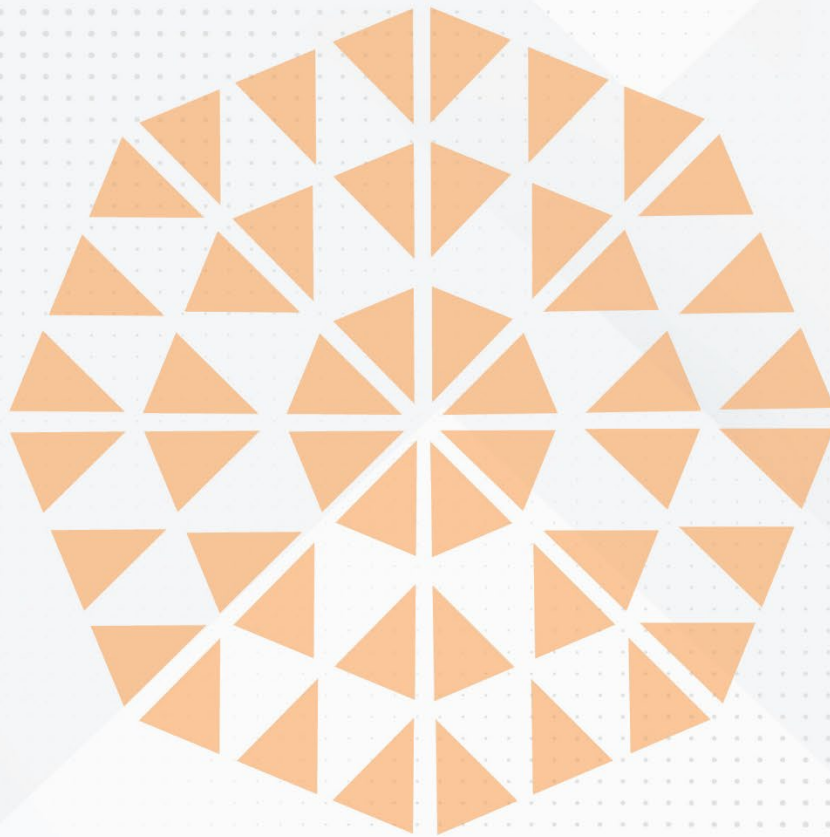


DENTAL BITES

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ORTHODONTIC AND ORTHOGNATHIC



a quarterly publication of



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

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Editorial

Dear Readers,

It gives me immense pleasure to share an exciting milestone in the academic journey of KMCT Dental College. We have recently signed a Memorandum of Understanding (MoU) with Indian Academy of Sports Dentistry and launched a Fellowship in Sports Dentistry, recognized by the European Academy of Sports Dentistry. This collaboration marks a significant step toward positioning our institution at the forefront of emerging dental specializations.

Sports Dentistry is a rapidly evolving field that bridges oral health and athletic performance. It focuses on the prevention, diagnosis, and management of orofacial injuries and associated oral diseases related to sports and exercise. With increasing awareness of athlete safety and performance optimization, the role of the sports dentist has become integral to sports medicine teams worldwide. From designing customized mouthguards and managing dental trauma to contributing to overall health monitoring, sports dentists play a vital role in safeguarding athletes' wellbeing both on and off the field.

This Fellowship opens new avenues for our postgraduate students and young faculty members to engage in a globally relevant and interdisciplinary domain. I encourage all aspiring clinicians to explore this exciting field with curiosity, commitment, and innovation. Let this be the beginning of a journey where your expertise in dentistry meets your passion for sports—contributing not only to academic excellence but also to the holistic care of athletes.

At KMCT Dental College, we continue to nurture forward-thinking professionals who lead with skill, empathy, and vision. Let us together make Sports Dentistry a proud hallmark of our institution.

With warm regards,
Dr. Manoj Kumar K.P
Principal



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Case Report

IMMEDIATE CONTACT HYPERSENSITIVITY TO FORMOCRESOL DURING PULPOTOMY PROCEDURE: A CASE REPORT

*Dr Anjana. T R *Dr Aashka Pavithran, **Dr Amith Adyanathaya

Abstract:

Formocresol has been widely used in pediatric pulpotomy procedures due to its efficacy. It helps to fix soft tissues in oral cavity such as pulp. However, hypersensitivity reactions, although rare, can occur. This case report presents an immediate hypersensitivity reaction following the application of formocresol during a routine pulpotomy in a pediatric patient. It demonstrates the underlying effect such as moderate pain burning sensation and patchy dark discoloration of skin and its resolution. Prompt identification and intervention led to resolution without sequelae. This case underscores the importance of proper handling and awareness of potential allergic and irritant reactions to formocresol in pediatric dentistry.

Key words: *Hypersensitivity, pulpotomy, formocresol.*

Corresponding author: Dr Anjana T R (anjanathiruvotte@gmail.com)

*Post graduate, **Professor and Head, Department of Pediatrics and Preventive Dentistry, KMCT Dental College

Introduction

According to American Academy of Pediatric Dentistry, pulpotomy is defined as the amputation of affected, infected coronal portion of the dental pulp preserving the vitality and function of the remaining part of radicular pulp. The main objectives of pulpotomy are to preserve radicular pulp vitality, promote

healing & to maintain tooth function. Formocresol, a mixture of formaldehyde and cresol in a glycerin-water base, is commonly used in pediatric pulpotomies. Due to its anti-bacterial and fixative characteristics, formocresol soon gained popularity for dental procedures such root canal treatment and deciduous teeth pulpotomy.¹ In order to treat non-vital permanent teeth,



Buckley (1904) introduced formocresol.² Sweet (1936) then developed a particular treatment technique for use on exposed primary teeth and had outstanding clinical outcomes.³ Since then, it has been accepted as the preferred intracanal/intra-pulpal medication for primary teeth receiving pulpotomy.⁴

With clinical success rates ranging from 70 to 100% and significant research on its efficacy, it has become the benchmark against which all other emerging modalities are measured.⁵ Despite its widespread use, it is a known potential allergen and can cause hypersensitivity reactions, ranging from mild skin rashes to severe anaphylaxis. Immediate reactions, particularly during dental procedures, require swift identification and management.

This report highlights a rare instance of an acute hypersensitivity reaction following formocresol application.⁶

The immune system in the pediatric age group is in the developing phase and hence, is less susceptible to developing a contact allergic response. In addition, there is less exposure to allergens in this age group which also contributes to the child being protected from allergic responses. However, the incidence is fairly on the rise on account of exposure to allergens at a much earlier age due to

rapid urbanization in recent times.⁷

Case report

A 6-year-old female patient presented to the Paediatric & Preventive Dentistry department with a chief complaint of intermittent pain in the upper left back tooth in the last 3 days. On clinical examination, deep dentinal caries was detected on maxillary left first primary molar (tooth #64) with no associated swelling, sinus tract, or abnormal mobility. On radiographic evaluation there was radiolucency involving coronal pulp without any periapical or furcal involvement suggestive of reversible pulpitis.

The tooth was diagnosed with reversible pulpitis, and a pulpotomy was planned. After obtaining consent and administering local anaesthesia, coronal pulp tissue was removed, and haemostasis was achieved. A cotton pellet dampened with Buckley's formocresol squeezed & applied to the radicular pulp stumps for 4 minutes. Within minutes of application, the patient exhibited mild discomfort and rubbing of her left cheek. The patient as well as parent was reassured & topical application of petroleum jelly was done on affected area. The cotton pellet was immediately removed, and the pulp chamber was irrigated thoroughly with

sterile saline. After that pulpotomy procedure was completed with zinc oxide eugenol & GIC restoration was given.⁷

After some time, clinical examination revealed a well-demarcated greyish-white patch on the left oral commissure & the lesion had turned blackish, with superficial tissue necrosis but no signs of deeper involvement (Fig.1). Given the rapid onset and localized presentation, an immediate hypersensitivity (Type I) reaction to formocresol was suspected. There was no prior history of allergies or atopic conditions. Face was cleaned with normal water & blot dried with gauze piece. After that lidocaine topical gel application was done on the affected area & topical analgesic gel was prescribed. Patient was recalled after 3 days, but they didn't report back, but was ready to send photographs of the lesion (Fig.3). Discoloured skin desquamated & healing occurred over the next 7-10 days without scarring (Fig.3).



Fig.1 Immediate photograph showing blackish discoloration in left oral commissure



Fig.2 Healing lesion in left oral commissure after 3 days



Fig.3 Complete healing after 10 days

Discussion

Buckley's formocresol contains 19% formaldehyde and 35% cresol, which acts as an alkylating and protein-coagulating agent respectively.⁸ Its application leads to pulp fixation and



bacterial elimination but also carries risk for tissue irritation and allergic sensitization. Formaldehyde and cresol are recognized sensitizers. They can bind with host proteins acting as haptens, triggering immune responses. Type I hypersensitivity reactions, such as in this case, involve IgE-mediated histamine release from mast cells leading to erythema, edema, and itching.⁶

There are conflicting studies on the allergenicity of formocresol. Studies have shown that after formocresol pulpotomy in dogs, formaldehyde-specific antibodies are formed.⁹ A review on immunology of pulpal-periapical infections by Morse DR (1977) indicated that the endodontics “flare-ups” such as pain, swelling and bone resorption following the use of formocresol occur as consequence of immunological reaction.¹⁰ Studies have demonstrated formation of formaldehyde-specific antibodies and even cases of systemic anaphylaxis, as reported by Ding et al. (2013), where a patient developed shock after formocresol application.¹¹ According to a recent systematic analysis by Syed M et al. female patients are more immunologically reactive to formaldehyde.¹²

