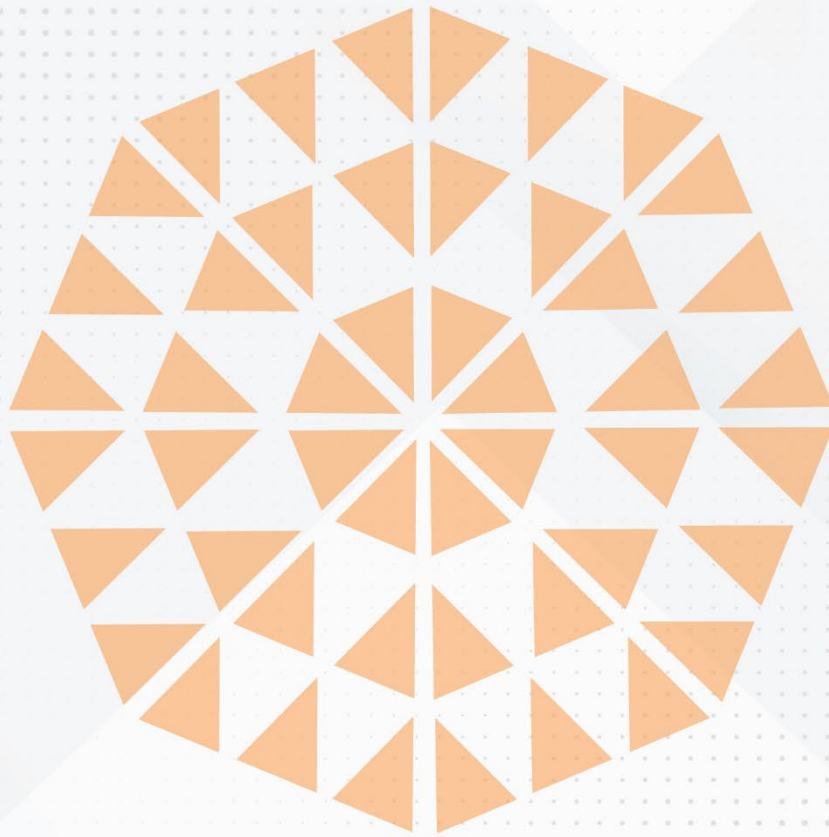


DENTAL BITES

Volume 12 issue 2 | April-June 2025

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



a quarterly publication of



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Editorial

Dear Readers,

Advancing Smiles with Technology: KMCT Dental College's Commitment to Excellence

In the ever-evolving world of dental science, technology continues to redefine the boundaries of learning, diagnosis, and clinical excellence. At KMCT Dental College, we have always believed that true progress lies in staying ahead of change—adopting innovations that empower our students and enhance patient care.

It gives me immense pride to share that our college has now incorporated Digital Dentistry and CAD-CAM technology into our academic and clinical framework. This marks a significant milestone in our journey towards modernizing dental education and practice.

Digital dentistry is not merely a trend—it is the new language of precision and efficiency. Through CAD-CAM (Computer-Aided Design and Computer-Aided Manufacturing), our students can now design and fabricate restorations with unparalleled accuracy, understand digital workflows from impression to final prosthesis, and appreciate the seamless integration between technology and clinical skill.

By introducing this cutting-edge facility, we aim to bridge the gap between traditional methods and the digital era of dentistry. Students gain early exposure to technologies they will encounter in advanced clinical practice, enabling them to develop confidence, competence, and a global perspective in oral healthcare.

As educators, it is our responsibility to prepare future dental professionals who can adapt, innovate, and lead. With this new addition, KMCT Dental College reinforces its commitment to academic excellence, research, and technological advancement—ensuring that our graduates are equipped to meet the challenges of modern dentistry.

Let us continue to nurture curiosity, embrace innovation, and strive together towards a future where technology enhances every smile we create.

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



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Review Article

Epithelial -Mesenchymal Transition Dynamics in Oral Cancers: A Review

*Usha B, ** Rajeesh M, ***Jyotsna K V, *** Lekshmipriya Reghu, ***Gopika S Raj

Abstract

Oral squamous cell carcinoma (OSCC) remains a significant global health burden, characterized by aggressive behavior and poor prognosis. Epithelial-mesenchymal transition (EMT), a key biological process enabling epithelial cells to acquire mesenchymal traits, plays a pivotal role in OSCC progression, invasion, metastasis, and therapeutic resistance. This review comprehensively explores the dynamic nature of EMT in OSCC, encompassing the molecular mechanisms, regulatory signaling pathways, and the interplay with the tumor microenvironment. Special attention is given to the plasticity of EMT, including partial EMT states and their relevance in tumor heterogeneity. Furthermore, we discuss emerging biomarkers and therapeutic strategies targeting EMT, emphasizing their potential translational applications in OSCC management. Understanding EMT dynamics offers critical insights into OSCC pathobiology and may inform future directions for diagnosis, prognosis, and personalized therapy.

Keywords: EMT, OSCC, TME (Tumor Micro Environment), ECM (Extra Cellular Matrix), CAF (Cancer Associated Fibroblast)

Corresponding Author: Jyotsna KV

*** Post graduate student, * Professor, **Professor and Head,

Department of Oral Pathology, KMCT Dental College, Kozhikode, Kerala.

Introduction

Oral cancers, particularly oral squamous cell carcinoma (OSCC), are among the most common cancers worldwide, with a

significant burden on public health, particularly in regions where tobacco and alcohol consumption are prevalent. OSCC accounts for approximately 90% of all malignancies of the oral cavity, and the prognosis for patients remains poor,



especially in advanced stages.¹ The process by which epithelial cells acquire mesenchymal characteristics, known as epithelial-mesenchymal transition (EMT), plays a pivotal role in the pathogenesis of OSCC. EMT is a key event in the progression of many cancers, including oral cancers, facilitating processes such as invasion, metastasis, and resistance to chemotherapy.²

This review aims to summarize the current understanding of EMT in oral cancers, specifically OSCC, and explore its implications for diagnosis, treatment, and prognostication. We also examine the molecular pathways involved, the role of the tumor microenvironment (TME), and potential therapeutic strategies targeting EMT in oral cancer.

Process of Epithelial-Mesenchymal Transition (EMT)

EMT is a biological process where epithelial cells lose their characteristic markers and acquire mesenchymal traits. This transition involves a series of molecular and morphological changes that enable epithelial cells to become more migratory, invasive, and resistant to apoptosis. The main features of EMT include:

1. Loss of Epithelial Markers: In EMT, epithelial markers such as E-cadherin, claudins, and cytokeratins are downregulated. E-cadherin, a cell-cell adhesion protein, plays a crucial role in maintaining the integrity of epithelial cell layers, and its loss is associated with increased motility and invasiveness of cells.²

2. Upregulation of Mesenchymal Markers: The mesenchymal markers, such as N-cadherin, vimentin, fibronectin, and β -catenin, are upregulated during EMT. These proteins are involved in cellular adhesion, migration, and extracellular matrix remodeling, which are essential for invasion and metastasis.³

3. Morphological Changes: EMT induces a shift from a polarized, tightly connected epithelial phenotype to a more elongated, mesenchymal-like morphology. Cells acquire a more spindle-shaped appearance, which facilitates migration and invasion into surrounding tissues.

4. Increased Motility and Invasiveness: Cells undergoing EMT gain the ability to invade through the extracellular matrix (ECM) and migrate to distant sites, a critical step in the metastatic spread of tumors.

5. Resistance to Apoptosis: EMT confers a survival advantage to cancer cells by enhancing their resistance to apoptosis.

This ability to evade cell death is a major contributor to tumor progression and therapeutic resistance.^{4,5}

Molecular Pathways Involved in EMT in OSCC

Various signaling pathways contribute to the initiation and progression of EMT in OSCC. These pathways can be triggered by genetic mutations, microenvironmental factors, and other stimuli. The most prominent pathways involved in EMT in OSCC are the TGF- β , Wnt/ β -catenin, Notch, and PI3K/Akt pathways.

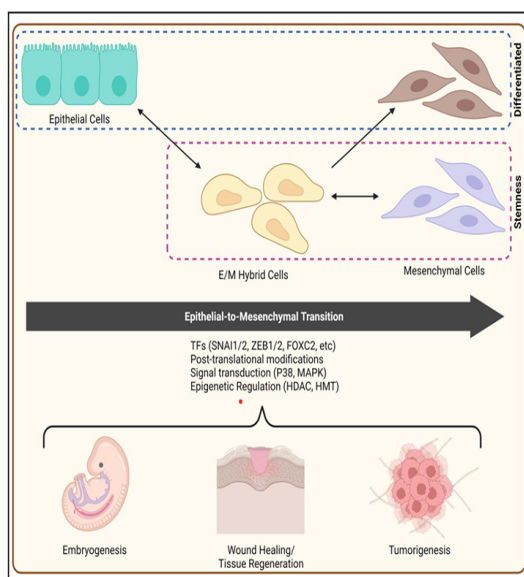


Fig.1. EMT Mechanism: Epithelial cells transforming into mesenchymal cells in Embryogenesis, Wound healing and Tumorigenesis (Den Hollander P, Maddela JJ, Mani SA. Spatial and Temporal Relationship between Epithelial–Mesenchymal Transition (EMT) and Stem Cells in Cancer. *Clinical chemistry*. 2024 Jan;70(1):190–205.)

