

DENTAL BITES

Volume 11 issue 2 | April - June 2024

**ORAL SURGERY, ORAL MEDICINE
AND ORAL PATHOLOGY**



a quarterly publication of



KMCT
DENTAL COLLEGE



KMCT Medical College Campus, Mukkom, Kozhikode - 673 602

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KMCT Medical College Campus, Mukkom, Kozhikode - 673 602

 www.kmctdentalcollege.org  dental@kmct.edu.in

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Editorial

Fostering an Interdisciplinary Approach for Comprehensive Patient Care

In the ever-evolving landscape of dental education and clinical practice, the significance of an interdisciplinary approach cannot be overstated. At KMCT Dental College, we strive to foster collaboration among various specialties, ensuring holistic and patient-centric care. In this regard, the synergy between Oral Pathology, Oral Medicine, and Oral & Maxillofacial Surgery (Triple O) stands as a cornerstone in improving diagnostic accuracy, treatment planning, and overall patient outcomes.

The interdependence of these three disciplines is profound. Oral Pathology plays a pivotal role in the accurate diagnosis of oral diseases by providing crucial histopathological insights. Oral Medicine, with its expertise in clinical diagnostics and management of systemic conditions with oral manifestations, bridges the gap between pathology and surgical intervention. Oral & Maxillofacial Surgery, on the other hand, is responsible for executing definitive surgical management based on precise pathological and clinical diagnoses. A seamless integration of these disciplines ensures that patients receive timely and appropriate treatment, reducing misdiagnosis and unnecessary delays.

For our postgraduate students, adopting an interdisciplinary mindset is essential. Engaging in collaborative discussions, case presentations, and multidisciplinary treatment planning will not only enhance their academic knowledge but also equip them with the skills necessary for evidence-based decision-making in clinical practice. Interdepartmental case discussions, joint research endeavors, and integrated patient management protocols should be encouraged as part of their training.

At KMCT Dental College, we envision a future where the Triple O disciplines work in unison, breaking silos to provide comprehensive and patient-centric care. By nurturing this culture of collaboration, we not only elevate the standard of clinical practice but also instill in our students the essence of teamwork and lifelong learning.

Let us continue to bridge the gaps and build a stronger, more integrated dental healthcare system for the benefit of both our patients and future dental professionals.

With warm regards,

Dr. Manoj Kumar K. P
Principal

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Endodontic Biofilm: “The Hidden Challenge in Root Canal Therapy”

*Athira Sreedharan, **Ravi S V, ***Elsy P Simon

Abstract:

Biofilm-like structures are the main form in which bacteria infecting the root canal system are organized. Bacterial biofilms can be found in virtually all areas of the root canal system, including the main canal, apical and lateral ramifications, isthmuses, and recesses. Biofilms are very frequent in the apical part of root canals of teeth with primary or posttreatment apical periodontitis. It consists of microbial cells of different species and is organized in multiple cell layers, embedded within a matrix. The composition and structure of this endodontic biofilm are highly variable. Biofilm infection may be very difficult to reach and eradicate and may require special strategies for successful management. This review article briefly describes different types of endodontic biofilms, its characteristics and eradication.

Corresponding Author: Athira Sreedharan (athirasreedharan1011@gmail.com)

Key words : Endodontic biofilim

** Post graduate student, ** Professor, ***Professor and Head, Department of Conservative Dentistry and Endodontics, KMCT Dental College, Kozhikode, Kerala.*

Introduction

A biofilm is a highly organized structure consisting of bacterial cells enclosed in a self-produced extracellular polymeric matrix attached on a surface. Biofilms may also be considered as a layer of condensation of microbiota or a microbial-derived community consisting

of cells that are irreversibly attached to a substratum or interface or to each other, and embedded in a matrix of extra-cellular polysaccharides in addition to extracellular DNA (eDNA) and extracellular proteins.^{1,2} In general, the exact composition varies with the microorganisms and nutrients available. The organisms in the biofilms exhibit an altered phenotype with respect to growth rate and gene transcription.^{3,4}

Biofilm can be defined as a sessile multicellular microbial community characterized by cells that are firmly attached to a surface and enmeshed in a self-produced matrix of extracellular polymeric substance (EPS, usually a polysaccharide).⁵

In biofilm microorganisms are wrapped in an extra cellular matrix made of polysaccharides that have internal water channels. Intraradicular infection can persist in the complex apical root canal anatomy: canal irregularities, deltas and isthmus areas, and accessory canals.

The most common etiology for the pulpal and periradicular pathologies is the microorganisms or the microflora.

Infection in the oral cavity is caused by a number of organisms from different species found in the human mouth. These oral bacteria have the capacity to form biofilms on distinct surfaces ranging from hard to soft tissues.

Biofilm mode of growth is advantageous for microorganisms, as they form three-dimensional structured communities with fluid channels for transport of substrate, waste products, and signal molecules. Biofilm formation in root canals is probably initiated sometime after the first invasion of the pulp chamber by planktonic oral microorganisms after some tissue

breakdown, as hypothesized by Svensäter and Bergenholtz.⁵

Costerton et al.⁶ stated that biofilm consists of single cells and microcolonies, all embedded in a highly hydrated, predominantly anionic exopolymer matrix. Bacteria can form biofilms on any surface that has nutrient-containing fluid. biofilm formation mainly involves the three major components: Bacterial cells, a solid surface, and a fluid medium.

Types of Biofilms

1. Intracanal: The film is on the internal surface of dentin of the infected teeth. Most of the microorganisms survived as free collections of cocci, rods, filaments, and spirochetes.

2.Extraradicular (cementum): Formed on the surface of root near to root apex. SEM evaluation of root apex showed that continuous, smooth, structure less layer having various bacteria in different morphological forms. In irregular surfaces, bacteria were seen held together by an extracellular material. Seen in teeth with asymptomatic apical periodontitis also in teeth with chronic apical abscesses and a sinus tract.

3.Periapical: Present in the periapical region of the tooth, independent of root canal infection.

4. Biomaterial/Foreign body centered: Seen when bacteria adhere to an artificial biomaterial surface. It is associated with implant and prosthesis in the mouth.

Composition of Biofilm

A fully developed biofilm is a mixture of microbial cells on a solid surface. Biofilm is made up of matrix material 85% volume and 15% cells. Surface adherent surface cells are the most important component of the biofilm.⁷

Implications of biofilm in endodontics

Microorganisms present in the oral cavity serves as primary source of biofilm formation within the root canal. The anatomical complexities in the root canal system provide shelter to microorganisms. Bacterial biofilm can be seen beyond the apex of the root as bacteria in biofilm survive in unfavorable environmental and nutritional conditions. Infectious processes in root canal gains sufficient power to cause subsequent destruction of the pulpal tissues only after biofilm formation. Biofilm formation in root canals is probably initiated at some time after the first invasion of the pulp chamber by planktonic oral organisms after some tissue breakdown.⁸ At this point, the inflammatory lesion frontage that moves successively toward the apex will provide the fluid vehicle for the invading planktonic organisms so these can multiply and

continue attaching to the root canal walls. (Hypothesis: Svensäter and Bergenholtz). The necrotic pulp tissue becomes a favorable environment for microbial proliferation due to the presence of organic residue or nutrients, which act as substrate or culture medium. Gram negative bacteria are more frequent than Gram positive bacteria. Facultative or strict anaerobic microorganisms are more frequent than aerobic microorganisms, and the presence of bacilli and filaments is equivalent to that of cocci.

Endodontic biofilm formation mechanism

First, there is penetration of the organism in the pulp where it attaches and spreads further along the root canal. Possibly, it is after biofilm formation that the infectious process gains sufficient power to cause subsequent destruction of the pulpal tissue. At some point in the breakdown process, a steady state is reached where the bacterial mass is held up by host defense mechanisms. The demarcation zone may be inside the root canal near the root canal exit, at the foramen, or, as demonstrated by scanning electron microscopy (SEM)⁷ on the external root surface near the exit of the foramen to the periapical tissue environment. It is not unreasonable to assume that organisms may be detached from these positions and occasionally

congregate in the lesion per se.⁹ Hence, the question remains as to whether bacterial condensations in a biofilm structure can develop or are retained in sites of the root canal system other than near the bacteria/inflammatory interface zone, where host-derived proteins and bacterially produced adhesive substances may provide the proper prerequisites.

Biofilms in endodontic infections

Endodontic microbiota transition is more conspicuous with the progression of infection. Nutritional and environmental status within the root canal changes as infection progresses. It creates more anaerobic environment and depletion of nutrition which offer a tough ecological niche for the surviving microorganisms. The anatomical and geometrical complexities (e.g. delta and isthmus) in the root canal systems shelter the adhering bacteria from cleaning and shaping procedures.

Biofilm Detection

- a) Atomic force microscopy- detects forces of interaction among bacterial cells and between bacterial cells and substrates
- b) Scanning electron microscopy – detects structure of microbial ecosystem
- c) Confocal scanning laser microscopy (CSLM) – 3D reconstruction of microbial

biofilm, reveals highly heterogeneous structure of biofilm

- d) Fluorescent probes along with CSLM – discriminate between classes, genera, species, viability of individual organism in microbial ecosystem
- e) Fluorescence in situ hybridization (FISH) – simultaneous detection of phylogenetically different bacteria
- f) FISH with oligonucleotide probe – specifically identifies targeted bacteria.¹⁰

Effects of instrumentation on biofilms.

Microorganisms that play an important role in periradicular diseases grow mostly in sessile biofilms, aggregates, and co-aggregates. By mechanical instrumentation and irrigation with tissue-lytic and microbicidal solutions and antimicrobial medicaments in the root canal, the microbial load is reduced leading to disruption of biofilm. NaOCl in different concentrations is used as a root canal irrigant because of its antimicrobial action and tissue-dissolving property. Previous studies have shown that instrumentation and antibacterial irrigation with NaOCl would eliminate bacteria in 50–75% of the infected root canals at the end of the first treatment session, whereas the remaining root canals contain recoverable bacteria. In their study, Nair et al. showed that 88% of root canal–

treated mandibular molars showed residual infection of mesial roots after instrumentation, irrigation with NaOCl, and obturation in a one-visit treatment. BioPure MTAD (Dentsply Tulsa Dental, Johnson City, TN, USA) has been described as a universal irrigating solution. Torabinejad et al.¹¹ have shown that MTAD removes the smear layer safely; also, it is effective against *E. faecalis* and it can eliminate bacteria in human root canals that had been infected by whole saliva. A new irrigant, Tetraclean, which is mixture of doxycycline hyclate present at a lower concentration than MTAD, an acid, and detergents, has the ability to eliminate microorganisms and smear layer in dentinal tubules of infected root canals with a final 4-min rinse. Consequently, recent laboratory studies have focused on evaluating the effectiveness of root canal irrigants and medicaments against *E. faecalis*. Many of these studies have grown the bacterial strains as planktonic cultures (bacteria in suspension). However, planktonic bacteria do not usually comply with the in vivo growth conditions found in an infected tooth, in which bacteria grow as a biofilm on the dentinal wall. Therefore, all studies about the clinical action of endodontic irrigants should be conducted with bacteria in “biofilm form.” Up to now, however, very few studies have been published about the action of antimicrobial irrigants against

biofilm. As a result, recent laboratory studies have attempted to evaluate the efficacy of antimicrobial agents used in root canal treatment against *E. faecalis* grown as a biofilm.¹²

Eradication of biofilm:

The structural dense organization of the biofilm within the polymeric matrix restricts the penetration of any agent into them. Biofilm are found to be resistant to amoxicillin, doxycycline and metronidazole.¹³ Sodium hypochlorite is an effective irrigant to destroy all forms of *Enterococcus faecalis* including its biofilm form. Chlorhexidine 2% gel or liquid form is effective to eliminate *Enterococcus faecalis* from the superficial layers of dentinal tubules up to 100micrometer. The new techniques include use of ultrasonic irrigation, ozone, plasma dental probe, photoactivated disinfection with low-energy laser for biofilm removal. 1-minute use of ultrasonically activated irrigation, followed by root canal cleaning and shaping has been shown to improve canal and isthmus cleanliness in terms of necrotic debris/biofilm removal. High concentrated gaseous and aqueous ozone is strain, dose and time dependently effective against the tested microorganisms in suspension and biofilm test model. However, NaOCl was the only method that eliminated biofilm. Plasma dental probe is effective for tooth

disinfection. Scanning electron microscopy shows complete destruction of endodontic biofilms for a depth of 1 mm inside a root canal after plasma treatment for 5 min. Plasma emission spectroscopy identifies atomic oxygen as one of the likely active agents for the bactericidal effect. The Er:YAG laser have produced excellent results due to its capacity for ablating hard tissue with very less thermal effects. They are considered to be effective tool for the removal of apical biofilm. Photodynamic therapy/ Light Activated Therapy is the latest method used to destruct endodontic biofilm. It involves the killing of microorganisms when a photo sensitizer selectively accumulated in the target is activated by a visible light of appropriate wavelength. PAD is a unique combination of a photosensitizer solution and low-power laser light. The photosensitizer, which is mostly colored, adheres to or gets absorbed by microbial cells. The low-power laser will destruct the target area and inactivate the microbial invaders. The photosensitizer then binds to microbial cell walls or even enters the cells. Further, the Laser light activates the photosensitizer and creates a cascade of energy transfer and variable chemical reactions in which singlet oxygen and free radicals play an important role. The other advantage is the time taken. Usually sodium hypochlorite, antibiotics and other methods against microbial threats need a lot

of time to inactivate the microbes. PAD needs a maximum of 150 seconds. PAD is effective against *Enterococcus faecalis*, *Streptococcus intermedius*, *Fusobacterium nucleotum*, *Peptostreptococcus micros*, *Prevotella intermedia*.¹⁴

Root canal disinfection

The application of PDT in clinical practice is as follows: The photoactive drug will be applied in the root canal system after instrumentation is complete for a short time (up to five minutes) and will strongly bind to the negatively charged matrix and to bacteria. Then a fiber optic will be used to deliver red light from a diode laser to irradiate microbial biofilms on the root canal surface as well as in the dentinal tubules. The entire root canal system will be exposed to light simultaneously for five minutes

Conclusion

Elimination of biofilms is pivotal to the success of endodontic treatment. The astute practitioner must diagnose the case and use the suitable intracanal irrigant to eliminate as much infection present in the canal. The treatment for vital teeth is different compare to the necrotic teeth with periapical lesion. The treating doctor must use the suitable medicament for the complete elimination of the biofilms.

