present.

Treatment of MIH [1,5]

For Molars:

- Resin Infiltration
- Restoration
- Full or Partial Coverage
- Extraction of severely affected Molars

For Incisors:

- Microabrasion
- Composite Restoration or Veneers
- Resin Infiltration
- Etch-Bleach Seal Technique
- Porcelain Veneers
- Tooth Bleaching

Treatment of Molars

Resin Infiltration[5,24,25,26]

It is also known as erosion infiltration. This technique uses a very low viscosity resin which is capable of penetrating demineralised enamel. Icon®resin infiltration (DMG America, Englewood, NJ, USA) is commercially available for aesthetic restoration of MIH affected incisors. The Icon system consists of Icon-Etch (15% hydrochloric acid), Icon-Dry (99% ethanol) and Icon-Infiltrant (Methacrylate-based resin). Use of hydrochloric acid eliminates the relatively intact surface layer resulting in open access to the body of the lesion, then the fluid resin is infiltrated into the broad channels of communication. This material could protect against acid attack, improve enamel micromechanical properties and decrease post-eruptive enamel breakdown and/or possible improvement in bonding and restorative outcomes.

Crombie et al. suggest that in MIH molars, the resin infiltrant has the potential to penetrate surfaces like hypomineralised cuspal inclines which are susceptible to post eruptive enamel breakdown without interfering with occlusion or being broken by occlusal forces so this material can be effective if used as 'fissure sealant', but the material here will be infiltrated into the hypomineralised enamel therefore this procedure, if done, is irreversible and it requires excellent isolation. As severity of MIH increases porosity increases resulting in more infiltrartion of resin. Increasing etching time could be needed in MIH cases as suggested by Kumar et al.

The main disadvantages of RC are the following: shrinkage due to the extent of the restoration, reduced strength due to impaired bond strength, microleakage, occlusal wear and restoration durability.

Restorations[11,20,27,28]

When restoring hypomineralised teeth, dentists frequently face difficulty in defining the cavity margins. When treating MIH affected teeth, the cavity design should involve removal of not just discolored enamel, but all porous enamel until resistance is felt. The rationale for this approach is that defective enamel remnants compromise the results. The choice of the materials depends on the severity of the defect and the cooperation of the child. Adhesive materials are selected due to the atypical cavity outlines following removal of hypomineralized enamel. Glass ionomer cement (GIC) or resin modified GIC restorations can be considered only as an intermediate approach until definitive restoration is placed.

Resin composite is the material of choice and recommended for one to three surface restorations and the pre-treatment with 5.25% sodium hypochlorite can improve the bond strength. The resin composite has shown long-term stability compared with other restorative materials in MIH-affected teeth. Bond strengths of resin composite to affected MIH enamel, however, are significantly lower than bond strengths to sound enamel for both single bottle total-etch and self-etching primer adhesives. The resin composite for hypomineralized enamel is susceptible to wear and marginal fractures. Therefore, long term maintenance is required. Amalgam should be avoided due to atypically shaped cavities in MIH molars so further breakdown often occurs at the margins, it is a non-adhesive so does not restore the strength of the tooth and is a poor insulator.

Full or Partial Coverage [27,29,30]

In moderate to severely damaged MIH affected molars, full coverage restorations with a preformed metal crown (PMC) are the treatment of choice in a grown-up. PMCs can prevent further post- eruptive enamel breakdown, manage sensitivity, are not expensive, can establish correct interproximal and occlusal contacts, require no/little tooth preparation, and can be done in single visit. Non-precious metal, gold or tooth-coloured indirect onlays can be used in older children but the procedure is time consuming, technique sensitive and expensive. Preformed malleable composite temporary crowns that come in different sizes (Protemp Crown Temporisation Material by 3M ESPE) can offer an aesthetic option, some tooth preparation is required and the crown will require some adjustments but the process is considered easy and requires a single visit. There are as yet no studies that assess the performance of these crowns in MIH molars.

Extraction of severely affected Molars[31,32]

For severely affected FPMs with poor prognosis, extraction might be considered at the dental age of eight to ten years.[57] This will give the second permanent molars (SPM) an opportunity to drift into the FPM position. It has been suggested that the ideal timing of FPM extraction is indicated radiographically by the calcification of the bifurcation of the roots of the lower SPMs. The chance of ideal positioning of the SPMs after the extraction of FPMs at the ideal time is 94% for upper SPMs and 66% for lower SPMs.

Treatment of Incisors

Microabrasion[11,33,34]

Microabrasion is effective in addressing the aesthetic concerns associated with incisors affected by mild MIH. Microabrasion involves the removal of a small amount of surface enamel(<100 μm) and erosion using 18% hydrochloric or 37.5% phosphoric acid with an abrasive paste. The process abrades the surface enamel while also polishing it which leads to changes in optical properties and this may improve the aesthetics. Microabrasion is indicated when the discolouration is limited to the outer surface of enamel and it is more effective at eliminating brown mottling. Home application of CPP-ACP after microabrasion was found to improve remineralization of the treated enamel surface. However, this microabrasion is limited to the superficial layer (shallow defects) of hypomineralized enamel.

Composite Restoration or Veneers[20,27]

Composite restorations involve removal of defective enamel and composite resin build-up using opaque resins to avoid excessive enamel reduction, while composite veneers could be a more conservative approach as it can be achieved with no tooth preparation that is, no removal of even defective enamel. These options could be indicated for large enamel defects that require treatment due to exposed dentine or chipped enamel. Pre-treatment with 5.25% sodium hypochlorite for one minute after etching can significantly improve bond strength . Therefore, long term maintenance is required as composite resins are susceptible to discolouration, wear and marginal fractures.

Resin Infiltration[25,26,35]

Since the refractive index of the resin infiltrant (1.52) is close to that of healthy enamel (1.62), this can improve the optical properties by improving the translucency and therefore improving the aesthetics. Attal et al suggested a modification in this technique for aesthetic management of MIH incisors and this was introduced as ' deep resin infiltration technique.' The technique involves preparing the affected tooth by an intraoral sandblasting device to ensure that the infiltration can indeed reach the full extent of the lesion in case of MIH. This should remove no more than 500 μm from surface enamel and after resin infiltration, some composite could be added to tooth surface. In general, the use of resin infiltration technique in MIH teeth requires further investigation, improvement in material properties and/or technique modifications to be strongly recommended in MIH cases.

Etch-Bleach Seal Technique[27,36]

Wright suggested this technique to remove yellow-brown stains. The affected tooth should be etched first with 37% phosphoric acid for 60 seconds, followed by continuous application of 5% sodium hypochlorite as the bleaching agent for five to ten minutes. Then the tooth should be re-etched and covered with a protective layer such as clear fissure sealant or composite bonding agent. With this technique the yellow-brown stains can be eliminated leaving a white mottled appearance which is more aesthetically acceptable.

Porcelain Veneers[5]

These are indicated for patients aged 18 years and above when the gingival margin has matured. It can be an option when the other techniques failed to produce satisfactory results.

Tooth Bleaching[27,37]

This option is indicated for adolescents. The possible side-effects of bleaching are: sensitivity, mucosal irritation, and enamel surface alterations. Home bleaching through daily placement of 10% carbamide peroxide gel into custom fitted trays is the gentlest bleaching option prescribed by the dentist, but for more protection, the combined use of CPP-ACP Tooth Mousse and bleaching gel is recommended. The CPP-ACP Tooth Mousse will protect the tooth structure and remineralise the MIH opacities during the bleaching process without interfering with bleaching effect. The combined use of hydrogen peroxide and CPP-ACP, could be done with a ratio range from 1:6 to 3:4, depending on the opacity response to the bleaching agent

Future Prospects of MIH[11,38]

A combination of factors may affect the occurrence of MIH and result in abnormal enamel formation. Although MIH was initially described as an idiopathic defect, it has recently been proposed that it is a genetic condition. A possible association has been observed between MIH and variations in the AMBN, ENAM, TUFT1, TFIP11, and SCUBE1 genes. However, one study indicated that environmental factors are also associated with the occurrence of MIH. HSPM and MIH share a similar clinical presentation, structural properties and putative etiology.

CONCLUSION

MIH is a common childhood condition that presents a unique set of clinical challenges to dental health professional that is why good understanding about the etiology, early diagnosis specifically by differentiating from other enamel defects and appropriate treatment are essential for proper and effective management of MIH. But as we know every field require continuous research and evidences for proper effectiveness of treatment and long term management .

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REVIEW ARTICLE

SWIFT MRI: VISUALIZE THE INVISIBLE

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ABSTRACT

The oral cavity is prone to a variety of diseases starting from simple tooth decay to life-threatening carcinomas. Injudicious use of ionizing radiation may increase the exposure of a patient and this has been overcome with the use of magnetic resonance imaging. For the better evaluation of dental pathosis, there is a need for non-invasive and accurate diagnostic methods in clinical dentistry. The magnetic resonance imaging (MRI) technique, called Sweep Imaging with Fourier Transform (SWIFT), is used to visualize soft tissue and hard tissue imaging. The state of art, sweep imaging with Fourier transform is fast, quiet, and identifies issues with ultra-short relaxation times.

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INTRODUCTION

Diagnostic imaging in dentistry depends mostly on x-ray–based techniques that carry some risks and limitations such as exposure to ionizing radiation and its associated increased risk of cancer and the inability to visualize the pulpal tissue.[1] Three dimensional diagnostic imaging like cone beam computed tomography (CBCT) imaging system is more likely to increase in the field of endodontics.[1,2] However, besides exposure to radiation, such systems cannot simultaneously image calcified and noncalcified dental tissues, which is a significant l imitation, particularly as regenerative endodontic procedures become more common in clinical practice.[3]

In a recent review of parameters used in diagnostic testing for assessing pulpal and periapical tissues, the following conclusion was highlighted: ‘‘diagnosis of dental pulp diseases suffers from the operator's inability to test/or image that tissue directly because of its location within a relatively hard tissue, dentin”.[1,2] This review also outlined technical advances underway to address these limitations but did not include magnetic resonance imaging (MRI) techniques. This is justified because of the technical challenges with this diagnostic technique that severely inhibit endodontic application at this time, which is likely the reason behind the paucity of research on the topic.[3,4]

Diagnosing and monitoring disease in soft tissues without using ionizing radiation non invasively, MRI has become an indispensable tool. In biological tissues, the MRI signals measured arise from the spinning magnetic moments of the hydrogen nuclei in water molecules (hereafter called ‘‘water signal'' or “signal”).[4] The water signal is detectable after a radiofrequency (RF) pulse is applied, which causes the nuclear spins to resonate in the strong static magnetic field. Due to the high mineral content; minerals occupy 50% of a tooth's dentin and 90% of its enamel by volume, with water and proteins occupying the rest, conventional MRI cannot easily visualize teeth.

Also, because the water signal has a highly restricted molecular motion within these densely mineralized tissues, the signal decays very quickly after RF excitation.[6,7] The time constant describing the signal's free induction decay (FID) is known as the transverse relaxation time (T2). The FID of mineralized dental tissue has multiple components, with a mean T2 of about 200 microseconds for the dentin and 60 microseconds for the enamel.[7] These time intervals are less than those needed for conventional MRI pulse sequences to accomplish spatial encoding with pulsed magnetic field gradients, which typically requires more than 1 millisecond.[7,8] In other words, the signal from mineralized dental tissues decays before MRI signal digitization occurs, resulting in MRI images with little or no image intensity (black zone).[9] Consequently, conventional MRI techniques in dentistry have been restricted to imaging pulp, attached periodontal membrane, and other surrounding soft tissues or have required indirect imaging of enamel and dentin through contrast produced by MRI-visible medium. Clinical dentistry is in need of non-invasive and accurate diagnostic methods to better evaluate dental pathosis.[10] The purpose of this work is to assess the feasibility of a recently developed magnetic resonance imaging (MRI) technique, called Sweep Imaging with Fourier Transform (SWIFT), to visualize dental tissues.