1. TGF- β Pathway: Transforming growth factor-beta (TGF- β) is one of the key

regulators of EMT. It induces the transcription of mesenchymal genes such as N-cadherin, vimentin, and fibronectin, while repressing epithelial markers such as E-cadherin. TGF- β signaling plays a crucial role in OSCC progression, and elevated TGF- β levels have been associated with poor prognosis in OSCC patients.^{6–9}

2. Wnt/ β -catenin Pathway: The Wnt/ β -catenin signaling pathway is involved in maintaining stemness and promoting EMT. In OSCC, aberrant activation of the Wnt pathway leads to the accumulation of β -catenin in the nucleus, where it binds to TCF/LEF transcription factors to promote the expression of EMT-related genes. This pathway has been implicated in both the initiation of oral cancer and its progression to metastatic stages.

3. Notch Pathway: The Notch signaling pathway is another important regulator of EMT in OSCC. Notch signaling is involved in cell fate determination, and its activation has been shown to enhance EMT in cancer cells. In OSCC, the upregulation of Notch receptors, such as Notch1, is linked to increased EMT and poor clinical outcomes.

4. PI3K/Akt Pathway: The PI3K/Akt pathway is involved in regulating cell growth, survival, and metabolism. In



OSCC, activation of the PI3K/Akt pathway promotes EMT by increasing the expression of mesenchymal markers and enhancing cell migration. The PI3K/Akt pathway also contributes to therapeutic resistance in OSCC by inhibiting apoptosis and promoting cell survival.^{10,11}

Role of Tumor Microenvironment in EMT in OSCC

The tumor microenvironment (TME) plays a crucial role in regulating EMT in oral cancer. The TME consists of cancer-associated fibroblasts (CAFs), immune cells, endothelial cells, and extracellular matrix components, all of which interact with tumor cells to promote cancer progression. Several key factors within the TME contribute to EMT in OSCC:

- 1. Cancer-Associated Fibroblasts (CAFs):** CAFs are one of the most abundant stromal cell types in the TME, and they play a critical role in tumor progression by secreting growth factors such as TGF- β , fibroblast growth factors (FGFs), and vascular endothelial growth factors (VEGF). These factors stimulate EMT in cancer cells by activating various signaling pathways, including TGF- β and Wnt/ β -catenin.

- 2. Immune Cells:** Infiltrating immune cells, particularly tumor-associated

macrophages (TAMs), contribute to the progression of EMT in OSCC. TAMs secrete pro-inflammatory cytokines and growth factors, including interleukin-6 (IL-6), which activate EMT-inducing pathways. TAMs also promote cancer cell invasion and metastasis by remodeling the extracellular matrix.

- 3. Extracellular Matrix (ECM):** The ECM is a dynamic structure that provides mechanical support to tissues and plays an essential role in regulating cell behavior. In OSCC, alterations in the ECM, such as the deposition of fibronectin and collagen, promote EMT by interacting with integrins and activating intracellular signaling pathways that regulate cell motility and invasion.¹²

- 4. Hypoxia:** Hypoxic conditions within the tumor microenvironment can also induce EMT in OSCC. Hypoxia-inducible factors (HIFs), particularly HIF-1 α , are activated under low oxygen conditions and promote EMT by upregulating mesenchymal markers and enhancing cell migration.

Clinical Implications of EMT in OSCC

EMT in OSCC has several clinical implications, particularly in terms of prognosis and therapeutic strategies. The presence of EMT markers in tumor cells



has been associated with poor prognosis, including increased tumor invasiveness, metastatic potential, and resistance to therapy. EMT biomarkers, such as E-cadherin, vimentin, and N-cadherin, can serve as prognostic indicators in OSCC, with reduced E-cadherin expression correlating with advanced stages and poor survival rates.

Furthermore, the plasticity of EMT means that OSCC cells can transition between epithelial and mesenchymal states, contributing to tumor heterogeneity and therapeutic resistance. This phenomenon, known as "partial EMT," complicates the treatment of OSCC by rendering tumor cells less responsive to conventional therapies like chemotherapy and radiation.

Therapeutic Strategies Targeting EMT in OSCC

Targeting EMT represents a promising strategy for improving the treatment and prognosis of OSCC. Several approaches are being explored, including:

1. Inhibition of EMT Signaling

Pathways: Small molecules and antibodies targeting key EMT-related signaling pathways, such as TGF- β , Wnt/ β -catenin, and Notch, are being investigated in preclinical and clinical trials. These therapies aim to block the

transition from epithelial to mesenchymal states and reduce the invasive and metastatic potential of tumor cells.

2. Targeting Cancer-Associated Fibroblasts (CAFs): Strategies aimed at inhibiting CAFs or disrupting their interactions with cancer cells are also being explored. By targeting CAFs, it is possible to disrupt the EMT-promoting signals within the TME and reduce cancer progression.¹⁴⁻¹⁶

3. Immunotherapy: Immune checkpoint inhibitors, which block inhibitory signals from immune cells, are gaining traction in the treatment of OSCC. By modulating the immune system, these therapies can also affect EMT-related pathways and enhance the anti-tumor immune response.

4. MicroRNA Therapy: MicroRNAs (miRNAs) are small non-coding RNAs that regulate gene expression, including the genes involved in EMT. Targeting specific miRNAs that regulate EMT markers, such as miR-200 family, offers a novel approach to reversing EMT and sensitizing tumors to treatment.^{17,18}

Conclusion

Epithelial-mesenchymal transition (EMT) is a critical process in the progression of oral cancers, including OSCC. It facilitates



invasion, metastasis, and resistance to therapy, contributing to the poor prognosis associated with these cancers. Understanding the molecular mechanisms of EMT, particularly the involvement of key signaling pathways and the tumor microenvironment, is crucial for developing new therapeutic strategies. Targeting EMT through the inhibition of signaling pathways, the disruption of the tumor microenvironment, or the use of novel therapies such as immunotherapy and microRNA-based approaches offers potential for improving the treatment and outcomes of OSCC patients.

References

1. González-González R, Ortiz-Sarabia G, Molina-Frechero N, Salas-Pacheco JM, Salas-Pacheco SM, Lavallo-Carrasco J, López-Verdín S, Tremillo-Maldonado O, Bologna-Molina R. Epithelial–Mesenchymal Transition Associated with Head and Neck Squamous Cell Carcinomas: A Review. *Cancers*. 2021 Jun 17;13(12):3027.
2. Rad HS, Shiravand Y, Radfar P, Ladwa R, Perry C, Han X, Warkiani ME, Adams MN, Hughes BG, O'Byrne K, Kulasinghe A. Understanding the tumor microenvironment in head and neck squamous cell carcinoma. *Clinical & Translational Immunology*. 2022;11(6):e1397.
3. Chen SM, Krinsky AL, Woolaver RA, Wang X, Chen Z, Wang JH. Tumor immune microenvironment in head and neck cancers. *Molecular Carcinogenesis*. 2020 Jul;59(7):766-74.
4. Den Hollander P, Maddela JJ, Mani SA. Spatial and Temporal Relationship between Epithelial–Mesenchymal Transition (EMT) and Stem Cells in Cancer. *Clinical chemistry*. 2024 Jan;70(1):190-205.
5. Krisanaprakornkit S, Iamaroon A. Epithelial-mesenchymal transition in oral squamous cell carcinoma. *International Scholarly Research Notices*. 2012;2012(1):681469.
6. Yang J, Antin P, Berx G, Blanpain C, Brabletz T, Bronner M, Campbell K, Cano A, Casanova J, Christofori G, Dedhar S. Guidelines and definitions for research on epithelial–mesenchymal transition. *Nature reviews Molecular cell biology*. 2020 Jun 10;21(6):341-52.
7. Brabletz S, Schuhwerk H, Brabletz T, Stemmler MP. Dynamic EMT: a multi-tool for tumor progression. *The EMBO journal*. 2021 Sep 15;40(18):e108647.