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Review Article

Tongue thrusting and its Management

*Amith Adyanthaya, **Mariam Raheema, ***Nileena Balan, ***Shemna MK, ***Laya Vijayaraj

Abstract

Oral habits are learned patterns of muscle contraction and have a very complex nature. They are associated with anger, hunger, sleep, tooth eruption and fear. Some children even display oral habits for release of mental tension. These habits might be non-nutritive sucking like thumbsucking, tongue thrusting, lip biting and bruxism events. Tongue thrust is the most common of them, these habits can result in damage to dento-alveolar structure hence its management plan is important to every clinician.

Keywords: *Appliance, Tongue thrusting*

Corresponding Author: Nileena Balan

Professor & Head, ** Professor, * Post graduate student, Department of Paediatric and preventive Dentistry, KMCT Dental College, Kozhikode, Kerala.*

Introduction

Tongue thrust is a term that describes a swallowing pattern in which an individual pushes the tongue against or between the teeth. This habit has also been called deviate swallow, deviant deglutition, reversed swallow, perverted swallow, oral myofunctional disorder, visceral swallow, infantile swallowing pattern and abnormal swallow.¹ Tongue thrusting is normal in the

neonate in which the tongue lies between the gum pads and the mandible is stabilized by facial muscles during a swallow. This gradually disappears with eruption of primary dentition. Normal mature swallow shows the positioning of the tongue high on the palate behind the maxillary incisors and no lip and cheek activity during swallowing. A transitional swallowing pattern is seen in mixed dentition, when some primary teeth are

lost and permanent are yet to erupt or are erupting. This type of swallow is selfcorrecting. In cases of open bite mostly created by habits like thumb sucking, the tongue gets thrust ahead to achieve a lip seal. This type of tongue thrust is called a “Simple Tongue Thrust”. “Complex tongue thrust” is seen in individuals with a diffuse open bite, most commonly in mouth breathers and children with a history of chronic nasorespiratory disease/allergies. “Retained Infantile Swallow” is when the infantile swallowing reflex perseveres after the eruption of permanent teeth. Intervention by a pediatric dentist is only required in cases of simple tongue thrust, complex tongue thrust as well as in retained infantile swallow.¹

Definition

Tulley 1969 - states tongue thrust as the forward movement of the tongue tip between the teeth to meet the lower lip during deglutition and in sounds of speech, so that the tongue becomes interdental. Tongue thrust is an oral habit pattern related to the persistence of an infantile swallow pattern during childhood and adolescence and thereby produces an open bite and protrusion of the anterior tooth segment.²

Etiology

Fletcher has proposed the following factors as being the cause for tongue thrusting.

a. **Genetic or heredity factor:** They are specific anatomic or neuromuscular variations in the orofacial region that can precipitate tongue thrust. E.g. Hypertonic orbicularis oris activity.

b. **Learned behaviour habit:** Tongue thrust can be acquired as a habit. The following are some of the predisposing factors that can lead to tongue thrusting:

1. Improper bottle feeding
 2. Prolonged thumb sucking
 3. Prolonged tonsillar and upper respiratory tract infections
 4. Prolonged duration of tenderness of gum or teeth can result in a change in swallowing pattern to avoid pressure on the tender zone.
- c. **Infections:** Upper respiratory tract infections such as mouth breathing, chronic tonsillitis, allergies, push the tongue forward due to pain and decrease in the amount of space which brings about a tongue thrust swallow. It may also be present due to the physiological need to maintain an adequate Airway

d. **Feeding practices:** Prolonged bottle

feeding and improper swallowing pattern has been attributed as one of the etiological factors of tongue thrusting.³

e. **Maturational**

1. Retained infantile swallow - There is a considerable amount of evidence which suggests that tongue thrust is merely retention of the infantile suckling mechanism. The infantile swallow changes to a mature swallow once the posterior deciduous teeth start erupting. Sometimes the maturation is delayed and thus infantile swallow persists for a longer duration of time. The tongue thrust resulting from the retained infantile swallow has poorest prognosis.[Figure1]⁴

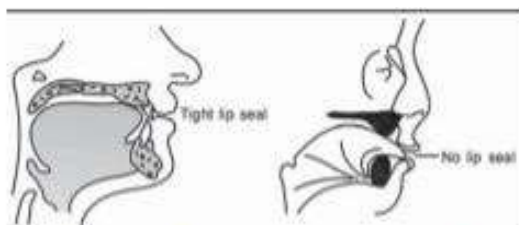


Figure 1: Etiology of tongue thrust habit - Retained infantile swallow.³¹ Mature adult swallow: The tongue touches the anterior palate. The lips contact tightly, forming "lipseal" creating negative pressure inside the oral cavity. The mandible is stabilised by muscles of mastication. Infantile swallow: The tongue protrudes in between gum pads and contacts the lip. The lips are apart. The mandible is balanced by muscles of facial expression. This type of swallow matures once the teeth erupt and come into contact and when child starts taking solid food

Functional adaptability: The tongue can protrude when the incisors are missing. Following the loss of deciduous teeth and prior to full eruption of the permanent incisors, there exists a natural opening for the tongue. The tip of the tongue may protrude into the open area during

swallowing. This may disappear with the eruption of permanent central incisors. The same may happen in the posterior region during transition of deciduous to permanent dentition.⁴

f. **Mechanical restriction**

1. Macroglossia: Large tongue limits the space in oral cavity and forces a forward thrust.

2. Constricted dental arches.

3. Enlarged tonsils and adenoids: Reduces space available for tongue movement .

4. Neurological disturbances

5. Hyposensitive palate

6. Moderate motor disability and loss of precision in oral function

7. Disruption of tactile sensory control and co-ordination

8. Psychogenic factors. Children who are forced to discontinue other oral habits like thumb sucking may develop tongue thrust ⁴.

Classification

According to Bahr and Bolt

1. Tongue thrust without deformation.

2. Tongue thrusting causing anterior deformation .

3. Tongue thrusting causing buccal

deformation .

4. Combined tongue thrust causing both anterior and posterior open bites

Moyers classification

Simple tongue thrust

Complex tongue thrust

Retained infantile swallow.⁵

James Braner and Holt classification

Type 1: Non-deforming tongue thrust

Type 2: Deforming anterior tongue thrust

Sub Group 1: Anterior open bite

Sub Group 2: Associated procumbency of anterior teeth

Sub Group 3: Associated posterior cross bite

Type 3: Deforming lateral tongue thrust

Sub Group 1: Posterior open bite

Sub Group 2: Posterior cross bite

Sub Group 3: Deep overbite

Type 4: Deforming anterior and lateral tongue thrust

Sub Group 1: Anterior and posterior open bite

Sub Group 2: Proclination of anterior teeth

Sub Group 3: Posterior cross bite.⁶

Clinical features

Intraoral features

1. Proclined, spaced and sometimes flared upper anterior resulting in increased overjet. [figure 2] .

2. Retroclined or proclined lower anterior depending upon the type of tongue thrust.

3. Presence of an anterior open bite.

4. Presence of posterior cross bites.

5. The simple tongue thrust is characterized by abnormal tooth contact during the swallowing act. They exhibit good intercuspation of posterior teeth in contrast to complex tongue thrust.⁷



Figure 2

Extraoral features

1. Usually dolichocephalic face.

2. Increased lower anterior facial height.

3. Incompetent lips.

4. Expressionless face as the mandible is stabilized by facial muscles instead of masticatory muscles during deglutition.⁵



Figure 3

Diagnosis

- History to rule out any upper respiratory tract infections, digit sucking habit, neuromuscular problems, swallow pattern in siblings and parents to check for the hereditary factor is done ⁸ .

Examination

- Tongue posture at rest using lateral cephalograms or by seating patient upright, here tongue assumes a lower posture at rest with the tip touching the cingulum/lingual fossae. Tongue activity during swallowing – Whether tongue thrust is simple/complex, anterior or lateral.⁹

Management and Treatment

Different methods have been attempted to correct the tongue thrust habit with variable success. The American Academy of Paediatric Dentistry states that the management of the tongue thrust may include “myofunctional therapy, simple habit control, habit-breaking appliances, orthodontics and possible surgery” (American Academy of Pediatric Dentistry Council on Clinical Affairs, 2005). Training of correct swallow and posture of the tongue. These exercises help in toning up respective muscles thereby eliminating tongue thrust.

Myofunctional exercises

- Educate the patient about normal swallowing by asking the patient to keep the tongue tip against the junction of soft and hard palate. Various muscle exercise of the tongue can help in training it to adapt to the new swallowing pattern. The child is asked to place the tip of the tongue in the rugae area for 5 minutes and is asked to swallow.
- The tongue tip against the palate can hold small orthodontic elastics during swallowing. If the swallow is correct the elastic will be retained in position.
- 4S exercises: Spot, salivating, squeezing the spot and swallowing.
- 2S exercise: It includes identifying -

spot and squeeze.

- Other exercise: Whistling, reciting the count from 60 to 69, gargling, yawning

Pre orthodontic trainers



Figure 4

Most encouraging results with preorthodontic trainers are realized in enhanced nasal breathing, better-quality swallowing pattern and removal of habits like tongue thrusting and mouth breathing.

10

Mechano therapy

Both fixed and removable appliances (cribs or rakes) can be fabricated to restrain anterior tongue movement during swallowing with the objective of retraining the tongue to a more posterior superior position in the oral cavity. Both fixed and removable are valuable aids in breaking the habit.

Removable appliance therapy

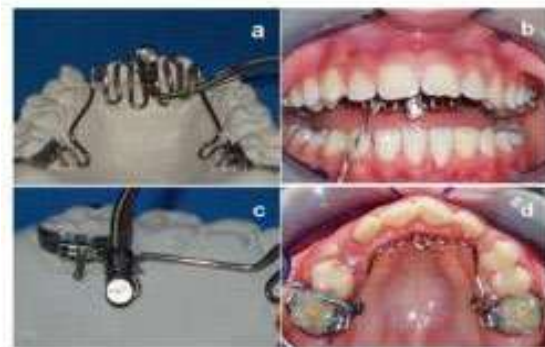


Figure 5

A variety of modifications of Hawley's appliance can be used to treat tongue thrust. It has an active labial bow, retentive clasps, a crib or rake or spikes present posteriorly to the upper anterior teeth. The crib can serve as a reminder. The spikes should be bent in such a way that when it is worn it should not impinge on lower anteriors or anterior lingual alveoli. Usually the open bite is closed down by activating the labial bow. Activation of labial bow reduces the proclination of the upper anterior teeth. The acrylic should be trimmed off from the gingival marginal area of the lingual surfaces of the maxillary anteriors to allow the incisors to be move palatally. The loops the patient is weaned from the habit of the tongue crib are removed one by one as the patient is weaned from the habit appliance over a 6 month period.¹¹

[Figure 5 a].

Fixed appliance therapy

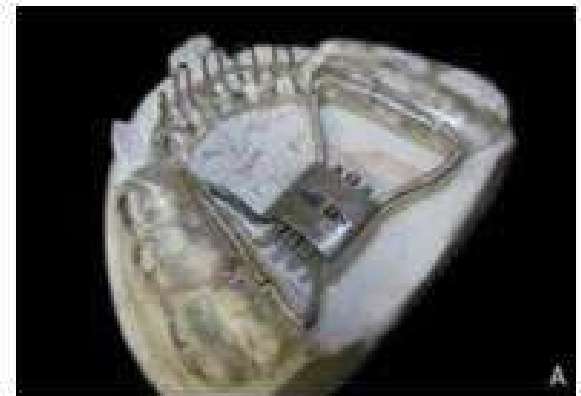
Bands are adapted on the first permanent molar and a 0.040 inch stainless steel 'U'–shaped wire is adapted from one molar to another molar of the opposite side. After the base bar is fabricated the crib can be formed and soldered to the base. Depending on the severity of the open bite, 6-12 months may be required for the autonomous correction of the malocclusion. The cribs acts by walling off the tongue from the dentoalveolar structures. They acts as reminders to the tongue whenever it tries to thrust forwards. A new skill is created by the nervous system so that the tongue learns proper position in long term. Thus this appliances create a new neuromuscular behavior. The cribs can be fabricated along with expansion devices like quadhelix and expansion screw if the arch is constricted.[figure 7a and figure 7b] 12

Modified tongue crib with quad helix



Figure 7a

Rapid palatal expander



New Concept

Galella Appliance [Figure 8]

It is primarily used to correct aberrant tongue habit. Appliance is designed to be physiologically congruent with normal tongue function and is simple appliance consist of large coffin loop and lingual arch wire. It is built on bands placed on permanent molars. Design position and function of these components that make this appliance unique.¹¹



Figure 8

Conclusion

Tongue thrusting is a human behavioral pattern in which the tongue protrudes through the anterior teeth during swallowing, speech and at rest. Such habits are considered to be normal up to 4-5 years of age. However, it can lead to deleterious effects in the oral cavity if these habits persist beyond the eruption of the permanent teeth. Elimination of the etiology is the primary and the most important step in the correction of the tongue thrusting habit. Prevention is always better than cure. Identifying and treating tongue thrusting habit at an early age prevents the development of severe skeletal malocclusions in the future.¹⁴

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Case report

From Clinical Challenge to Clarity: How Histopathology Diagnosed Granular Cell Ameloblastoma

*Gopika S Raj, *Rajeesh Mohammed P K, **Mayeesh Radhakrishna, ***Lekshmi Priya Reghu,
***Jyotsna K V

Abstract:

Ameloblastoma, a common benign odontogenic tumor is characterized by slow growth and local invasion and typically presents as a painless jaw swelling. Granular cell ameloblastoma, a rare subtype making up less than 5% of odontogenic tumors, is marked by granular cells with eosinophilic cytoplasmic granules. Although often linked to aging or degenerative changes in long-standing lesions, it can also occur in younger patients. The primary treatment is complete surgical excision to reduce the risk of recurrence, followed by long-term monitoring. This case report describes a 57-year-old male patient who presented with swelling in the lower anterior region and finally diagnosed as granular cell ameloblastoma.