Principle of SWIFT

The key innovation of SWI F T is the simultaneous signal acquisition and time-shared excitation which is acquired by inserting gaps into an FM pulse. An MRI image is acquired through the spinning magnetic moments of hydrogen molecules that are present in tissues as water molecules.[10]

A radiofrequency is then applied to detect the signals causing the spins to resonate in the strong magnetic field. Transverse relaxation time (T2) is the time constant used to describe the signals' free induction decay (FID). The FID value of enamel and dentin has multiple components with a mean T2 of 200 µs for dentin and 60 µs for enamel which is very short when compared to the time interval needed for the standard MRI to acquire spacial encoding with pulsed magnetic field gradients which is typically more than 1 ms.10 Solid-state MRI techniques such as single-point imaging and stray field imaging techniques are used in imaging mineralized structures.[11] Rapid acquisition with relaxation enhancement and echo-planar imaging are the multi-echo imaging methods used for the rapid acquisition of data. However, these methods depend on tissues with relatively long T2 for multiple data acquisition.

SWIFT is an advanced imaging technique that overcomes most of these difficulties in detecting fast relaxing signals by using low peak amplitude and also is feasible for in vivo studies.[10]

The basic principle involved in SWIFT is the simultaneous excitation and signal acquisition in a time-shared mode which is achieved in a field gradient by inserting gaps into an FM.[11,12] With simultaneous RF excitation and signal acquisition, SWIFT obtains signals from densely calcified tissues that have fast decaying signals, produces less distortion in the presence of materials that have magnetic susceptibility, and is less sensitive to motion artefacts, overcoming three significant barriers inhibiting MRI use for dental applications.

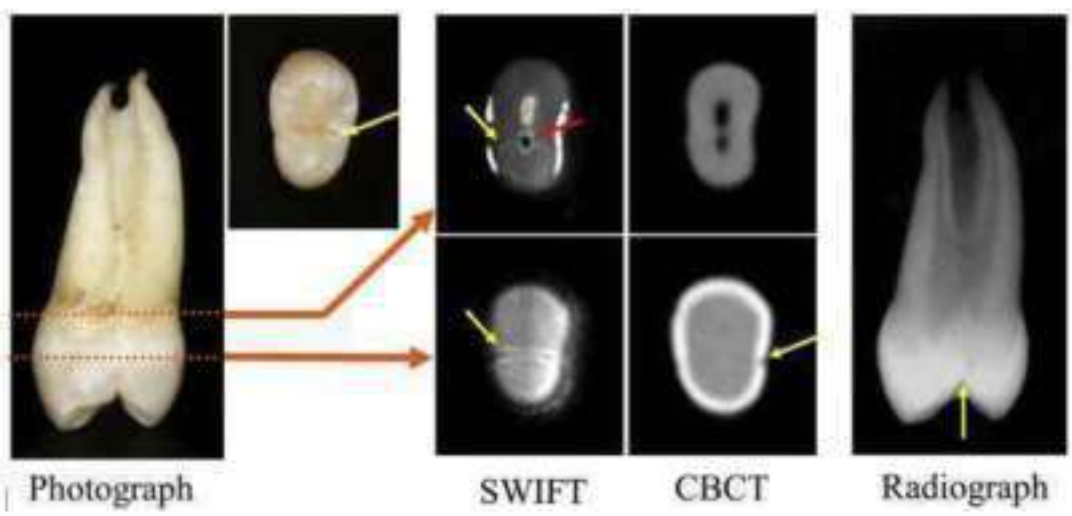
Unlike "adiabetic pulse" in which the carrier frequency during the pulse varies with time, SWIFT uses a frequency where the power is dropped thereby producing a small tip angle for spin excitation.[13] The transmitter and the receiver are alternatively switched on and off with only 1-2 µs of signal acquisition delay in between them. This allows efficient imaging of tissues with a short T2 value.[11,12] The repetition time TR is accordingly comparable with the pulse length resulting in a shorter acquisition time. This gapped FM pulse is applied repeatedly in the magnetic field changing its orientation with each TR in a stepwise manner resulting in almost continuous gradients with low stress and relatively quiet operation.[13]

SWIFT can simultaneously image both hard and soft dental tissues with high resolution in short enough scanning times to be practical for clinical applications.[12] With SWIFT, minute details not observed with currently available clinical imaging techniques can be visualized within three dimensions without the use of ionizing radiation. Also, at present, there does not seem to be an acceptable method for in vivo evaluation of the contribution accessory canals, filled or unfilled, have on the outcome of endodontic treatment, which is a clinical issue that may also be able to be addressed with the development of dental MRI.[12] Moreover, SWIFT-based MRI has the potential to precisely determine the extent of carious lesions and simultaneously assess pulpal tissue, which would be an important step toward being able to distinguish between reversible and irreversible pulpitis.

Applications

Tooth anatomy and dental caries

Applications of MRI in imaging teeth are broadly classified into hard tissue imaging and soft tissue imaging.[13] Hard tissue imaging, in particular, remains challenging because of less water content in enamel and dentin and the T2 relaxation times of water in these tubules are very short. Studies have shown that imaging teeth with SWIFT, which helps in acquiring such ultra-short T2 relaxation times, not only



gives well-resolved tooth anatomy, delineating enamel, dentin and pulp but also detects early carious lesions.[14] It clearly demarcates the extent of demineralization which is not acquired by any of the radiographic methods. The relative variation in the intensities of enamel, dentin and pulp is in the order of 10:35:100 owing to the amount of water (8:20:100) in these structures, respectively.15 The finest details of the tooth-like accessory canals are identified with help of SWIFT images which are not visualized by standard radiographic techniques.

Restorations and calcifications in pulp

Composite restorations are generally demarcated as radiopaque or radiolucent as they contain varying amounts of minerals or heavy metals. Hence, conventional radiographic methods have difficulty in detecting recurrent caries when present adjacent to the radiolucent restoration or when present in the gingival margins of the restoration.[15] Fortunately, the composite resin materials exhibit short T2 relaxation times and hence easily be detected on swift images.[16] It also helps in demarcating reparative dentin which is formed as a result of past lesions thereby reducing the misconception of existing recurrent caries and multiple restorations. Moreover, in contrast to CBCT images, the presence of restorative materials does not seem to cause image distortion in SWIFT.

Detect microcracks in teeth

Detection of microcracks in teeth is mainly done by visual findings in conjunction with other methods such as transillumination, magnification, or using dyes.[17] These methods lack the ability to determine the exact extent and detect the cracks that are within the roots or are apical to restorations. SWIFT MR image helps in visualizing cracks which are as small as 20 μm as the water content in the cracks results in a positive enhancement of the contrast and also have the advantage of minimum artefacts due to any adjoining restorations.[18]

Detection of oral cancer

SWIFT MRI aids in the three-dimensional assessment of medullary and cortical bones in the finest detail and also has the potential to detect mandibular invasion, and the results were found to be in excellent qualitative agreement with histopathological findings.

Implantology

Taking the advantage of SWIFT MR imaging which helps in imaging ultra-short relaxation times of hard tissues such as bone not only aids in accurately visualizing the density of the bone during the initial planning of implant placement but also helps in assessing the success of implant placements.[19]

Advantages of swift over standard MRI

SWIFT has the advantage of not only acquiring the images of tissues with ultra-short T2 relaxation times but also is fast, avoiding associated delays of refocusing pulses and time required for an excitation pulse.[20] It demonstrates little or no motion artefacts because it does not have echo time and less distortion due to dental restorations. It is quiet, uses TR in a stepwise manner, and hence can be used in patients with ligyrophobia. This technique is unique in imaging both hard and soft tissues simultaneously with high resolution detecting even minute pathological and anatomical abnormalities.[21]

CONCLUSION

SWIFT imaging is a fast and newer imaging modality that offers simultaneous three-dimensional imaging of soft and hard tissues of the teeth without the use of ionizing radiation. This modality has many important applications in the field of dentistry with some powerful features such as its ability to visualize hard tissues such as enamel, dentin, and bone and offer a nearly silent operation reducing anxiety in claustrophobic patients.

Furthermore, it has the potential to image

minute dental structures within clinically relevant scanning times. This technology has implications for endodontists because it offers a potential method to longitudinally evaluate teeth where pulp and root structures have been regenerated. But more in vivo trials are to be done to demonstrate its application in regular diagnostic imaging.

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REVIEW ARTICLE

DENTIFRICES: ITS COMPOSITION, FORMS AND FUNCTION - A LITERATURE REVIEW

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ABSTRACT

Due to extended knowledge of the dental caries process, its prevention has been greatly advanced over the past fifty years, it is fair to state that the management of this disease at the level of the individual patient remains largely empirical. Recent innovations in oral care products have been directed toward making cosmetic marketing claims. There continues to be a need for innovation and collaboration with other scientific disciplines to fully understand and prevent dental caries.

Keywords: Abrasive, Caries, Dentifrices, Toothbrush

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INTRODUCTION

For centuries the main uses of dentifrices were related to cleaning the teeth, removal of unsightly enamel stains and promoting fresher breath. Today toothpastes represent by far the most commonly manufactured preparation which is used, in conjunction with the tooth brush, for affecting the accumulation, removal and the metabolic activities of dental plaque.[1]

As with time people are more concerned in relation to dental problems there should be processes to increase effectiveness and functionality of toothpaste, which is being achieved by adding a variety of safe, more biologically active yet compatible ingredients that may interact chemically with tooth structure, reduce demineralization, interfere with bacterial adhesion to the teeth, provide antibacterial action, prevent the formation of supragingival calculus, promote remineralization and reduce dentinal hypersensitivity.[2]

It is a complex process to design and produce clinically effective, multifunctional toothpastes which should satisfy all basic concerns, including safety, optimal rheology, pleasant flavor, packaging, shelf life and acceptable cost. Beyond that, the ultimate goal is to ensure that the toothpaste ingredients designed to accomplish each specialized function will remain compatible in a combined or final formulation[3,4]. The anti-plaque, anti-gingivitis and anti-calculus benefits of modern toothpastes also are also likely to be contributing factors to the retention of the natural dentitions.[2] Thus in the best interests of the public, dentists should be fully equipped with a body of knowledge about dentifrices so as to be able to advise their patients to make evidence based choices with regard to the most appropriate and effective toothpaste to use for improved oral health and a better quality of life.

DISCUSSION

Dentifrices are agents used along with toothbrush to clean and polish natural teeth. They are supplied as paste, powder, gel or liquid form. The most essential dentifrice recommended by dentists is toothpaste which is used in conjunction with a toothbrush to help remove food debris and dental plaque.[5]

Forms of Dentifrices

Toothpaste[6]

Toothpastes are products to be used with the toothbrush, that comprise ingredients toe nhance the basic plaque removing functionality of the toothbrush and provide additional benefits, i.e., cavity reduction, breath freshening, removal of dental stain, overall oral cleanliness and delivery of therapeutic agents. Toothpaste is semisolid in consistency and flows slowly. The essential components are abrasives, binder, surfactants and humectants. A paste is essentially a thick, soft, moist substance typically produced by mixing dry ingredients with a liquid.

Gel form [7]

Gels are defined as a substantially dilute cross-linked system, which exhibits no flow when in the steady-state. Gel form toothpastes consist of abrasives, binders, surfactants, humectants and flavouring agents. Gel is composed of silica rather than calcium carbonate as an abrasive and also include fatty acids.

Tooth powder[5]

Tooth powder is an alternative to toothpaste which is available in both fluoride and non-fluoride version. Tooth powder is a mildly abrasive powder which is used in combination with a toothbrush to maintain oral hygiene. The primary ingredient in a tooth powder is, of course, an abrasive to lift plaque and food from the teeth. Baking soda is a common abrasive, along with salt or chalk. A soap may be included to encourage the tooth powder to foam. A tooth powder may also include antibacterial ingredients like tea tree extract, or a flavoring agent such as mint to make it more palatable.

Liquid dentifrice [8]

Liquid dentifrices have advanced physical properties and are more efficient than other forms of dentifrices in reaching interproximal areas and other inaccessible areas of the dentition.

Composition of Dentifrices

Dentifrices are generally a mixture of an abrasive or polishing agent, detergent, binders, flavoring agents and substances necessary to facilitate their preparation and use. Therapeutic dentifrices contain, in addition to the above, one or more chemicals intended to reduce the incidence of oral dental diseases. More recently gel dentifrices have appeared in the market that contain the same components as the toothpastes, with the exception that the gels have a higher proportion of the thickening agents.[9]

Dentifrice Ingredients

Dentifrices contain both active and inactive ingredients. Active ingredients are those that offer a therapeutic benefit, while inactive ingredients are non-therapeutic and also contribute to the physicochemical properties of the dentifrice - its feel, consistency, sweetness, flavor, pH, texture, abrasiveness and appearance.[9,10]

Active Ingredients[5,9]

Active ingredients helps in prevention of caries, sensitivity, plaque/gingivitis, calculus formation and halitosis. The first active ingredient included was fluoride.