8. Parikh AS, Puram SV, Faquin WC, Richmon JD, Emerick KS, Deschler DG, Varvares MA, Tirosh I, Bernstein BE, Lin DT. Immunohistochemical quantification of partial-EMT in oral cavity squamous cell carcinoma primary tumors is associated with nodal metastasis. *Oral oncology*. 2019 Dec 1;99:104458.
9. Wodarz D, Komarova N. Dynamics of cancer: mathematical foundations of oncology. World Scientific; 2014 Apr 24.
10. Manasa VG, Kannan SJ. Impact of microRNA dynamics on cancer hallmarks: an oral cancer scenario. *Tumor Biology*. 2017 Feb;39(3):1010428317695920.
11. Amack JD. Cellular dynamics of EMT: lessons from live in vivo imaging of embryonic development. *Cell Communication and Signaling*. 2021 Jul 22;19(1):79.
12. Inchingolo F, Santacroce L, Ballini A, Topi S, Dipalma G, Haxhirexha K, Bottalico L, Charitos IA. Oral cancer: A historical review. *International journal of environmental research and public health*. 2020 May;17(9):3168.
13. Scully C, Porter S. Oral cancer. *Bmj*. 2000 Jul 8;321(7253):97-100.
14. Radisky DC. Epithelial-mesenchymal transition. *Journal of cell science*. 2005 Oct 1;118(19):4325-6.
15. Dongre A, Weinberg RA. New insights into the mechanisms of epithelial–mesenchymal transition and implications for cancer. *Nature reviews Molecular cell biology*. 2019 Feb;20(2):69-84.
16. Ribatti D, Tamma R, Annese T. Epithelial-mesenchymal transition in cancer: a historical overview. *Translational oncology*. 2020 Jun 1;13(6):100773.
17. Mittal V. Epithelial mesenchymal transition in tumor metastasis. *Annual Review of Pathology: Mechanisms of Disease*. 2018 Jan 24;13(1):395-412.
18. Wang S, Fan H, Bai J. NKD2 as a Mediator of IFIX Antioncogene-Induced Wnt Signalling and Epithelial–Mesenchymal Transition in Human OSCC. *Journal of Cellular and Molecular Medicine*. 2025 Jan;29(2):e70342.



Review Article

DEMYSTIFYING THE SINUS TRACT: MANAGEMENT OF EXTRAORAL SINUS WITH NON-SURGICAL ENDODONTIC INTERVENTION- A CASE REPORT

*Hanna Kizhakayil Hafiz, **Mariam Raheema, ***Amith Adyanthaya,
Asif Ismail, **Darshana V, *Jadeera N A.

Abstract:

Extraoral sinus tracts of odontogenic origin often develop as a result of persistent dental infections due to trauma, caries, or periodontal disease. As it often lacks intraoral symptoms, it is commonly misdiagnosed as a cutaneous lesion. Chronic apical periodontitis of tooth can drain through sinus tract, which may be intra oral or extraoral. Hence proper diagnosis is the key of success in such cases and timely dental treatment can resolve the condition. The purpose of this study is to report a case of nonsurgical endodontic management of an extraoral sinus tract.

Key words: *Extraoral sinus tract, misdiagnosis, non-surgical endodontic treatment, Calcium hydroxide*

Corresponding Author: Hanna Kizhakayil Hafiz (hannakhafiz@gmail.com)

Post graduate student, **Professor, * Professor and Head, ****Assistant Professor,
Department of Pediatric and Preventive dentistry, KMCT Dental College, Kerala.*

Introduction

Apical periodontitis is an inflammatory disease that may take an acute, sub-acute, or chronic course. Chronic apical periodontitis may present as

a periapical abscess, periapical granuloma or a periradicular cyst.¹

The most common initiating factor for an acute periapical abscess is carious exposure and subsequent bacterial invasion of the tooth pulp. In some cases, the chronic presence of inflammation



can give rise to a sinus tract.²

A sinus tract is defined as a communication pathway between a confined inflammatory site and an epithelial surface. Depending on the path with the lowest resistance, the sinus tract opening may be located intraorally or extraorally.¹

Intraoral sinus tract is a frequent occurrence, while extraoral sinus tract is a rare condition. Extraoral sinus tract of odontogenic origin often lacks intraoral symptoms and thus the patient suspects it to be a cutaneous lesion. Esthetic concern and discomfort caused due to frequent pus drainage on the face by extraoral sinus tract often makes the patient to visit either a physician or a dermatologist and rarely a dentist. In such cases, a misdiagnosis by them can lead to an ineffective and inappropriate management of a sinus tract.³ Factors that can determine the position of the sinus tract are the thickness of alveolar bone and overlying soft tissue, distance from the root apex, outer cortical bone, and shape of the bone. The vestibule of the mouth along the buccal alveolar plate is the most common site for the emergence of sinus.⁴

These tracts tend to occur more frequently from infected mandibular teeth (80%) than from infected maxillary teeth (20%).⁵

The management of an extraoral draining sinus tract involves eliminating the origin of infection either via endodontic treatment or tooth extraction if the tooth is not restorable. The sinus tract tends to progressively heal within 2 weeks. Endodontic treatment of the affected tooth has been effectively proven to result in a satisfactory outcome as these types of extraoral tracts are lined with granulation tissue; hence, surgical intervention is not necessary.⁶

Case report

An 8-year-old female child reported to the Department of Pediatric and Preventive dentistry with chief complaint of a lesion on the face in the lower left back tooth region (**figure 1.1**). According to the patient's parents, a localized swelling developed abruptly on the child's left cheek with pain and fever for which antibiotics were prescribed by the pediatrician. The pediatrician suspected the lesion to be of dental origin and hence referred to the department.



Figure 1.1 Extraoral swelling in the left submandibular region



Figure 1.2 Yellow pus discharge on palpation of the surrounding tissue



Figure 1.3 Intraoral pre-operative view showing deep caries with respect to 36



Figure 1.4 Intraoral periapical radiograph with respect to 36

On extraoral examination, a 2.5×3 mm localized swelling with a crusted surface was seen on the left submandibular region. The swelling was fluctuant on palpation and mildly ached after pressure; simultaneously, yellow pus was discharged on palpation of the surrounding tissue (**figure 1.2**). The patient had no complaints of dental pain. Intraorally, the tooth 36 was tender to percussion. The tooth was non responsive to electrical pulp testing or heat testing (**figure 1.3**). Periodontal probing around the tooth discovered a pocket depth within physiological limits. The intraoral periapical radiograph revealed deep dental caries with radiolucency extending into the pulp, indicating pulpal involvement. A well-defined periapical radiolucency was observed, accompanied by the loss of lamina dura and widening of the periodontal ligament with mild bone resorption, suggestive of chronic periapical infection with an open apex. After clinical and radiographic examination, the final diagnosis was established as chronic periapical abscess with an extraoral sinus tract caused from pulp necrosis due to caries. Informed consent was obtained from the parent and a non-surgical endodontic treatment was initiated.

In the first treatment session, an access cavity was prepared in relation to 36. The working length was determined using both apex locator and radiograph. The canals were subsequently cleaned using ISI size 10 and 15 stainless steel K-files and irrigated with chlorhexidine solution (0.2%), followed by normal saline. Calcium hydroxide was given as an intracanal medicament.



Figure 2.1 One week post treatment: No pus discharge and closure of the extraoral sinus tract (Frontal view)



Figure 2.2 One week post treatment: No pus discharge and closure of the extraoral sinus tract (Lateral view)



Figure 2.3 One week post treatment: cutaneous view

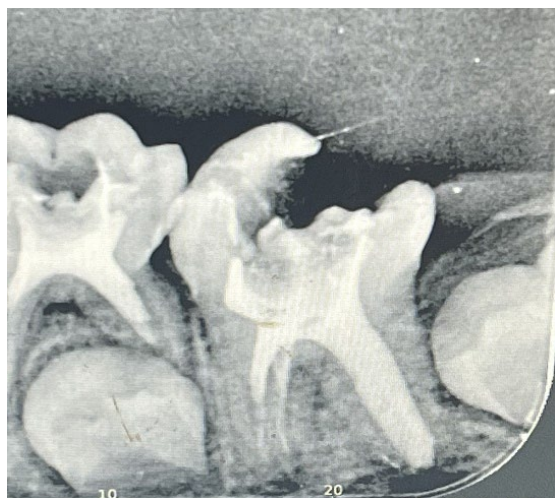


Figure 2.4 Root canals medicated with metapex

The second session was scheduled one week later. In this session, there was no pus discharge, and the sinus tract was closed (**figure 2.1-2.3**).

Biomechanical preparation was performed using rotary files (Neo Endo) and irrigated with chlorhexidine solution (0.2%) followed by normal saline. The canals were dressed with Metapex (**figure 2.4**).

The patient was reviewed after 2 weeks. She was asymptomatic and the extraoral lesion had healed (**Figure 3.1-3.2**).



Figure 3.1 Review after 2 weeks: Healed extraoral lesion



Figure 3.2 Review after 2 weeks (frontal view)

Discussion

Extraoral sinus tracts are often misdiagnosed as cutaneous skin lesions. The dental origin has to be considered the primary factor when diagnosing a discharging lesion in the facial or cervical region. Dental caries, trauma, or failed root canal treatment are often responsible for an infection of the pulpal tissue leading to pulpal necrosis. A diverse mix of anaerobic bacteria colonize the root canals once the intact pulp chamber is breached and a specialized



mixed anaerobic biofilm colonizes the walls of the necrotic root canals. Since asymptomatic pulp necrosis is a common condition, abscess formation typically develops only when bacteria and their toxic byproducts enter the periapical tissues through the apical foramen, inducing inflammation and pus accumulation.³

The purulent exudate of the odontogenic infection will move towards the path of the least resistance from the periapical area. Once the cortical plate has been penetrated, the sinus tract exits as an intraoral or extraoral sinus, depending on the location of the muscle attachments and the fascial sheaths. If the apices of the maxillary teeth are above the maxillary muscle attachments, and apices of the mandibular teeth are below the mandibular muscle attachments, the spread of the infection may be extraoral. These sinus tracts were originally thought to be lined by epithelium and therefore to require a surgical intervention apart from the endodontic treatment.