Keywords: *Ameloblastoma, Granular cell ameloblastoma*

Corresponding Author: Gopika S Raj (gopikasraj@gmail.com)

Professor and Head, **Professor, *Post graduate students, Department of Oral Pathology and Microbiology, KMCT Dental College, Kerala.*

Introduction

Ameloblastomas are benign but locally aggressive tumors originating from epithelial tissues involved in tooth development. These intra-osseous neoplasms are known for their progressive growth and their potential for local expansion. Despite being classified as benign, ameloblastomas can aggressively

infiltrate the surrounding bone and soft tissues, leading to substantial disruption, if not properly managed.¹

Among the different subtypes, granular cell ameloblastoma (GCA) is notable for its rarity and distinctive cellular features. GCA is identified by the presence of granular cells within the tumor's histological structure. These cells are

located in stellate-like cells within the inner portion of the epithelial follicles. Accurate diagnosis relies on recognizing these granular cells to differentiate GCA from other ameloblastoma types.² GCA behaves similarly to other ameloblastomas in terms of local aggression and potential for expansion. However, its rarity can pose diagnostic challenges, affecting treatment strategies. The primary treatment for ameloblastomas, excluding unicystic ameloblastoma, is surgical removal with clear margins. Follow-up is essential to detect any recurrence of the disease or the presence of residual disease, ensuring that any signs of a relapse or remaining illness are identified early.³

This case report illustrates an unusual case of GCA which presented as a swelling in lower anteriors.

Case Report

A 57 year old male patient presented with a swelling in lower front tooth region since 6 months. Swelling was gradual in onset, intermittent in growth and increased to the present size. There was no associated pain.



Figure1: No evident extra oral findings

Patient was under medication for coronary artery disease, dust allergy and osteoporosis of right leg and had undergone uneventful extraction of lower left back tooth 12 years ago. His personal history was notable for cigarette smoking that was stopped 3 years ago and daily alcohol consumption for 30 years.

No evident extra oral findings (Figure 1).

Intra-orally, a 5×4 cm swelling in the left region of the mandible was observed. There was no associated bleeding or pus discharge (Figure 2).



Figure 2: 5×4 cm swelling in the left anterior region of the mandible extending buccally and lingually

On palpation, the swelling was firm, smooth surfaced and fluctuant with mild tenderness. It was non compressible and non-reducible. There was expansion of both buccal and lingual cortical bones. Mobility was noted in teeth 31, 32, 33, 34, 35, 41 and 42.

CBCT showed the presence of a solitary, well defined, multilocular

expansile osteolytic lesion in panoramic view with bicortical expansion and perforation of the buccal and lingual cortex in axial view (Figure 3,4,5).

A provisional diagnosis of aggressive central benign odontogenic neoplasm was made and an incisional biopsy was done under LA.

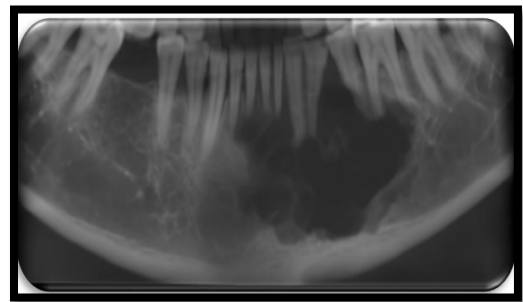


Figure 3: Panoramic view

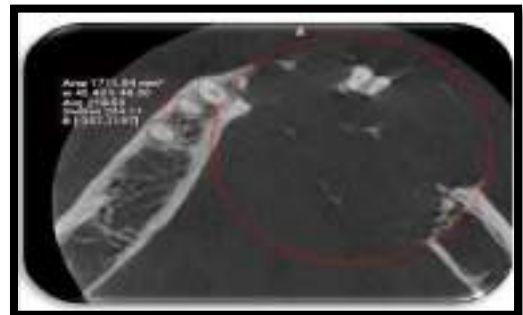


Figure 4: Axial view

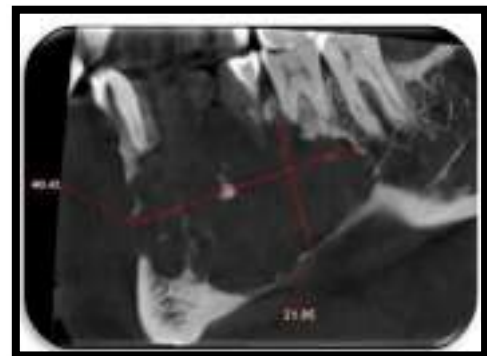


Figure 5: Sagittal view

Figure 3,4,5: Solitary, well defined, multilocular expansile osteolytic lesion with bicortical expansion and perforation of the buccal and lingual cortex

Gross features showed two bits of soft tissue specimen: one large and one small (Figure 6). Both were dirty white in color, measuring $1 \times 0.2 \times 0.9$ cm for the large bit and $0.8 \times 0.6 \times 0.4$ cm for the small bit. The large bit was cut longitudinally into two sections and all bits were sent for processing.



Figure 6: Gross specimen

The H&E-stained soft tissue sections revealed tumor cells invading into underlying stroma in the form of follicles. The follicles showed outer tall columnar cells resembling ameloblast like cells and central cells resembling stellate reticulum like cells. Some regions of these follicles displayed extensive granular cell transformation, characterized by large cells with

abundant granular eosinophilic cytoplasm and pyknotic nuclei, while other follicles showed intrafollicular cystic degeneration (Figure 7,8,9).

Correlating clinical history, radiological details and histopathological findings, a diagnosis of granular cell ameloblastoma was made.



Figure 7: H&E stained section showing tumor cells invading into underlying stroma in the form of follicles (scanner view)

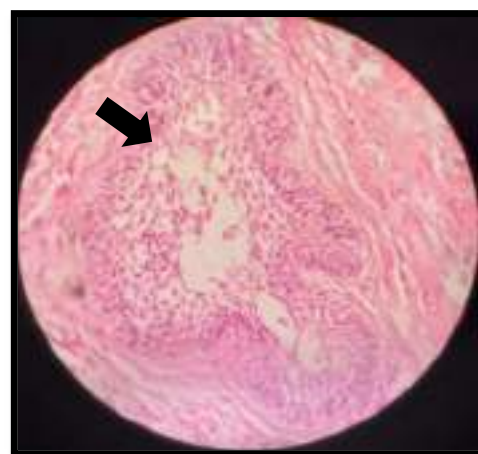


Figure 8: H&E stained section showing peripheral ameloblast like cells and central stellate reticulum like cells (magnified view)

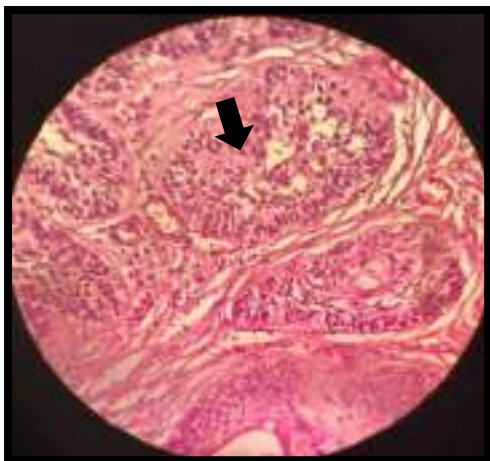


Figure 9: Follicles showing extensive granular cell transformation with large cells having abundant granular eosinophilic cytoplasm and pyknotic nucleus (magnified view)

Discussion

In 1934, Churchill defined ameloblastoma as a true neoplasm, which is unicentric, non-functional, intermittent in growth, anatomically benign and clinically persistent. This tumor is the second most commonly occurring benign odontogenic tumors in the jaw, representing around 10% of all tumors in the mandible and maxilla. Despite its slow growth, characteristic of benign tumors, it is enigmatic due to its locally invasive nature, high likelihood of recurrence, and potential for metastasis—features usually linked with malignant tumors.

Benign epithelial odontogenic tumors	Frequency	Histological variants
Ameloblastoma	91%	Follicular, plexiform, acanthomatous, granular cell, basal cell, keratopapillary, desmoplastic
Ameloblastoma, unicystic type	6%	Luminal, mural
Ameloblastoma, extraosseous/ peripheral type	2%	
Metastasizing ameloblastoma	1%	

• Classification of ameloblastoma ⁴

GCA is a rare form of ameloblastoma characterized by its slow growth but highly aggressive nature due to local tissue invasion. The first report of granular cell change in ameloblastoma was made by Krompecher in 1918, who referred to them as pseudoxanthomatous cells. Kameyama et al, in their clinicopathological study, reported that only 1 out of 77 ameloblastoma cases were identified as GCA.⁵ GCA accounts for 3.5% of all ameloblastomas. It typically presents as an asymptomatic, small-sized sessile nodule and most commonly occurs with an average median age of 40 years old with no significant gender preference. All tumors were located in the mandible, with most (19 out of 20) affecting the posterior regions with a recurrence rate

of approximately 33.3%. GCA treated with enucleation or curettage have a high recurrence rate because the tumor borders extend beyond the visible macroscopic surface and the radiographic boundaries within the cancellous bone leading to metastasis. As a result, radical surgical methods are recommended.⁶

Histopathologically, GCA is characterized by the presence of granular cells, which are usually small structures of around 1 μ m. These cells typically appear within the central area of ameloblastic tumor follicles, progressively replacing the stellate reticulum, which may also extend to the peripheral columnar or cuboidal cells. The "granular change" is believed to occur due to a dysfunctional state of neoplastic cells, and the tumor pathogenesis appears to be age-related. However, it remains unclear whether the granular cell change in ameloblastoma is a degenerative process or an indicator of a more aggressive progression.⁷

The differential diagnosis of GCA clinically includes median mandibular cyst, central giant cell granuloma, calcifying odontogenic cyst, desmoplastic ameloblastoma, lesions of

hyperparathyroidism and rarely aneurysmal bone cyst as these lesions occur in anterior mandible. Histologically, differential diagnosis includes oral lesions characterized by similar granular cell accumulation, such as granular cell myoblastoma, congenital epulis, and granular cell ameloblastic fibromas. Although the morphology of granular cells in these conditions are similar, the tissue of origin is specific to each condition and must be distinguished from GCA.^{7,8}

Immunohistochemical (IHC) analysis of cellular differentiation showed that granular cells tested positive for cytokeratin, CD68, lysozyme, and alpha-1-antichymotrypsin, but were negative for vimentin, desmin, S-100 protein, neuron-specific enolase, and CD15. These findings suggest an epithelial origin with lysosomal aggregation.⁹ IHC studies conducted by Kumamoto H and Ooya K on six cases of granular cell ameloblastoma revealed that the granularity may be due to an increase in apoptosis, alongside a decrease in antiapoptotic factors like Bcl-2 and p53 proteins and the associated phagocytosis.¹⁰

Lapthanasupkul P (*et al*) conducted a study that evaluated the expression of laminins 1 and 5, collagen type IV, and fibronectin in the cytoplasm of tumor cells in granular cell ameloblastoma. Immunoreactivity was assessed by visually classifying the staining intensity of positive cells into three categories: weak (W), moderate (M) and strong (S).

Examined proteins	Staining intensity		
	Peripheral cells	Central cells	Granular cells
Laminin 1	M to S	M	S
Laminin 5	W	W	M to S
Collagen type 4	No staining	No staining	No staining
Fibronectin	W to M	W	M to S

- **Investigation of basement membrane proteins in a case of granular cell ameloblastoma.¹¹**

The granular cells exhibited strong positivity for laminins 1 and 5, as well as fibronectin. The heightened expression of fibronectin in these cells suggests a potential age-related transformation on granular cells in ameloblastoma. As age progresses, certain tumor cells accumulate more cytoplasmic components, while their lysosomes exhibit a reduced ability to digest these materials, leading to cytoplasm densely packed with lysosomal granules.¹¹

Conclusion

Granular cell ameloblastoma is a rare condition with distinct histopathologic and immunohistochemical features. Since the lesion was located in the lower anterior region, making a clinical diagnosis was challenging and required histological confirmation. While the treatment and prognosis are similar to other subtypes of solid/multicystic ameloblastoma, GCA must be distinguished from other granular cell lesions due to its greater aggressiveness and higher recurrence rate.

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Obturing materials in Pediatric Dentistry: Literature Review

*Amith Adyanthaya, **Laya Vijayaraj, **Shemna MK, **Nileena Balan

Abstract

Pulpectomy of primary teeth is indicated when the radicular pulp tissue is necrotic. It should be maintained in the dental arch to maintain the arch integrity. Various obturation materials are reported with successful outcomes by various authors. Hence, the aim of this review is to present various obturation materials used in daily clinical practice from traditional to novel materials, along with their antibacterial properties, toxicity and biocompatibility.

Key words: Pulpectomy, Obturing materials

Corresponding Author: Laya Vijayaraj

**Professor and Head, **Post graduate student, Department of Oral and Maxillofacial surgery, KMCT Dental College, Manassery, Kozhikode, Kerala.*

Introduction

Primary teeth are crucial for maintaining space in the mouth and should be preserved as long as possible. Pulpectomy involves removing infected pulp and debris from the tooth's root canals and filling them with an antibacterial, resorbable material. Ultimately, pulpectomy is needed to achieve good hermetic seal which depends on various factors such as good biomechanical preparation, types of obturating material used and achievement of minimum voids.¹

Pulp therapy for pulpally involved primary teeth is a very challenging situation for clinicians due to:

1. Roots get resorbed physiologically
 2. In order to allow for the development of the succedaneous tooth, primary molar roots are usually curved, these curves increase the chance of perforation of the apical portion of the root or the coronal one-third of the canal into the furcation.³
- Obturing the canal creates a fluid tight seal along the length of the root from the coronal opening to the apical system and eliminating all portals of entry between the

periodontium and the root canal system[4]. Zinc oxide eugenol is most widely used obturation material; nonetheless, it has few drawbacks, such as, delayed resorption of extruded from the apex and concerns of toxicity. So, to overcome these, many obturation materials have been introduced with promising results that can be used as advantage to traditional ZOE.³

Optimal requirements of obturating material for deciduous teeth

Rabinowitch stated, "The history of the treatment of root canals is the discussion of medication used:

- ❖ It should not irritate the periapical tissues nor coagulate any organic remnants in the canal.
- ❖ It should not be soluble in water.
- ❖ It should not discolour the tooth.
- ❖ It should have a stable disinfecting power.
- ❖ Excess pressed beyond the apex should be resorbed easily.
- ❖ It should be inserted easily into the root canal and removed easily if necessary.
- ❖ It should adhere to the walls of the canal and should not shrink.
- ❖ It should be radiopaque.
- ❖ It should induce vital periapical tissue to seal the canal with calcified or connective tissue.