When applying formocresol, proper

precautions must be taken, especially to prevent contact with any nearby soft tissues; otherwise, there is a risk of the tissue damage. Inappropriate usage of formocresol often results in localized gingival recession, ulcerations, and mucosal burns along with extensive mucosal sloughing throughout the entire affected area.¹³ The ulcerative lesion could be severe, and there could be sloughing that resembles coagulative necrosis. The lesions may seem erythematous, edematous, or whitish in colour. Injuries to salivary gland ducts may first result in transient obstructive sialadenitis and ductal opening scarring before becoming permanently obstructed and resulting in chronic sialadenitis. Reduced food intake and a reduced mouth opening may be observed, in addition to pain and edema in the exposed area. In severe situations, the alveolar bone and teeth may also be affected.¹⁴

The immune system in the pediatric age group is in the developing phase and hence, is less susceptible to developing a contact allergic response. In addition, there is less exposure to allergens in this age group which also contributes to the child being protected from allergic responses. However, the incidence is fairly on the rise on account of exposure to allergens at a much earlier age due to



rapid urbanization in recent times.⁷

Although severe allergic reactions are rare, localized mucosal and cutaneous reactions are well-documented. Issrani et al. (2020) reported a facial skin burn due to formocresol exposure, manifesting as dark staining and localized pain.¹⁶ Clinical presentation of the chemical injuries might differ according to the composition and concentration, pH of the substance, the quantity applied, the manner and duration of tissue contact, and the extent of penetration into tissue. These changes can vary from diffuse erosive lesions ranging from simple sloughing to complete mucosal detachment with extension into the submucosa.¹⁴

As the duration of exposure increases, the necrosis progresses, and the affected epithelium is separated from the underlying tissue, leading to desquamation. Thus, tissue exposed to formocresol manifests change in its texture and colour.¹⁶ Risk factors of formocresol injury includes improper technique or spillage onto surrounding tissue, overapplication or failure to blot excess solution, female gender (greater immunological reactivity reported) and atopic background or previous sensitization of same compound.

Immediate action after the accidental application of formocresol on skin

should be to wash the affected skin with water or saline to reduce the severity of burns. If pain is significant, symptomatic treatment such as systemic or topical analgesics may be beneficial. Treatment of oral ulcerations due to chemical injury primarily requires identification and removal of the responsible agent. Since ulcers due to chemical injuries usually heals up within two weeks without scarring; only palliative and symptomatic treatment should be considered.

In severe tissue damage topical corticosteroid (Triamcinolone – TESSTM) applied along with carboxymethyl cellulose would be of help. Antibiotic therapy should be considered only in very extensive cases.¹⁴ Hence, it is recommended that whenever a pediatric endodontic procedure is carried out necessary preventive isolation steps such as rubber dam application should be mandatorily followed by every clinician.

Conclusion

It is advised that all dental procedures in pediatric patients should be performed with all the preventive isolation techniques such as use of rubber dams, sterile instruments, and gloves while taking utmost precautions during use of



agents like formocresol. Appropriate referrals and rapid intervention are required if any hypersensitivity reaction to the dental materials is suspected.

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Review Article

IRRIGATION PROTOCOLS IN ENDODONTICS

*Dr Mubeena TA, **Dr Dr Anju R V, ***Dr Amith Adyanthaya

Abstract

Irrigation is a key part of successful root canal treatment as it fulfils its several important mechanical, chemical and (micro) biological functions including the healing of periapical tissues. It is the only way to reach and impact those areas of the root canal wall which are not touched by mechanical instrumentation. The initial and primary endodontic treatment (root canal treatment) goal must be to optimize root canal disinfection and to prevent reinfection. Sodium hypochlorite is proposed as the primary irrigant by virtue of its organic tissue dissolution capacity and broad antimicrobial properties. On the other hand, chelation solutions are recommended as auxiliary solutions to remove the smear layer or to hinder its formation on dentin surface. Through this article we are proposing a sequence for the different irrigating agents in order to achieve the best chemical preparation possible.

Key words: Endodontic irrigants, irrigation, root canal treatment.

Corresponding author: Mubeena T.A (mubeena.tak@gmail.com)

Assistant Professor, **Associate Professor, *Professor and Head, Department of Pediatric and Preventive Dentistry, KMCT Dental College*

Introduction

The main cause of pulpal and periapical diseases are different living and non-living irritants. Non-living irritants include the mechanical, thermal and chemical irritants. The living irritants include different types of microorganisms such as bacteria, yeasts and viruses. When different pathological changes start to occur within dental pulp, the space within canal of root, harbour irritants including various species of bacteria, their toxins and by-products.

Investigations in animals and patients have shown that pulpal or peri radicular diseases cannot develop without the presence of bacteria.^{1,2} The greater test for irrigation might be the regions immaculate by the files, for example, fins, isthmuses and enormous lateral canals.³ Additionally, enormous territories in the oval and flat canals may remain untouched notwithstanding careful instrumentation and those zones contain tissue left overs and biofilm that just can be taken out by substance implies utilizing irrigation system.⁴



Irrigation has an important role during endodontic treatment.⁵ The aim of root canal treatment is to remove virulence factors from this system. Canal irrigation during the process of cleaning and shaping can lead to the elimination of microorganism, which are not removable through physical methods.⁶ There is no single irrigating solution that alone sufficiently provides all ideal properties and the functions required from an irrigant. So for optimal irrigation we have to combine two or several irrigating solutions, in a specific sequence, to predictably obtain the goals of safe and effective irrigation.⁷

Irrigating solution differ in their way of action so sequence of irrigation is important. Sodium hypochlorite is proposed as prime irrigant by virtue of its organic tissue dissolution capacity and broad antimicrobial properties. Chelating solutions like EDTA are recommended as auxiliary solutions to remove smear layer so that sealers and root canal files can penetrate to dentinal tubules. After smear layer removal final irrigation with Chlorhexidine which is antiseptic solution is helpful.⁶

Desired functions of irrigating solutions

During and after instrumentation, the irrigants facilitate removal of

microorganisms, tissue remnants, and dentin chips from the root canal through a flushing mechanism. Irrigants can also help prevent packing of the hard and soft tissue. Some irrigating solutions dissolve either organic or inorganic tissue in the root canal. They serve as a lubricant. In addition, several irrigating solutions have antimicrobial activity and actively kill bacteria and yeasts when introduced in direct contact with the microorganisms. They should be nontoxic and biocompatible in nature. They should penetrate to the canal periphery in an attempt to achieve above results; irrigation in different situations is done.⁷

We are proposing a sequence for the different irrigating agents in order to achieve the best chemical preparation possible.⁵

Sequence of irrigation in endodontics

Vital teeth

Treatment is started by:

- Access cavity preparation
- Followed by biomechanical preparation
- Irrigation done with 2ml of sodium hypochlorite(5.25percent) at 60°C and/or urea peroxide.



- A second application and its activation is done by using a K file (08-10). This step has to be preceded by an abundant irrigation with distilled water in order to eliminate the first mixture present in the access cavity.

- Once the preparation of the canal has begun, Smear Clear must be used. It is advised to alternate the use of EDTA from the beginning of the preparation in order to eliminate the mineral layer before its thickening and condensing it inside the canal systems which will close the entrances of lateral and accessory canals and dentinal tubules.

- Chlorhexidine can be used for a total elimination of the bacteria inside the canal. Distilled water is used between each irrigating solution in order to prevent an acid/ base reaction, between sodium hypochlorite and EDTA, for a more efficient action of the chemicals on the tissues.

- A maximum neutralization of all the chemical agents must be done by the end of the preparation and before the fitting of the gutta percha cones so that the master cone does not push any of the chemicals outside the canal that might cause an inflammation.

Nonvital teeth

- Irrigation will be initiated with either sodium hypochlorite (5.25%, 60%C) for its

bacterial effect or with chlorhexidine (0.2%) (10 minutes) for the elimination of various bacterial types present in the root canals and dentinal tubuli.

- We will use distilled water to neutralize the effect of these irrigants.

- Then we can repeat the same irrigation sequence described previously for vital teeth.

The EDTA (liquid form), by eliminating the smear layer and opening the dentinal tubuli will permit an easy flow of NaOCl or chlorhexidine for a better disinfection of the endodontic system.

In both clinical situations (vital and nonvital teeth) it is necessary to end our sequence by using distilled water or normal saline in order to eliminate the chemical agents or to neutralize their effects.

Resorptions

- When we suspect an internal resorption, the irrigation sequence is the same that was described for vital teeth.

- But this sequence will be followed by the use of citric acid 50 percent (10 minutes) in order to eliminate the granulation tissue and to obtain smooth dentinal walls. The citric acid is eliminated by NaOCl and distilled water. The same sequence is adopted for



external apical resorptions but with an activation of the patency.

Weeping canal

- Irrigation done with normal saline.
- Then canal is irrigated with chlorhexidine.
- Calcium hydroxide placed as intracanal medicament

Abscess

- Irrigation done by using 2.5% sodium hypochlorite with open 30- gauge needle at 2mm from working length.⁸
- Then canal is irrigated with normal saline.

Hyperinflamed teeth

- Irrigation with normal saline
- Then irrigated with sodium hypochlorite combined with EDTA
- Then follow same irrigation sequence sodium hypochlorite followed by EDTA

Pulp polyp

- Irrigation done with 5ml of 5% sodium hypochlorite solution.⁹
- Followed by irrigation with normal saline.

Open apex

- After coronal access, root canal filled with 3% sodium hypochlorite
- Then irrigation performed with 10 ml of saline
- Then root canal was flushed with 5 ml of 17% EDTA and finished with 10 ml of 3% sodium hypochlorite gel and 10 ml of saline
- Care should be taken to prevent apical extrusion of irrigation solution.⁵

Primary teeth

- Canal is irrigated with copious amount of sodium hypochlorite.
- Then rinsed with aqueous EDTA or citric acid.
- Final rinse with chlorhexidine.
- After introduction of MTAD irrigant new irrigating regimen is initial rinse with 1.3%NaOCl for 20 min followed by final rinse with MTAD for 5min.¹⁰

Conclusion

Elimination of microorganisms from infected root canals of primary teeth is a complicated task. The chances of a favourable outcome with root canal treatment are significantly high if infection is eradicated effectively before obturation. Irrigation has a key role in successful endodontic treatment. Although hypochlorite is the most important



irrigating solution, no single irrigant can accomplish all the tasks required by irrigation. Detailed understanding of the mode of action of various solutions is important for optimal irrigation.