Active ingredients and their functions

Anti- caries: Sodium fluoride, Sodium monofluorophosphate, Stannous fluoride, Amine fluoride, Xylitol

Anti-plaque/anti-gingivitis: Triclosan/ copolymer, Stannous fluoride, Zinc citrate

Anti-calculus: Tetrapotassium pyrophosphate, Tetrasodium pyrophosphate, Sodium hexametaphosphate, Zinc compounds, Triclosan/ copolymer.

Anti-halitosis: Essential oils, Chlorine dioxide, Triclosan/copolymer, Stannous fluoride/ sodium hexametaphosphate

Desensitizers: Potassium citrate, Potassium nitrate, Potassium chloride, Stannous fluoride, Strontium chloride.

Anti-apthous agents: Aminoglucosidase, Glucose oxidase.

Inactive Ingredients [9]

Inactive ingredients in dentifrices include binders, abrasives, surfactants, buffering agents.

Abrasives[2,11,12]

Functions

1. Removal of debris and residual stains
2. Abrasives are used in dentistry for abrading, grinding and polishing
3. Abrasives affect the consistency of the toothpastes

The degree of abrasivity depends on the hardness of the abrasive, the morphology of the particles, and on the concentration of abrasive in the paste. Abrasives usually do not damage enamel, but may dull the tooth lusture. To compensate for this, polishing agents are added to the dentifrice formulations. These polishing agents are usually small sized particles of aluminum, calcium, tin, manganese or zirconium compounds. Agents such as chalk or silica may have both polishing and abrasive effects.

E.g. **Phosphates**:

- ✔ Dicalcium phosphate dehydrate
- ✔ Calcium pyrophosphate

Carbonates

- ✔ Sodium bicarbonate
- ✔ Calcium carbonate

As the abrasive level increases, greater care must be taken to perfect brushing techniques that do not cause self-inflicted injury to their teeth or soft tissues. The safe limits for an abrasive in a toothpaste according to the British Standards Institute is:

- ✔ Substrate - Abrasivity limit
- ✔ Dentin - Twice that to standard toothpaste.
- ✔ Enamel - Four times that of standard toothpaste

Humectants[13]

Humectants are moisturizers and also provide smooth texture to the toothpaste. Proper usage levels produce a clear translucent toothpaste. Humectants were added to maintain the moisture. These humectants are nontoxic but mold or bacterial growth can occur in their presence, for this reason, preservatives such as sodium benzoate are added. Eg. Glycerin (99.5%) and sorbitol (70%), Polyethylene glycol, Xylitol and Propylene glycol.

Binders[7]

Binders are hydrophilic colloids which disperse or swell in the presence of water. Humectants help to maintain the consistency of toothpaste, but despite their presence, the solids tend to settle out of the paste. To counteract this, thickening or binding agents are added to the formula.

Eg. **Natural polymers:** carboxy methyl cellulose, carageenans and Xyntholgum, Synhethic polymers, Gums.

Surfactants/ Detergents [7,14]

Detergents are cleansing or purging agents that through a surface action that depends on their possessing both hydrophilic and hydrophobic properties, exerts cleansing (oil-dissolving) and antibacterial effects. Sodium lauryl sulphate (SLS) is the most commonly used detergent. It is stable, possesses some antibacterial properties and has a low surface tension, which facilitates the flow of the dentifrice over the tooth surface.

Eg. Sodium lauryl sulphate, Sodium N lauryl sarcosinate, Sodium dodecyl benzene sulphonate, PEG.

Flavoring Agents[5]

Flavor, along with smell, colour and consistency of products is an important characteristic that leads to public acceptance of dentifrice. The flavoring agents are solubilized and dispersed through the paste or liquid via the detergent.

Eg. Peppermint, spearmint, wintergreen modified with other essential oils of aniseed, clove, caraway, eucalyptus, citrus, menthol, nutmeg, thyme or cinnamon.

Sweeteners[9]

Saccharin, cyclamate, sorbitol and mannitol serve as primary non cariogenic sweetening agents;the latter two also serve as humectants. A new sweetener in dentifrice is xylitol. It demonstrated an anticaries capability by facilitating the remineralisation of incipient carious lesions.

Eg. Sodium saccharin, Sodium cyclamate, Acesulphame K.

Preservatives[5]

Preservatives prevent the growth of micro-organisms in the toothpaste. Microbial contamination of dentifrices is restricted by a low water activity and by the inclusion or preservatives such as benzoates. E.g. Sodium benzoate, Methyl paraben, Propyl paraben.

Coloring Agents[15]

The colour-substances are classified by the Colour Index (CI), published by the Society of Dyers and Colourists and the American Association of Textile Chemists and Colourists, or by a system called the F D & C Colours. Titanium dioxide is often added to toothpastes to give them a white, opaque colour.

Eg. Titanium dioxide, Various food dyes for coloured pastes and gels.

Solvents[7]

Water is the most common solvent used in toothpastes which helps in dissolving ingredients and allows them to be mixed. Manufacturers are required to list all the ingredients present in toothpaste however most manufacturers do not reveal all the ingredients as it is a trade secret for them.

Functions of Dentifrices

Various functions of A multifunction toothpaste are[16]

1. Chemotherapeutic prevention of bacterial biofilm and gingivitis.

2. Preventing and controlling calculus

formation

3. Tooth whitening by prevention and reduction of extrinsic stains

4. Controlling breath malodor with toothpastes

5. Dentifrices in caries control

6. Dentifrices for the treatment of dentine hypersensitivity

1. Chemotherapeutic prevention of bacterial biofilm and gingivitis[2,17,18]

Dentifrice is a logical vehicle to introduce appropriate antibacterial and effective non-antiseptic agents to intervene against microorganisms as well as extracellular matrix that forms and constitute the harmful biofilm on the teeth. Populated with acidogenic and aciduric microorganism, bacterial biofilm on the teeth (dental plaque) is a key etiological contributor to the undesirable dental conditions: Dental caries, gingivitis and its sequels and calculus formation. Significantly controlling and reducing the dental biofilm would ameliorate all three conditions.

The strongest antibacterial agent identified is the bisguanide antiseptic chlorhexidine's gluconate, which inhibits bacteria by disrupting their cell wall causing leakage from the bacterial protoplasm. In contrast, divalent metal ions compounds ,stannous fluoride and zinc citrate as well as non ionic antiseptic, triclosan have all found their way into numerous dentifrice formulations, and all three have been effective in the clinical setting with respect to bacterial biofilm control and gingivitis prevention. Stannous fluoride in a newly stabilized form has returned to toothpaste as both an anti caries and as an anti plaque and anti gingivitis agent. Zinc citrate containing toothpastes have been formulated to include .3% triclosan.

These formulations have shown good anti plaque and anti gingivitis efficacy.

Toothpaste formulated with triclosan and a copolymer of polyvinyl methyl ether and maleic acid (gantez) have consistently demonstrated good efficacy in both dental plaque prevention and gingivitis reduction.

2. Preventing and controlling calculus formation [19,20]

Several agents that are well known as crystal growth inhibitors including pyrophosphates, diphosphotases, hexametaphosphate, zinc citrate , zinc chloride and gantrez acid among others.

Agents for calculus formation

- Pyrophosphates
- Diphosphonates
- Polyphosphates
- Hexametaphosphates
- Zinc citrate
- Zinc chloride
- Gantez acid

All of these agents have found their way into modern dentifrices and in clinical trials conducted till date have consistently exhibited clinically relevant reductions in calculus formation. Calculus reduction percentages obtained in these studies ranged from 5 to 5 0%.

White made an interesting point that in the 1970s there was considerable concern that agents interfering with mineral nucleation to prevent calculus formation might also be expected to diminished remineralization of early caries lesion, as per the dimineralisation-remineralisation model then emerging to explain the dynamics of caries initiation and prevention. Careful attention to this issue indicated that the daily renewal of fluoride from the dentifrice to plaque fluid on the enamel surface "reversed the negative effects of inhibitors of remineralisation".

3. Tooth whitening by prevention and reduction of extrinsic stains [21,22,23,24]

Dentifrices can be formulated to provide a measure of tooth whitening through their potential of preventing extrinsic stain formation or by effecting the removal of extrinsic stain from tooth enamel. Extrinsic stains on enamel are generally the result from adsorption of chromagens to salivary pellicle film existing on the teeth. Chromagens most typically come from dietary products such as tea or red wine, from preparations containing certain metallic salts and also from tobacco use. In general, focusing on improved tooth brushing habits and combining that with a modern whitening dentifrice is a conservative and tooth friendly first option in seeking to control and diminish dental stain, extent and intensity.

Agents formulated in dentifrices for preventing and/or removing extrinsic stains Three groups of agents that may be formulated into dentifrices for the purpose of preventing and/or removing extrinsic enamel stains are abrasive and chemical and bleaching agents.

Abrasive Agents: Dicalcium phosphate dehydrate, Calcium pyrophosphate, Calcium carbonate, Hydrated silica Chemical Agents: Surfactants(eg SLS), EDTA, Citrates, Pyrophosphates, Polyphosphates.

Bleaching Agents: Hydrogen peroxide, Carbamide peroxide.

Dentifrices relying on abrasive systems for extrinsic stain prevention or removal will generally employ a mixture of a abrasive materials to form an abrasive system an example of such a system is one where a certain quantity of perlite has been added to the main abrasive agent being used. Perlite abrasive enhancement appears to have achieved clinically superior extrinsic stain removal.

Dentifrices relying on chemical agents for stain prevention or removal will usually incorporate elected compounds from a test that includes surfactants, enzyme system, edta, citrates, pyrophosphates, diphosphonates and polyphosphates. Currently only a few dentifrices rely on bleaching ingredients to counteract the stain trapped on the salivary pellicle and enamel surfaces.

4. Controlling breath malodor with toothpastes [7,25]

Halitosis is an oral health concern for many individual. Conscientious and regular oral hygiene is basic to the prevention and control of breath malodor. In recent year dentifrice manufacturers have evaluated methods to incorporate breath freshening technologies in their formulations. In the main, it relies on incorporating one or a combination of the following four constituents in toothpaste:

a) Essential oils for stronger flavours.

b) Zinc and stannous salts as antibacterial agents

c) Triclosan as an antibacterial and

d) Higher levels of sodium bicarbonate as part of the abrasive system.

5. Dentrifrices in caries control 26

Abrasives which are major constituents of dentifrices, contribute minimally to plaque removal and thus to caries reduction. Plaque removal efficacy depends on efficient brushing, not on whether a dentifrice is used or not. The caries inhibitory effect of fluoride is documented for dentifrices containing any of the three fluoride compounds-sodium fluoride, sodium monofluorophosphate and stannous fluoride. Other fluoride compounds such as amine fluoride have also proved to reduce caries development.

6. The role of fluoride in caries reduction[26,27]

Fluoride dentifrices have an indirect effect on the bacterial flora. Fluoride levels down to 2 to 5 ppm fluoride has been shown to reduce lactate and acetate formation. This may reduce the advantage of aciduric bacteria in acidic environments and may theoretically impede the emergence of an aciduric flora.

7. Dentrifices for the treatment of dentine hypersenstivity[28,29,30]

The term 'dentine hypersensitivity' has come into use to describe the condition in which sharp pain is produced in response to mild stimuli which disappears when stimulus is removed. Sensitivity in young adults isp robably caused in many cases by consumption of acid diets which causes erosion of thin cervical enamel and thereby exposes dentine.

Incidence of sensitive dentine diminishes with advancing age. Apart from age changes in dentine and pulp which might reduce sensitivity, the proportion of dentate patients also decreases with age. Most frequently affected teeth from sensitivity are premolars, incisors and canines.

Specific dentifrices designed to combat dentinal or cervical hypersensitivity have existed for several decades. These pastes were formulated empirically, offering lower abrasivity and containing a variety of active ingredients.These agents had three aims:

- Mineral salts(e.g., strontium chloride, potassium oxalate, stannous fluoride) occluded the dentinal tubules
- Occluding the tubules using proteinp recipitants (formaldehyde and glutaraldehyde)
- Desensitising nerve fibres in the dentinal tubules (potassium nitrate)

Desenitizing agents used in dentifrices: Strontium acetate, Strontium chloride, Formaldehyde, Potassium nitrate, Potassium chloride and Sodium citrate.