But later, studies suggested that it was lined by granulation tissue and not epithelium, which means that the intraoral or extraoral sinus tracts could be treated by a non-surgical endodontic treatment. Also it is considered as the most conservative

approach.⁷

This method is sometimes complemented with endodontic surgery or, as the last option, dental extraction.⁸

As the sinus tract provides drainage of exudate from the odontogenic primary site, it prevents swelling or pain from pressure build-up. Thus, the draining sinus tract maintains the infection in a localized condition and systemic involvement is a rare occurrence.³

In the discussed case, the etiology behind the skin lesion was proved to be odontogenic infection. The spontaneous closure of sinus tract was noticed within 2 weeks after commencing nonsurgical root canal treatment.

The cornerstone of treatment in such cases is the elimination of infection from the root canal system, which often leads to the healing of the extraoral sinus tract. For this purpose, chlorhexidine was used for root canal irrigation during root canal instrumentation followed by calcium hydroxide as intracanal medicament.

Due to its antibacterial properties, calcium hydroxide is a substance that is frequently utilized in endodontic treatment. It is believed to promote the development of hard tissue and establish favourable circumstances for periapical healing. According to Souza et al., calcium hydroxide may have four different actions beyond the apex: (a) anti-inflammatory activity; (b) neutralization of acid products; (c) activation of alkaline phosphatase; and



(d) antibacterial action. When calcium hydroxide is utilized for endodontic treatment of teeth with periapical lesions, success rates of 80.8 and 73.8% have been documented.⁹

Conclusion

This case highlights that an odontogenic etiology should always be considered and ruled out when patients are presented with a cutaneous sinus tract on the face, particularly in mandibular, submandibular, and zygomatic regions. The elimination of infection through nonsurgical root canal treatment led to the resolution of the sinus tracts and promoted periapical healing of the teeth involved. Communication between the dentist and the physician is imperative to provide timely recognition and treatment of such rare cases.

References

1. Azizlou E, Sobhani MA, Ghabraei S, Khoshkhounejad M, Ghorbanzadeh A, Tahan SS. Extraoral Sinus Tracts of Odontogenic Origin: A Case Series. *Front Dent*. 2020 Nov 12; 17:29. doi:10.18502/fid.v17i29.4750. PMID: 36042809; PMCID: PMC9375119
2. Curvers F, Haes P, Lambrechts P. Non-Surgical Endodontic Therapy as Treatment of Choice for a Misdiagnosed Recurring Extraoral Sinus Tract. *Eur Endod J*. 2017 Jun 15; 2(1):1-6. doi: 10.5152/eej.2017.17007. PMID: 33403325; PMCID: PMC7757942.
3. Tekwani RA, Nanda Z, Rudagi K, Reddy KK, Deore R, Fotani S. Nonsurgical Management of an Extraoral Sinus Tract of Endodontic Origin: A Case Report. *J Oper Dent Endod* 2019; 4 (1):54-56.
4. Siddharth B. Management of Extraoral Sinus with Non-Surgical Endodontic intervention. Zenodo [Internet]. 2024 Dec 11 [cited 2025 Feb 11];
5. Muzaffer Emir Dinçol, Bülent Yılmaz, Handan Ersev, Vildan Mert Gündüz, Burak Arslanoğlu, Turgut Yağmur Yalçın, et al. Treatment of extraoral cutaneous sinus tracts with non - surgical endodontic intervention: report of six cases. *Journal of İstanbul university faculty of dentistry/Journal of Istanbul University faculty of dentistry*. 2015 Apr 29; 49(2):35–45.
6. Soo E, Nurul Ain Ramlan, Khairulzan SH, Nordin R, Muhammad. The Successful Management of Non-healing Extraoral Draining Sinus of



Odontogenic Origin: A Report of Two Cases. Journal of Dentistry Indonesia. 2023 Aug 31; 52(2):35–45.

7. Kumar KS. Management of an Endodontic Infection with an Extraoral Sinus Tract in a Single Visit: A Case Report. Journal of clinical and diagnostic research. 2013; Jun 16; 2(1):5-10.

8. Alex DrJ, F DrR, Nair DrMG, K DrS. Management of extraoral draining sinus of odontogenic origin: A case report. International Journal of Applied Dental Sciences. 2024 Jan 1; 10(2):81–84.

9. Priyanka Rudrapada, BR P, Rupali Karale. Non- Surgical Management of ExtraoralCutaneous Sinus Tract with Odontogenic Origin of Mandibular Incisors - A Case Series. International Journal of Health Sciences and Research. 2024 May 13; 14(5):234–241.



Review Article

TAILORED CARE: ADDRESSING MUCOCELE IN AN ACHONDROPLASIA PATIENT: A CASE REPORT

*Jadeera N A, ** Amith Adyanthaya, ***Marium Raheema***George Babu *Krishna.N S

ABSTRACT

Mucocele is a common lesion of the oral mucosa resulting from dysfunction of the minor salivary glands. It can present in two histological forms: extravasation and retention, each with different underlying causes. Extravasation mucoceles often arise due to trauma, which leads to the severance of ducts and the spillage of mucin into the adjacent connective tissue, while retention mucoceles are caused by duct obstruction. Clinically, mucoceles appear as soft, bluish, transparent cystic swellings, which typically resolve spontaneously. However, treatment may be required in some cases, with options including surgical excision, micro marsupialization, cryosurgery, steroid injections, and CO2 laser therapy. This case report highlights the management of a mucocele on the lower lip in a 9-year-old female patient with achondroplasia.

Key words: Achondroplasia, Mucocele, Surgical excision.

Corresponding Author: Dr Jadeera N A(drjadeerashanavas@gmail.com)

Post graduate student, ** Professor and Head, * Professor, Department of Pediatric and Preventive dentistry, KMCT Dental College, Kerala.*



Introduction

A mucocele is the most common minor salivary gland disorder and one of the frequently biopsied oral lesions in pediatric patients. It affects both genders, with peak incidence among children and young adults. It results from the accumulation of mucus that spills from the salivary glands and their ducts into the subepithelial tissue of the oral cavity. Clinically, a mucocele appears as a round, well-circumscribed, painless swelling, with colors ranging from deep blue to mucosa-like. Mucoceles are generally asymptomatic; however, in some cases, they can cause discomfort and interfere with speech, chewing, and swallowing. The lower lip is the most common site for a mucocele, followed by the cheek mucosa and the floor of the mouth.¹ This is likely due to the sharp borders of the incisors, which can traumatize the lower lip through biting, leading to injury or repeated stimulation.² Mucocele can be classified as the mucous extravasation cyst and the mucous retention cyst.³ Clinically, it appears as an asymptomatic nodule, either pink or bluish in color, with varying sizes. It typically affects the lip, cheek, tongue, palate, and floor of the mouth, with no gender

predilection.⁴

Various procedures have been used to remove mucoceles, including conventional surgery (the most recommended method), electrosurgery, cryosurgery, micromarsupialization, and marsupialization. Steroid injections have also been reported as a treatment option.²

Achondroplasia is a form of skeletal dysplasia characterized by stunted stature and disproportionate limb shortening. It is of particular interest in dentistry due to its characteristic craniofacial features, including relative macrocephaly, a depressed nasal bridge, and maxillary hypoplasia.⁵

This article presents a case report of a 9-year-old patient with achondroplasia who presented with a recurrent mucocele on the lower lip. The patient also had a family history of similar cases. The case report discusses the management of the condition and explores the potential relationship between achondroplasia and intraoral mucoceles.

Case report

A 9-year-old female patient presented to the Outpatient Department of Pediatric and Preventive Dentistry at KMCT Dental College with a chief complaint of swelling on her lower lip for the past three months. The patient was a known case of achondroplasia, and her father and younger sister also had a history of achondroplasia. Both family members had presented with similar swelling on the



lower lip, which had been surgically managed a few years earlier.

Extraorally, the patient exhibited short stature, frontal bossing, and midface hypoplasia (Figure 1). There was no known history of systemic diseases or other syndromic associations beyond achondroplasia. The patient also had a habit of lip biting.

Intraorally, there was a 2 cm by 1.5 cm, dome-shaped, fluid-filled swelling located at the center of the lower lip (Figure 2). The swelling appeared bluish and translucent, was soft and fluctuant, and was non-tender upon palpation. No signs of secondary infection or ulceration were observed. The surrounding mucosa appeared normal. The patient's dentition was appropriate for her age, with a narrow V-shaped upper arch and mild crowding in the lower anterior

Treatment approach

After obtaining informed consent from the parent, an antiseptic mouth rinse (chlorhexidine) was administered. Local anesthesia (2% lignocaine with adrenaline) was applied via infiltration. A small, semilunar incision was made around the lesion using a #15 scalpel (Figure 3). The

lesion was carefully separated from the underlying tissue (Figures 4). Using fine surgical scalpel, the pedunculated lesion was excised in its entirety. Special care was taken to avoid damaging the adjacent minor salivary glands, which could compromise complete excision of the mucocele and increase the risk of recurrence.