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Review Article

Oculocardiac reflex: pathophysiology, risk factors, and management strategies

***Dr Veda T *Dr Binshad Basheer *Dr Arun Kumar C B **Dr Kavya K Dinesh **Dr Krishnapriya P*

Abstract

Background: The oculocardiac reflex (OCR) is a well-documented physiological response characterized by bradycardia, arrhythmias, or even cardiac arrest following mechanical stimulation of the ocular structures. This reflex is of significant concern in ophthalmic and orbital surgeries, particularly in paediatric patients. Understanding the underlying mechanisms, risk factors, and management strategies is crucial to ensuring patient safety during surgical procedures. This article reviews the pathophysiology, risk factors, and advancements in OCR management based on recent literature.

Key words: *Oculocardiac Reflex (OCR), Trigemino-vagal Reflex Arc, Strabismus Surgery, Orbital Surgery, Paediatric Patients*

Corresponding Author: Dr Veda T

***Post graduate student, *Assistant Professor, KMCT Dental College, Manassery, Kozhikode 673602, Kerala.*

Introduction

The OCR, first described by Aschner and Dagnini, is mediated by the trigemino-vagal reflex arc. Stimulation of the afferent limb (the ophthalmic division of the trigeminal nerve) triggers an efferent response through the vagus nerve, resulting in bradycardia or asystole. OCR is frequently observed in paediatric **strabismus surgery** but is also a concern in **orbital and neurosurgical procedures**.

With ongoing research, various **preventive and management strategies** have emerged, including pharmacological interventions, anaesthetic modifications, and minimally invasive surgical techniques.^{1,2}

Pathophysiology of OCR

The OCR occurs due to mechanical stimulation of orbital structures, such as the extraocular muscles, conjunctiva, or



orbital fat. The afferent limb consists of the ciliary nerves, which synapse in the trigeminal ganglion and subsequently stimulate the vagus nerve, forming the efferent limb. This reflex results in parasympathetic activation, leading to a decrease in heart rate.² If the reflex is not promptly managed, severe bradycardia or even asystole may occur, posing significant risks to the patient.³

Incidence and Risk Factors

OCR is more prevalent in **paediatric patients undergoing strabismus surgery**. Studies indicate an incidence rate ranging from **14% to 90%**, depending on the surgical approach and patient-specific factors.³

Other major risk factors include:

- **Age:** Younger patients are more susceptible due to enhanced vagal tone.
- **Type of Surgery:** Strabismus and orbital surgeries have a higher OCR incidence.
- **Anaesthetic Technique:** The choice of anaesthetic agents influences OCR risk. For instance, the use of **remifentanil** can modulate the reflex.⁴
- **Preoperative Anxiety:** Increased anxiety levels in paediatric patients correlate with higher OCR susceptibility.

Preventive Strategies

Several methods have been proposed to prevent OCR during surgery. These include **pharmacological** and **surgical** techniques aimed at reducing reflex activation.

1. Topical Anaesthesia

The application of **topical anaesthetics** has been shown to reduce the incidence of OCR. **Kim et al.** demonstrated that preoperative topical anaesthesia significantly diminished OCR occurrence in paediatric patients undergoing strabismus surgery.¹

2. Pharmacological Agents

- **Anticholinergic Medications:** **Atropine** and **glycopyrrolate** have been traditionally used to prevent OCR by inhibiting vagal stimulation.
- **Opioids:** **Remifentanil** has been studied for its role in modulating OCR. **Lee et al.** found that remifentanil reduced the severity of OCR during paediatric strabismus surgery.⁵

3. Surgical Modifications

- **Minimally Invasive Techniques:** **Zhang et al.** highlighted the role of minimally invasive surgical approaches in reducing OCR incidence.⁶ These include careful handling of extraocular muscles and avoiding excessive traction.
- **Gradual Muscle Traction:** Slow and controlled tension application on the extraocular muscles reduces abrupt vagal activation.⁷
- **Alternative Surgical Approaches:** Some researchers advocate for alternative resection techniques that minimize direct nerve stimulation, thereby reducing OCR incidence.⁸

Management of OCR During Surgery

Despite preventive measures, OCR may still occur. Immediate intervention is



required to prevent **hemodynamic instability**.

1. Cessation of Stimulus

The first step in managing OCR is the **immediate cessation of ocular manipulation**. In most cases, heart rate normalizes within seconds. Ensuring **minimal mechanical pressure** on the globe can also help prevent recurrence.²

2. Pharmacological Intervention

If bradycardia persists, **intravenous administration of atropine (0.01–0.02 mg/kg)** is recommended.⁸ In severe cases, **epinephrine** may be required for hemodynamic support. Recent research suggests that **dexmedetomidine**, an α_2 -adrenergic agonist, may offer an alternative approach to OCR management by modulating vagal tone.^{9, 10}

3. Anaesthetic Adjustments

Increasing **anaesthetic depth** can help mitigate OCR responses.¹⁰ Using short-acting opioids such as **remifentanyl** allows better control of the reflex.⁴ Some studies propose that **total intravenous anaesthesia (TIVA)** provides more stable hemodynamic conditions, reducing OCR occurrence.⁶

Future Directions

Research into novel **anaesthetic techniques** and **surgical modifications** continues to evolve. **Nguyen and Davis** emphasize the role of **multimodal anaesthesia** in mitigating OCR while ensuring optimal surgical conditions.¹⁰ Additionally, studies on **preoperative anxiety management** suggest that **psychological interventions** could play a role in reducing OCR incidence.¹¹

Emerging technologies such as **intraoperative nerve monitoring** and **precision-guided surgical instruments** may also help minimize OCR risk in high-risk patients.⁵

The role of **genetic predisposition** in OCR susceptibility is another area of interest. Preliminary studies suggest that certain **genetic markers** may indicate increased vagal responsiveness, making some individuals more prone to OCR-related complications. Further research in this area could lead to **personalized risk assessment** and **targeted prophylactic interventions**.¹²

Moreover, **non-invasive neuromodulation techniques** such as **transcutaneous vagus nerve stimulation (tVNS)** have shown promise in regulating vagal activity and could be explored for their potential to modulate OCR responses.⁷

Conclusion

The **Oculocardiac Reflex** remains a significant concern in ophthalmic and orbital surgeries, particularly in **paediatric patients**. Understanding the **pathophysiology**, identifying **risk factors**, and implementing effective **preventive and management strategies** are crucial for patient safety. Pharmacological agents, anaesthetic modifications, and minimally invasive surgical techniques have proven effective in reducing OCR incidence. Continued research, particularly in the fields of **neuromodulation**, **genetic risk assessment**, and **intraoperative monitoring**, holds promise for future improvements in OCR management.

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Review Article

The Periodontal–Systemic Interface: Linking Oral Inflammation to Chronic Disease

*Dr Naseeba Mohammed Ali ** Dr.Santhosh VC

Abstract

Periodontitis is a chronic inflammatory disease that generates a systemic burden of bacteria and pro-inflammatory mediators. Evidence increasingly shows strong associations between periodontal inflammation and cardiovascular disease, diabetes mellitus and neurodegenerative disorders such as Alzheimer's disease. Mechanistic pathways include bacteremia, lipopolysaccharide-induced endothelial dysfunction, insulin resistance and cytokine-driven neuroinflammation. Clinical and epidemiological studies demonstrate that individuals with periodontitis have higher systemic inflammatory markers and a greater risk of systemic complications. Periodontal therapy has been shown to improve endothelial function and glycemic control, highlighting benefits beyond the oral cavity. Because of these links, periodontal health is increasingly recognized as a crucial component of overall medical care.

Key words: Periodontitis, Cardiovascular disease, Diabetes mellitus, Alzheimer's disease, Neuroinflammation, periodontal- systemic axis

Corresponding Author: Dr Naseeba Mohammed Ali

**Post graduate student, **Professor, Department of Periodontology, KMCT Dental College, Manassery, Kozhikode 673602, Kerala.*

Introduction

Periodontitis is a chronic inflammatory disease caused by dysbiotic subgingival microbiota and an exaggerated host immune response.¹ It is now recognised that the effects of periodontitis are not confined to the oral cavity.² Bacteria and

inflammatory mediators originating from periodontal pockets can enter the bloodstream during chewing and toothbrushing.³ This allows periodontal pathogens and cytokines such as IL-1 β , IL-6 and TNF- α to circulate systemically.⁴



As a result, periodontitis is increasingly associated with several systemic diseases, including cardiovascular disease, diabetes mellitus and neurodegenerative disorders such as Alzheimer's disease.⁵

Understanding these associations is essential, as the interplay between periodontal inflammation and systemic health represents a growing field of clinical and research significance.

This review aims to synthesise current evidence on the biological pathways linking periodontitis to systemic conditions like cardiovascular diseases, diabetes and Alzheimer's disease. It also highlights the importance of periodontal health as an integral component of overall systemic well-being.