- ❖ It should be harmless to the adjacent tooth germ.
- ❖ It should not set to a hard mass, which could deflect an erupting permanent tooth.¹

Rifkin identified criteria for an ideal obturating material used in pulpectomy that include

- 1) Resorbability.
- 2) Should have an Antiseptic property.
- 3) Noninflammatory and nonirritating to the underlying permanent tooth germ,
- 4) Good Radiopacity for visualization on radiographs,
- 5) Ease of insertion, and Ease of removal.
- 6) Should not cause any tooth discoloration.

But till now none of the currently available obturating materials possess all of these criteria.¹ Various root canal obturating materials for primary teeth are zinc oxide eugenol, calcium hydroxide, iodoform based pastes, walkhoff paste, kri paste, maistopaste, vitapex/ metapex, endoflas, endoflas-chlorophenol-free (cf), calenpaste, smartseal, gudes pinto paste, chirita hap-fil, pulpotec, aloevera, ozone, rifocort, ctz paste.

ZINC OXIDE–EUGENOL CEMENT

Zinc oxide eugenol was discovered by Bonastre (1837) and subsequently used in dentistry by Chisholm (1876). Sweet in 1930 said that it was the first root canal

filling material to be recommended. ZOE is a commonly used filling material for primary teeth. Camp introduced the endodontic pressure syringe to overcome the problem of underfilling, a relatively common finding when thick mixes of ZOE are employed.[3]Composition of zinc oxide eugenol is: Zinc oxide - 69.0%, White resin – 29.3%, Zinc acetate – 1.0%, ZincStearate – 0.7%, Liquid (eugenol- 85%, olive oil-15%).² Advantages of zinc oxide eugenol are anti-inflammatory and analgesic properties, greater zone of bacterial inhibition, radiopaque for good radiographic visibility ,easy to manipulate and fill in the canals, insoluble in tissue fluids, easily available, cost effective and absence of tooth discolouration.

Disadvantages are alters the path of eruption of succedaneous teeth, causes anterior crossbite, palatal eruption and ectopic eruption of succedaneous tooth, necrosis of cementum and bone, variation in resorption rate of ZOE or slow resorption in comparison to root resorption, enamel defects in permanent successors, failure of extruded material to resorb at the periapical region due to hardening, soft tissue irritation, allergy to eugenol and exhibits cytotoxicity and neurotoxicity. To improve the properties and success rate of zinc oxide eugenol combination with different components were used like formocresol, formaldehyde

and paraformaldehyde and cresol but the addition of these compounds neither elevated the success rate nor made the material more resorbable as compared to zinc oxide eugenol alone

Table 1 Shows authors and their observation for zinc oxide eugenol.¹

Authors	Observations
Allen	Speculated that the resorption rate of zinc oxide eugenol (ZOE) and the root differed, resulting in small areas of ZOE paste possibly being retained
Barker and Lockett	Material when extruded from the apex cause a mild foreign body reaction
Barker and Lockett Spedding Mortazavi and Mesbahi	Stated that extruded ZOE resisted resorption and took months or even years to resorb
Coll and Sadrian	Pulpectomized teeth rarely exfoliate later than normal and timing of exfoliation was not related to retention of ZOE paste. Anterior cross-bite, palatal eruption, and ectopic eruption of the succedaneous tooth

	following ZOE pulpectomy
Coll et al.	Reported that when ZOE extrudes, it develops a fibrous capsule that prevents resorption of the material. Thus, it has a slow rate of resorption and has a tendency to be retained even after tooth exfoliation. Areas of cementum resorption were evident, periodontal ligament exhibited intense and moderate thickening. Dentin resorption was not observed, whereas bone resorption was found.
Erasquin et al.	Reported that the canals overfilled with (ZOE) are not recommended because it irritates the periapical tissues and causes necrosis of bone and cementum.
Flaitz et al.	Observed deflection of permanent tooth eruption in 20% of pulpectomized tooth that were extracted
Coll and Sadrian	
Garcia-Godoy , Ranly and GarciaGodoy , Praveen et	Reported deflection of developing permanent tooth bud because of its hardness

al.	
Hashieh et al.	Studied the beneficial effects of eugenol. The amount of eugenol released in the periapical zone immediately after placement was 10-4 and falls to 10-6 after 24 hours, reaching zero after one month. Within these concentrations eugenol is said to have anti inflammatory
Holan and Fuks ; Moskovitz and Samara	Malformation of successor is attributed to the cytotoxic and neurotoxic nature of eugenol
Jerrell and Ronk	Reported a case of developmental arrest of a premolar following overfilling of the root canal of the second primary molar using zinc oxide-eugenol/formocresol paste
Loevy	Premolars erupt early after primary teeth pulpotomies. Possibly a mild chronic inflammation exists in periapical area of some pulpectomies judged successful that is not clinically evident. This could cause premature

	eruption of succedaneous tooth and uneven resorption of pulpectomy treated tooth
Praveen et al. ; Sunitha et al	Excess material forced through the apex during filling procedures can remain in the apical tissue during the process of physiological root resorption and it takes few months or even years to resorb

Table 2: Zinc Oxide combinations with other materials.

Combination	
Zinc oxide + Propolis (ZOP)	ZOP paste was synthesized by mixing 50% zinc oxide powder with 50% hydrolytic propolis. There was acceptable clinical and radiographic success rate with faster resorption seen in some cases.
Zinc oxide + Ozonated oil	It has biological properties such as, bactericidal action, debriding effect, angiogenesis stimulation capacity and high oxidizing power (Guinesi et al., 2011). After 12 months followup there was progressive bone

	regeneration at the periapical region with good clinical and radiographic success rate.
Zinc oxide eugenol (ZOE)+ Calcium hydroxide (CA(OH)2 +Sodium fluoride	Ca(OH) ₂ - demerit of resorbing at a faster rate than the physiologic root resorption. To overcome this filling material incorporated with fluoride was utilized. The addition of fluoride was seen to give this material a resorption rate that matched the resorption rate of primary teeth.
Iodoformize d ZOE	It was found to be effective for both aerobic and anaerobic bacteria with a maximum sustaining period of 10 days.
Zinc oxide + Calen past	Clinical and radiographic outcomes for calen/zo were equal to ZOE after 18 months, suggesting that both the materials can be indicated for obturation of primary teeth
Zinc oxide + Calcium hydroxide	Obtured material remained up to the apex of root canals till the beginning of physiologic root resorption and was found to resorb at the same rate as that of

	primary teeth
Zinc oxide eugenol + Aldehydes	The addition of these compounds neither increased the success rate nor made the material more resorbable as compared to zinc oxide eugenol alone

CALCIUM HYDROXIDE

Calcium hydroxide was introduced by Herman. The main drawback of the material is that despite of its antiseptic and osteoconductive properties, it has the tendency to get depleted from the canals earlier than the physiologic root resorption. Antibacterial effect is primarily due to the liberation of hydroxyl ions and activation of enzymes in the bacterial cytoplasmic membrane.³ Calcium hydroxide containing root canal filling materials can trigger inflammatory root resorption when come in contact with some vital tissue, when used in primary teeth with hyperemic pulp. When this paste is used in necrotic pulp, it produces a superficial layer of necrosis causing damage to dentin which, in turn can lead to exposure of dentin to odontoclasts and cause subsequent damage.⁵

VITAPEX/METAPEX

Kawakami et al introduced it in 1979 [4]. Metapex (METABIOMED) and Vitapex

(Neo Dental Chemical Products Co., Ltd, Tokyo, Japan) are available in preformed syringes, which is directly placed into the canals and the material is extruded by simple pressure. Metapex composed of iodoform - 40.4%, calcium hydroxide - 30.3%, silicone oil- 22.4% and others – 6.9% . Addition of polysiloxane oil in Vitapex, enhances fluidity and permeability, which also improves the collateral benefit of root canal filling.³ Advantage are resorbability (When extruded from the apex of a primary tooth, vitapex can be resorbed as early as one week to three months, without causing a foreign body reaction. Its rate of resorption from within the canals is faster than physiological root resorption), easy delivery system, radio-opaque, does not set to a hard mass. It has bone regeneration potential and decreases abnormal tooth mobility and pre-existent bone radiolucency

Pabla et al in 1999 evaluated the antimicrobial efficacy of zinc oxide eugenol, iodoform paste, KRI paste, Maisto paste and vitapex against intracanal microbes and found that Maisto paste had the best antibacterial activity. Iodoform paste was the second best followed by zinc oxide eugenol paste. Vitapex showed the least antibacterial activity.⁵

ODOFORM

It is a preparation of iodine obtained by action of chlorinated lime upon an alcoholic solution of potassium iodide when heated at 1040°F. No irritant action. Relieves pain and is a potent disinfectant. Better re-sorbability and disinfectant properties than ZOE. But they may produce a yellowish brown discoloration of the tooth. Erasquin in 1989 have shown that iodoform is irritating to the periapical tissues and can cause cemental necrosis. Iodoform containing root canal filling materials are available in different formulations such as KRI paste, maisto paste, guedes-pinto paste, rifocort, endoflas, vitapex.¹

KRI Paste

KRI, basically an Iodoform paste, was introduced by Volkoff as a resorbable paste suitable for root canal filling. It consist of Iodoform (80.8%), camphor (4.86%), para chlorophenol (2.025%), Menthol (1.215%). KRI paste is a radiopaque endodontic root filling. Camphor and menthol are mixed with the antimicrobial agent and para chlorophenol, to minimize coagulation with adjacent tissues. Iodoform is added as a vehicle to carry the antimicrobial agent as it is a non-irritant and radiopaque.⁵ Overall success rate for KRI paste was 84% versus 65% for ZOE

WALKHOFF PASTE

Introduced by Walkhoff in 1928, it consists of iodoform, parachlorophenol 33-37% (disinfectant action depend on the liberation of the chlorine in the presence of phenol), Camphor – 63-67% and menthol. It can be used as intracanal dressing in cases of non- vital teeth associated with large periapical lesions.⁵

MAISTO'S PASTE

Maisto introduced it in 1967. Tagger et al. used it as root canal filling material in primary teeth. It consists of zinc oxide -14 g, iodoform-42 g, thymol-2 g, chlorophenol camphor-3 cc, and lanolin – 0.5 g. Maisto's paste differs from KRI paste, in that it also contains zinc oxide, thymol and lanolin. This formulation change was made to reduce the resorption rate of the paste from within the canals of endodontically treated primary teeth. Eliyahu mass in 1989 found Maisto paste to be successful in infected posterior primary teeth and had positive healing effect on periradicular tissue.⁴

GUEDES-PINTO PASTE

Guedes-pinto in 1981 proposed a root filling material for primary teeth named as guedespinto paste (GPP), Composed of rifocort, camphorated para chlorophenol and iodoform. The paste is made up of one equal part of each component, mixed on a sterilized glass plate.⁴

ENDOFLAS

Endoflas is a resorbable paste produced containing components similar to that of Vitapex, with an addition of Zinc oxide eugenol. The powder contains triiodomethane and iodine dibutylorthocresol (40.6%), zinc oxide (56.5%), Calcium hydroxide (1.07%), Barium sulfate (1.63%) and with a liquid consisting of eugenol and Paramonochlorophenol.² The rationale behind incorporating three materials ZOE, Ca(OH)₂ and iodoform into Endoflas was probably to compensate the disadvantages of one individual material with the advantages of the other.⁵ Navit S et al (2016) evaluated the antimicrobial efficacy of obturating materials against *E. faecalis*, amongst all the groups Endoflas had significantly higher zone of inhibition.⁵ Advantages are hydrophilic and can be used in mildly humid canals, firmly adheres to the surface of the root canals to provide a good seal, disinfect dentinal tubules and difficult to reach accessory canals that cannot be disinfected or cleansed mechanically, only resorbs when extruded extraradically, but does not wash out intra-radically. Disadvantage are eugenol content that can cause periapical irritation and can cause teeth discoloration.⁵

ENDOFLAS-CHLOROPHENOL-FREE (CF)

Following endodontic treatment of primary teeth radiolucent lesions may be due to the filling material that contain phenol. Because of this, Endoflas CF was developed which is chlorophenol free. Chlorophenol was eliminated from endoflas as it has fixation effect which may affect the osteoblast cells.⁵

CALEN PASTE

It is a calcium hydroxide-based paste. Calen paste exhibits biocompatibility, high antimicrobial activity and satisfactory clinical, radiographic outcomes and intermediate setting time values.⁵

ALOE VERA

Aloe vera is an herbal and naturally found material and its properties made possible its wide usage in dentistry for various therapeutic properties. Khairwa et al in 2014 evaluated clinical and radiographic success of zinc oxide Combined with aloe vera and showed good success rate. They reported that this material can be used as an alternative for Zinc oxide eugenol.⁴

PULPOTEC

It has antibacterial, antiseptic and anti-inflammatory properties. Iodoform is the main component and because of its antiseptic properties, it acts like an antibiotic paste at the entry of the empty root canal. It can be used in teeth with bone lesion and also help in reducing the

infection clinically. Clinical and Radiological results show that this procedure could be considered as an alternative to the conventional endodontic treatment for the treatment of necrotic primary teeth in paediatric dentistry.³

OZONE

Ozone is gaseous, energized form of oxygen. It is unstable and dissociates readily back into oxygen, thus liberating so called singlet oxygen, which is a strong oxidizing agent. They are responsible for remarkable bactericidal and fungicidal effects.⁴ Ozonated oil-ZnO demonstrated a good clinical and radiographic success at 12 months follow-up, hence can be considered as an alternative obturating material in infected primary teeth.²

Chitra HAP-Fil

Jeeva and Retnakumari et al. in 2014 observed the current trend in dentistry towards the use of biomaterials such as hydroxyapatite. In an attempt to find an appropriate root canal obturating material, they designed a new product named “chitra hap-fil”. It is a hydroxyapatite nanoparticle gel based root filler material, which exactly corresponds to the mineral content of bone and dentine, deemed to be highly biocompatible. “Chitra hap-fil” apparently satisfies all requirements of an ideal pulpectomy material.⁵ In Hydroxy apatite - Iodoform paste (Chitra HAP-Fil), The prime ingredient is hydroxyapatite

nanoparticle gel (65%) which is the basic mineral content of human bone and pure Iodoform (32%) which imparts antibacterial property to the paste. The gelling agent (alginate) – 3% (including 0.2% surfactant) binds with the calcium ions in the hydroxyapatite. The study evaluated the cytotoxicity and antimicrobial activity of three pulpectomy materials, namely Zinc oxide eugenol, Chitra HAP-Fil and Metapex. The cellular response of three materials were evaluated and results showed that Metapex is significantly least cytotoxic than Chitra HAP Fil which is less cytotoxic than Zinc oxide eugenol.²