- **Hemostasis:** Bleeding was controlled by gently pressing the tissue, and the area was then checked to ensure all mucin-filled tissue was removed
- **Closure:** After confirming the excision of the mucocele and achieving hemostasis, the surgical wound was closed with absorbable sutures. A simple interrupted suture technique was employed to bring the edges of the mucosal incision together (figure 5). Care was taken to precisely align the mucosal edges to minimize tension and promote optimal healing.

Postoperative care

Analgesics were prescribed, and the patient was advised to follow a soft diet, avoid lip biting, and use a chlorhexidine mouth rinse twice daily for one week.



Figure 1: Extraoral view showing frontal bossing and midface hypoplasia.



Figure 3: Semilunar incision made around the lesion.



Figure 2: Intraoral view showing mucocoele on lower lip



Figure 4: Excision of the lesion from surrounding tissue



Figure 5: Wound closed with absorbable sutures.



Discussion

Mucocele is a common minor salivary gland disorder, most frequently affecting the lower lip, followed by the buccal mucosa and the floor of the mouth.⁶ The lips consist of adipose tissue, connective tissue, blood vessels, nerves, and salivary glands. Therefore, any abnormality in these tissues might result in swelling of the lips. Mucocele, fibroma, lipoma, mucus retention cyst, sialolith, phlebolith, and salivary gland neoplasm manifest as lip swelling. Nevertheless, they can be differentiated from mucocele by their clinical presentation, color, texture, cause, and site of occurrence.⁷ Small salivary gland mucoceles are always superficial, rarely exceeding 1.5 cm in diameter, and can cause convex swelling that may hinder chewing or speaking, depending on their size and location.⁸

Mucoceles can be treated using a variety of techniques, like scalpel, laser, electrocautery, or marsupialization.⁹ In the present case, mucocele was treated by surgical excision using a scalpel. Patient had the history of achondroplasia which is also known as *Chondrodystrophia fetalis* is a non-lethal form of chondrodysplasia. It is transmitted as an autosomal dominant trait with complete penetrance.¹⁰ It has a

prevalence estimated to be 1 in 15000-40000 cases worldwide. Approximately 80 % of cases are due to de novo dominant mutations with a mutation rate estimated to be 0.000014 per gamete per generation. General physical features include a disproportionate short stature, lordotic lumbar spine, a trident hand configuration, limitation of elbow extension, rhizomelic shortening of the arms and legs, prominent buttocks and a protuberant abdomen. Craniofacial features include enlarged calvarium with hydrocephaly, brachycephaly, midfacial hypoplasia, low nasal bridge, prominent forehead and dental malocclusions.⁶

In the present case, the patient's father and younger sister also had achondroplasia and manifested recurrent swelling over the lower lip, which had been surgically managed a few years earlier.

In children with achondroplasia, anatomical features such as midface hypoplasia, micrognathia, a depressed nasal bridge, choanal stenosis, a high-arched palate, and reduced temporomandibular joint mobility predispose them to upper airway obstruction. Together with the natural reduction in muscle tone during sleep, which further narrows the airway, these factors play a critical role in the development of obstructive sleep apnea.¹¹

Although a direct association between achondroplasia and the occurrence of mucoceles has been reported in the literature, altered sleep patterns, increased stress, and psychological factors may



contribute to the development of parafunctional habits such as lip biting, which in turn can be a contributing factor for mucocele formation.

Dealing with achondroplastic children needs special psychological approach during dental treatment, as the presence of disproportionate short stature can cause a number of psychosocial and social problems.

Dental development may be delayed in these patients as a result of altered bone growth.⁶

During school years, the inclusion of children in school may require environmental modifications and psychological follow-up. Children should be taught about their condition to improve acceptance and self-esteem and should be encouraged to have as similar lifestyle as possible as an average-stature child.¹¹

In this case, the patient's habitual lip biting during stressful periods, especially while studying, combined with the presence of lower anterior dental crowding, could have caused chronic trauma and played a significant role in the development of a mucocele. It is reported in the literature that dental crowding could have exacerbated the situation by contributing to abnormal

occlusal forces or abnormal lip contact, increasing the likelihood of repetitive trauma.¹²

The most frequent cause of a mucocele is trauma, such as accidental biting of the lip or cheek, which can damage or rupture the salivary gland duct, leading to the accumulation of mucin in the surrounding tissues and the formation of a cyst-like structure. Chronic irritation, such as that caused by sharp teeth or dental appliances, can also contribute to the development of a mucocele. Orthodontic issues like crowding, deep bites, or malaligned teeth cause repetitive trauma or compression to the salivary glands. Less common causes include salivary gland duct obstruction due to factors like sialolithiasis (salivary stones), which causes backflow and extravasation of mucus.¹³

The management of mucoceles typically involves surgical excision, especially for persistent or recurrent cases. In some cases, less invasive methods like cryotherapy, laser excision, or marsupialization may be considered, particularly for smaller lesions. Conservative observation is an option for very small, asymptomatic mucoceles that may resolve on their own. In this case report patient underwent complete excision.¹⁴

Since the father and sibling of the child in the present case report also have achondroplasia along with the appearance of a mucocele on the lip, further studies are needed to determine whether there is a direct association between achondroplasia and mucocele formation.



Conclusion

Mucocele are generally benign and self-limiting, diagnosed based on clinical findings, followed by a definitive diagnosis through histopathological investigation. Trauma and habitual lip biting are considered key etiological factors. The importance of awareness about mucoceles is emphasized, as they are common in the general population.

In the present case, the patient had a history of achondroplasia. Although no definitive relationship exists between achondroplasia and mucocele, individuals with achondroplasia may be more predisposed to developing mucoceles due to abnormal bone growth patterns, increased mucin production, and genetic predisposition. Further studies are needed to establish a conclusive relationship.

References

1. Bagher SM, Sulimany AM, Kaplan M, Loo CY. Treating Mucocele in Pediatric Patients Using a Diode Laser: Three Case Reports. *Dent J (Basel)*. 2018 May 9;6(2):13. doi: 10.3390/dj6020013. PMID: 29747378; PMCID: PMC6023325.
2. Besbes A, Elelmi Y, Khanfir F, Belgacem R, Ghedira H. Recurrent Oral Mucocele Management with Diode Laser. *Case Rep Dent*. 2020 Oct 3;2020:8855759. doi: 10.1155/2020/8855759. PMID: 33083064; PMCID: PMC7556084.
3. Skaleric U, Kovac-Kavcic M. The prevalence of oral mucosal lesions in a population in Ljubljana, Slovenia. *J Oral Pathol Med* 2000;29:331-5
4. Nico MM, Park JH, Lourenco SV. Mucocele in pediatric patients: analysis of 36 children. *Ped Dermatol* 2008;25:308-11.
5. Rohilla S, Kaushik A, Vinod VC, Tanwar R, Kumar M. Orofacial manifestations of achondroplasia. *EXCLI J*. 2012 Aug 27;11:538-42. PMID: 27298609; PMCID: PMC4897656.
6. Cohen PR. Biting Fibroma of the Lower Lip: A Case Report and Literature Review on an Irritation Fibroma Occurring at the Traumatic Site of a Tooth Bite. *Cureus*. 2022 Dec 5;14(12):e32237. doi: 10.7759/cureus.32237. PMID: 36620845; PMCID: PMC9815785.
7. Mukundan D, R R. Pediatric Oral Mucocele Management: A Case Series Investigating Different Treatment Approaches. *Cureus*. 2024 Jun 28;16(6):e63342. doi: 10.7759/cureus.63342. PMID: 39077290; PMCID: PMC11283918.
8. Bodner L, Manor E, Joshua BZ, Shaco-Levy R. Oral mucoceles in children: analysis of 56 new cases. *Pediatr Dermatol*. 2015;32(5):647-50. doi:10.1111/pde.12535.



9. Sadiq MS, Maqsood A, Akhter F, et al. The effectiveness of lasers in treatment of oral mucocele in pediatric patients: a systematic review. *Materials (Basel)*. 2022;15(7):2452. doi:10.3390/ma15072452.
10. Jones KL. *Achondroplasia Smith's recognizable patterns of human malformation*. 4th. Philadelphia, PA: WB Saunders; 1988
11. Pauli RM. *Achondroplasia: a comprehensive clinical review*. Orphanet J Rare Dis. 2019 Jan 3;14(1):1. doi: 10.1186/s13023-018-0972-6. PMID: 30606190; PMCID: PMC6318916.
12. Solanki D, Fulzele P, Thosar NR, Ragit R, Shirbhate U, Rahate I, Kanani H. Understanding the distinction between traumatic fibroma and mucocele in pediatric patients: a report of two cases. *Cureus*. 2024;16(3):e55631. doi:10.7759/cureus.55631.
13. Al-Saleem A, Al-Jobair A. *Achondroplasia: Craniofacial manifestations and considerations in dental management*. *Saudi Dent J*. 2010 Oct;22(4):195-9. doi: 10.1016/j.sdentj.2010.07.001. Epub 2010 Jul 14. PMID: 24151409; PMCID: PMC3804960.
14. Kannan N, Ramalingam K, Ramani P, Krishnan M. *Mucocele of the Lower Lip and Its Surgical Management*. *Cureus*. 2024 Oct 5;16(10):e70874. doi: 10.7759/cureus.70874. PMID: 39497885; PMCID: PMC11534429.