Pathways Underlying the Oral-Systemic Connection

Bacteremia from ulcerated epithelium of periodontal pockets has been demonstrated in clinical studies.³ Periodontal pathogens like *Porphyromonas gingivalis* and *Aggregatibacter actinomycetemcomitans* can invade endothelial cells and distant organs.⁶ Lipopolysaccharides from these bacteria trigger systemic inflammatory responses.⁷ This promotes the release of acute-phase proteins such as C-reactive protein from the liver.⁸ Inflammatory cytokines from periodontal tissue aggravate endothelial dysfunction, oxidative stress and atherosclerotic plaque formation.²

Thus, periodontitis creates a continuous low-grade inflammatory burden that can influence systemic pathology.⁹

Periodontitis and Cardiovascular Disease

Multiple epidemiological studies have shown a relationship between periodontitis and coronary heart disease, myocardial infarction and stroke. DNA of *P. gingivalis*, *Tannerella forsythia* and *Treponema denticola* has been identified in atherosclerotic plaques as well.¹⁰ This is because periodontal LPS stimulates endothelial dysfunction by increasing adhesion molecule expression and oxidative stress. A meta-analysis reported increased relative risk of cardiovascular disease in individuals with periodontitis.¹¹ Also, patients with periodontitis exhibit higher systemic CRP levels, a recognised cardiovascular risk marker.¹² Randomized clinical trials show that non-surgical periodontal therapy improves endothelial function and reduces inflammatory markers.¹³ A multicentre trial demonstrated improvement in vascular endothelial function four weeks after periodontal therapy.¹³

Thus, periodontal treatment may contribute to cardiovascular risk reduction indirectly by lowering systemic inflammation.⁵

Periodontitis and Diabetes Mellitus

The association between diabetes and periodontitis is bidirectional.¹⁴ Poor glycemic control increases susceptibility to severe periodontitis due to impaired neutrophil function and altered immune responses.¹⁵ Advanced glycation end products promote inflammation and periodontal destruction in diabetic patients.¹⁶

Conversely, periodontitis worsens glycemic control by increasing systemic inflammatory mediators such as TNF- α ,



which induces insulin resistance.¹⁷ A systematic review confirmed that periodontal treatment is associated with a significant reduction in HbA1c levels in type-2 diabetes patients.¹⁸ Also, there are randomized clinical trials that demonstrate that non-surgical periodontal therapy reduced HbA1c by 0.6% at three months.¹⁹ In addition, meta-analysis evidence suggests that controlling periodontal inflammation improves metabolic outcomes.⁵ Because of this reciprocal relationship, diabetes management guidelines now emphasize periodontal evaluation.²⁰

Periodontitis and Alzheimer's Disease

Chronic systemic inflammation contributes to neurodegeneration in Alzheimer's disease.²¹ This is because periodontal pathogens and their virulence factors can reach the brain through blood circulation or cranial nerves.²²

A recent study identified the presence of *Porphyromonas gingivalis* in the post-mortem brain tissue of patients with Alzheimer's disease.²² Gingipain proteases have been shown to induce neuroinflammation and neuronal damage in animal models as well.²³ Periodontitis also increases systemic inflammatory cytokines, which can cross the blood-brain barrier and accelerate amyloid- β deposition.²⁴ A meta-analysis has reported that individuals with severe periodontitis had higher amyloid biomarkers compared to healthy controls.²⁵ Also, there are longitudinal studies that indicate individuals with periodontitis have a higher risk of developing cognitive impairment.²³

Thus, periodontal disease may act as a chronic peripheral source of inflammation contributing to Alzheimer's pathology.⁵

The Oral Microbiome and Systemic Disease

Periodontitis is now understood as a dysbiosis of the oral microbiome rather than infection by a single pathogen.⁶ Next-generation sequencing has identified complex microbial networks associated with systemic inflammation.²⁷ Oral bacteria can alter gut microbiota composition when swallowed, promoting metabolic dysfunction and systemic inflammation.²⁸ This oral-gut axis is emerging as a novel explanation for systemic impacts of periodontal dysbiosis.⁵

Host genetics and epigenetic mechanisms also influence susceptibility to both periodontal and systemic inflammation.²⁹

Clinical and Public Health Implications

Periodontal assessment is recommended for patients with diabetes, heart disease or neurodegenerative risk.²⁰ Interdisciplinary care between physicians and dentists improves early detection and management.⁵ Education on oral hygiene, smoking cessation and regular periodontal maintenance reduces systemic inflammatory burden.³⁰ Salivary and serum biomarkers such as CRP, IL-6 and MMP-8 are being explored for early detection of high-risk individuals.³¹

These findings support the concept of oral health as an essential component of overall well-being.⁵



Conclusion

Periodontitis is a chronic inflammatory disease with effects that extend beyond the mouth.¹ Strong evidence links periodontal inflammation with cardiovascular diseases, diabetes and Alzheimer's disease.⁵ Bacteraemia, disseminated bacterial toxins and cytokine-driven systemic inflammation provide biological pathways for these associations.⁶ Clinical studies show that periodontal therapy can reduce inflammatory markers and improve systemic outcomes.¹³

Future research is focused on personalized diagnostics, salivary biomarkers and microbiome-based therapies.²⁷ Maintaining periodontal health is therefore not only a dental concern but a systemic medical priority.²⁰

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Review Article

Targeted Therapies for Ameloblastoma: A New Era in Treatment

****Krishnapriya P, *Jaslin P A, *Arun Kumar C B **Megha Raj C, **Tijin Titus**

Abstract

Ameloblastoma is one of the most prevalent but enigmatic benign odontogenic tumors of the jaw, accounting for approximately 10% of all maxillary and mandibular tumors. It is an aggressive neoplasia formed by odontogenic epithelium with mature fibrous stroma and odontogenic ectomesenchyme. Conventional surgical management often leads to significant facial deformities and functional impairment. The discovery of the BRAF V600E mutation in ameloblastoma has opened new avenues for targeted molecular therapies, offering alternative treatment options for cases where surgery is not viable. This article provides an in-depth review of the role of BRAF V600E in ameloblastoma pathogenesis, the potential of targeted therapies and the implications of additional genetic mutations. Understanding these molecular pathways could significantly enhance treatment outcomes and reduce recurrence rates, marking a paradigm shift in ameloblastoma management.

Key words: Ameloblastoma, **BRAF V600E**, Targeted Therapy, MAPK Pathway, Oncogene Mutation, Odontogenic Tumors

Corresponding Author:

**Assistant Professor, **Post graduate student, Department of Oral and Maxillofacial surgery , KMCT Dental College, Manassery, Kozhikode 673602, Kerala.*

Introduction

Ameloblastoma is defined by WHO as a benign epithelial odontogenic intraosseous neoplasia, which is characterized by

expansion and a tendency for local recurrence.¹

Ameloblastoma are common, benign odontogenic tumor that mostly affects the



jawbones and develops from the enamel epithelium. It is an aggressive neoplasia formed by odontogenic epithelium with mature fibrous stroma and odontogenic ectomesenchyme.²

Histologically, it is characterized by cyst like formations and tumor nests that remind the epithelial component of the enamel organ, as well as by the anastomosis of strands of odontogenic epithelium limited by columnar cells that lack of morphological pattern of reticulum stellate-like cells.^{2,3}

It is the most common odontogenic epithelial neoplasia, with severe clinical implications, capacity of malignant transformation, and metastases.³ It is quite invasive and has a high propensity for local recurrence, despite being benign.

In the appearance of recurrent ameloblastoma, either metastatic ameloblastoma (MA) or ameloblastic carcinoma (AC), adjuvant therapies are implemented, and they consist of radiotherapy (RT) and chemotherapy (CT), which are controversial in their use due to a high recurrence rate and unpredictable results when they are used as a first-line and sole therapy without surgical treatment.^{4,5}

Treatment has traditionally involved aggressive surgical excision, such as segmental mandibulectomy or maxillectomy, which frequently has serious functional and esthetic repercussions. Due to these facts, alternative therapy approaches, especially targeted molecular medicines, have gained popularity.

New strategies of targeted therapies have been implemented in order to knock down the signaling pathways that participate in the development of this neoplasia, highlighting the MAPK signaling pathway with its predominant B-raf proto-oncogene serine/threonine kinase (BRAF) V600E mutation and the presence of additional mutations.³

Recent advancements in molecular biology have identified the presence of specific genetic mutations in ameloblastoma, most notably the BRAF V600E mutation. This discovery has led to the exploration of targeted therapies that can inhibit tumor growth at the molecular level, providing a promising alternative for patients with recurrent or inoperable tumors.

This article explores the molecular mechanisms of ameloblastoma, the role of BRAF mutations in tumor progression, and the potential of targeted therapies in ameloblastoma treatment.



Molecular Pathogenesis of Ameloblastoma

Ameloblastoma arise from odontogenic epithelial cells and exhibit aggressive, infiltrative growth patterns. Several signaling pathways are implicated in their pathogenesis, including:

1. **MAPK/ERK Pathway** – This pathway is crucial in cell proliferation and differentiation. BRAF, a serine/threonine kinase, plays a key role in this pathway, and its mutation leads to uncontrolled cell growth.
1. **Sonic Hedgehog (SHH) Pathway** – The SHH signaling cascade is essential for tooth development, and its dysregulation is linked to various odontogenic tumors, including ameloblastoma.
2. **PI3K/AKT/mTOR Pathway** – Alterations in this pathway contribute to cell survival and resistance to apoptosis, further promoting tumor progression.

The presence of these pathways suggests that molecular inhibitors targeting specific mutations could be effective in controlling tumor growth.

BRAF V600E in Ameloblastoma

BRAF regulates cell metabolism and proliferation. More than 40 mutations of BRAF were identified in different neoplasms. The most frequent ones are missense mutations of the 600 residues of the BRAF gene, in which valine is replaced by glutamine (V600E) and results in the constitutive activation of MEK/ERK signaling in tumors.^{6, 7} The V600E mutation, the most common BRAF alteration, causes continuous MEK/ERK activation and serves as a key biomarker in tumors, including ameloblastoma (AM). Studies linked it to resistance against EGF receptor-targeted therapy and the RAS/MAPK pathway in ameloblastoma.

BRAF V600E is found in over 50% of ameloblastoma cases, with variants like L597R and G606E. SMO mutations, common in maxillary ameloblastoma, often occur independently. Immunohistochemistry (IHC) with VE-1 antibody confirms BRAF V600E with high specificity.

The presence of BRAF V600E in Ameloblastomas is commonly associated with other mutations and can frequently be present in younger patients.^{2, 8,9,10}

Peripheral ameloblastoma (PA) show 83.3% BRAF V600E positivity but are less

aggressive. Metastatic ameloblastomas (MA) rarely occur, with 66.6% carrying BRAF V600E but no secondary mutations.