CONCLUSION

Dentifrice was originally used to promote oral hygiene by cleaning teeth. Currently over-the-counter (OTC) dentifrices offer various preventive, aesthetic and treatment benefits. While some dentifrices offer only cleaning benefits together with fluoride for anti-caries benefits, in recent years dentifrices with multiple benefits aimed at offering solutions to as many potential problems as possible have been introduced. Recommendations should be based on an individual patient's specific needs and desires as well as the scientific support for a dentifrice Dental education through its various media and even at chairside is an important tool in raising awareness for this simple and relatively inexpensive method of controlling dental diseases.

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CASE REPORT

MANAGEMENT OF C SHAPED ROOT CANALS

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ABSTRACT

The aim of this article is to discuss the etiology, incidence, anatomic features, classification, diagnosis and management of the C-shaped canal configuration along with some case presentations. C- shaped canal configuration is a variation that has a racial predilection and is commonly seen in mandibular second molars. The intricacies present in this variation of canal morphology can pose a challenge to the clinician during negotiation, debridement and obturation.

Keywords: C-shaped canals, mandibular second molar, mandibular first premolar, root canal morphology

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INTRODUCTION

A thorough knowledge of the root canal anatomy and its variations is required for achieving success in root canal therapy, along with diagnosis, treatment planning and clinical expertise. One such variation of the root canal system is the C-shaped canal configuration. It is termed so because of the C-shaped cross-sectional anatomical configuration of the root and root canal. This condition was described for the first time in literature by Cooke and Cox1 in 1979, though Weine et al.,[2] reported that several clinicians had suggested its presence in lectures earlier.

Numerous incidence studies prove the racial predilection of this variation. Though most commonly found in mandibular second molars, the C-shaped canal configuration may also occur in mandibular premolars, maxillary molars, and mandibular third molars. The C-shaped canal configuration presents with variations in both the number and location of the canal(s), as the canal(s) courses from the coronal to the apical third. The complexity of this canal configuration proves to be a challenge with respect to debridement and obturation and possibly the prognosis during root canal therapy. Recognition of a C-shaped canal configuration before treatment can facilitate effective management, which will prevent irreparable damage that may put the tooth in severe jeopardy. The aim of this article is to discuss the etiology, incidence, anatomic features, classification, diagnosis and management of the C-shaped canal configuration with the help of few case reports.

Etiology

Ever since the identification of the C-shaped canal anatomy, various causes have been postulated for its formation. The failure of fusion of Hertwig's epithelial sheath is the most lucid explanation for the formation of the C-shaped canal configuration. Failure of the Hertwig's epithelial sheath to fuse on the buccal side will result in the formation of a lingual groove, and failure to fuse on the lingual would result in a buccal groove. Hence, this fusion is not uniform and a thin interradicular ribbon connects the two roots together. Failure of the sheath to fuse on both the buccal and lingual sides will result in the formation of a conical or prism-shaped root.[3]

Incidence

The C-shaped canal configuration shows an ethnic predilection. It has frequently been reported in countries belonging to the Asian continent. East Asian population groups like Chinese (0.6%-41.27%) and Koreans (31.3%-45.5%) display a high prevalence of this variant. Among the South Asian countries, Burmese population showed a prevalence of 22.4%, which was much higher than the Indian, Thai or Sri Lankan population.[3]

Canal configuration has been shown to have a high prevalence in mandibular second molars with a percentage ranging between 2.7%-45.5%. Incidence studies in mandibular premolars have been reported in Chinese, Indian and Iranian population, with the highest frequency being reported in the Chinese population (29.7%). The C-shaped variation in canal anatomy has also been reported in maxillary first molars (0.12%), maxillary third molars (4.7%), mandibular third molars (3.5%-4%) and mandibular second premolars (1%).[3] There is no correlation of C-shaped canal configuration with gender and also with age and tooth position. Bilateral occurrence of C-shaped canals has been reported in a percentage of 70%-81%.[3]

Anatomic Features

The following are the pertinent features in relation to the external root anatomy and configuration of the pulp chamber and the root canal system usually found in C-shaped mandibular molars, though similar features may be found in C-shaped maxillary molars and mandibular premolars.[3]

Roots

A conical or square configuration is characteristic of roots having a C-shaped canal. The root configuration of molars having this canal shape may be represented by fusion of either the facial or lingual aspect of the mesial and distal roots. The roots display an occluso-apical groove on the buccal or lingual surface, which represent the line of fusion between mesial and distal roots. The surface opposite this radicular groove is convex.

Pulp Chamber

The pulp chambers of teeth with C-shaped canals mostly have greater apico-occlusal width with a low bifurcation. This results in a deep pulp chamb er floor, which has uncommon anatomical configuration. The connecting slit that gives the tooth its name of "C-shaped" may have closure to the buccal or lingual. If the buccal portion of the mesial and distal roots is fused, the slit goes through the area of fusion, and so the "C" is closed to the lingual. If the lingual portion of the roots is fused, then the "C" is closed to the buccal.

Root canal system

The root canal system of C-shaped canals shows broad, fan-shaped communications from the coronal to the apical third of the canal. The canal(s) change shape from the coronal aspect of the root. For example: A continuous C-shaped canal would change to a semicolon configuration in the midroot and then becomes continuous C-shape in the apical third of the root or vice versa. Accessory and lateral canals, inter-canal communications and apical delta can be found in the apical region of C-shaped canals.

Classification

Classification The C-shaped canal system can assume many variations in its configuration so a comprehensive classification can help in true diagnosis and management.[4]

Melton's Classification

Melton et al.5 in 1991 proposed the following classification of C-shaped canals based on their cross-sectional shape: Melton's Classification Melton et al. 5 in 1991 proposed the following classification of C-shaped canals based on their cross-sectional shape:

1. Category I: continuous C-shaped canal running from the pulp chamber to the apex defines a C-shaped outline without any separation (i.e., C1 in Fig. 1).
2. Category II: the semicolon-shaped (;) orifice in which dentine separates a main C-shaped canal from one mesial distinct canal (i.e., C2 in Fig. 1).
3. Category III: refers to those with two or more discrete and separate canals: subdivision I, C-shaped orifice in the coronal third that divides into two or more discrete and separate canals that join apically; subdivision II, C-shaped orifice in the coronal third that divides into two or more discrete and separate canals in the

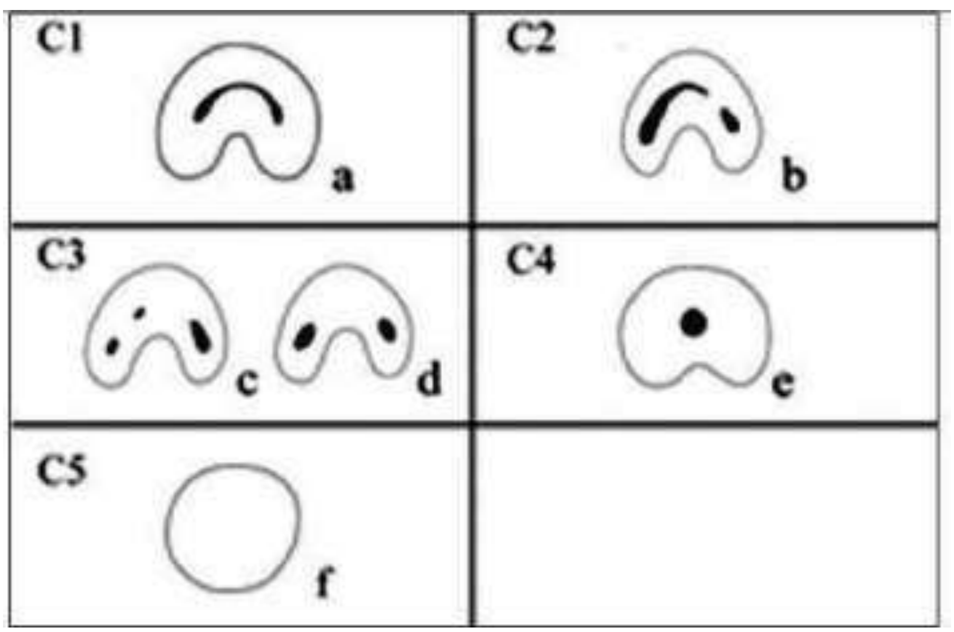


Figure 1. Classification of C-shaped canal configuration[4]

midroot to the apex; and subdivision III, C-shaped orifice that divides into two or more discrete and separate canals in the coronal third to the apex (i.e., C3 in Fig. 1).

In this classification, there has been no clear description of the difference between categories II and III as well as the clinical significance. Furthermore, they examined three arbitrary levels of the root, and hence little information is present describing how the canal shape may change over its length. Also, they noted that the second type of C-shaped canal is the most common.

Fan's Classification

(Anatomic Classification)

Fan et al. 6 in 2004 modified Melton's method into the following categories:

1. Category I (C1): the shape was an interrupted "C" with no separation or division (Fig. 1A).
2. Category II (C2): the canal shape resembled a semicolon resulting from a discontinuationof the "C" outline (Fig. 1B), but either angleor (Fig. 2) should be no less than 60°.
3. Category III (C3): 2 or 3 separate canals (Fig. 1C and D) and both angles, and , were less than 60° (Fig. 3).
4. Category IV (C4): only one round or oval canal in that crosssection (Fig. 1E).
5. Category V (C5): no canal lumen could be observed (which is usually seen near the apex only) (Fig. 1F).

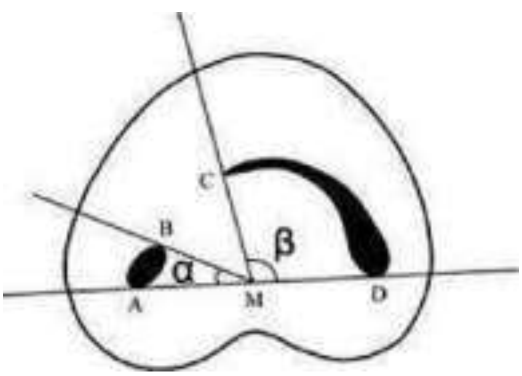


Figure 2. Measurement of angles for the C2 canal. Angle is more than 60°.
(A and B) Ends of one canal cross-section,
(C and D) ends of the other canal cross-section;
M, middle point of line AD; angle between line AM and line BM; angle between line CM and line DM

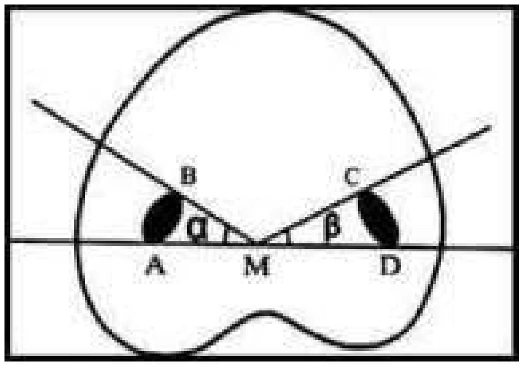


Figure 3. Measurement of angles for the C3 canal. Both angle and angle are less than 60°. (A and B) Ends of one canal cross-section; (C and D) ends of another canal cross-section; M, middle point of line AD; , angle between line AM and line BM; , angle between line CM and line DM

They considered that although the C-type orifice may look like 2 or 3 separate orifices, an isthmus linking them is often discernible. The single, round, or oval canal (C4 in their classification), which may be found near the apex, should be considered as a variation because other parts of the canal have shown the "C" configuration. They noted that "C" shape can vary along the root length so the clinical crown morphology or the appearance of the orifice may not be good predictors of the actual canal anatomy. In this classification, one of the canals in the C2 category would appear as an arc (with 60°, Fig. 2) (i.e., the C2 canal would be more likely to extend into the fused area of the root where the dentin wall may be quite thin). They are more difficult to clean and shape than C3 canals.

Fan's Classification

(Radiographic Classification)[7]

Fan et al. (11) classified C-shaped roots according to their radiographic appearance into three types:

1. Type I: conical or square root with a vague, radiolucent longitudinal line separating the root into distal and mesial parts. There was a mesial and a distal canal that merged into one before exiting at the apical foramen (foramina) (Fig. 4A).