Original article

EVALUATION OF REMINERALIZATION POTENTIAL OF GRAPE SEED EXTRACT AND COCOA EXTRACT ON DEMINERALIZED TOOTH – AN INVITRO STUDY.

*Nikitha Rajeev, **Ravi SV, ***Elsy P Simon, ****Chandini Raveendran, *****Nimmy Kurian

Abstract

Background:

Dental demineralization is an early indicator of caries and erosion, where mineral ions are lost from enamel. While fluoride-based agents like Clinpro™ are effective in promoting remineralization, excessive fluoride use poses risks such as fluorosis. Natural alternatives such as grape seed extract (GSE) and cocoa extract are being investigated for their biocompatibility and therapeutic potential.

Aim:

To evaluate and compare the remineralization potential of grape seed extract and cocoa extract on demineralized tooth enamel.

Materials and Methods:

An in vitro study was conducted on 24 extracted human teeth, which were sectioned and subjected to demineralization using a lactic acid solution. The samples were then divided into four groups (n=6): Group 1 – Demineralized (negative control), Group 2 – Clinpro™ paste (positive control), Group 3 – Grape seed extract, and Group 4 – Cocoa extract. The remineralizing agents were applied once daily for 5 minutes over a defined period. Following treatment, surface microhardness was assessed using a Vickers hardness tester to evaluate the extent of remineralization.

Results:

Group 2 (Clinpro™) showed the highest surface microhardness, followed closely by Group 3 (GSE), with no statistically significant difference between them. Group 4 (Cocoa extract) also demonstrated an increase in enamel hardness, but less than the other treatment groups. The negative control group showed minimal change, confirming effective demineralization.

Conclusion:

Grape seed extract demonstrated substantial remineralization potential, comparable to fluoride based Clinpro™ paste, indicating its usefulness as a natural alternative. Cocoa extract also showed beneficial effects but to a lesser extent. Both natural agents present promising roles in preventive and minimally invasive dentistry.



Keywords:

Remineralization, Grape seed extract, Cocoa extract, Demineralization, Theobromine, Proanthocyanidins, Enamel microhardness, Herbal dentistry.

Corresponding author: Nikitha Rajeev (nikinikirajeev@gmail.com)

** Post graduate student, ** Professor, ***Professor and Head, ****Associate Professor, *****Assistant Professor,*

Department of Conservative Dentistry and Endodontics, KMCT Dental College, Kozhikode, Kerala.

Introduction

Dental caries and enamel erosion remain prevalent oral health concerns globally, especially among children and adolescents. These conditions are primarily the result of demineralization, a process in which hydroxyapatite crystals in enamel lose mineral ions due to acid attacks from bacterial metabolism or dietary acids.¹ In the natural oral environment, this process is often counterbalanced by remineralization, which involves the redeposition of calcium and phosphate ions onto the enamel surface, restoring its structural integrity.² Maintaining this balance is critical in the prevention and reversal of early carious lesions.

Fluoride-based agents, such as Clinpro™, have long been the gold standard for promoting remineralization by enhancing the precipitation of fluorapatite, which is more acid-resistant than hydroxyapatite.³ However, prolonged or excessive exposure to fluoride, especially in children, has raised concerns about dental and skeletal fluorosis, leading researchers to explore safer, naturally derived alternatives.⁴

In this context, herbal and plant-based products have garnered increasing interest due to their biocompatibility, minimal

toxicity, antioxidant, and antimicrobial properties.⁵ Among these, grape seed extract (GSE) and cocoa extract have shown promising results in dental research. GSE is rich in proanthocyanidins (PAs)—potent flavonoids known for their ability to strengthen the dentin matrix by promoting collagen cross-linking, thus aiding in the remineralization of both enamel and dentin.^{6,7}

Cocoa extract, on the other hand, contains theobromine, an alkaloid that has been shown to increase enamel microhardness by promoting the formation of larger and more stable hydroxyapatite crystals.⁸ Theobromine has also been suggested as a safer alternative to fluoride, especially in pediatric formulations.⁹

This study aims to investigate and compare the remineralising efficacy of grape seed extract and cocoa extract on artificially demineralized human teeth. By assessing enamel surface microhardness post-treatment, the study seeks to determine the potential of these natural agents as viable alternatives to conventional fluoride-based products in preventive and restorative dentistry.

Materials and Methods

Sample Selection and Preparation

Sample Preparation

A total of 24 extracted, caries-free human premolar teeth was collected for the study. Teeth with cracks, carious lesions, restorations, or developmental defects were excluded. The collected teeth were thoroughly cleaned of soft tissue debris and calculus using an ultrasonic scaler and stored in distilled water until further use. Each tooth was then decoronated at the cemento-enamel junction (CEJ) using a diamond disk under water cooling. The crown portion was retained and mounted vertically on an acrylic resin block with the buccal surface oriented upwards to allow consistent surface exposure (Figure 1). To prepare the enamel surface for treatment and testing, the buccal surface was flattened using a sequential polishing protocol with silicon carbide abrasive papers of increasing grit size (400, 600, 800, and 1200 grit) under running water. This process ensured a smooth, standardized, and flat enamel surface suitable for uniform demineralization and accurate microhardness measurement.



Figure 1: Samples decoronated and mounted on acrylic resin blocks.

Demineralization Procedure

All samples were immersed in a lactic acid demineralising solution (pH ~4.5) for a standardized period of 96 hours at 37°C to induce artificial enamel demineralization.

Grouping

After demineralization, the samples were randomly assigned into four experimental groups (n = 6) as follows:

- **Group 1 – Negative Control:** No treatment (demineralized enamel only)
- **Group 2 – Positive Control:** Treated with Clinpro™ Tooth Crème (fluoride and tricalcium phosphate)
- **Group 3 – Grape Seed Extract (GSE):** Treated with 6.5% grape seed extract solution
- **Group 4 – Cocoa Extract:** Treated with 0.1% theobromine-containing cocoa extract solution

Each treatment was applied to the enamel surface for 5 minutes once daily for 7 consecutive days using a microbrush, simulating routine application (Figure 2). After each application, specimens were rinsed with distilled water.



Figure 2: Agents applied as per each grouping

Microhardness Testing

At the end of the treatment period, all specimens were subjected to Vickers surface microhardness testing using a microhardness tester. A load of 100 grams was applied for 15 seconds at three standardized locations on each specimen, and the average Vickers Hardness Number (VHN) (Figure 3a) as recorded for each sample by viewing the indentations under digital microscopy (Figure 3b).

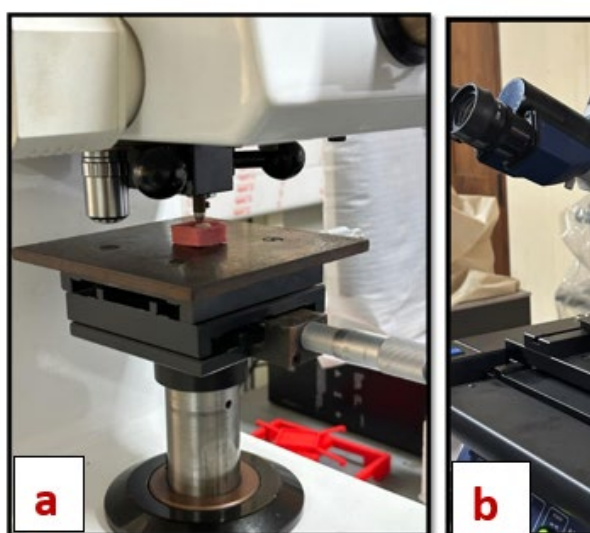


Figure 3: a. Specimens subjected to Vickers hardness tester, b. Indentations viewed under digital microscopy

Statistical Analysis

The data obtained were compiled and statistically analysed using one-way ANOVA followed by post hoc Tukey's test to determine significant differences among the groups. A p-value of <0.05 was considered statistically significant.

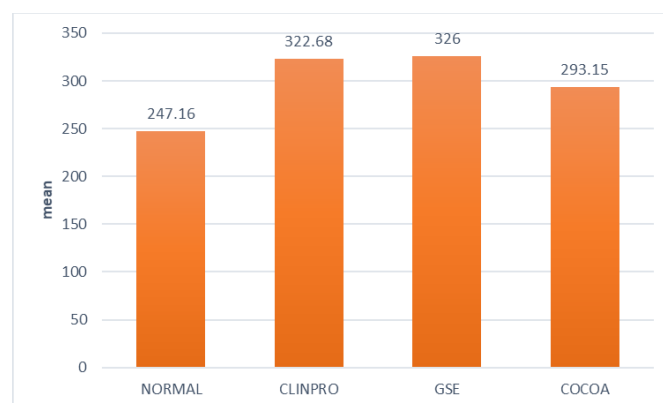
Results

Group 2 (Clinpro™) showed the highest surface microhardness, followed closely by

Group 3 (GSE), with no statistically significant difference between them. Group 4 (Cocoa extract) also demonstrated an increase in enamel hardness, but less than the other treatment groups. The negative control group showed minimal change, confirming effective demineralization. (Table1 & Graph 1).