Unicystic ameloblastomas (UA) may represent an earlier tumor stage, showing only BRAF V600E without additional mutations. Ameloblastic carcinoma (AC), an aggressive variant, had BRAF V600E in 23% of cases. Further research is needed to explore its role in tumor behavior and treatment resistance.

LOCATION

Overall, ameloblastomas have a predilection for the mandible, mainly located in the body, ramus, and symphysis.^{1, 2, 9} Ameloblastomas mostly affect the mandible (21:1 ratio).

BRAF V600E is present in 93.7% of cases without additional mutations, making targeted therapy effective. However, multiple mutations are more common in maxillary tumors (27.7% vs. 4.3% in the mandible), suggesting a need for combined therapies, especially against SMO, linked to the aggressive SHH pathway.

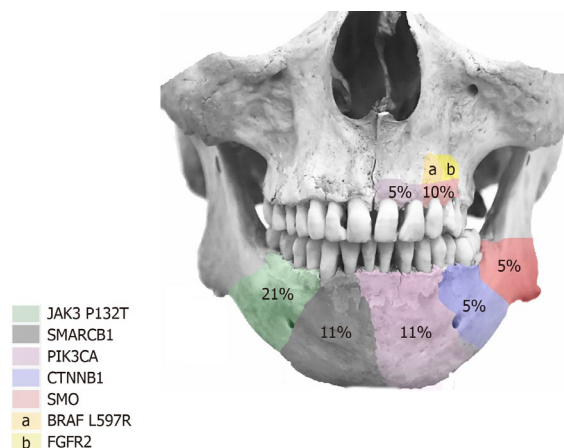


FIGURE 1: Anatomic location of B-raf proto-oncogene serine/threonine kinase V600E additional mutations.

a , b : Additional mutations of the same ameloblastomas. Figure does not represent the specific site of each additional mutation, only whether it is present in the maxilla or the mandible.

The Role of BRAF V600E

Mutation in Ameloblastoma

The BRAF V600E mutation involves a substitution of valine (V) for glutamic acid (E) at position 600, leading to constitutive activation of the BRAF kinase. This results in continuous stimulation of the MAPK pathway, driving tumor cell proliferation and survival. Studies have shown that BRAF V600E is present in 57% of conventional ameloblastomas and 77.7% of unicystic ameloblastomas.



Implications of BRAF V600E

Mutation:

- **Increased Tumor Aggressiveness:** Ameloblastomas harboring the BRAF V600E mutation tend to be more invasive and recurrent.
- **Potential for Targeted Therapy:** The presence of this mutation makes ameloblastoma amenable to therapies that specifically inhibit BRAF or its downstream effectors.
- **Diagnostic and Prognostic Marker:** BRAF V600E mutation analysis could serve as a useful tool in diagnosing ameloblastomas and predicting treatment response.

Additional Genetic Alterations in Ameloblastoma

Besides BRAF V600E, other genetic mutations have been identified in ameloblastomas, which may influence tumor behavior and treatment response. These include:

- **SMO Mutations:** Involvement in the SHH pathway, contributing to uncontrolled cell proliferation.
- **PIK3CA Mutations:** Activates the PI3K/AKT/mTOR pathway, promoting tumor survival.

- **JAK3 Mutations:** Affects the JAK/STAT signaling pathway, influencing cell growth and differentiation.

Understanding these additional mutations is essential for developing combination therapies that target multiple oncogenic pathways simultaneously.

Targeted Therapies in Ameloblastoma

The discovery of molecular alterations in ameloblastomas has paved the way for targeted therapies. The most promising agents include:

1. BRAF Inhibitors

Vemurafenib & Dabrafenib: These are small-molecule inhibitors that specifically target BRAF V600E. Clinical case studies have demonstrated significant tumor regression with these agents in patients with inoperable ameloblastomas. Vemurafenib is recommended as an alternative treatment for locally aggressive tumors in patients who are not candidates for surgery.⁸

- **Mechanism of Action:** Inhibits the abnormal BRAF kinase activity,



preventing excessive cell proliferation.

- **Clinical Evidence:** Patients treated with BRAF inhibitors have shown marked tumor shrinkage and improved symptoms.
- **Limitations:** Resistance to therapy may develop over time, necessitating combination treatments.

2. MEK Inhibitors

Trametinib: Inhibits MEK, a downstream component of the MAPK pathway, often used in combination with BRAF inhibitors to enhance therapeutic efficacy and prevent resistance.

3. PI3K/AKT/mTOR Inhibitors

These inhibitors target the PI3K/AKT/mTOR pathway, which is frequently upregulated in ameloblastomas. Their role is still under investigation in clinical trials.

Future Directions and Challenges

While targeted therapies have shown promise, several challenges remain:

- **Development of Resistance:** Tumors may develop secondary mutations, leading to resistance to BRAF inhibitors.

- **Long-Term Safety and Efficacy:** More clinical trials are needed to evaluate the long-term benefits and potential side effects of these treatments.
- **Cost and Accessibility:** Targeted therapies are expensive, limiting access for many patients.
- **Combination Therapy Strategies:** Future research should explore combination treatments targeting multiple pathways to enhance efficacy and overcome resistance.

Conclusion

The identification of the BRAF V600E mutation in ameloblastoma has revolutionized its management. Targeted therapies, particularly BRAF inhibitors, offer a promising alternative to traditional surgical treatment, especially in cases where surgery is not feasible. While these treatments are still in their early stages, ongoing research and clinical trials are expected to refine therapeutic strategies, improve patient outcomes, and establish standardized treatment protocols. The integration of molecular diagnostics with



personalized therapy marks a new era in ameloblastoma management, shifting towards a more precise and effective approach to treatment.

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Review Article

Pathway to Pink: Patient Education and Motivation Interviewing in Periodontal Therapy

*Sunanda Sudhakaran **Harish Kumar VV

Abstract

Periodontal diseases are chronic inflammatory conditions primarily caused by dental plaque biofilm. Though professional intervention plays a critical role, the success of periodontal treatment depends on patient compliance along with oral hygiene measures. This review reflects on the significance of patient education and motivation in periodontal therapy, highlighting strategies, tools, and the psychological aspects involved in influencing patient behaviour, emphasising the importance of communication techniques, behavioural models, and the integration of tailored educational approaches to ensure effective plaque control and improved outcomes

Keywords: *motivational interviewing, patient education, oral hygiene motivation*

Corresponding Author: Dr Sunanda Sudhakaran

* Senior Lecturer, **Professor and HOD, Department of Periodontology, KMCT Dental College, Manassery, Kozhikode 673602, Kerala

Introduction

Periodontal diseases are microbiota dysbiosis-associated, host-mediated inflammatory conditions characterised by inflammation and slow destruction of both soft and hard tissues¹. The complex etiology of periodontal diseases necessitates an effective treatment that consistently involves controlling dental plaque and infection.² Maintaining good oral hygiene is crucial for preventing the further

progression of periodontal diseases.³ A well-motivated patient is the prime need if a successful periodontal treatment has to be carried out.⁴ Over time, patients do face difficulty in maintaining fair oral hygiene consistently.⁵ The most important factor in both prevention and treatment of periodontal disease is the individual's standard of daily self-performed oral care. Henceforth, core concern is to motivate the patient to perform oral hygiene efficiently.⁶

Oral health education interventions



Individualised and patient-centred educational interventions, based on health behaviour theories, are preferable to conventional educational interventions for improving patients' adherence to self-performed periodontal infection control.⁶ The interventional programmes directed to patients in treatment for periodontitis have given- step-by-step strategy, including the distribution of pamphlets, demonstration of the presence of signs and symptoms of disease in the patient's mouth, and providing information regarding the daily oral hygiene instructions, and using a disclosing agent as the pedagogical tool to demonstrate the location of bacterial plaque.⁷

Motivating patients to change their oral health behaviour acts as a challenge for dental professionals, which has led to the introduction of Motivational Interviewing (MI) in dentistry.⁷ MI can initiate a change in behaviour after a few freestanding interventions of 1 or 2 MI sessions, and the change in behaviour lasts over time.⁷ The tailored education program with counselling inspired by MI has been proven effective in improving the oral hygiene of the patients when compared to traditional oral health education interventions⁸

Patient education:

Establishing a rapport with the patient is the primary thing that has to be established. This is then followed by further learning of the oral hygiene measures. Conditioning, insight learning, repetition, praise or punishment and guidance are the methods to which a patient responds. One way of accomplishing this is to start the first few visits on examination and personal plaque control programs to negate the previous fear of the patient towards dental

treatments. A properly conditioned patient will show an effective insight into learning, which shows an instantaneous association between formerly unknown or poorly understood events and their progress. Repetition is a mastery of the manual tasks, which demonstrates that oral hygiene measures must be repeated. Praising and refusal to proceed with treatments are adjunctive techniques in the learning process.

Before educating a patient, additional points like the motives and desires of the patient, understanding how important the patient is, providing attention to the patient as an active partner in the treatment, how good you are at listening to the patient, and the use of audio-visual aids should be considered.⁴

Principles of Motivational Interviewing:

- The preventive measures should be pursued with enthusiasm
- Emphasise the objective empathy for the patient rather than subjective sympathy.
- Responsibility for oral hygiene has to be solely on the patient, as we aim for a long-term prognosis.
- Emphasize the importance of plaque control measures and allow the patient to discern what oral hygiene alone can accomplish
- Patients' responses need to be anticipated by the dentist and dealt with effectively and atraumatically.⁹
- Proper communication between the dentist and the patient needs to be established.