SMART SEAL

It is a root canal obturating material which is based on polymer technology. It uses a hydrophilic principle which can absorb surrounding moisture and expand which results in filling of spaces and voids. Hydrophilic nature is revealed by ProPoints, which permits infinite water volume existing in the root canal system that is engrossed by these points. This water can hydrogen bond to the existing polar locations, therefore, permitting the enlargement inside the polymeric chain.¹

RIFOCORT

It is a product formed from a corticosteroid and an antibiotic, presenting a great antimicrobial action and recommended for the treatment of primary teeth presenting

with pulpal infectious processes. The paste also presented bactericidal action against most organisms except for *Enterococcus faecalis* and *Bacillus subtilis*.¹

CTZ Paste

CTZ is an antibiotic paste combination of chloramphenicol 500mg+tetracycline 500mg+zinc oxide 1000mg+ eugenol 1 drop. Chloramphenicol is an antimicrobial agent that acts against a large number of aerobic, facultative anaerobe and spirochetes as well as gram +ve and gram -ve microorganisms. Tetracycline is a broad spectrum antibiotic which can be bactericidal at high conc. offering excellent effectiveness against gram -ve bacteria and all anaerobes. ZOE provides analgesic properties and potent antibacterial action against staphylococcus, micrococci, bacillus and enterobacteria for more than 30 days.¹

Conclusion

With adherence to sound principles in case selection and techniques, pediatric pulp therapy is a major health benefit to the child. It has been found that the current obturating materials for primary teeth while providing satisfactory clinical results still need to be modified to suit the various clinical situation that are encountered. The current combinations of calcium hydroxide and iodoform seem to provide better results than zinc oxide

eugenol cements. Hence, researches have to be done further to develop a root canal filling material for primary teeth that meets all the essential needs of ideal obturating materials.

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Case report

Cemento-Ossifying Fibroma in A 13-Year-Old Male: A Case Report

*** Lekshmi Priya Reghu, *Rajeesh Mohammed P K, **Swapna Honwad,

***Jyotsna K V, ***Gopika S Raj

Abstract:

Cemento-ossifying fibroma (COF) is a relatively rare, benign jaw tumor classified under fibro-osseous lesions. It exhibits a range of histological appearances, with the potential to differentiate into cementum, lamellar bone, fibrous elements, or a combination of these. The terminology and diagnostic criteria for this tumor are often debated. Terms like ossifying fibroma and cementifying fibroma were also used. COF was previously classified as a benign mesenchymal odontogenic tumor in 2017 WHO classification and listed under fibro-osseous and osteochondromatous lesions, has been fully reclassified in 2022 as a benign mesenchymal odontogenic tumor. It is now distinctly separated from non-odontogenic juvenile trabecular and psammomatoid types. Typically occurring in the 3rd and 4th decades of life, it is more common in females and tends to affect the mandible more than the maxilla. This case report discusses a rare case of COF in the mandible of a 13-year-old male patient.

Keywords: *Fibro-osseous lesions, Cemento ossifying fibroma, Cementum*

Corresponding Author: Lekshmi Priya Reghu (lekshmipriya2013l.15@gmail.com)

Professor and Head, **Associate Professor, *Post graduate students, Department of Oral and Maxillofacial Pathology and Oral Microbiology, KMCT Dental College, Kerala.*

Introduction

Fibro-osseous lesions are a diverse group of processes that are characterized by replacement of normal bone by fibrous tissue containing a newly formed constitute a specific diagnosis. Lesions

belonging to this category may be developmental, reactive, dysplastic, or neoplastic.¹

Cemento-ossifying fibroma (COF) is an uncommon type of benign fibro-osseous lesion.² It occurs over a broad age

range, with a peak in 3rd and 4th decades of life. There is a female predilection, with the mandible involved far more often than maxilla(70%). Small lesions are often asymptomatic and may be detected only by radiographic examination while larger tumors may produce painless jaw swelling and obvious facial asymmetry.¹ Radiographically, COF presents with distinct borders and exhibits mixed radiolucent and radiopaque areas due to varying levels of calcification. Histopathological examination shows a fibrous connective tissue stroma with masses resembling osteoid and cementum. The management of COF is controversial, involving challenges in diagnosis and treatment planning. Typically, the approach includes surgical resection of the bony lesion along with curettage of the affected bone area.³ Here, we present a case report of COF in the mandible of a 13-year-old male patient.

Case report

A 13-year-old male patient reported with a chief complaint of swelling in his lower left side of face since 1 month. The swelling was gradually increasing in size and was not associated with pain, paresthesia and fever.



Figure 1: Extraoral image

Extraoral examination showed a 2.5×3 cm diffused, solitary swelling on the left side of face extending superiorly from tragus of the ear and to the inferior border of the mandible and mediolaterally from left corner of mouth to 1.5cm from angle of mandible which was firm to hard and non-tender on palpation.

Intraoral examination showed a swelling of 4x3 cm in size extending from mesial aspect of 35 to distal aspect of 37, non-tender, non-compressible with a fluctuancy noted at the anterior aspect of swelling and was without any bleeding and pus discharge. Expansion of buccal cortical plate with vestibular obliteration was noted.



Figure 2: Intraoral image

OPG revealed a multilocular radiolucency in relation to left posterior mandible extending from mesial surface of 36 towards ramus. Knife edge resorption in relation to 36 and distal displacement in relation to 38 was also noted.

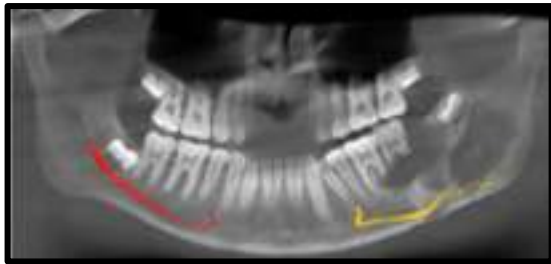


Figure 3: OPG showing multilocular radiolucency

CBCT showed multilocular expansile lesion causing ballooning expansion buccolingually and thinning of inferior border of mandible with bowing of inferior cortex. CT angiogram with contrast and limited MR revealed multiloculated lytic lesion with soft tissue component involving left side mandible with multiple bony spicules, causing expansion, cortical thinning and erosion. Post contrast image shows moderate heterogeneous enhancement and multiple small arterial feeders. A provisional diagnosis of aneurysmal bone cyst was made. Incisional biopsy was done and specimens were sent for histopathological examination.

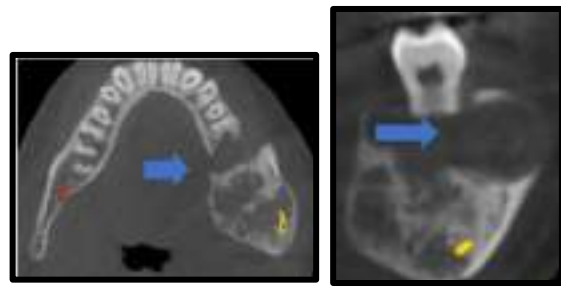


Figure 4: Axial and coronal view showing multilocular appearance, ballooning expansion, thinning of inferior border of mandible and knife edged resorption of 36



Figure 5: CT angiogram

Gross Features

Received two bits of soft tissue specimen from anterior-I (Figure 1) and posterior-II (Figure 2) margins of the lesion. Both specimens had a firm consistency with irregular surfaces and borders. They were sent for processing.



Figure 6: Specimen I - Creamish white in colour measuring 0.8x0.7x 0.3cm in size



Figure 7: Specimen II - Brownish black colour measuring 1x0.6x0.5 cm in size

Microscopic Features

H and E stained section of both the specimens showed highly cellular connective tissue stroma with numerous proliferating plump spindle shaped cells. Numerous hematoxyphilic acellular calcified spherules resembling cementum and irregular immature bony trabeculae with varying grades of calcifications were seen. Periphery of the section shows more calcifications and endothelium lined vascular channels engorged with RBCs

and hemorrhagic areas are also seen. The lesion was diagnosed as a cemento-ossifying fibroma



Figure 8: H&E stain showing COF under 4X magnification



Figure 9: H&E stain showing COF under 10X magnification



Figure 10: H&E stain showing hematoxyphilic acellular calcified spherules resembling cementum under 10X magnification

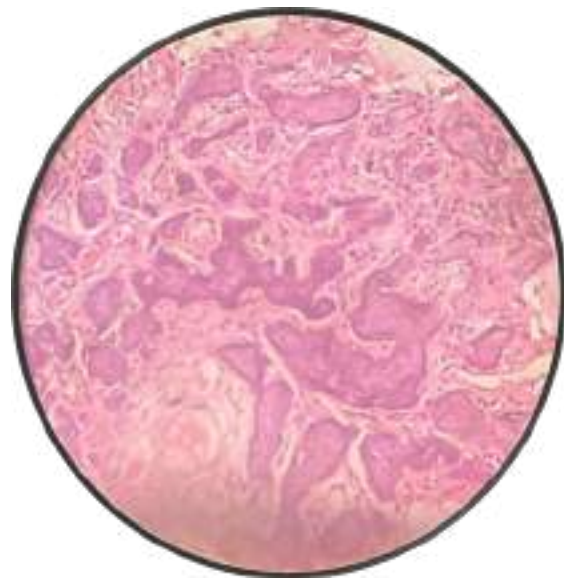


Figure 12: H&E stain showing irregular immature bony trabeculae with varying grades of calcifications under 40X magnification

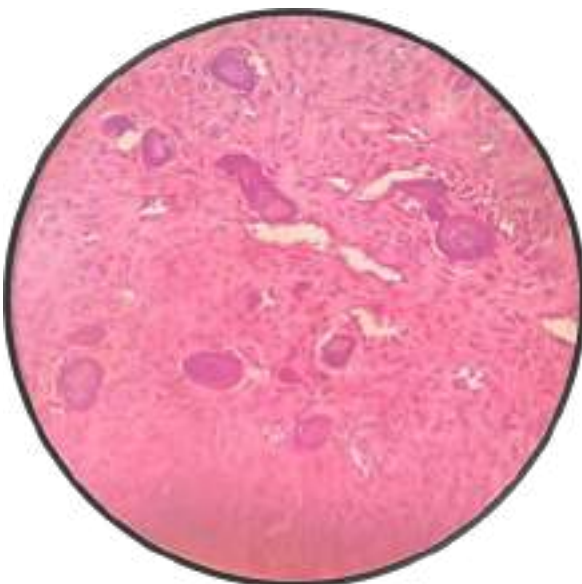


Figure 11: H&E stain showing COF under 40X magnification

Discussion

Fibro-osseous lesions encompass a diverse group of conditions in which normal bone is replaced by fibrous tissue that contains newly formed mineralized material¹. These lesions encompass conditions such as fibrous dysplasia, periapical cemento-osseous dysplasia, focal cemento-osseous dysplasia, florid cemento-osseous dysplasia, and cemento-ossifying fibroma (COF).⁴

COF is a rare, benign fibro-osseous tumor first described by Menzel in 1872.⁵ WHO defines it as a well-defined, occasionally encapsulated neoplasm composed of fibrous tissue with varying

amounts of mineralized material, including bone and/or cementum.⁴ There has been significant debate about its origin and its relationship to similar lesions. Whether COF is an odontogenic or non-odontogenic osseous tumor remains contentious. WHO classifies COF as a fibro-osseous neoplasm, categorizing it among non-odontogenic tumors derived from mesenchymal blast cells of the periodontal ligament. These blast cells have the capacity to develop into fibrous tissue, cementum, bone, or a combination of these elements.⁵ COF can present in two forms: central and peripheral variants. Central variant arises from the periodontal ligament near the root apex and peripheral cemento-ossifying fibroma is a reactive gingival overgrowth, often found in the maxillary anterior region of teenage and young females. It is supposed to be originating from the periosteum or periodontal ligament.^{6,11} The central variant is neoplastic, whereas the peripheral variant is a localized, reactive, non-neoplastic growth in the soft tissue, containing mature collagen, cellular fibroblastic tissue, mineralized tissue, and multinucleated giant cells.⁶

COF originally categorized as a benign mesenchymal odontogenic tumor in the 2017 WHO classification but later grouped under fibro-osseous and

osteochondromatous lesions. It has been reclassified in 2022 as a core entity within benign mesenchymal odontogenic tumors and is now distinctly separated from non-odontogenic juvenile trabecular and psammomatoid variants.⁷

Most cases are asymptomatic, but over time, the lesion's growth can cause facial asymmetry due to the expansion of the mandible and potential displacement of tooth roots⁵ as seen in present case. The exact cause of COF is still unknown. Bernier suggested that an irritant stimulus might prompt the formation of new tissue from the remaining periodontal membranes. These membranes contain multipotential cells that can develop into cementum, lamellar bone, and fibrous tissue. Current theories about the origin of COF involve both traumatic and developmental factors.⁴ In present case there was no history of trauma.