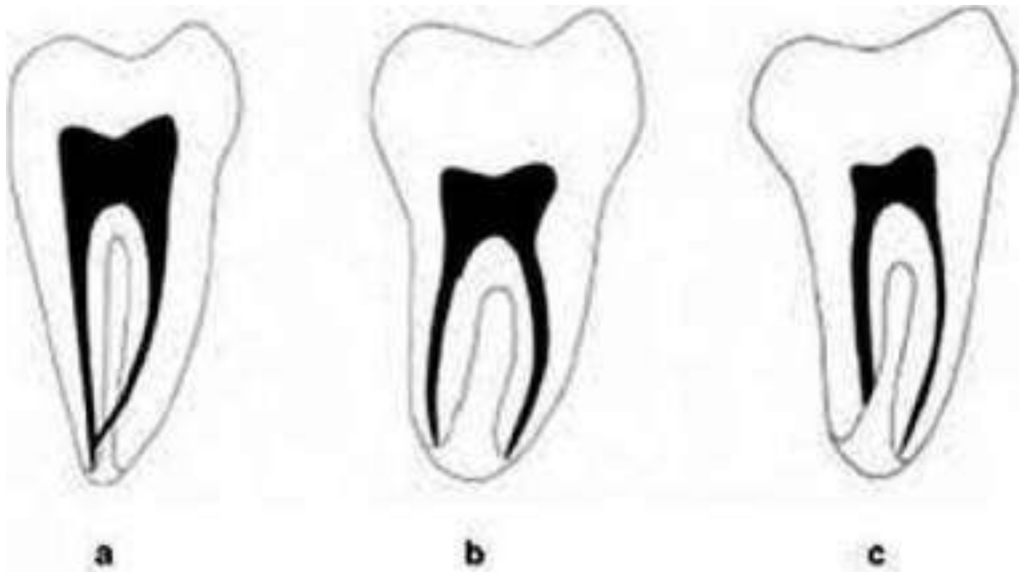


Figure 4. Radiographic types. (A) Type I, (B) type II, and (C) type III4

2. Type II: conical or square root with a vague, radiolucent longitudinal line separating the root into distal and mesial parts. There was a mesial and a distal canal, and the two canals appeared to continue on their own pathway to the apex (Fig. 4B).

3. Type III: conical or square root with a vague, radiolucent longitudinal line separating the root into distal and mesial parts. There was a mesial and a distal canal, one canal curved to and superimposed on this radiolucent line when running toward the apex, and the other canal appeared to continue on its own pathway to the apex (Fig. 4C).

Diagnosis

Preoperative radiographic diagnosis

A preoperative radiograph usually provides various clues in the identification of any variation in root canal morphology. Some investigators described four radiographic characteristics that can allow prediction of the existence of this anatomical condition: radicular fusion, radicular proximity, a large distal canal or a blurred image of a third canal in between. Hence, a C-shaped root in a mandibular second molar may present radiographically as a single-fused root or as two distinct roots with a communication. When the communication or fin connecting the two roots is very thin, it is not visible on the radiograph and may thus give the appearance of two distinct roots. The radiograph may also reveal a large and deep pulp chamber, usually found in C-shaped molars.

Fan et al.[8], divided the radiographic appearance that the C-shaped teeth are present with three types In type I, the C-shaped canal system actually appears as two distinct canals, because the isthmus that links the mesial and distal "main" canals is very thin and hence is not detected radiographically. In the radiographic type II, the mesial and distal canals assume their own individual course to the apex. Thus, there are apparently two distinct canals on the radiograph. In type III, one canal continues its course to the apex giving the image of a distinct canal whereas the other(s) proceeds very close to or within the fused area, that is, the "web" between the two main roots in the apical third. Hence, the canal may seem to exit into the groove radiographically. Wang et al.,[9] reported a higher incidence in the recognition of C-shaped canals using a combination of radiography and clinical examination under the microscope (41.27%) than using the radiography (34.64%) or clinical examination (39.18%) alone.

Preoperative clinical diagnosis

The crown morphology of teeth with C-shaped anatomy does not present with any special features that can aid in the diagnosis. A longitudinal groove on lingual or buccal surface of the root with a C-shaped anatomy may be present. Such narrow grooves may predispose the tooth to localized periodontal disease, which may be the first diagnostic indication.

Clinical diagnosis following access cavity preparation

Some investigators asserted that since radiographic diagnosis is difficult, clinical diagnosis of C- shaped canals can be established only following access to the pulp chamber. Magnification with Loupes and microscopes are very useful for clinical procedures. The pulpal floor in C-shaped teeth can vary from peninsula like with a continuous C-shaped orifice to non C-shaped floors as per the classification given by Min et al., However, when a C-shaped canal orifice is observed, say, under the operating microscope, one cannot assume that such a shape continues throughout its length. Fan et al.,[6] stated that for mandibular second molar to qualify as having a C-shaped canal system, it has to exhibit all the following three features:

a. Fused roots;

b. A longitudinal groove on lingual or buccal surface of the root;

c. At least one cross-section of the canal should belong to the C 1 , C 2 or C 3 configuration, as per Fan's anatomic classification.

Clinical and radiographic diagnoses during working length determination

Working length radiographs are more helpful than preoperative and final radiographs in diagnosing C-shaped canals. In a true C-shaped canal, (single canal running from the orifice to the apex) it is possible to pass an instrument from the mesial to the distal aspect without obstruction. In the semicolon type, (one distinct canal and a buccal or lingual C-shaped canal) whenever an instrument was inserted into any side of the C-shaped canal, it always ends in the distal foramen of the tooth and a file introduced in this canal could probe the whole extension of the C. When negotiating the C-shaped canal, instruments may be clinically centered. Radiographically, the instruments may either converge at the apex or may appear to be exiting the furcation, thus adding to the confusion and troublesome task of determining whether a perforation has occurred. Usage of diagnostic aids like cone-beam CT can help in understanding the anatomical variations.

Management

The high percentage of canal irregularities, such as accessory to lateral canals, and apical delta in a C-shaped canal makes it difficult to clean and seal the entire canal system adequately. The wide fins and small surface area of these canals preclude complete debridement using traditional hand instrumentation techniques, which can lead to failure of root canal therapy.[3] Therefore, careful location and negotiation of the canals and the meticulous mechanical and chemical debridement of the pulp tissue should be carried out in order to successfully treat a C-shaped canal.

Location and negotiation of canals

Modifications in the access cavity designs may be required for teeth with C-shape configuration to facilitate location and negotiation of the complete canal system. When the orifice is continuous C-shape or arc like Mesiobuccal-Distal (MB-D), the number of canals can vary from one to three; when the orifice is oval or flat, the number of canals may be one or two; and when the orifice is round, there is usually only one canal below the orifice. Hence, for continuous C-shape orifice,[3] initial files are inserted, one at either end and one in the middle. When the orifice is oval, two files are inserted, that is, one file at each end of the orifice and when the orifice is round, one initial file is inserted. Calcifications present in the pulp chamber may disguise the C-shape of the canal system. In such cases, several orifices may be probed that link up on further instrumentation. There are also chances of missing out on canals because of bifurcation, dentin fusion, and curvatures. Exploration should be carried out with small size endodontic files, such as a no. 8, 10, 15 K-file with a small, abrupt apically placed curve, to ensure that these irregularities are not missed.[3]

Cleaning and shaping

In order to access all the irregularities in the C-shaped canal system, the orifice portion of the slit can be widened with orifice openers. However, C1 (continuous C type) and C2 (semicolon type) configurations always have a narrow isthmus and care should be taken to avoid perforation during their preparation. There is a high risk of root perforation at the thinner lingual walls of C-shaped canals during cleaning and shaping. The Abou-Rass et al.[10],'s anti-curvature filing technique has been recommended to avoid danger zones that are frequently present at mesiolingual walls. However, Jin et al.[11] reported that the tooth structure of the groove area in C-shaped canal was thicker than that of the danger zone of normal second mandibular molar and hence, the C-shaped canals were as safe from strip perforation as other teeth in the limitation of this study. Extreme caution must be taken to prevent strip perforation during cleaning and shaping of C-shaped mandibular premolars, which display thin dentinal walls in the radicular groove area.

Very few studies have evaluated the effectiveness of cleaning procedures in relation to C-shaped root canals. Though nickel-titanium rotary instruments seem to be safe in such canals, further enlargement to an apical dimension greater than size 30 (0.06 taper) is not recommended.[12] After instrumentation by NiTi rotary instruments, K-files could be passively introduced into the canal, and filling could be specifically directed towards the isthmus areas to obtain better debridement in clinical practice. The recently developed self-adjusting file (SAF) system has been reported to be more efficacious than the protaper system for shaping of C-shaped canals.

Because of the large area of canal space, it is doubtful that intracanal instruments can reach and debride the entire portion of the continuum, making irrigation procedures more significant. It is recommended that cleaning of the C-shaped canal system with rotary instruments should be assisted by ultrasonic irrigation. Besides the use of sonication and ultrasonication, the use of chemical agents for disinfection cannot be over emphasized in the treatment of C-shaped root canal system.Some authors have advocated the use of calcium hydroxide as an intracanalmedicament for a period of 7-10 days.

With regard to the management of C-shaped canal configuration in mandibular premolars, many complicating factors make them difficult to treat. Anatomically the diameter and width of mandibular first premolar is much smaller than mandibular second molars.The small size of mandibular first premolar limits the coronal access to the complex root canal system, which unlike the mandibular second molar, is found apically.

Obturation

Obtaining a three dimensional fill of a C-shaped canal may prove to be a problem due to the various intricacies present within the root canal system. If a cold condensation technique is adopted for obturation, deeper penetration of condensation instruments in several sites will be necessary. To ensure proper placement of the master cones in C-shaped canals, Barnett13 recommended placing a large diameter file in the most distal portion of the canal, before seating the master cone in the mesial canal. The file is then withdrawn and the master cone of the distal canal is seated, followed by placement of accessory cones in the middle portion of the C-shaped canal.

Studies have shown that following the cleaning and shaping, the remaining dentin thickness around the canals is usually 0.2 to 0.3 mm. The resultant forces of compaction during obturation can exceed the dentin canal resistance, which may result in root fracture and perforation of the root. In this regard, the thermoplasticized gutta-percha technique may prove to be more beneficial.The aim of this technique is to move the gutta-percha and sealer into the root canal system under a hydraulic force. But in C-shaped canals the hydraulic forces can dramatically decrease and can seriously compromise the obturation quality due to the following reasons: (a) there are divergent areas that are frequently unshaped, which may offer resistance to obturating material flow (b) communications exist between the main canals of the C-shape through which the entrapped filling materials that should be captured between the apical tug back area and the level of condensation may pass from one canal to another. Walid's technique[14] aimed to overcome these problems. This technique involves placing the master points simultaneously in the C-shaped canal. A large plugger is placed on one of the seared master points while the other master point is down packed with a smaller plugger. This increases the resistance towards the passage of obturating material from one canal to another. The smaller plugger is then held in place while the other point is down packed. This offers backpressure on entrapped filling materials and enhances the seal.

Ultrasonic compaction (UC) Lateral compaction was performed, and the extended ends of the cones were seared off. The SO4 ultrasonic spreader tip attached to the Suprasson PMax Ultrasonic unit (Satelec, Merignac, France) with a power setting of [8] was inserted into the canal without force to within 2-3 mm from the end-point of preparation, and was placed into the centre of the gutta-percha mass and activated. The spreader was moved in short continuous in and out motions approximately 8-10 times with slight apical pressure until 2-3 mm short of the working length. Subsequently, the ultrasonic spreader was deactivated, slightly rotated and then withdrawn. The selected finger spreader was used to compact laterally the softened mass of gutta-percha. Additionally, 2-3 accessory cones were laterally compacted in the same manner. Ultrasonic compaction, followed by cold lateral compaction, was repeated one more time.

Canals with increased flare resulted in significantly poorer quality of fill using LC. For wider and irregular-shaped canals, instead of compacting and deforming gutta-percha cones during spreader penetration, the cones will be displaced laterally. Voids and sealer will mostly found along the perimeters of the gutta-percha mass, possibly indicating eventual loss of integrity because of poor adaptation of gutta-percha to the canal walls. Void formation was probably due to the failure of the accessory gutta-percha cones in filling the space created by the compacting instrument..