Factors influencing the motivation Interviewing:

1. **Role of the Dentist:** The dentist must be able to handle the patient's resentment adequately, further helping in the proper planning of the treatment and plaque control.
2. **Anxiety and fear of the patient:** The conflicting anxiety of the patients that has arisen due to past bad experiences from dental treatments. These conflicts manifest as resentments toward the dentists and prevent them from seeking dental care, and thereby from following the proper oral hygiene measures.⁹
3. **The nature of the periodontal disease:** The painless nature of the periodontal disease serves as a factor that prevents patients from seeking dental care at the initial treatable stage.⁴
4. **Age of the periodontal patients:** In general, most periodontal patients are adults, and altering their long-established habits can be challenging, as it requires overcoming deeply ingrained concepts about oral health practices.¹⁰

Works best for patients with intrinsic motivation rather than those seeking only symptom relief.

5. Time constraints: MI requires extended consultation time, which may not be feasible in routine dental practice with tight schedules.

6. Need for Specialised Training: Clinicians must be adequately trained to

apply MI effectively; lack of communication skills or formal training limits its success.¹⁰

7. Follow-up and Reinforcement Needed: Behavioural changes achieved through MI often require periodic reinforcement sessions to maintain long-term oral hygiene improvement.¹⁰

Conclusion

Motivational interviewing represents a promising, patient-centred approach to enhance behavioural change and improve oral hygiene practices in periodontal therapy. This review underscores its significance in bridging the gap between clinical expertise and patient compliance—transforming the dentist–patient interaction into a partnership aimed at achieving long-term periodontal health. However, while evidence suggests positive outcomes in patient motivation and adherence, variability in methodologies and limited longitudinal data still constrain its widespread application

Future research should focus on standardising MI protocols specific to dental settings, integrating them into undergraduate and continuing dental education, and evaluating their sustained impact on clinical parameters over extended follow-up periods. Incorporating motivational interviewing into everyday periodontal practice could ultimately shift the focus from treatment to true prevention—paving the way for more personalised, empathetic, and effective patient care.

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Original Article

EFFICIENCY OF AN INTEGRATED APEX LOCATOR IN DETERMINING WORKING LENGTH IN VARIOUS IRRIGATING SOLUTIONS – IN VITRO STUDY

*Parvathy Narayanan, **Ravi SV, ***Elsy P Simon, ****Chandini Raveendran, ****Sarin Korothe

Abstract

Background:

For a successful endodontic therapy, the ability to precisely measure the working length (WL) plays a vital role. Failure to establish proper WL leads to the damage of peri-radicular tissues and various procedural errors. Measuring the length from the coronal reference point to the apical foramen (AF) but not to the radiographic apex is a major advantage of electronic apex locators (EALs). Further advancements in the technology have led to apex locators that have been used in combination with the endomotors to simultaneously determine the WL during root canal instrumentation.¹ However, the performance of WL-measuring electronic devices might be affected by the presence of these solutions in the canal during WL determination.

Aim:

The aim of the present *in vitro* study was to evaluate the accuracy of WOODPECKER ENDO RADAR PRO IAL (which is an integrated apex locator) and compare it with WOODPEX V (which is a conventional apex locator) for WL determination in the presence of two commonly used endodontic irrigants, that is, 3% sodium hypochlorite (NaOCl) and 2% chlorhexidine (CHX).

Materials and Methods:

Thirty extracted human single-rooted teeth with mature apices were used for the study. The real working length (RWL) was established by subtracting 0.5 mm from the actual root canal length.



The teeth were be decoronated at the cementoenamel junction with a diamond disc to simplify access to the root canal and to obtain a reliable occlusal landmark. Teeth were divided into 2 groups – 15 each – Chlorhexidine and NaOCl respectively. WL was determined using conventional apex locator and integrated apex locator (IAL).

Results:

Both apex locators performed with high accuracy. NaOCl showed slightly shorter WLs due to higher electrical conductivity. However, neither irrigant significantly affected the accuracy of WL determination for either device.

Conclusion:

Both integrated apex locator and conventional apex locator are effective tools for accurate WL determination irrespective of the irrigating solution used.

Keywords:

Conventional apex locator, integrated apex locator, irrigating solutions

Corresponding Author: Dr Parvathy Narayan (narayananparvathy993@gmail.com)

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

Introduction

Working length (WL) determination is a fundamental step in root canal therapy that directly influences clinical outcomes. Establishing WL accurately ensures adequate canal debridement and proper obturation, while over- or under-instrumentation, can lead to procedural failures or damage to periapical tissues. Electronic apex locators (EALs) have largely replaced traditional radiographic methods due to their improved accuracy and reduced radiation exposure. EALs work on the principle of electrical

impedance and have evolved significantly across generations. More recently, integrated apex locators (IALs), which are incorporated into endomotors, allow for real-time WL determination during instrumentation. Although these technologies offer great promise, their performance can be influenced by the electroconductivity of irrigants within the root canal, such as sodium hypochlorite (NaOCl) and chlorhexidine (CHX), commonly used for canal disinfection.¹ For a successful endodontic therapy, the ability to precisely measure the working length

(WL) plays a vital role. Failure to establish proper WL leads to the damage of peri-radicular tissues and various procedural errors. Measuring the length from the coronal reference point to the apical foramen (AF) but not to the radiographic apex is a major advantage of EALs. Further advancements in the technology have led to apex locators that have been used in combination with the endomotors to simultaneously determine the WL during root canal instrumentation.² However, the performance of WL-measuring electronic devices might be affected by the presence of irrigating solutions such as sodium hypochlorite (NaOCl) and chlorhexidine (CHX) in the canal during WL determination. Thus, this study was conducted to evaluate the accuracy of a conventional apex locator and an integrated apex locator for WL determination in the presence of two commonly used endodontic irrigants, that is, 3% NaOCl and 2% CHX.

Materials and Methods

Sample Selection and Preparation

In this in vitro experimental study, thirty extracted human single-rooted teeth with mature apices were used. The study was conducted using Woodpex V (CAL) (figure 1) and Endo Radar Plus (IAL) (figure 2).

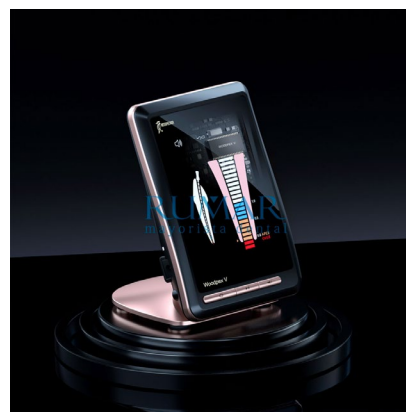


Figure 1: Conventional apex locator



Figure 2: Integrated apex locator

All the extracted teeth were numbered and kept in 5.25% sodium hypochlorite (NaOCl) for 2 h and then stored in sterile 0.9% saline solution. The teeth were decoronated at the cemento-enamel junction with a diamond disc to simplify access to the root canal and to obtain a reliable occlusal landmark. Then, an adequate amount of alginate was condensed within the plastic boxes and upon setting; the corresponding roots were embedded within the alginate, leaving approximately 5 mm of the root surface exposed. The roots were kept in that position until the alginate had

completely set.

Regular biomechanical preparation was done with 3% sodium hypochlorite (NaOCl), 2% Chlorhexidine (CHX) and K-files (#15 and #10). Endo-M-Block was used to measure the working length. During electronic measurement, the labial clip of the corresponding locator was inserted into the alginate. Initial patency of the canal was obtained using 10k file. The samples were grouped into two, with 15 samples per group:

1. **Group I – NaOCl:**
Teeth were irrigated with 3% NaOCl. WL was measured using CAL and IAL. For IAL, instrumentation was performed in a pecking motion until the auto-stop function engaged. CAL measurements were recorded when the device displayed the apex signal.
2. **Group II – CHX:**
NaOCl was removed using saline, followed by CHX irrigation. Excess CHX was aspirated before WL measurement using both apex locators.

Actual Working Length determination (AWL)^{3,4}

Teeth were sectioned, and #10 K-file was inserted until visible at the apical foramen under a microscope. The silicon stop was adjusted, and 0.5 mm was subtracted to determine the AWL. The real working length (RWL) was established by subtracting 0.5 mm from the actual root canal length (figure 3).

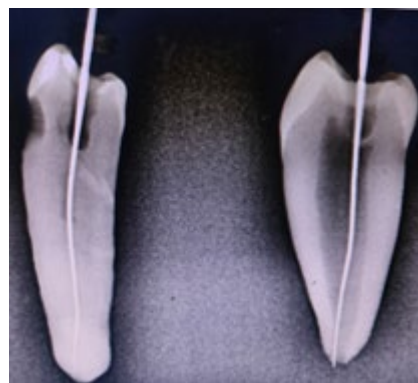


Figure 3: Working length determination

Results

SPSS v21.0 was used for statistical analysis. Paired t-tests assessed statistical differences. A *p* value of < 0.05 was considered significant.

No statistically significant differences were found between IAL and CAL. NaOCl's higher electrical conductivity led to marginally shorter readings (table 1).

	Irrigant	Mean WL (mm) ± SD	Accuracy (%)	Observation
Wood pex V	NaOCl	21.55 ± 1.9	95%	Readings slightly shorter than AWL
Endo Radar	NaOCl	21.53 ± 1.9	90%	Readings within 0.5 mm of apex
Wood pex V	CHX	Comparable	95%	Shorter WL due to lower conductivity



	Irrigant	Mean WL (mm) $\pm$ SD	Accuracy (%)	Observation
Endo Radar	CHX	Comparable	95%	Accurate measurements maintained

Table 1: Mean values of working length

Discussion

Accurate WL is pivotal for cleaning and shaping the root canal system without overextension. Modern EALs, particularly those using multiple frequency impedance like the Root ZX Mini, have greatly improved precision even in wet canal conditions.

Correct WL determines the treatment outcome of root canal therapy, thus ensures removal of the contents of the root canal system followed by filling prepared root canal space up to the WL without under or over extension of the final filling material. In newer generations of EALs, multiple frequencies are used to determine WL, resulting in a more precise WL measurement in the presence of different electrolytes. However, the presence of highly electroconductive irrigants, such as saline, CHX, and NaOCl, may compromise the accuracy of the EAL's performance.⁵

Kocak et al (2013) conducted a laboratory study showed that the combination of EAL and endodontic motor was accurate in terms of length control during root canal preparation.⁶

The results revealed that the accuracy of multi-functional endodontic motor with integrated apex locator was acceptable and quite comparable to EAL and conventional radiographs. Besides, the continuous monitoring of the WL may help clinicians to prevent the procedural errors like loss of reference point and over instrumentation.