COF primarily affects the mandible, often appearing in the molar and premolar regions. Some cases have also been reported in other areas beyond the mandible, including the maxilla, as well as orbital and ethmoidal regions. In a series of 16 COF cases, 50% were located in the maxilla and 50% in the mandible.⁸ There was also one case involving the right zygoma, presenting with diffuse swelling extending towards the upper vestibule. In

the maxillary region, COF can lead to facial deformities, sinus obstruction, and discomfort in the intraorbital and intracranial areas due to its involvement with adjacent structures. A recent 2020 report described a large, neglected COF in the maxilla that caused significant pressure on the patient's left eye.⁸

Radiologically, these tumors can exhibit various patterns based on their level of mineralization. Two primary patterns have been identified: one featuring a unilocular or multilocular radiolucent appearance, and another displaying mixed density due to varying amounts of internal radiopaque material. In some instances, the enlargement of lesion can cause root resorption and displacement of adjacent tooth roots, as seen in the present case.⁹ Depending on the amount of cementum deposition, it may resemble fibrous dysplasia, cemento-osseous dysplasia, odontogenic cysts and tumors like keratocystic odontogenic tumor, calcifying odontogenic cyst (Gorlin cyst), and calcifying epithelial odontogenic tumor (Pindborg tumor). The distinct border of the central COF is a key feature that helps distinguish it from aggressive sarcomas and carcinomas. A significant diagnostic characteristic of COF is its centrifugal growth pattern, which gives the tumor a rounded shape and

aids in differentiating it from typical keratocystic odontogenic tumors.⁶ Unlike fibrous dysplasia, which exhibits a characteristic "ground glass" appearance and a blending margin with the surrounding bone, the central COF remains well circumscribed and clearly demarcated from the surrounding bone, regardless of its developmental stage.⁶ Cemento-osseous dysplasias, on the other hand, is multifocal with thick sclerotic border, which is not the case with COF.⁶ Radiographically, it is difficult to differentiate central COF from Gorlin cyst and Pindborg tumor, particularly when not associated with impacted teeth, with which they often share a strong association. Therefore, the final diagnosis typically relies on histological examination.⁶

Histologically, these tumors consist of well-vascularized fibrocellular tissue capable of forming immature bone trabeculae and cementoid structures.⁹ Distinguishing histologically between osteoid and cementum can be challenging. On H&E staining, calcified fragments made up of immature cementum appear basophilic, while those composed of osteoid display eosinophilic coloration.⁶ In the present case, highly cellular connective tissue stroma with numerous proliferating plump spindle shaped cells and hematoxyphilic acellular calcified

spherules resembling cementum with irregular immature bony trabeculae showing varying grades of calcifications were, suggestive of COF.

In an effort to distinguish COF from ossifying fibroma and fibrous dysplasia, Endo et al. employed immunohistochemical analysis, focusing on keratan sulfate and chondroitin-4-sulfate. The study demonstrated that COFs exhibited marked immunoreactivity for keratan sulfate, whereas ossifying fibromas and fibrous dysplasias exhibited by strong immunostaining for chondroitin-4-sulfate.⁶ Therefore, establishing a definitive diagnosis requires the integration of clinical, radiological, and histological findings.⁹ In the present case IHC was not performed as the patient was not willing for further follow-up.

Several studies have reported on the use of segmental resection of a large ossifying fibroma, followed by the reimplantation of the excised segment post-cryotherapy. Conservative surgery is recommended for such tumors, even when they cause significant mandibular bowing and erosion. In cases of recurrence due to the tumor's aggressiveness, more radical treatment, such as en bloc resection, should only be considered. The prognosis is generally favorable, with recurrence after surgical excision being uncommon.¹⁰

Conclusion

COF presented with varying clinical and radiological features should be differentiated from other pathologies by considering its histopathological features along with routine radiological, and clinical examination.¹⁰ COF should be considered as one of the differentials for any lesion originating in the mandible or maxilla that shows a mixture of fibrous and osteoid tissue.⁵ Though COF shows low recurrence rate, extensive removal of the lesion should be advised.⁸

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Smart composites: A Review

*Aleena Nizar **Elsy. P. Simon

Abstract

Smart composites, integrating advanced materials and technologies, are transforming dental restorations. These innovative materials combine self-healing properties, antimicrobial activity, and real-time monitoring capabilities. Nanoparticles, shape-memory alloys, and fiber optics enables improved mechanical strength and durability, enhanced aesthetics and color stability, bioactive surfaces inhibiting bacterial growth, real-time stress and decay detection and adaptive responses to environmental changes. Smart composites offer personalized dentistry, optimizing treatment outcomes and patient satisfaction.

Keywords: *Amorphous Calcium Phosphate; Hydroxyapatite; Selfhealing*

Corresponding Author: Aleena Nizar

* Post graduate student, **Professor and Head, Department of Conservative Dentistry & Endodontics , KMCT Dental College, Kozhikode, Kerala.

Introduction

Smart composites

Boskey mentioned that Aaron S. Posner to have firstly described amorphous calcium phosphate (ACP) in the mid-1960s. It was obtained as an amorphous precipitate by accident when mixing high concentrations (30 mM) of calcium chloride and sodium acid phosphate (20 mM) in buffer. ACP based materials have been developed for a number of applications like bases/liners,

orthodontic adhesives, endodontic sealers, and as pit and fissure sealants.¹

ACP has been evaluated as a filler phase in bioactive polymeric composites. Skrtic has developed unique biologically active restorative materials containing ACP as filler encapsulated in a polymer binder, which may stimulate the repair of tooth structure because of releasing significant amounts of calcium and phosphate ions in a sustained manner. In addition to excellent biocompatibility, the ACP

containing composites release calcium and phosphate ions into saliva molecules, especially in the oral environment caused by bacterial plaque or acidic foods. Then these ions can be deposited into tooth structures as apatitic mineral, which is similar to the hydroxyapatite (HAP) found naturally in teeth and bone.² ACP at neutral or high pH remains as ACP. When low pH values (at or below 5.8) occur during a carious attack, ACP converts into HAP and precipitates, thus replacing the HAP lost to the acid. So, when the pH level in the mouth drops below 5.8, these ions merge within seconds to form a gel. In less than 2 minutes, the gel becomes amorphous crystals, resulting in calcium and phosphate ions which can be described as smart. This response of ACP containing composites to pH can be described as smart.³

Ariston pH control was introduced by Ivoclar-Vivadent. It is a light-activated alkaline, nano filled glass restorative material. It releases calcium, fluoride and hydroxyl ions when intraoral pH values drop below the critical pH of 5.5 and counteracts the demineralization of the tooth surface and also aids in remineralisation. The material can be adequately cured in bulk thickness up to 4 mm. It is recommended for the restoration

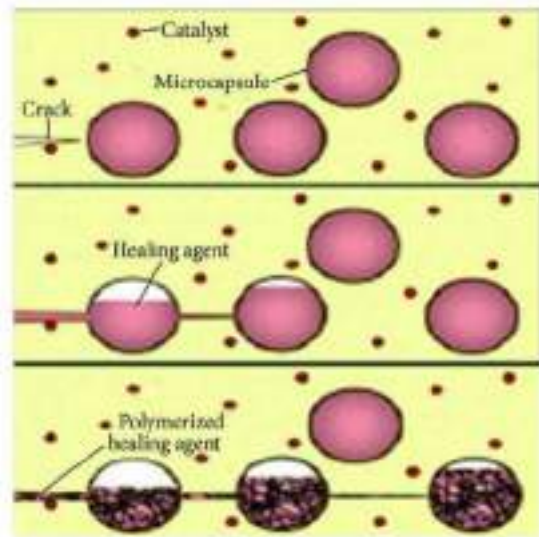
of class 1 and class 2 lesions in both primary and permanent teeth.⁴

Self-repairing or self-healing composite

Materials usually have a limited lifetime and degrade due to different physical, chemical, and/or biological stimuli. These may include external static (creep) or dynamic (fatigue) forces, internal stress states, corrosion, dissolution, erosion, or biodegradation. This gradually leads to a deterioration of the materials structure and finally failure of the material. Nature has inspired scientists and researchers to develop materials which can repair by themselves. A great many natural "materials" are themselves self-healing composite materials. An example for this is natural bone which is permanently remodelled and which can self-repair (heal) even after a major fracture has occurred. A key focus of current scientific research is the development of bioinspired materials systems.⁵

One of the first self-repairing or self-healing synthetic materials reported interestingly shows some similarities to resin-based dental materials, since it is resin-based. This was an epoxy system which contained resin filled microcapsules. If a crack occurs in the epoxy composite material, some of the microcapsules are destroyed near the crack

and release the resin. The resin subsequently fills the crack and reacts with a Grubbs catalyst dispersed in the epoxy composite, resulting in a polymerization of the resin and a repair of the crack.⁶



Similar systems were demonstrated to have a significantly longer duty cycle under mechanical stress in situ compared to similar systems with the self-repair.

It can be expected that dental composites using this technology would have a significantly longer duty cycle and enhanced clinical performance. Problems may arise from the potential toxicity of the resins in the microcapsules and from the catalyst, which needs to be present in the composite. The amounts of these agents necessary to repair microcracks in the dental composite, however, seem to be rather small, and may well be below the toxicity threshold.⁷

The self-repairing mechanism based on microcapsules may be more promising, and composites repaired in that way may perform better than those repaired with macroscopic repair approaches, some of which have been shown not to lead to satisfactory mechanical properties of the repaired composite with an aesthetically pleasing result. These conventional composites, however, have little in common with natural tooth structure and do not support any kind of tissue regeneration.⁸

Wertzberger et al conducted a study to determine the efficacy of self-healing of a highly filled composite and to investigate the physical properties of a model dental compound formulated to automatically heal cracks.⁹ A visible light cured model resin consisting of Triethylene Glycol Dimethacrylate (TEGMA) : Urethane Dimethacrylate (UDMA):Bisphenol A Glycidyl Methacrylate (BiSGMA) (1:1:1) at 45% ww with silane 0.7 μ glass was formulated with a self-healing system consisting of encapsulated dicyclopentadiene and Grubbs catalyst. The base resin was also formulated and characterized with the microcapsules alone, Grubbs catalyst alone, and no healing additives. Fracture toughness (K_{Ic}) was assessed using single edge notch specimens in three-point bend test. The

fracture toughness of the self-healing material was statistically similar to the control.¹⁰

Conclusion

Smart materials have properties that can be altered according to the environment, such as stress, temperature, moisture and pH, and electric or magnetic field. A Key feature of smart behaviour includes the ability to return to the original state even after the stimulus has been removed. The recent advances in the design of smart materials have created novel opportunities for their application in dental field which is an indicator of potential and rapid progress in this area. The most sophisticated class of smart materials in the foreseeable future will be that which emulate biological systems. This class of materials has the potential to execute specific functions intelligently in order to anticipate challenges based on the potential to recognize, analyze, and discriminate the local environment changes. The benefit for the patient and the quality of dental therapy will undergo a significant improvement if such materials are developed and introduced.

The numerous applications of smart materials have revolutionized many areas of dentistry, and there is no doubt that smart materials hold a real good promise

for the future. Thus these innovations in material science have marked the beginning of an era in biosmart dentistry, a step into the future.

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Dentin bonding agents and recent advances: A Review

*Athira Raghunath **Elsy. P. Simon

Abstract

The development of dentin bonding agents has revolutionized the field of esthetic and restorative dentistry. Buonocore's discovery on enamel acid-etching followed by description of hybrid layer by Nakabayashi et al are some of the major breakthroughs which are responsible for changing paradigms in adhesive dentistry. On the basis of mode of use, dental adhesives can be divided into generations. Dentin bonding is one challenging concept in clinical practice due to an increase in demand for aesthetic restorative treatments. Currently, challenges lie in front of the researchers to develop products that not only bind to the tooth but also contain antibacterial, remineralizing and enzymatic-inhibitory properties that can increase the longevity of the adhesive procedures. With the advent of acid etching into clinical practice, many bonding agents are developed until this date to improve the quality of adhesives and composite restorations. This article describes the strategies that have been proposed to improve and/or develop new adhesive systems that can help prevent degradation at the adhesive interface. It will specially focus on new clinical techniques or new materials with characteristics that contribute to increasing the durability of adhesive restorations and avoiding the recurrent replacement restorative cycle and the consequent increase in damage to the tooth.

Keywords: *Dentin Bonding Agents; Smear Layer; Hybrid Layer; New Modification*

Corresponding Author: Athira Raghunath (athiraakhil5201@gmail.com)

* Post Graduate student, ** Professor and Head, Department of Conservative dentistry & Endodontics KMCT Dental College, Kozhikode, Kerala.

Introduction

The first attempt to develop an adhesive system for bonding acrylic resins to tooth structure was made by Dr. Hagger

who was a Swiss chemist and worked for DeTrey/Amalgamated Dental Company.¹ He patented the first dental adhesive product called "Sevriton Cavity Seal" in

1951. This bonding agent contained adhesive glycerol phosphoric acid dimethacrylate (GPDM).² In the year 1952, a study published by Mclean and Kramer suggested that, “Sevriton Cavity Seal” material containing GPDM improved adhesion to dentin by “penetrating the surface and forming an intermediate layer”.³

The initial attempts at adhesion of resin concentrated on enamel, the first successful attempts to achieve a micro mechanical interlocking of resin tag formation with acid pre-treatment being reported by Dr. Michael Buonocore in the year 1955.⁴ However, resin bonding to dentin could not be achieved due to its complicated structure involving surface moisture and the collagen network. He subsequently applied this idea to enhance the adhesion of resin to enamel surfaces and in his ground-breaking research used 85% phosphoric acid.^{5,6}

Bowen in his ground-breaking research developed the Bis-GMA (bisphenol glycidyl methacrylate), a monomer which is used in most modern composite resin materials.⁷ In his efforts to effectively bond this compound to the tooth, in the year 1965, he also developed a surface active co-monomer named NPG-GMA (N-phenyl glycine-glycidyl methacrylate). He concluded that the mechanism by which

the NPG-GMA coupling agent improves bonding between a methacrylate resin and hard tooth tissues may be primarily by interaction with the mineral phase rather than with the organic phase of the tooth structures.⁸ This formed the basis of development of NPG-GMA origin dentin bonding agents, also known as the first generation adhesives. The first commercially available product was Cervident (SS White).

In the 1970s, identification of smear layer was made possible using the scanning electron microscope (SEM) and was first reported by Eick et al.⁹ The second generation adhesives evolved around this time. The first and second generation adhesives were applied over the smear layer which resulted in low bond strengths.¹⁰ Commercial products from second generation bonding agents includes Clearfil and Prisma Universal Bond.

The researchers soon realized that the smear layer had to be removed or modified/ in order to let the adhesives bond with dentin¹¹ which led to the advent to the third-generation adhesives. Scotchbond 2 (3M Dental) was one of the first bonding agents in this generation. Developed in the 1980s-1990s, the fourth generation bonding agents were the first ones aiming to completely eliminate the smear layer. They make use of the “Total-Etch”

technique, which was based on a Japanese research originally conducted by Fusayama et al.¹² Nakabayashi et al. reported micro-mechanical bonding of a functional monomer containing resin system (4-META/MMA-TBB) to collagen fibrils in demineralized dentin in 1982.¹³ Since a smear layer created during tooth preparation has an adverse effect on dentin bonding^{14,15} due to weak adhesion to underlying dentin¹⁶ its removal by an acidic agent prior to application of a bonding resin require to gain stronger bond strength.