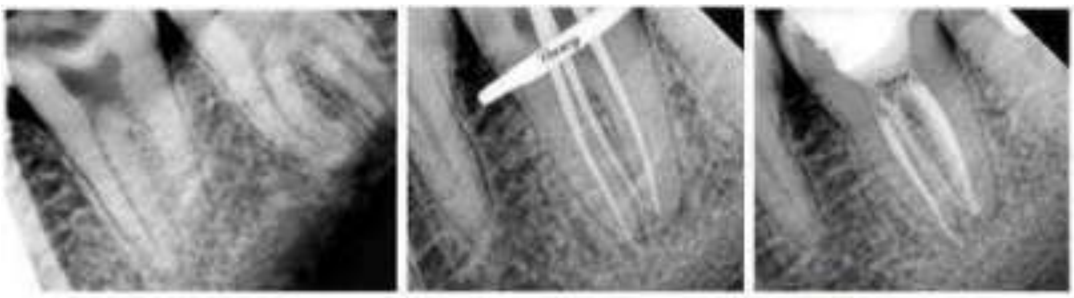
The pilot study showed that two insertions of the ultrasonic spreader into the canal that was initially filled by the lateral compaction technique were sufficient to thermoplasticize the whole guttapercha mass. Although not significant, this observation suggests that the UC may result in a filling of greater density. A higher percentage of gutta-percha was observed at all three levels in the UC group compared with the LC group.[15] This finding also supports the scanning electron microscope investigation by Baumgardner & Krell [16], where a more homogeneous gutta-percha mass with fewer voids was reported in root canals filled by UC. They found that canals filled by UC resulted in significantly less apical leakage than canals obturated by LC. The warm gutta-percha should adapt more adequately to the canal walls and irregularities. The lower percentage of sealer compared with LC was probably due to the mixing of sealer and gutta-percha during ultrasonic compaction, so the definite areas of sealer became smaller.

Post endodontic restorations

Post endodontic restoration of teeth with a C-shaped canal configuration may also be compromised due to the relatively small amount of dentin between the external surface of the root and the internal canal system. At least 1 mm of sound tooth structure should be present around a post if needed, for resistance to root fracture. Hence, prefabricated or cast posts increase the risk of creating a strip perforation. Besides, no prefabricated post (circular or conical i.e. of a circular cross section) would fit the C-shaped canals. Since the floor of the pulp chamber is deep it can provide ample retention from the available undercuts. Chamber- retained, bonded amalgam or composite is a better choice as the core or as the final restoration in these teeth.[3]

Case 1

Mandibular second molar with irreversible pulpitis, buccal caries, Preoperative IOPA radiograph gave indication of a possible 'C' shaped anatomy. Caries driven access, MB and Distal canals are connected in a C Shape manner. ML canal as a separate one. Manual dynamic and Sonic agitation of Irrigation solutions. (1ml 17% EDTA, 30-35ml 5%Na Hypo), Zno Eugenol Sealer (Zical, Prevest), Obturation by Ultrasonic aided lateral compaction.




Case 1

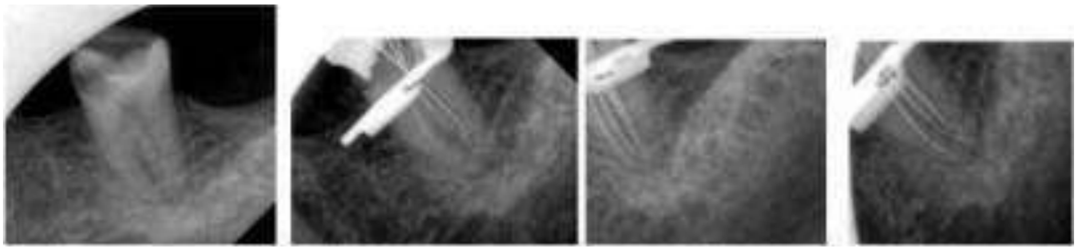
Case 2

Mandibular second molar with irreversible pulpitis. Preoperative IOPA radiograph gave indication of some abberent anatomy and a possible 'C' shaped canal configuration. On opening 'C'shaped canal configuration found, Mb and D canals were joining. 3 canal openings were found with ML as a separate one. Two visit RCT with CaOH as ICM. Manual dynamic and Sonic agitation of Irrigation solutions (1 ml of EDTA, 40-45 ml of 5% Na Hypo), Zno Eugenol Sealer(Zical, Prevest), Obturation Technique-Ultrasonic aided Lateral compaction.

Case 3

Mandibular second molar with C shape and interesting anatomy. A crack was there in the


Case 2



Case 3

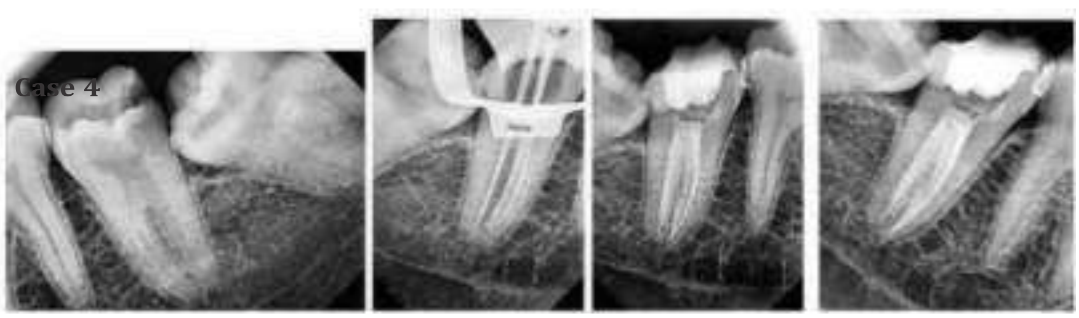
distal wall. Patient informed the risks. We decided to give a try to save the tooth as his first molar is already missing on that side. 4 orifices in a C shape with no obvious coronal isthmus connecting them all,ML canal has separate POE,the other three canals with common exit towards distal aspect. Distal canal is having sharp apical curve. Precurving after coronal flaring helped to negotiate the apical curve. Severely narrow mesial canals. Ultrasonic ,Sonic and Manual dynamic agitation of irrigation solutions(1ml of 17% EDTA,30 ml of 5% Na Hypo),30 gauge side venting metallic needles and Truanatomy needles used for irrigation. Extracanal warming of Na hypo done for final irrigation. Sealer-Zno Eugenol sealer(Zical),Obturation technique-Ultrasonic aided Lateral compaction, Orifices sealed with GIC,Core build up done with paracore.

Case 4

An interesting mandibular second molar with irreversible pulpitis, C shaped anatomy, sonic and ultrasonic activation of irrigation (17%EDTA and 5%Na Hypo), seal apex sealer, ultrasonic aided lateral compaction.

Case 5

C shaped mandibular second molar with



Case 5

irreversible pulpitis, sonic and ultrasonic activation of irrigation (17%EDTA and 5%Na Hypo), seal apex sealer, ultrasonic aided compaction.

CONCLUSION

The C-shaped root canal configuration has an ethnic predilection and a high prevalence rate in mandibular second molars. Understanding the anatomical presentations of this variation will enable the clinician to manage these cases effectively. Usage of diagnostic aids like cone-beam CT and operating microscopes help in understanding the anatomical variations. Continuous circumferential anticurvature filing along the periphery of the C-shaped root canal assisted with ultrasonic activation of sodium hypochlorite enhances tissue removal. Modifications in obturation techniques like ultrasonic lateral compaction and warm vertical compaction help in increasing the adaptation and density of filling.

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ENDODONTIC RETREATMENT OF C-SHAPED AND RADIX ENTOMOLARIS ANATOMIC VARIATIONS IN MANDIBULAR MOLARS: TWO CASE REPORTS

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ABSTRACT

Endodontic success depends on multiple factors. The tooth position, morphology, anatomic variations, clinical skills, and expertise along with equipment and materials used, all contribute to clinical success. This article describes in detail non-surgical retreatment of two anatomic variations in mandibular molars that were failing because of persistent periapical disease, due to previous misdiagnosis and inadequate endodontics.

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INTRODUCTION

Root canal disinfection, thorough debridement and three-dimensional filling is the goal of root canal treatment (RCT).[1] Failure to perform any of these steps could result in post-treatment endodontic diseases. Lack of healing is primarily attributed to persistent inter-radicular infection residing in previously un-instrumented canals, isthmi, or other complex irregularities of the root canal system.[2]

Anatomical and morphological variation in the root canal system often put the clinicians in a difficult scenario where identification of root canal orifices, cleaning, shaping, and debridement become a challenging task. Hence, good knowledge of internal anatomy and morphological variation is prerequisite for proper diagnosis and treatment planning. Mandibular molars are known to show variations in root canal morphology. Among many such variations, Radix entomolaris (RE) & C-shaped canal configuration have clinical implications.[3]

Previously treated teeth with persistent periapical lesion(s) might be preserved with nonsurgical retreatment or endodontic surgery, assuming the tooth is restorable, periodontally sound, and the patient desires to retain the tooth. This paper discusses non-surgical retreatment of a two mandibular molar; one with RE & another having C-shaped canal system.

CASE REPORTS:

These are the retreatment case reports of two patients referred to "Root Canal Point", Kochi, India for specialized endodontic treatment. A thorough history was recorded from the referring dentist & patient, and the cases were examined both clinically and radiographically. The medical history of both patients was non-contributory. Local anesthesia was obtained and the entire procedure in each case was carried under a surgical operating microscope. Fixed prosthesis on the teeth were sectioned and removed using high speed hand piece. Split-dam technique was used to remove old fillings/secondary decay, and restorability of tooth was assessed. After adequate soft tissue management, a permanent pre-endodontic composite build-up was done under rubber-dam isolation for optimal irrigant dynamics. Later, required access modifications were done for initiation of retreatment.

CASE 1

27-year-old, female patient presented with a chief complaint of intermittent swelling on right lower back region since 3 months. The swelling was diffused and recurring in nature.

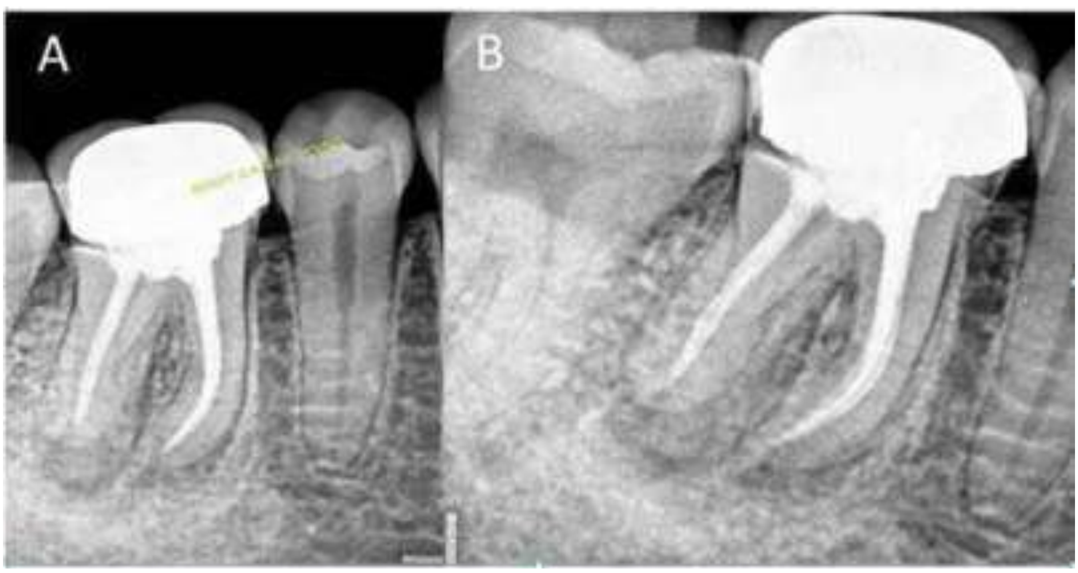

Fig 1. (A) Pre-operative radiograph **(B)** mesial shift radiograph.