IALs offer real-time monitoring during canal preparation and eliminate the need for separate WL determination. The auto-stop feature helps prevent over-instrumentation, improving clinical safety.

The present study investigated the accuracy of integrated apex locators (IAL) and conventional apex locators (CAL) in determining working length in the presence of sodium hypochlorite and chlorhexidine. The results demonstrated no significant difference between the two, suggesting that both are reliable for determining working length.

According to Cruz et al (2017), NaOCl was used in this study as it is a widely used irrigant. An advantage of NaOCl is the ability to dissolve tissues and has antibacterial activity, was used in this study.



NaOCl is valued for its tissue dissolution and antimicrobial properties. Despite its high conductivity, the apex locators maintained accuracy in its presence. CHX, commonly used as a final rinse, also did not compromise measurement precision.

Results showed that concentration of NaOCl does not adversely affect the WL determination of the IAL and CAL though there were some readings that were shorter than that of AWL, but the result was not statistically significant ($P < 0.05$). 2% Chlorhexidine is commonly used as a final endodontic irrigant. In this study, results showed that chlorhexidine does not adversely affect the working length determination of both IAL and CAL with a 95% of accuracy of both the apex locators.

The presence of sodium hypochlorite and chlorhexidine, commonly used irrigants in endodontics, did not compromise the accuracy of either locator⁷

The ability of different types of matter to conduct an electric current is known as electrical conductivity. NaOCl showed slightly shorter WLs due to its higher electrical conductivity when compared to that of CHX.

These findings align with previous literature – According to Yahya et al. (2024) noted that electroconductive irrigants may

influence EALs, but newer devices compensated effectively.

Conclusion

Within the limitations of this study, it can be concluded that both the apex locators IAL and CAL were equally effective in determining WL. NaOCl and chlorhexidine are the most used irrigants and from the study it was found these irrigants did not have any influence on determination of the working length.

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Review Article

Green Dentistry in Periodontal Practice: Bridging Clinical Excellence with Environmental Responsibility

*Dr. Risvana S * Dr. Sruthi VG *Dr.Aswathi S *Dr Sunanda S

Abstract

The growing global emphasis on environmental conservation has prompted healthcare sectors, including dentistry, to re-evaluate their ecological footprint. Periodontal practice, with its routine use of disposables, chemical irrigants, and energy-intensive equipment, contributes significantly to clinical waste and resource consumption. *Green dentistry*—a concept integrating sustainability with patient care—aims to minimize environmental impact without compromising clinical outcomes. This review explores the principles of green dentistry and its application within periodontal practice, emphasizing the transition toward eco-friendly materials, digital technologies, efficient waste management, and sustainable clinic design. Innovations such as biodegradable biomaterials, herbal irrigants, digital record systems, and energy-saving equipment are reshaping the way periodontal care is delivered. By bridging clinical excellence with ecological responsibility, periodontology can serve as a model for sustainable healthcare delivery.

Keywords: *green dentistry, sustainability, biodegradable materials, sustainable oral health care*

Corresponding Author: Dr Risvana S

* Senior Lecturer, , Department of Periodontology, KMCT Dental College, Manassery, Kozhikode 673602, Kerala

Introduction

Environmental sustainability has become a global imperative, urging all sectors of healthcare to reassess their ecological impact. Dentistry, though primarily

focused on improving oral health, is not exempt from contributing to environmental degradation through the generation of biomedical waste, consumption of energy and water, and use of chemical-based materials and



sterilization processes¹. Within dentistry, periodontal practice involves extensive use of disposable materials, irrigants, and radiographic and sterilization procedures, all of which collectively add to the carbon footprint of dental care².

The concept of **green dentistry**—also known as *eco-dentistry*—emerged in response to this growing environmental concern. It is defined as “a high-tech approach to dentistry that reduces the environmental impact of dental practices and embodies a service model that supports wellness”.³ Green dentistry is built on four core principles: **Rethink, Reduce, Reuse, and Recycle**, encouraging clinicians to incorporate sustainability into everyday clinical decision-making.³ This philosophy emphasizes the responsible use of resources, reduction of waste, and adoption of digital and biodegradable alternatives without compromising the quality or safety of patient care.³

Recent advances in periodontal therapy have opened new avenues for integrating sustainability. The adoption of digital radiography has reduced the need for chemical developers and minimized radiation exposure.⁴ Similarly, the use of biodegradable membranes, herbal irrigants, and energy-efficient devices

supports both patient outcomes and environmental goals.⁵ In addition, ozone therapy, laser-assisted periodontal procedures, and photodynamic therapy have shown potential to minimize chemical usage and clinical waste generation.⁶

Beyond materials and techniques, sustainability in periodontics also involves ethical and educational dimensions. Clinicians are increasingly recognized as environmental stewards, responsible not only for patients’ oral health but also for reducing the ecological footprint of their practice.⁷ Incorporating sustainability into dental education fosters awareness among future practitioners and promotes the culture of environmental responsibility.⁸

Despite these promising developments, challenges such as the high cost of eco-friendly materials, limited awareness, and lack of standardized guidelines continue to hinder the widespread adoption of green practices in periodontics. Nevertheless, with growing global advocacy for sustainable healthcare, green dentistry offers a transformative opportunity—to bridge clinical excellence with environmental responsibility, and to ensure that periodontal care contributes to a healthier planet as well as healthier smiles.



Principles of Green Dentistry

The philosophy of *green dentistry* emphasizes integrating high-quality oral healthcare with environmental sustainability. It encourages clinicians to adopt practices that reduce waste, conserve resources, and promote ecological balance without compromising patient care.⁹ The **Eco-Dentistry Association (EDA)** conceptualized the *Four R's of Green Dentistry* — **Rethink, Reduce, Reuse, and Recycle** — which serve as the guiding framework for sustainable dental practice.¹⁰

Rethink:

This principle urges clinicians to reassess traditional clinical procedures and materials in terms of their environmental impact.³ For example, the shift from conventional film-based radiography to digital radiography significantly reduces chemical waste and radiation exposure.⁴ Similarly, replacing synthetic irrigants with herbal or ozone-based alternatives lowers the release of harmful chemicals into wastewater.⁶

Reduce:

Reducing resource consumption and waste generation is fundamental to green dentistry. Strategies include minimizing single-use plastics, optimizing water flow during ultrasonic scaling, and using

energy-efficient devices such as LED curing lights and modern autoclaves.⁸ The adoption of paperless systems, such as digital record-keeping and electronic consents, also helps decrease paper waste.¹⁰

Reuse:

Reusability involves opting for materials and instruments that can be sterilized and reused without compromising infection control. Stainless-steel suction tips, metal impression trays, and reusable barrier instruments are sustainable alternatives to disposable counterparts.⁷ Proper maintenance and sterilization of these instruments contribute to long-term cost-effectiveness and reduced environmental burden.¹¹

Recycle:

Recycling entails proper segregation and disposal of non-biohazardous waste, including paper, plastic, and packaging materials.² Use of amalgam separators to prevent mercury contamination, recycling packaging waste, and collaborating with certified biomedical waste handlers ensure responsible waste management.²

Beyond these four pillars, green dentistry also encompasses energy conservation, eco-friendly clinic design, and sustainable procurement policies. Incorporating solar power, natural lighting, low-VOC



materials, and ergonomic layouts not only minimizes environmental impact but also creates a healthier atmosphere for both patients and clinicians.¹¹ Thus, the principles of green dentistry provide a holistic framework for achieving a balance between clinical excellence and ecological responsibility in periodontal care.

Eco-friendly Innovations and Strategies in Periodontal Practice

The evolution of periodontal care is increasingly being guided by eco-friendly innovations that align patient welfare with planetary health.⁵ The integration of green technologies, sustainable biomaterials, and digital workflows has transformed modern periodontology into a model of responsible clinical practice. These innovations reduce the ecological footprint of dental care while maintaining or even enhancing clinical outcomes.⁸

Sustainable Biomaterials and Therapeutics

Recent years have seen a surge in the development of biodegradable and biocompatible materials for periodontal regeneration. Natural polymers such as chitosan, collagen, and polylactic acid are preferred over non-biodegradable counterparts due to their minimal environmental impact.⁴ Similarly, herbal

formulations, ozone therapy, and photodynamic therapy (PDT) are being adopted as alternative antimicrobial approaches that minimize chemical use and promote eco-safety.⁶ These modalities provide comparable antimicrobial effects against *Porphyromonas gingivalis* and other pathogens while avoiding ecological toxicity associated with chlorhexidine and other synthetic antiseptics.⁹

Digital and Paperless Periodontology

Digitization has played a crucial role in creating a more sustainable dental workflow. Digital charting, e-prescriptions, and radiography not only streamline patient management but also drastically reduce paper and chemical waste.³ Cone-beam computed tomography (CBCT) and intraoral scanners allow precise imaging and diagnosis with reduced radiation exposure and the elimination of film developers.⁷ Additionally, tele-periodontics and remote consultation systems have emerged as low-carbon alternatives to frequent in-person visits, thereby reducing transportation-related emissions.⁷

Energy and Water Conservation in Clinics

Dental clinics consume significant energy and water resources. Incorporating energy-efficient LED lighting, smart HVAC



systems, and motion-sensor switches can lower energy use by up to 40%.² Water-saving technologies such as foot-controlled taps, dry suction systems, and optimized ultrasonic scalers further reduce wastage.³ Clinicians are also encouraged to use non-toxic cleaning agents and biodegradable disinfectants, minimizing the release of harmful chemicals into the environment.³