Acid-etching of etch-and-rinse systems (total-etching system) demineralizes the dentin surface to expose a few-micron-thick collagen network providing space for resin infiltration. The following application of a primer and/or adhesive penetrates into the inter-fibrillar spaces of the collagen web, leading to the formation of a hybrid layer composed of collagen fibrils and adhesive resin. Wet bonding leaves the dentin surface visibly moist after acid etching. This leads to increased resin infiltration into the exposed collagen network as a result of increasing bond strength. However, the degree of dentin surface wetness (i.e. moist, wet or over wet) greatly affects the bond strength in both the laboratory and clinical situations. The depth of demineralization and

completeness of monomer diffusion affect the quality of the hybrid layer. When the former exceeds the latter, a region of naked collagen fibers is left exposed as a bond defect. For the first system of self-etching adhesives, an acidic monomer of phenyl-P diffuses through extant smear layers to reach the underlying calcium-rich dentin as a result of formation of a hybrid layer where the smear layer remains in the lower half of the hybrid layer. The hybridization occurs among resin, collagen fibrils, and inorganic matter of the smear layer. Theoretically, there are no demineralized dentin zones in the bond face because of the lack of acid pre-treatment. This system is attractive to clinicians because it is thought the application step is simple and easy compared with total-etching systems with separate etching and water rinsing step.¹⁷

Newly marketed one-bottle self-etching systems, have been developed with a view to further simplifying the bonding procedure, combining etching, priming, and bonding steps into one component . These adhesives can be categorized as a self-etching system. If the hybridized layer is impermeable to water or various chemical stimuli, it could make dentin stable for long-term clinical use.¹⁷

Seventh generation:

(Single Stage Self-etch Adhesive Systems)

Self-etch adhesive materials that combine acid, primer and bonding steps in a solution, without washing and with reduced clinical application stages are gaining increasing popularity. There is a mixing process prior to application in type 1 single-stage adhesive systems with two-components, the mixing process is not necessary in type 2 single-stage (all-in-one) adhesive systems with one component. Single-stage adhesive systems, unlike classical ones, contain non-polymerized ionic monomers in direct contact with composites, leading to mismatches with self-cure composites. They act as semi-permeable membranes, hydrolytically degrading the resin-dentin interface. Adhesives, containing organophosphate and carboxylate structure, are acidic and hydrophilic, allowing ionization. However, they are susceptible to hydrolysis, hydrolytic degradation, and chemical degradation. Polymerized adhesive's permeability allows water to pass through dentin, causing water bubbles and hydrolytic degradation, indicating unevaporated free water in the adhesive that is not polymerized during drying. Tay and

Pashley found microscopic formations of water clinging to adhesive-dentin interface, varying depending on ionic structure, hydrophilicity, and adhesive thickness, first observed in resin infiltration regions before polymerization. The TEM (Transmission Electron microscopy) microscope revealed water masses causing nano-leakage formation in the adhesive-composite interface, forming spotted or reticular images. These water masses hinder polymerization and hydrogel formation, unlike two-stage SE adhesives, which are less permeable and hydrophobic.¹⁸

Eighth generation

Eighth generation adhesive systems containing nanoscale particles were first introduced in 2010. These systems have single component and have nano fillers with an average particle size of 12 nm in their structure. These nano fillers increase the thickness of the hybrid layer which improves the penetration of resin monomers and the mechanical properties of adhesive systems. Nano-binding agents are nano-filling solutions with a longer shelf life, which demonstrate better enamel and dentin binding strength and stress absorption. Acidic hydrophilic monomers are involved in the structure of eighth generation adhesive systems. The main

advantages of these systems are that they can be easily applied to acidified enamel surface even if they are subsequently contaminated with saliva or moisture. The manufacturer claims that nanoparticles acting as crucibles will reduce dimensional changes. The type and manner in which nano-fillers are incorporated into the structure affect the viscosity of the adhesive and the ability of resin monomers to penetrate collagen fiber cavities. With dimensions greater than 15-20 nm or with content greater than 1.0% by weight, these systems can increase the viscosity of adhesives. It can also result in clustering of fillers on the moist surface. These clusters can cause cracks and decrease in binding force.¹⁸

Universal (multi-mode) adhesive systems

Universal adhesives, also known as multi-mode or multi-purpose adhesives, have been used in clinics since 2011. These systems improve the strength of single-step SE adhesives and provide strong bonding in enamel tissue. They are designed based on the all-in-one concept of existing single-stage SE adhesives, requiring water to ionize hydrophilic acidic monomers. Universal adhesives with a pH range of 2.2-3.2 may be effective for dentin tissue attachment, but

may not be effective for enamel tissue attachment, especially prepared enamel. Universal adhesives contain carboxylate or phosphate monomers, such as 10-MDP, silane, and poly-acrylic acid, which bind to calcium in hydroxyapatite. They also include BPDM, PENTA, and poly-alkenoic acid copolymers for increased attachment to dental tissues. Universal adhesive systems consist of hydrophilic HEMA, hydrophobic UDMA, and Bis-GMA monomers, providing a bridge between hydrophilic dental tissue and hydrophobic composite resin, and silane, which eliminates silanization during binding. Universal adhesives offer a wider application area than 7th generation dentin bonding systems, allowing clinicians to apply selective etch and SE techniques, direct and indirect restorations, and compatibility with self-cure, light-cure, dual-cure resin-based materials, metal, zirconia, porcelain, and composites. However, the main disadvantage of universal adhesives is that they contain water like other single stage SE adhesives, resulting in hydrolytic destruction. Therefore, it is recommended to apply hydrophobic resin on the polymerized universal adhesive. Since the presence of water is a problem for all single-stage adhesives, ethanol is being studied.¹⁸

Recent Advances

Matrix-metalloproteinase inhibitors and collagen cross-linking agents

Matrix metalloproteinase (MMPs) are over 25 enzymes that damage tooth structure, primarily collagen, and the extracellular matrix, leading to the degradation of the hybrid layer. When the environment's pH drops to 4.5 or less during carious processes and acid etching, latent MMPs are activated, degrading exposed collagen beneath the hybrid layer. Acidic adhesive systems can activate MMPs in the dentinal substrate, even if some are inhibited by demineralization, allowing other MMPs to be activated. Various substances have been studied to improve adhesive interface durability by inhibiting MMPs, but issues like substantivity and release from polymer matrices remain. Chlorhexidine (CHX) is the most widely used synthetic bioactive agent for this purpose. MMP inhibitors can be applied through various methods, including acid-etching gel incorporation, adhesive system addition, or direct application on dentin surface, acting through chelating cation, collagen cross-linking, and competitive inhibition. CHX has been used as a potential inhibitor of MMPs, interacting with dentin matrix organic components to preserve collagen

integrity. This interaction distorts MMP molecules, competing for calcium and zinc ions, which are essential for MMPs' catalytic activities. In vitro studies show CHX can preserve adhesive bond durability up to 12 months.¹⁹

Polymer hydrolysis

Adhesion to enamel and dentin remains a challenge due to differences in adhesive hydrophilicity and water content. Water is crucial in acid-etching and self-etching techniques, enabling ionization of acidic monomers, which demineralize underlying enamel and dentin. Different bonding systems produce varying water sorption rates, with newer systems offering conventional or self-etching bonding strategies or selective enamel etching and self-etching into dentin. Universal self-etching adhesives contain specific carboxylate and/or phosphate monomers, with 10-MDP being the main adhesive, which ionically binds to dentin and is more effective and stable in water. Moisture in oral or storage environments contributes to polymer degradation and negatively impacts the resin-dentin interface. Leaching occurs due to water penetration into hydrophilic groups in adhesives, limiting monomer/polymer conversion. Adhesive systems use Bis-GMA and HEMA to improve material quality and

dentin infiltration, but their durability and protective ability are compromised by tooth/restoration interface failure, necessitating the development of longer-lasting dental products without Bis-GMA/HEMA.

New monomers and polymerization systems, like TEGBE(triethylene glycol vinyl-benzyl-ether)monomer, bypass Bis-GMA/HEMA hydrolysis process. Its hydrolytically stable ether-based structure offers higher conversion degree without diffusion limitation. Song et al. demonstrated that ASMA, a functional amino silane methacrylate monomer, can function as both a co-monomer and co-initiator, resulting in a simplified adhesive with enhanced durability and mechanical properties.¹⁹

Adhesive systems with antimicrobial activity

Antimicrobial substances in dental adhesives enhance tooth-restoration bonding, inhibit bacteria growth, prevent new entry, and limit degradation factors, enhancing durability and reducing secondary caries. New dental adhesives with antibacterial properties have been developed using inorganic fillers, modified monomers, or additives like zinc oxide nanoparticles, silica nanoparticles, silver nanoparticles, modified monomers,

flavonoids, plant extracts, gold nanoparticles, and titanium dioxide. Aguiar et al. conducted studies on commercially available antimicrobial adhesives, experimental materials, and modified adhesives with antimicrobial agents, including QAM (quaternary ammonium methacrylate), DMADDM (dimethylamine dodecyl methacrylate), DMAHDM (dimethylamine hexa-decyl methacrylate), silver nanoparticles, titanium dioxide, zinc oxide, BAG, and compounds like triclosan and quercetin. The tested compounds effectively inhibited pathogens like single layer bacteria and biofilm without affecting adhesive properties. Silver nanoparticles showed specific antibacterial activity in dental adhesives.

In 2020, Münchow et al. combined electrospinning and cryomilling to create bioactive fillers with doxycycline, a MMP inhibitor, and antimicrobial properties against *S. mutans* and *Lactobacillus*, without compromising the physical-mechanical properties or the bond strength (up to 12 months). Silver resistance against bacteria is challenging due to its multiple antibacterial mechanisms, including interaction with enzymes, electron transport system blockage, and binding to cell membranes or walls. Silver ions can inhibit organism movement, cause

membrane leakage, damage intracellular structures and biomolecules, and form an organometallic complex. When broken down, these ions can accumulate, inactivate DNA and RNA, damage cell membrane, and cause cell death.¹⁹

Bonding agents with the potential for biomimetic remineralization

Biomimetic remineralization is being considered as a replacement for restorative methods, allowing selective caries tissue removal in deep cavities, leaving demineralized dentin on pulp areas. Adhesion challenges in clinical settings due to low bond strength in demineralized or contaminated dentin, prone to hydrolytic or enzymatic degradation, potentially compromising composite resin restoration durability. Dental research focuses on developing bioactive restorative materials to remineralize mineral-depleted sites at dentin-adhesive interfaces. Bioactive glasses in adhesives improve mineral gain, micro hardness, and resin-dentin interface sealing. The mechanism involves the release of Si (OH)₄ from bioactive glasses, which binds to collagen and forms an absorbent SiO₂-rich layer. This layer aids in calcium phosphate precipitation and apatite conversion. Zinc-containing materials reduce metalloproteinase-mediated

collagen degradation, protecting sensitive sites in demineralized dentin. Casein phosphopeptide-amorphous calcium phosphate (CPP-ACP) and self-assembling peptide P11 -4 may increase dentin-resin interface longevity by releasing, deposition, and stabilizing gradients with high calcium and phosphate ions on teeth. P11 -4 forms a 3D biomimetic scaffold capable of nucleating hydroxyapatite, potentially controlling hydroxyapatite crystal growth on enamel. P11 -4 may be a promising method for caries-affected dentin treatment.

Remineralization of caries-affected dentin is challenging, but biomimetic strategies may promote mineral precipitation and reduce collagen degradation. However, more studies are needed to determine clinical protocols and long-term efficacy. Residual water in dentin hybrid layers can cause hydrolytic degradation, low mechanical properties, and nanoleakage. Adhesive systems containing solvent and less hydrophilic monomers are preferred for residual water removal, with ethanol being more effective than water. Acetone solvents show promising performance in simplified adhesive systems and have higher vapor pressure and water-chasing effect. Both types yield similar clinical performance and survival rates in challenging clinical situations. Ethanol

wet bonding, an alternate technique, replaces water with ethanol, increasing inter fibrillar spaces and reducing collagen matrix hydrophilicity, but is not a new technique. In vitro studies show promising results for ethanol wet bonding, but in vivo studies or clinical trials show no promising results due to the constant permeability of sound dentin. Alternatives include multiple adhesive layers, hydrophobic resin agents, air-blowing, and a polar aprotic solvent, dimethyl sulfoxide (DMSO), to improve adhesive infiltration and bond strength.¹⁹

Conclusion and points of view for further research

To satisfy the growing esthetic demands of today's dental patients, improvements in materials and procedures have been made to make it possible to reproduce the natural appearance of natural teeth with direct and/or indirect esthetic restorations. Adhesive systems have improved over time, but durability remains a challenge. Measures to improve dental bonding systems include addressing degradation issues, preserving bonding strength, and developing bioactive products. Thus, the ideal bonding system should be biocompatible, bond indifferently to enamel and dentin, have sufficient strength to resist failure as a result of masticatory

forces, have mechanical properties close to those of tooth structures, and be resistant to degradation in the oral environment and easy to use for the clinician. However, these materials require further clinical investigation in different substrates and challenging oral environments for better results and validation.

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Review Article

Calcium Hydroxide as an intracanal medicament –A Review

*Shehin P.K, **Mohammed Ashik P, ***Elsy .P. Simon

Abstract

This review paper aims to provide a comprehensive idea about calcium hydroxide as an intracanal medication. The ultimate goal of endodontic therapy is to eradicate the microbes residing in the root canal system. Calcium hydroxide has been included in antimicrobial formulations used in several treatment modalities in endodontics, one such application is an inter-appointment intracanal medicament. The purpose of this article was to review the mechanisms and the properties of calcium hydroxide in endodontics as a medicament. Calcium hydroxide has a high alkaline pH and the lethal effects of calcium hydroxide on bacterial cells are due to protein denaturation and damage to DNA and cytoplasmic membranes. Calcium hydroxide is effective against common endodontic pathogens but is less effective against *Enterococcus faecalis* and *Candida albicans*. Calcium hydroxide is also a valuable growth anti-endotoxin agent.