GROUPS	MEAN	STD. DEVIATION
1. DEMINERALIZED TOOTH (NEGATIVE CONTROL)	247.16	24.52
2. CLINPRO PASTE (POSITIVE CONTROL)	322.68	24.89
3. GRAPE SEED EXTRACT	326.00	24.06
4. COCOA EXTRACT	293.15	28.87

Table 1: Comparison of Mean Surface Microhardness Values (VHN) and Standard Deviation Among Experimental Groups



Graph 1: Bar Graph Showing Mean Surface Microhardness Values (VHN) of Enamel Across Different Experimental Groups



Discussion

Dental caries and erosion begin with the demineralization of enamel, resulting in the loss of calcium and phosphate from hydroxyapatite crystals. Timely remineralization is essential to prevent lesion progression. While fluoride has been the cornerstone of remineralization therapies, growing concerns about its potential adverse effects, especially fluorosis in children, have prompted the exploration of natural, biocompatible agents as safer alternative.¹⁰ Thus, this study was undertaken to assess and compare the remineralization potential of grape seed extract (GSE) and cocoa extract, two naturally derived substances with reported bioactivity in hard tissue regeneration.

The use of Vickers surface microhardness testing is a widely accepted and reliable method to assess changes in enamel structure following demineralization and remineralization, providing objective and reproducible data on surface mechanical properties.¹¹

The enamel surface of each specimen was standardized by flattening the buccal surface with abrasive papers before demineralization, ensuring uniform exposure to the treatment agents. Decoronation and mounting on acrylic blocks allowed for easy handling, uniform loading during microhardness testing, and consistent orientation of samples. The enamel was then subjected to controlled demineralization using lactic acid, which mimics the acidic challenges found in early caries development.¹²

The study findings revealed that Clinpro™, a fluoride-based remineralising agent,

produced the highest increase in microhardness values. This is consistent with literature demonstrating the efficacy of fluoride in promoting remineralization and forming fluorapatite, which is more resistant to acid dissolution than hydroxyapatite.¹³

However, the standout result was the performance of grape seed extract, which showed remineralization potential comparable to Clinpro™. This suggests that proanthocyanidins, the active polyphenols in GSE, not only support mineral uptake but also stabilize collagen and dentin matrices, playing a significant role in enamel repair.¹⁴

Cocoa extract, containing theobromine, also exhibited a significant increase in enamel hardness, albeit less than that observed with GSE. Theobromine enhances the crystallinity of enamel by encouraging the formation of larger hydroxyapatite crystals, thus improving resistance to acid challenges. Previous studies have indicated that theobromine-based dentifrices can improve enamel surface strength and act as a non-toxic alternative to fluoride, especially in pediatric populations.¹⁵

This study provides compelling evidence for the potential application of GSE and cocoa extract in preventive dentistry, especially as alternatives for fluoride-sensitive individuals. The use of natural extracts with additional antioxidant, antimicrobial, and anti-inflammatory properties may offer holistic benefits in managing early enamel lesions.¹⁶

Conclusion

Within the limitations of this in vitro study, it can be concluded that both grape seed extract (GSE) and cocoa extract exhibit the ability to remineralise demineralized



enamel surfaces, as evidenced by increased surface microhardness values. Among the two, grape seed extract demonstrated a remineralization potential comparable to that of fluoride-based Clinpro™ paste, indicating its promise as a natural and effective alternative to conventional agents.

Cocoa extract, while less effective than GSE and Clinpro™, still showed a measurable improvement in enamel hardness, suggesting its potential as a mild remineralising agent with additional benefits like safety and biocompatibility.

References

1. Featherstone JD. Dental caries: a dynamic disease process. Aust Dent J. 2008 Sep;53(3):286-91.
2. ten Cate JM. Remineralization of caries lesions extending into dentin. J Dent Res. 2001 May;80(5):1407-11.
3. Buzalaf MAR, Levy SM. Fluoride intake of children: considerations for dental caries and dental fluorosis. Monogr Oral Sci. 2011; 22:1-19.
4. Das G, Tirth V, Arora S, Algahtani A, Kafeel M, Alqarni AHG, Saluja P, Vij H, Bavabeedu SS, Tirth A. Effect of Fluoride Concentration in Drinking Water on Dental Fluorosis in Southwest Saudi Arabia. Int J Environ Res Public Health. 2020 Jun 1;17(11):3914.
5. Dewhirst FE, Chen T, Izard J, Paster BJ, Tanner AC, Yu WH, Lakshmanan A, Wade WG. The human oral microbiome. J Bacteriol. 2010 Oct;192(19):5002-17.
6. Liu Y, Dusevich V, Wang Y. Proanthocyanidins rapidly stabilize the demineralized dentin layer. J Dent Res. 2013 Aug;92(8):746-52.
7. Jawale KD, Kamat SB, Patil JA, Nanjannawar GS, Chopade RV. Grape seed extract: An innovation in remineralization. J Conserv Dent. 2017 Nov-Dec;20(6):415-418.
8. Kargul B, Özcan M, Peker S, Nakamoto T, Simmons WB, Falster AU. Evaluation of human enamel surfaces treated with theobromine: a pilot study. Oral Health Prev Dent. 2012;10(3):275-82.
9. Amaechi BT, Porteous N, Ramalingam K, Mensinkai PK, Ccahuana Vasquez RA, Sadeghpour A, Nakamoto T. Remineralization of artificial enamel lesions by theobromine. Caries Res. 2013;47(5):399-405.
10. Hegde MN, Moany A. Remineralization of enamel subsurface lesions with casein phosphopeptide-amorphous calcium phosphate: A quantitative energy dispersive X-ray analysis using scanning electron microscopy: An in vitro study. J Conserv Dent. 2012 Jan;15(1):61-7.
11. Prabhakar AR, Paul M J, Basappa N. Comparative Evaluation of the Remineralizing Effects and Surface Micro hardness of Glass Ionomer Cements Containing Bioactive Glass (S53P4): An in vitro Study. Int J Clin Pediatr Dent. 2010 May-Aug;3(2):69-77.
12. Neelakantan P, John S, Anand S, Sureshbabu N, Subbarao C. Fluoride release from a new glass-ionomer cement. Oper Dent. 2011 Jan-Feb;36(1):80-5.



13. Karlinsey RL, Mackey AC, Stookey GK, Pfarrer AM. In vitro assessments of experimental NaF dentifrices containing a prospective calcium phosphate technology. Am J Dent. 2009 Jun;22(3):180-4.
14. Ravi PV, Sekar R, Ramar K. Evaluation of Remineralization Potential of Natural Substances on Artificially Induced Carious Lesions in Primary Teeth: An *In Vitro* Study. Int J Clin Pediatr Dent. 2023 Mar-Apr;16(2):244-250.
15. Durhan MA, Ozsalih S, Gokkaya B, Kulan PY, Kargul B. Caries Preventive Effects of Theobromine Containing Toothpaste on Early Childhood Caries: Preliminary Results. Acta Stomatol Croat. 2021 Mar;55(1):18-27.
16. Manso T, Lores M, de Miguel T. Antimicrobial Activity of Polyphenols and Natural Polyphenolic Extracts on Clinical Isolates. Antibiotics (Basel). 2021 Dec 30;11(1):46



Original article

EFFECT OF THREE DIFFERENT ANTIOXIDANTS ON THE SHEAR BOND STRENGTH OF COMPOSITE RESIN TO BLEACHED ENAMEL: AN INVITRO STUDY

*Rishana P, **Elsy P. Simon, ***Ravi SV, ****Chandini Raveendran, *****Kavya Belaram

Abstract

Introduction: Dental bleaching using agents such as hydrogen peroxide and carbamide peroxide is a widely accepted esthetic procedure for treating intrinsic and extrinsic discoloration. However, bleaching significantly reduces the shear bond strength (SBS) of composite resin to enamel due to residual oxygen that interferes with resin polymerization and bonding mechanisms. Antioxidants can neutralize residual oxygen, restore redox potential, and improve composite bonding to bleached enamel. Common natural antioxidants include sodium ascorbate, grape seed extract (GSE), and green tea extract. These agents possess anti-inflammatory, antimicrobial, and free-radical scavenging properties that may counteract bleaching-induced bond degradation. This study investigates the efficacy of three such antioxidants in improving SBS following bleaching.

Aim & Objective: The present in vitro study aimed to evaluate and compare the effect of three antioxidant agents—10% sodium ascorbate, 10% grape seed extract (GSE), and 10% green tea extract—on the shear bond strength (SBS) of composite resin to bleached enamel.