Waste Management and Recycling Protocols

Effective waste management remains a cornerstone of green periodontal practice. Segregation of biomedical, recyclable, and hazardous waste ensures proper disposal and recycling.⁹ Installing amalgam separators prevents mercury contamination of wastewater, while eco-friendly sterilization methods, such as hydrogen peroxide plasma sterilizers, reduce environmental pollution compared to conventional chemical sterilants.⁶ Reusable stainless-steel suction tips, impression trays, and autoclavable barrier covers also contribute to significant reductions in disposable waste.⁸

Sustainable Clinic Design and Green Procurement

The concept of a green dental clinic extends beyond clinical operations to include architectural and procurement

considerations. Eco-friendly clinics employ natural lighting, low-VOC paints, bamboo or recycled furniture, and solar energy systems.⁹ Green procurement policies emphasize selecting suppliers who follow sustainable manufacturing practices and minimize packaging.¹⁰ Such holistic design not only enhances indoor air quality and energy efficiency but also promotes patient comfort and professional well-being.¹⁰

Collectively, these innovations underscore that sustainability in periodontal care is achievable through conscious choices—by rethinking materials, technology, and daily practices. When clinicians embrace these eco-friendly strategies, they help ensure that oral health advancements contribute positively to both community well-being and the planet's ecological balance.¹⁰

Green Periodontal Therapies

Modern periodontology is witnessing a paradigm shift toward eco-friendly therapeutic strategies that ensure clinical efficacy while minimizing environmental harm. These *green periodontal therapies* utilize biocompatible materials, energy-efficient technologies, and natural or minimally toxic agents, aligning with the principles of sustainable healthcare.¹²



Herbal and Phytotherapeutic Approaches

Herbal formulations are gaining importance as substitutes for synthetic antimicrobials in periodontal therapy. Extracts of green tea (*Camellia sinensis*), neem (*Azadirachta indica*), turmeric (*Curcuma longa*), and aloe vera have demonstrated anti-inflammatory and antimicrobial effects comparable to chlorhexidine, but with superior biocompatibility and environmental safety²⁶. These phytochemicals inhibit periodontal pathogens such as *P. gingivalis* and *T. forsythia* by disrupting biofilm formation while avoiding the ecological toxicity of conventional mouthrinses.¹³

Ozone Therapy

Ozone (O₃) acts as a powerful oxidizing agent that destroys microorganisms without producing harmful residues. In periodontics, ozone gas and ozonated water are used for pocket irrigation, root surface detoxification, and post-surgical disinfection.¹⁴ Studies have shown ozone therapy to be effective in reducing bacterial counts and improving clinical attachment levels when used as an adjunct to scaling and root planing. Importantly, ozone decomposes back into oxygen,

eliminating chemical waste and aligning with green clinical protocols.²

Laser-Assisted Periodontal Therapy

Diode and Er: YAG lasers have emerged as minimally invasive alternatives for debridement, pocket disinfection, and soft-tissue management.¹⁵ Their precision minimizes tissue trauma and enhances healing while reducing the need for chemical hemostatic agents. Laser technology, though energy-dependent, is increasingly optimized through energy-efficient systems that reduce power consumption without compromising clinical efficacy.¹⁶

Biodegradable Regenerative Materials

In regenerative periodontics, biodegradable membranes, scaffolds, and growth factor carriers based on collagen, chitosan, or polylactic acid are preferred over synthetic, non-degradable materials.¹⁷ These bio-based materials minimize surgical re-entry and environmental impact, while supporting cell proliferation and guided tissue regeneration.¹⁷ Advances in 3D bioprinting and nanotechnology have further enhanced the precision and sustainability of regenerative therapies.¹⁸



Challenges, Barriers, and Future Directions in Implementing Green Periodontology

Despite the growing advocacy for eco-friendly dental care, the integration of green principles into periodontal practice faces several practical, economic, and educational challenges.⁸ The transition toward sustainable dentistry requires a systemic shift in mindset, infrastructure, and policy, extending beyond individual clinician efforts.⁶

Economic and Logistical Constraints

A major barrier to adopting green periodontal practices is the initial cost associated with upgrading clinic infrastructure. The installation of energy-efficient systems, amalgam separators, or digital radiographic equipment involves substantial investment.² Moreover, in developing regions, limited access to eco-certified suppliers and sustainable materials restricts widespread adoption.⁹ Although these technologies lead to long-term savings through resource optimization, the upfront expenses deter many practitioners, especially in small or independent clinics.³

Lack of Awareness and Training

There remains a gap in awareness regarding the environmental implications

of traditional periodontal practices. Most dental curricula still lack structured education on sustainability or eco-friendly protocols.⁷ Periodontists often rely on self-learning or continuing education courses for exposure to these topics. Integrating environmental sustainability modules into undergraduate and postgraduate dental training could cultivate environmentally responsible clinicians.¹⁹

Behavioural Resistance and Cultural Barriers

The introduction of sustainable practices often meets resistance due to perceived inconvenience, time constraints, or scepticism about efficacy.²⁰ Traditional habits—such as the use of disposable materials for convenience or overreliance on chemical disinfectants—are difficult to change without visible incentives.²⁰ Continuous motivation, leadership from professional bodies, and demonstration of the clinical and financial benefits of green dentistry are essential for long-term behavioural change.⁴

Future Directions

The future of green periodontology lies in integrated sustainability frameworks combining clinical excellence, technological innovation, and ecological mindfulness. Digitalization, renewable energy integration, and biocompatible



materials will continue to shape the eco-friendly dental clinic of tomorrow.²¹ Interdisciplinary collaborations—linking dental professionals with environmental scientists and engineers—will foster innovations such as carbon-neutral clinics and closed-loop waste systems.²¹ Global professional organizations and academic institutions must prioritize sustainability education, green research funding, and policy advocacy to ensure a lasting transition toward a greener periodontal future.²¹

Conclusion

The integration of **green dentistry principles into periodontal practice** represents a paradigm shift toward a more responsible and holistic model of oral healthcare. Sustainability in periodontology extends beyond reducing environmental waste—it encompasses energy efficiency, ethical material selection, digital innovation, and preventive care approaches that minimize ecological impact while preserving clinical efficacy.

Eco-friendly periodontal therapies such as ozone treatment, and biodegradable biomaterials highlight the potential for biocompatible interventions that maintain therapeutic outcomes with minimal environmental burden. Similarly,

digitalization in record keeping, imaging, and patient education contributes to a significant reduction in the carbon footprint of dental practice.

However, the true realization of sustainable periodontology requires collaborative action among clinicians, policymakers, educators, and researchers. The development of universal green dental practice standards, incorporation of sustainability modules in dental curricula, and investment in eco-innovation research are essential for translating theory into practice.

As global health systems move toward carbon neutrality, periodontists have an ethical obligation to adopt and advocate environmentally conscious practices. A **green periodontal clinic** is not only a reflection of professional excellence but also a testament to the profession's commitment to planetary health and intergenerational responsibility.

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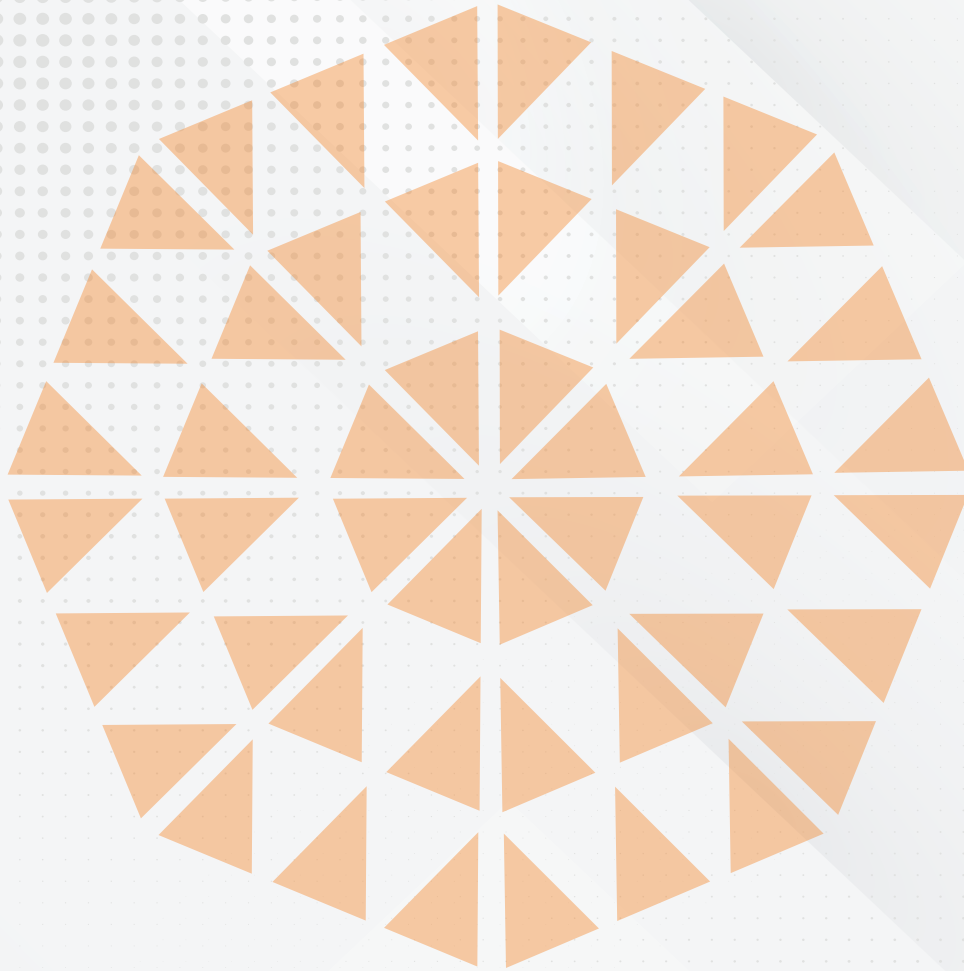
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