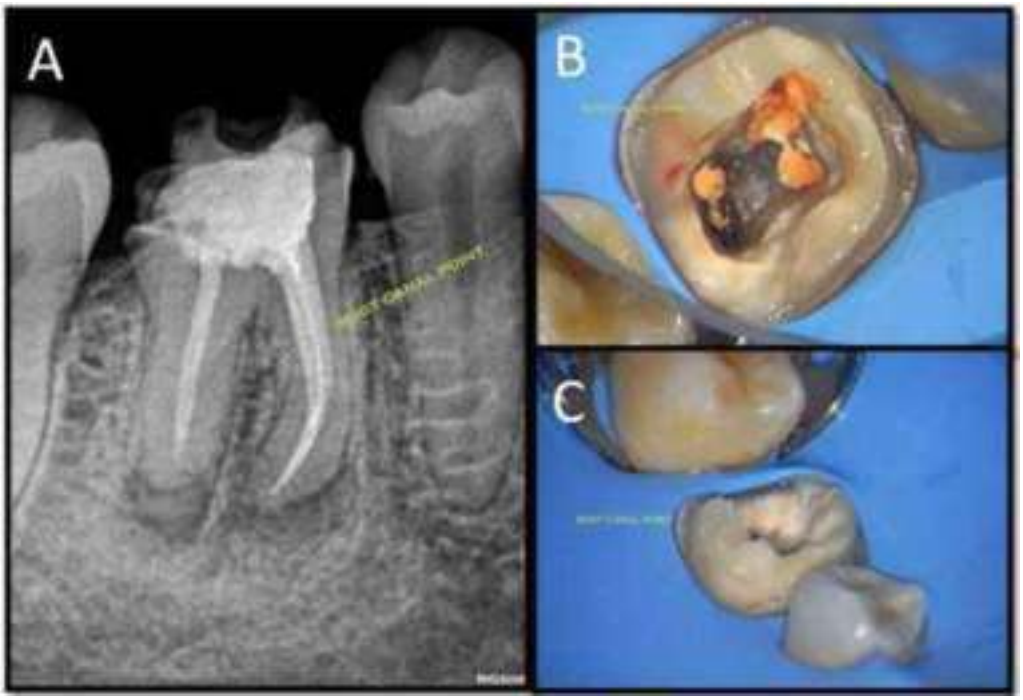

Fig 2. (A) IOPAR after crown removal (Note the secondary decay towards the distal aspect). **(B)** Initial access on re-entry after old restoration caries removal (Note the discoloration and percolation of the distal canal suggestive of an infection). **(C)** Restorative assessment showing good ferrule.

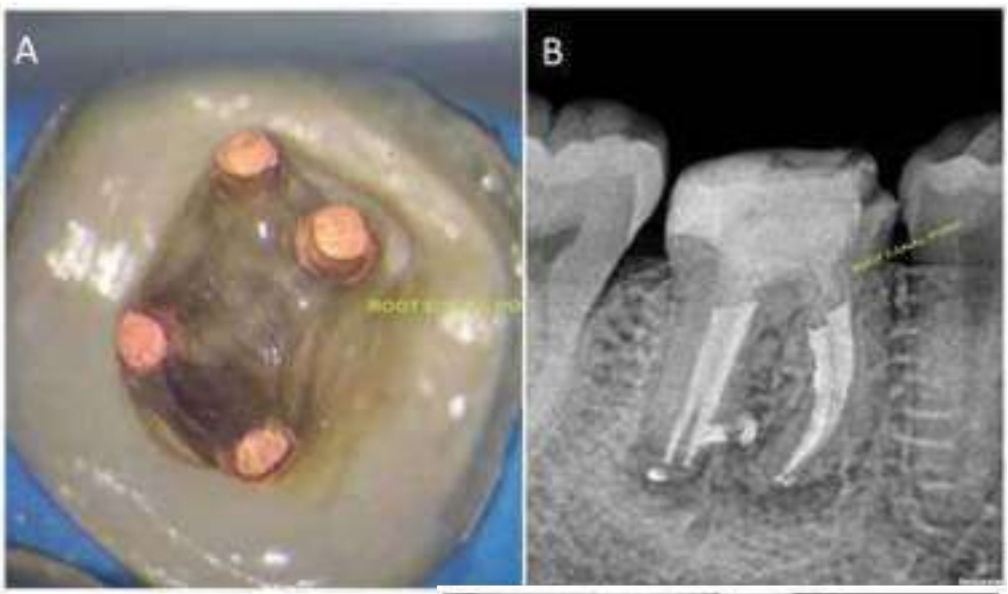

Fig 3. (A) Post-operative microscopic image (Note the clean pulpal floor to facilitate adhesion). **(B)** Immediate post-operative IOPAR after adhesive composite restoration (Note the accessory canal & 3D filled root canal system).

Fig 4. 5-months follow-up showing good periapical healing

On clinical examination, patient had a fixed prosthesis on tooth #46, associated with a sinus opening in relation to the buccal aspect. Tooth was tender on percussion. Patient reported that the primary root canal treatment was done 8 years ago and a periapical surgery was performed on the same tooth 4 years back. Intra Oral Periapical Radiograph (IOPAR) revealed endodontic treatment with a diffuse periapical pathology in relation to mesial and distal roots (Fig.1 A). Mesial shift IOPAR revealed the presence of disto-lingual root which was not negotiated & filled (Fig.1 B), which could be the possible cause for the failure of previous non-surgical & surgical endodontic treatment. Based on clinical and radiographic examination, it was diagnosed as a case of incomplete RCT with symptomatic apical abscess.

On proper rubber dam isolation access was gained and 3 obturated canals were identified and gutta percha (GP) was removed using retreatment files, ultrasonic tips, and down pack pluggers under magnification. After complete elimination of GP, additional canal was identified on the disto-lingual aspect following the Developmental Root Fusion Line (DRFL). Patency was achieved in all the four canals and working length was determined with apex locator. Root canals were instrumented using ProTaper Universal rotary file system. Irrigation was performed by using normal saline, 5.25% sodium hypochlorite solution, and 17 % EDTA coupled with ultrasonic agitation. A three-dimensional obturation was done using continuous wave compaction (System B, Sybron Endo) and AH plus sealer. The tooth was then restored with a posterior composite resin core (Fig 3B). The patient was referred to her general dentist for crown. 5-months follow-up showed satisfactory periapical healing (Fig 4).

CASE 2

A 45-year-old female patient reported with a chief complaint of pain associated with intermittent swelling in lower left back tooth region for the past 3 months. She also complained of lip paresthesia on the same side. Patient reported a history of RCT in relation to tooth #37 five years back. Clinical examination revealed a fixed prosthesis on #37 and the tooth was tender on percussion. Radiographically, the tooth was conical in shape with fused mesial and distal root with a thin radiolucent

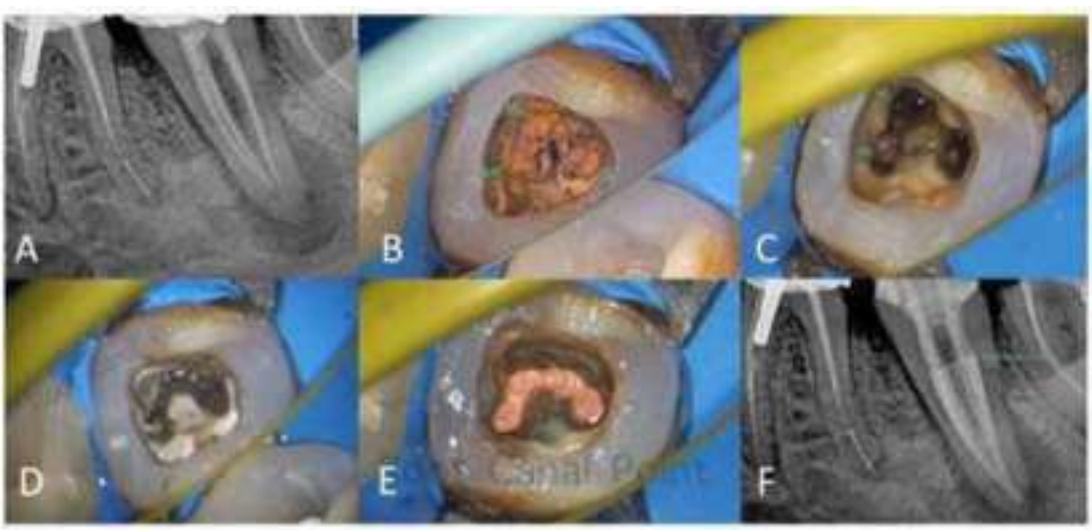

Fig 5. (A) Pre-operative IOPAR showing tooth #37 with a periapical abscess involving inferior alveolar nerve canal, **(B)** Clinical image showing GP filling the pulp chamber space, **(C)** Single cone obturation GP removal, **(D)** C-shaped canal after cleaning and shaping, **(E)** 3D obturation, **(F)** Post-operative IOPAR.

line between them, with a suspected C-shaped canal obturated with single cone technique. There was large periapical radiolucency partially involving the mandibular canal (Fig 5A). Based on the clinical & radiographic finding a diagnosis of incomplete RCT with symptomatic periapical abscess was made.

On removal of old filling, GP was found to filling up all over the pulp chamber space which was removed to reveal single cone obturation in 3 canals (Fig 5B). Complete removal of the GP was done using the combination of ultrasonic (US) tips, retreatment rotary files (Protaper-Dentsply Tulsa, USA) and micro-debrider. A careful evaluation of the pulp chamber floor revealed isthmus connecting the 3 artificially created canals (Fig 5C).

US tips coupled with hand files were used to open-up the isthmus connecting the 3 canals to enhance irritant dynamics (Fig 5D). Ultrasonic activation with 17% EDTA was done to remove the sealer/GP remnants from the root canal system. Patency was achieved and working length was determined. Cleaning & shaping was performed with 4% rotary files followed by circumferential filing with hand K-files. Copious amount of 5.25% sodium hypochlorite was used for irrigation which was activated

Fig 6. Three-year follow-up showing complete healing

using the Endo activator system. Obturation was performed using System S technique (Fig 5E) (B & L, USA). Tooth was then restored with composite resin (Fig 5F). 3-years follow-up radiograph revealed a sufficiently good periapical healing (Fig 6). The patient also reported relief from lip paresthesia for the past 2 years.

DISCUSSION

When primary root canal treatment fails, clinicians have three possible options. The first and most desirable option is non-surgical endodontic retreatment. When coronal access to post-treatment disease is not desirable/ blocked, the second option, ie surgical endodontics followed by retrograde sealing of the root canal can be performed. While the last option, which is not desirable, is dental extraction.

The most important step in retreatment is to identify the cause of post-treatment disease. Hence, a good clinical and radiographic examination is important. If needed, a 3D Cone Beam Computed Tomography (CBCT) examination can be done. Later, a decision must be made to whether to initiate retreatment or call on a specialist endodontist. Knowing when to treat an endodontic case and when to refer is an invaluable clinical skill for a clinician. Making clinical decisions about which teeth we can treat, and which should be referred, ultimately pivots on the following fundamental question: Do I have the skills, time, equipment & experience to perform this procedure? If the answer is "yes", the treatment should be started and if "no", the patient should be referred.

Retreatment cases with long standing fixed prosthesis should be initiated with the removal of existing prostheses as it will help us to identify secondary decay, understand the original angulation of the tooth and better assessment of restorability. In both cases, the removal of the crown revealed the presence of secondary decay. Additionally, it helped the authors to plan a better post endodontic restoration which plays a key role in overall survivability of endodontically treated teeth.

An additional third root, first mentioned in the literature by Carabelli, is called the RE.[4] This supernumerary root is located disto-lingually in mandibular molars, mainly first molars. Unpublished in-vivo clinical study data from the authors reported an incidence of 6% in the South-Indian population. This additional root is generally short, acutely curved, and narrow.[5] Hence, relocation and enlargement of the orifice of the RE, initial root canal exploration with small files (size 10 or less) together with radiographic root canal length and curvature determination, and the creation of a super loose glide path before preparation are invaluable in avoiding procedural errors.

Case 1 failed because the previous clinician failed to identify and fill an additional root / canal. Patient had undergone a periapical surgery on the distal root 3-years back. However, the second clinician also failed to identify this variation and only the distobuccal root had been resected. Kottoor et al had reported the relationship of DRFL and additional roots in mandibular molars.[6] This is a good clinical tip that can lead to identification of additional roots clinically.