Key Words: *Calcium hydroxide, Intracanal medicament, Antimicrobial.*

Corresponding Author: *Shehin P.K

Post Graduate student, ** Professor, * Professor and Head, Department of Conservative Dentistry & Endodontics KMCT Dental College, Kozhikode, Kerala.*

Introduction

Intracanal medicament is an antimicrobial agent placed inside the root canal between treatment appointments to destroy remaining microorganisms and prevent reinfection.¹ They are used to kill bacteria, reduce inflammation and pain, eliminate apical exudate, and control

inflammatory root resorption.² Endodontic treatment requires using intracanal medicaments in addition to instrumentation that simultaneously eliminates bacteria, prevents them, stops their ingress, and cuts off their nutrient supply.² Calcium hydroxide is most commonly used as an intracanal medicament for disinfection of

the root canals since its introduction by Herman in 1920.³

Calcium Hydroxide is a white odorless powder which is low solubility in water, which decreases as the temperature rises. The dissociation coefficient of calcium hydroxide $\text{Ca}(\text{OH})_2$ permits a slow, controlled release of both calcium and hydroxyl ions². It has a high pH (about 12.5-12.8), which is insoluble in alcohol and it is a strong base.⁴

It is used as a inter-appointment intracanal medicaments, pulp-capping agents, root canal sealers, treatment of root perforations, root fractures, root resorptions, tooth avulsion, and luxation injuries.⁵

This review highlights the mechanism of action of calcium hydroxide, various properties of calcium hydroxide as an intracanal medicament in endodontics, placement and retrieval.

Mechanism of action of Calcium Hydroxide

The application of calcium hydroxide paste at intervals of at least 7 days is able to eliminate or reduce the number of bacteria surviving even after biomechanical preparation. The main actions of calcium hydroxide come from the ionic dissociation of Ca^{2+} and OH^- ions.⁶ However, when Ca^{2+} ions come into contact with carbon dioxide (CO_2) or carbonate ions in

tissue, calcium carbonate is formed which alters the mineralization process by the overall consumption of the Ca^{2+} ions.⁷

The high pH and the ionic activity in the healing process, diffusion through dentinal tubules, influence on apical microleakage and placement within the root canal, interim flare-ups, the importance of periodic follow-up, redressing, and inter-appointment restoration.⁵ The hydroxyl ions present provide an alkaline environment and highly oxidant free radicals which help in early healing and has an antimicrobial action.⁸

Properties of Calcium Hydroxide as Intracanal Medicament

1. Anti-bacterial activity

Calcium hydroxide will exert an antibacterial effect in the root canal system as long as a high pH is maintained.⁶ Lin et al. reported that treatment with electrophoresis was significantly more effective than pure $\text{Ca}(\text{OH})_2$ up to depths of 200–500 μm . Specimens treated with electrophoretically activated $\text{Ca}(\text{OH})_2$ revealed no viable bacteria in dentinal tubules to a depth of 500 μm from the root canal space within days.⁷

2. Anti-inflammatory action

The elevated pH of Calcium hydroxide inhibits the substrate adherence capacity of macrophages and decreases or eliminates the amount of MMP-8, improving tissue

circulation and controlling exudation as an immunomodulatory effect. Endogenous inflammatory mediators like Interleukin 1α and TNF- α play a role in regulation of inflammation, tissue destruction, and denaturation of proinflammatory cytokines.¹⁰

3. Physical barrier

In addition to eliminating remaining viable bacteria unaffected by the chemomechanical preparation of the root canal, intracanal medicaments have been advocated for other reasons. They should also act as a physicochemical barrier, precluding the proliferation of residual microorganisms and preventing the reinfection of the root canal by bacteria from the oral cavity.¹¹

4. Damage to bacterial cytoplasmic membrane

Hydroxyl ions induce lipid peroxidation resulting in the destruction of the phospholipid structure of the cellular membrane, remove hydrogen atoms from unsaturated fatty acid generating free lipid radicals to react with oxygen resulting in the formation of lipid peroxide radical which removes other hydrogen atom from a second fatty acid generating another lipid peroxide. These act as free radicals initiating an autocatalytic chain reaction resulting in further loss of unsaturated fatty acids and extensive damage.¹²

5. Protein denaturation and DNA damage

Cellular metabolism is highly dependent on enzymatic activities. The alkalinization provided by calcium hydroxide induces the breakdown of ionic bond that maintain the tertiary structure of proteins. These changes result in loss of biological activity of the enzyme and disruption of the cellular metabolism. Damage to the bacteria DNA and induced splitting of strands and replication inhibited.¹³

6. Bactericidal property

Ca(OH)_2 is bactericidal in direct contact with most bacteria but not active against *E. faecalis* and *Pseudomonas aeruginosa*. Asgary tested Ca(OH)_2 against *P. aeruginosa*, *E. faecalis*, *Staphylococcus aureus*, and *Escherichia coli* and found it to inhibit the growth of these bacteria.⁹

Effects on biofilms

Ca(OH)_2 was 100% effective in eliminating *E. faecalis* biofilm. Brändle et al. evaluated the effects of growth condition (planktonic, mono- and multi-species biofilms) on the susceptibility of *E. faecalis*, *Streptococcus sobrinus*, *C. albicans*, *Actinomyces naeslundii*, and *Fusobacterium nucleatum* to alkaline stress. The findings showed that planktonic microorganisms were most susceptible; only *E. faecalis* and *C. albicans* survived in

saturated solution for 10 minutes, and the latter also survived for 100 minutes. Dentine adhesion was the major factor in improving the resistance of *E. faecalis* and *Actinomyces naeslundii* to calcium hydroxide, whereas the multispecies context in a biofilm was the major factor in promoting resistance of *S. sobrinus* to the disinfectant. In contrast, the *C. albicans* response to calcium hydroxide was not influenced by growth conditions.¹¹

Placement of Ca(OH)₂ as a medicament

Calcium Hydroxide should come in contact for tissues to act. Mixture should be thick to carry Ca(OH)₂ particles. For maximum effectiveness, the root canal is filled homogeneously till root length with aid of syringes, finger spreader, rotary Lentulo spiral, and Paste Carriers.

Recently single-paste system which is injectable is available and the most preferable method. Some of the products are Centrix, Calcijet, Prevestcalci, and Pyraxcalci.⁹

Combinations with calcium hydroxide

Combination of Calcium Hydroxide and sodium hypochlorite

Metzler demonstrated that long-term (7 days) pretreatment with pulp dent paste (Watertown, USA), a non-setting Ca(OH)₂ paste, followed by sodium hypochlorite irrigation cleaned canal isthmuses in mandibular molars better than hand

instrumentation alone. The amount of debris was reduced in teeth treated with NaOCl for >30s or Ca(OH)₂ for 7 days. However, the combination of Ca(OH)₂ and NaOCl was more effective than the separate treatments.⁹

Combination of Calcium Hydroxide and chlorhexidine

Chlorhexidine is a cationic biguanide whose optimal antimicrobial activity is achieved within a Ph range of 5.5–7.0 and alkalinizing the pH by adding Ca(OH)₂ to CHX will lead to precipitation of CHX molecules, thereby decreasing its effectiveness. Athanassiadis et al. demonstrated that the alkalinity of Ca(OH)₂ when mixed with CHX remained unchanged when used as an intracanal medicament, CHX was more effective than Ca(OH)₂ in eliminating *E. Faecalis* from inside dentinal tubules by mixing Ca(OH)₂ with CHX the antimicrobial activity of Ca(OH)₂ is increased.⁹

Effects of calcium hydroxide

Diffusion of hydroxyl ions through dentin

Nerwich et al. investigated pH change over a 4-weeks period after the application of a Ca(OH)₂ dressing and they concluded that hydroxyl ions derived from Ca(OH)₂ dressings diffused in a matter of hours into

the inner root dentin, required 1–7 days to reach the outer root dentine and 2–3 weeks to reach peak levels. Hydroxyl ions diffused faster and reached higher levels cervically more than apically. For calcium hydroxide to act effectively as an intracanal medicament, hydroxyl ions must be able to diffuse through dentin.

Saif et al. indicated that a final canal rinse with 3 ml 17% EDTA and 10 ml 6% NaOCl before $\text{Ca}(\text{OH})_2$ placement allowed the greatest hydroxyl ion diffusion to the root surface. Diffusion of hydroxyl ions through dentine depends on the period of medication, diameter of dentinal tubules, and smear layer removal.¹⁶

Buffering effect of dentin on Calcium Hydroxide

Haapasalo et al. said the root canal is a complex mixture of a variety of organic and inorganic components. Hydroxyapatite is the major representative of the inorganic components.¹⁸ Pulp tissue, microorganisms, and inflammatory exudate, rich in proteins such as albumin are the major organic components. A new dentin powder model for studying the inhibitory effect of dentin on various root canal irrigants and medicaments.¹⁸ Dentin, hydroxyapatite and remnants of necrotic pulp tissue as well as inflammatory exudate

decrease the antibacterial potential of $\text{Ca}(\text{OH})_2$

Effect of Calcium Hydroxide on Dentin Fracture Strength

The flexural strength of dentin depends on the link between two main components of dentin, the hydroxyapatite crystals and the collagenous network. The organic matrix is composed of acid proteins and proteoglycans containing phosphate and carboxylate groups. These substances may act as bonding agents between the collagen network and the hydroxyl apatite crystals.¹⁷

Doyon et al. examined the resistance of human root dentin with $\text{Ca}(\text{OH})_2$ and found that the fracture resistance of dentin decreased significantly after 6 months.¹⁷

Rosenberg et al. (2017) measured the effect of $\text{Ca}(\text{OH})_2$ on the micro tensile fracture strength (MTFS) of teeth and found that it was reduced by almost 50% following 7–84 days of application.¹⁹

Clinical protocol for using Calcium hydroxide as an intracanal medication in root canal treatment⁹

- Perform final irrigation and dry the root canal thoroughly.
- Radiopaque calcium hydroxide paste is recommended for facilitating X-ray examination. To ensure easy removal of

medicaments from the root canal, it is preferable to use water-based agents. The medication should be precisely injected or introduced throughout the entire final working length (FWL) of the root canal to achieve maximal disinfection.

- Using glass ionomer cement (GIC) to seal the crown entrance.
- Immediate X-ray imaging is suggested, to examine the quality of intracanal medicaments, which provides a predictive reference for controlling infection and guiding communication with patients about treatment procedures and prognosis.
- The sealing period for root canal therapy is 1–2 weeks.
- Medicament removal: Water-based calcium hydroxide can be removed by irrigation, and it is recommended to use dynamic irrigation under a microscope. Irrigation needle with a bristle brush (NaviTip FX), XP-endoFinisher, M3-Max, and Finisher GF Brush can be used for agitation during root canal irrigation, which enhances the effectiveness and efficiency of removing medicaments.
- In general, intracanal medication is typically performed 1–2 times during interappointment visits. If symptoms and signs persist, a thorough analysis should be conducted to identify any deficiencies in

the root canal cleaning process or the presence of extra-radicular infections, other diseases, or issues. This analysis will help develop targeted infection control strategies for subsequent steps or consider modifying the treatment plan. It is advised to consider an alternative treatment plan rather than repeating the same medication for more than three visits.

Methods to Remove the Intracanal Medicament

Use of patency filing, combining with the type of vehicle used for dilution, EDTA, and NaOCl with hand instrumentation and Ultrasonics.²⁰

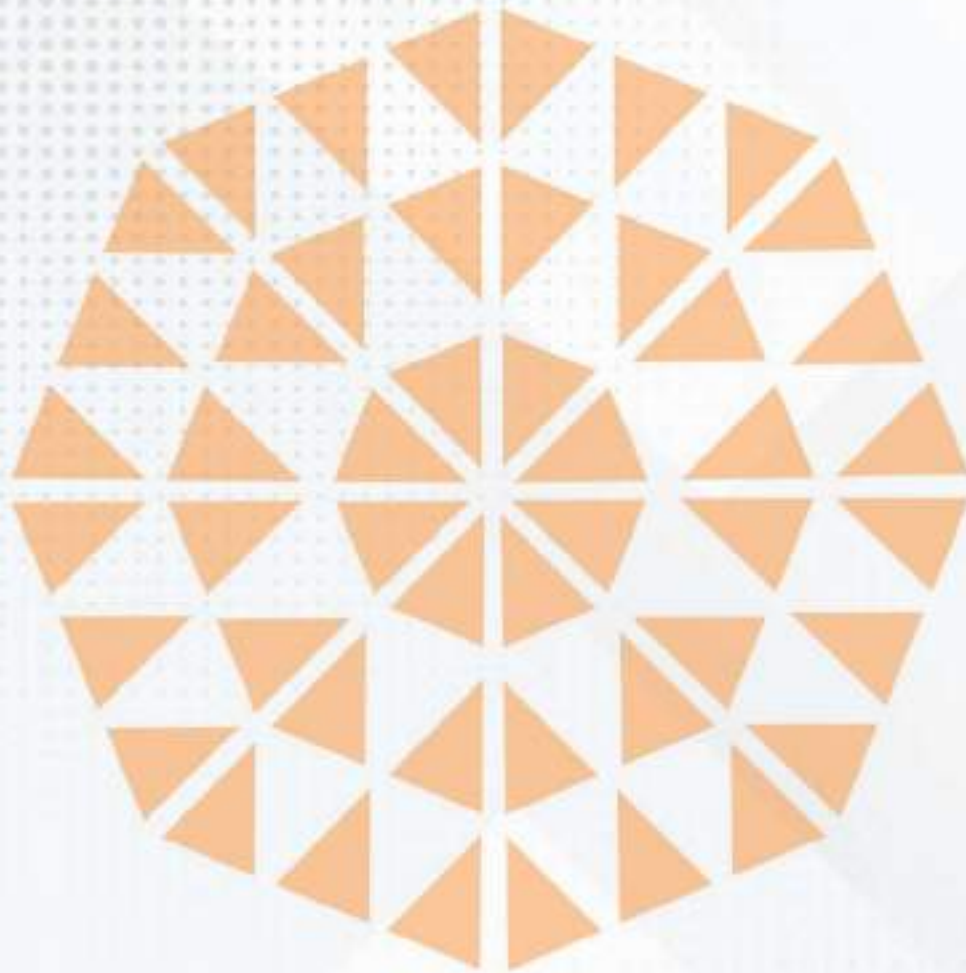
Conclusion

Calcium hydroxide as an intracanal medicament has a great value in endodontics, indicated for several clinical scenarios due to its varied properties. However poses limitations of reduced antibacterial spectrum that is not effective against the wide range of endodontic microbiota and in disinfecting the entire root canal system after a short-term use. Although numerous materials have been tried for this purpose calcium hydroxide still holds promise and sets a comparable standard for other evolving materials even today.

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