Presence of accessory canals which was revealed following the obturation could also be a contributing factor for post-treatmentdisease in case 1 (Fig 3B). These lateral canals, when sufficiently large, can harbor large amounts of micro-organisms which then act asa nidus of infection and lead to peri-radicular disease. However, filling of these lateral canals are prudent only when there is a chance of bacterial penetration from the necrotic canal to peri-radicular tissue.[7] Accessory canal cannot be accessed through routine bio-mechanical preparation hence, thorough irrigation plays the key role.

A C-shaped root canal is defined as a root canal that in the transverse section is shaped like the letter "C". In a recent in-vivo CBCT study, it has an incidence of 13% in the South-Indian population.[8] C-shaped canal poses diagnostic difficulty radiographically, because of the two-dimensional view of the radiograph. However, Fan et al. (2007) came up with a radiographic classification of C-shaped canals, which can help the clinician identify this anomaly pre-operatively. Dentine thickness around the isthmus towards the center of C-shaped canals are very thin especially towards the lingual wall. Hence, preparation should be restricted with lesser taper hand / rotary files and anti-curvature filing is recommended to avoid strip perforations.

It is difficult to ensure complete removal of diseased pulp or necrotic tissues from the isthmi. Hence, use of dynamic irrigation with chemical solutions such as NaOCl is of particular importance.[9] In addition, warm gutta-percha condensation techniques can be expected to result in favorable canal filling in C-shaped root canals.[10]

It can be noticed in case 2, radiographically all the 3 GP cones (white lines) had reached .5mm short of apex (Fig 5A). Despite a radiographically good looking obturation it failed primarily because of improper 3-dimensional filling. Hence, particular attention should be paid to the 'isthmus' of C-shaped canal configuration. This is a highly challenging task for a clinician because rotary files, conventional syringe irrigation and single cone obturation with dedicated cones will fail to shape, clean, and fill the isthmus.

A successful clinical outcome of endodontically treated teeth depends on adequate root canal treatment as well as on adequate restorative treatment. Hence, before jumping into Re-RCT clinician should plan for the restorative assessment (Fig 2A & B). In addition, a clean pulpal floor is important for proper bonding of any adhesive restoration (Fig 3A, 5E). Hence, a planned restoration on a clean bondable surface will improve the long-term survivability of an endodontically treated tooth.

CONCLUSIONS

Every dental practitioner and specialist endodontists should possess deep knowledge of all existing anatomicalv ariants and their radiographic characteristics to avoid treatment failures. Appropriate pre-clinical analysis by the general dentist for assessment of the tooth, anatomy, position, pathology, skill, and equipment, are important parameters to consider for case referral to a specialist endodontist.

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ORIGINAL RESEARCH

KNOWLEDGE, ATTITUDE AND PERCEPTION AMONG POPULATION OF RANCHI FOR REPLACEMENT OF MISSING TOOTH WITH DENTAL IMPLANT : A CROSS SECTIONAL STUDY

ABSTRACT

Introduction: Dental Implant is a successful treatment modality for replacing single tooth or multiple teeth. It also prevent the natural teeth contrary to fixed partial denture therapy. Comfort level is high in implant and also gives better aesthetic results. Despite its advantages it is not a very common treatment modality. So this study was conducted to evaluate the awareness among population of Ranchi for dental implants.

Aims: The aim of the study was to assess the awareness of the patients regarding implant-retained prosthesis as an option for tooth replacement and the knowledge about tooth replacement as a whole including source of information and attitude towards it amongst Ranchi population.

Materials and Methods: A survey was conducted printed questionnaire with multiple questions to evaluate awareness of dental implant therapy among population of Ranchi in 2016 (Jan to March). A random sampling method with convenient sample size was used. Questionnaire was prepared both in English and Hindi to facilitate completion and to get better understanding of the questions by the respondents. The questionnaire was handed to the head of hospital and dental clinics based in Ranchi and the response was recorded from the regular visitor having dental problems.

Results: Amongst the 1352 response retrieved, 27% of respondents felt moderately well informed about the dental implant treatment. Only 9% of the respondents had dental implant treatment before and 17% felt well informed about different alternatives of replacing missing teeth. The dentists were the main source of information regarding dental implant treatment modality followed by friends and electronic media. 55.6% respondents felt implant to be as good as own teeth during function whereas high cost was the major limiting factor for implant treatment.

Conclusion: Awareness about the implant treatment option available as mode of replacement of missing teeth is low. Extensive awareness programme is needed to be done to increase the awareness among people. Dentists share the most important part in making peoples aware about implants.

Keywords: Dental Implants, Prosthodontics, Awareness

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INTRODUCTION

Dental Implant is a successful treatment modality for replacing single tooth or multiple teeth. It also prevent the natural teeth contrary to fixed partial denture therapy. Comfort level is high in implant and also gives better aesthetic results. Although it is not very common treatment plan as compared to fixed partial denture or removable dentures because of lack awareness among patients and its high cost. Pommer et al. reported 79% of the Austrian populations choose implant therapy as the treatment of choice[1]. In 1999, a survey from Sweden reported a rise in desire for implant treatment to 95% over a period of 10 years.[2-4] Chawdhary et al. reported that the level of awareness of implant treatment was 23.24% in 2010.[5] Zimmer et al. in 1992 found higher interest and general awareness for implant therapy.[6]

Material and Methods

A survey was conducted printed questionnaire with multiple questions to evaluate awareness of dental implant therapy among population of Ranchi in 2017 (Jan to March). A random sampling method with convenient sample size was used. Questionnaire was prepared both in English and Hindi to facilitate completion and to get better understanding of the questions by the respondents. The questionnaire was handed to the head of hospital and dental clinics based in Ranchi and the response was recorded from the regular visitor having dental problems.

Aims and objectives of the study were clearly stated to all the respondents. Response was recorded only from those who agreed to give informed consent. So out of 2000, only 1352 respondents agreed to participate in the survey with the non-responsive rate 32.46%.

Respondents were divided into groups according to age and level of education.

Age: (a) 16 20 yrs, (b) 21 40 yrs, (c) 41 60 yrs, (d) 61 80 yrs, (e) 81 yrs and above

Education: (a)Up to high school, (b) Up to college, (c) Up to university and above.

The survey form included self explanatory questions which were in correspondence to previous studies conducted Chowdhary et al.,[5] and Berge et al.[7]

Results

87% respondents had no previous experience of dental implant whereas 9% had undergone implant treatment before [Table 1]. 21 to 40 age group was having highest awareness for dental implants. When asked about the alternatives for replacing missing teeth, 17% were well informed, 41% moderately informed, 36% poorly informed, out of 1352 respondents.

Awareness for complete denture was highest 59%, slightly less awareness for implant supported dentures (56%). 55% and 43% respondent were aware for Partial denture and Fixed bridge respectively. There were 148 respondent who did not have any information for any kind of alternative treatment available [Table 2]. Only 8% of respondents felt very well informed about dental implant, 14% well informed, 27% moderately well informed and 47% poorly informed [Table 3]. Questions on source of information regarding different alternatives for replacement of missing teeth was to all respondents in which 47 % respondents were moderately aware where as 48% peoples were having poor awareness. Dentists were the major source of information for 53.6% followed by relatives & friends (45.3%). Some respondents (34.6%) stated the role of internet and similar percentage (33.5%) gave reference to someone who has undergone implant treatment [Table 4]. 69.9% respondents agreed to get more information for dental implants whereas 30 percent respondent disagreed. Most of the respondents (72.16) agreed that they want to get more information regarding dental implants from dentists [Table 5].

when asked about non- removable in comparison to removable 51.4% agreed that it is more comfortable, 47.8 % suggested it gives better appearance and 55.6 % told it to be as good as own teeth during function [Table 5].

When asked about the disadvantage of implant

Table 1: Have you had dental implant treatment before

	N	Percentage
YES	121	9
NO	1176	87
NO ANSWER	55	4

Table 2: Questions on alternatives for replacing missing teeth

	N	Percentage
How well do you subjectively feel informed about alternatives of replacing teeth		
Very well	67	5
Well	229	17
Moderately well	554	41
Poor	486	36
No Answer	16	1
Alternatives for replacing missing teeth		
Implant supported dentures/bridge	757	56
Partial dentures	743	55
Complete dentures	797	59
Bridges (fixed partial dentures)	581	43
None of the above	148	11
People may select more than one option, so numbers may add up to more than 1013		

Table 3: How well do you subjectively feel informed about dental implant?

	N	Percentage
Very well	108	8
Well	189	14
Moderately Well	365	27
Poor	635	47
No Answer	55	4

Table 4: Questions on source of information regarding different alternatives for replacement of missing teeth		
	N	Percentage
How well do you subjectively feel informed regarding source of information about different alternatives for replacement of missing teeth		
Very well	36	2.7
Well	27	20.5
Moderately well	635	47
Poor	648	48
No answer	2028	1.5
Source of information regarding dental implants		
Television/radio	128	9.5
Internet	467	34.6
Dentist	724	53.6
Relatives/friends	612	45.3
Someone who received implant	452	33.5
People may select more than one option, so numbers may add up to more than 1352.		

Table 5: Questions on expectations about the source of information		
	N	Percentage
Would you like to get more information regarding dental implants		
YES	945	69.9
NO	407	30.0
From where would you like to get information about dental implants		
Television/radio	92	6.81
Internet	223	16.5
Dentist	975	72.16
Relatives/friends	40	2.96
Someone who received implant	23	1.77

Table 6: Questions on advantages and disadvantages of different prosthesis		
	N	Percentage
What do you think are the advantages of Non-removable versus removable dentures?		
More comfortable in the mouth	694	51.4
Better appearance	646	47.8
As good as own teeth during function	751	55.6
What do you think are the disadvantages of implant supported dentures/bridges?		
High costs	1084	80.2
Lack of knowledge	446	33.0
Need of surgery	512	37.9
Long treatment time	557	41.2
People may select more than one option, so percentages may add up to more than 100%		

treatment; high cost was most raised concern as 80.2% of respondent. Lack of knowledge, need of surgery and the duration of treatment were other concern and reason to refuse treatment related to implant [Table 6].

Discussion

In the present study 21 to 40 age group respondents were well informed for dental implants which is similar to finding of Chowdhary et al[5]., in which 25 to 44 age group were more aware of dental implants in India. Whereas, in a study conducted by Berge et al.[7] in Norway, they found people of age of 45 and above with high level of education were well informed for dental implants. Awareness about the treatment options available for replacing missing teeth, 56% respondents were informed about dental implants. This result is significantly different from the results reported by Zimmer et al.[6] and Berge et al.[7] which reported high level of awareness as 77% and 70.1% respectively.

Dentists are the primary source of information as well as the choice of source for information regarding dental implants among most of the respondents which increases the responsibility on Dentists. This result is in agreement with Pommer et al.,[1] Chowdhary et al.,[5] Satpathy et al.,[8] Mukatash et al.,[9] and Ravi Kumar et al.,[10] all of which stated dentists as the main source of information. This finding is contrary to that reported by a study done in the USA, stating media as the main source.[7,11] Relatives and Friends as well as the treated people are other source through which people are acquainted about implant therapy. Apart from these conventional sources Internet is the new emerging source which is stated by 34.6% of the of the respondents. The role of social Media is crucial among the internet users and that is also a platform where awareness should be increased. The difference between No-removable and Removable prosthesis is well appreciated by most of the respondents as 51.4% agreed that it is more comfortable, 47.8% of respondents also recommended non removable as better in aesthetics compared to removable.

High cost was the major concern to 80.2% of respondent and stated as its disadvantage.[6,12] Recent studies[13,14,15] found lack of knowledge, need of surgery and the duration of treatment were other concern and reason to refuse treatment related to implant. These results were consistent with the studies which reported the similar results.

CONCLUSION

The Study conducted clearly show that awareness about the dental implant treatment is not optimum among the population of Ranchi. It is high time when Implant treatment should be approachable to every people whenever it is needed. Dentists hold a major share of responsibility for increasing awareness among patient and inform them the option of implants. The cost factor is another hurdle in becoming this treatment therapy a common therapy. It is restricted only to affordable class of people because of its higher price. Extensive work should be done to lower the price of dental implant therapy with initiative from governing bodies. Dentist should also go through extensive study and research to increase the success rate of the treatment. General Practitioners are needed to be more informed and get thorough knowledge about the implant procedures through continuing dental educations. The advantages of implant therapy should be emphasized to the patient and long term benefits should be illustrated. Social media may also play a vital role to make aware people about implant therapy through visuals and animations.

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