Materials and Methods: Twenty-four extracted human premolars were decoronated at the cemento-enamel junction and embedded in acrylic resin with the labial surface exposed. All specimens were bleached using 35% hydrogen peroxide and divided into four groups (n=6): Group 1 (Control, no antioxidant), Group 2 (10% sodium ascorbate), Group 3 (10% GSE), and Group 4 (10% green tea extract). After treatment, specimens were restored using composite resin and subjected to SBS testing.

Results: All antioxidant-treated groups demonstrated significantly higher bond strength than the control group ($p < 0.001$). Green tea extract exhibited the highest mean SBS (10.41 MPa), followed by GSE (9.54 MPa), and sodium ascorbate (8.3 MPa).

Conclusion: The application of antioxidants effectively reversed the reduction in bond strength associated with dental bleaching. Green tea and grape seed extract showed superior performance compared to sodium ascorbate.

Keywords: Antioxidants, shear bond strength, dental bleaching.

Corresponding Author: Dr Rishana P (rishanap497@gmail.com)



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

Introduction:

Dental bleaching has emerged as a cornerstone in modern aesthetic dentistry, offering patients a conservative, non-invasive, and cost-effective approach to improving dental appearance. It is commonly employed to manage both intrinsic discolorations—resulting from systemic conditions, aging, or trauma—and extrinsic stains caused by dietary factors, smoking, or poor oral hygiene. The most frequently used bleaching agents include hydrogen peroxide (H₂O₂) and carbamide peroxide, which decompose into water and nascent oxygen, releasing reactive oxygen species (ROS) such as hydroxyl radicals and per hydroxyl ions. These ROS are capable of breaking down complex pigmented organic molecules (chromophores) embedded within the enamel and dentin matrix, thereby restoring natural tooth color.^{1,2}

Despite the popularity and effectiveness of these bleaching systems, a major drawback is the adverse impact on enamel properties—particularly its surface

morphology, microhardness, and bonding capability. The shear bond strength (SBS) of composite resin to enamel is significantly reduced when adhesive restorations are performed immediately after bleaching procedures. This is attributed to the residual oxygen and peroxide byproducts retained within the interprismatic enamel and dentinal tubules, which inhibit the free-radical polymerization of methacrylate-based dental resins.^{3,4} This oxygen-inhibition layer compromises the hybrid layer formation, resulting in weak resin–enamel bonding, increased microleakage, and ultimately, restoration failure.⁵ To address this clinical dilemma, antioxidant therapy has been proposed as a viable adjunct to neutralize the oxidative stress induced by bleaching. Antioxidants are substances capable of donating electrons to free radicals, thus stabilizing them and preventing further molecular damage. When applied topically to the bleached tooth surface, antioxidants scavenge residual ROS and restore the oxidation-reduction balance, allowing proper



polymerization of resin materials and thereby enhancing bond strength.

Among the antioxidants studied in dentistry, sodium ascorbate, a water-soluble salt of ascorbic acid with a neutral pH, has demonstrated significant efficacy. It acts by converting residual peroxide molecules into water and oxygen, reversing the redox changes in the enamel substrate and improving composite bonding.⁶

Grape seed extract (GSE), a natural product derived from *Vitis vinifera*, is rich in oligomeric proanthocyanidins (OPCs)—a class of potent polyphenolic bioflavonoids. OPCs exhibit antioxidant activity 20–50 times greater than vitamin C or E, in addition to anti-inflammatory, antimicrobial, and collagen cross-linking properties, making GSE highly beneficial for enhancing the durability of adhesive interfaces.^{7,8} Green tea extract, obtained from *Camellia sinensis*, contains high levels of catechins, particularly

epigallocatechin gallate (EGCG), which possess strong antioxidative potential. Recent studies have shown that green tea extract not only neutralizes free radicals effectively but also offers antibacterial effects against oral pathogens and promotes collagen stability, making it a promising agent in restorative dentistry.^{9,10}

In light of the increasing use of bleaching procedures followed by resin-based restorations in everyday dental practice, it becomes crucial to explore effective strategies to mitigate the adverse effects of bleaching on bond strength. This in vitro study was designed to assess and compare the efficacy of three different antioxidant agents—10% sodium ascorbate, 10% grape seed extract, and 10% green tea extract—in reversing the compromised SBS of composite resin to enamel surfaces treated with 35% hydrogen peroxide bleaching agent.

Materials and Methods

Sample Preparation

This in vitro study utilized twenty-four sounds, extracted human premolars that had been removed for orthodontic or periodontal reasons. Teeth with visible cracks, caries, restorations, or developmental anomalies were excluded from the study. The selected teeth were

thoroughly cleaned of soft tissue debris and calculus using an ultrasonic scaler and were then stored in 0.1% thymol solution at room temperature to prevent microbial growth until use.

Each tooth was decoronated at the cemento-enamel junction (CEJ) using a diamond disc to obtain standardized crown segments. The crown sections were

embedded in self-cure acrylic resin blocks using cylindrical plastic moulds (2 cm diameter × 2 cm height), with the labial enamel surface oriented perpendicular to the base and exposed for bonding procedures (Fig 1). The exposed enamel surfaces were flattened using 600-grit silicon carbide paper under water to create a standardized flat bonding surface and to remove surface irregularities.

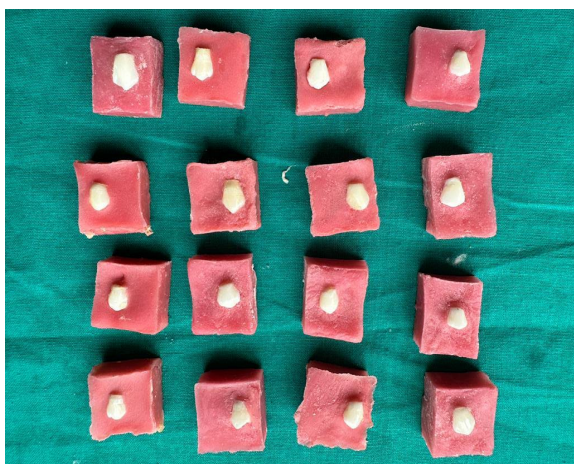


Fig 1: Samples decoronated at CEJ and embedded in acrylic resin moulds, labial surface facing upwards

Bleaching Protocol

All specimens were subjected to bleaching using 35% hydrogen peroxide gel (commercially available in-office bleaching agent). The bleaching agent was applied to the enamel surface using a microbrush and left undisturbed for 15 minutes, consistent with manufacturer instructions and clinical protocols (Fig 2a). After the bleaching period, the teeth were thoroughly rinsed with distilled water for 30 seconds to remove residual peroxide and then stored in deionized water at 37°C for 30 minutes to simulate the oral environment before antioxidant treatment.

Following bleaching, the specimens were randomly divided into four groups (n = 6):

- Group 1 (Control): No antioxidant treatment
- Group 2: Treated with 10% Sodium Ascorbate solution
- Group 3: Treated with 10% Grape Seed Extract (GSE) solution
- Group 4: Treated with 10% Green Tea Extract (GTE) solution

For the antioxidant treatment, each group was treated with the respective antioxidant solution using a saturated cotton pellet applied to the enamel surface for 10

minutes (Fig 2b). During application, cotton was replenished every 2 minutes to maintain efficacy. After the treatment period, each specimen was rinsed thoroughly with distilled water for 30 seconds to remove any residue, and then gently air-dried.

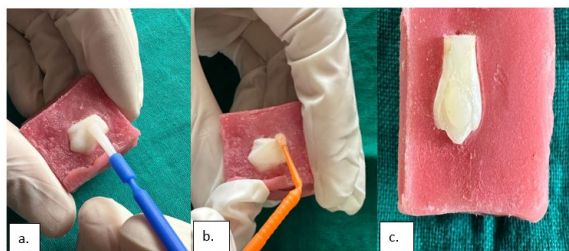


Fig 2: a. Application of bleaching agent to the enamel surface using a microbrush, b. Application of antioxidants, c. Composite resin placement.

All antioxidant solutions were freshly prepared prior to application:

- 10% Sodium Ascorbate was prepared by dissolving 10 g of sodium ascorbate powder in 100 mL of distilled water.
- 10% Grape Seed Extract was similarly prepared using standardized pharmaceutical-grade GSE powder.
- 10% Green Tea Extract was prepared using green tea polyphenol powder standardized to catechin content.

After antioxidant application, all specimens were etched with 37% phosphoric acid gel for 15 seconds, rinsed with water for 10 seconds, and gently air-dried. A universal adhesive system was applied according to manufacturer instructions using a micro brush and light-cured for 20 seconds with a LED curing unit (light intensity ≥ 1000 mW/cm²). Composite resin cylinders were fabricated by placing a Teflon mould (3 mm in diameter and 2 mm in height) on the treated enamel surface and incrementally filling it with nanohybrid composite resin (Fig 2c). Each increment was light-cured for 20 seconds. After mould removal, the composite build-ups were further cured from multiple directions to ensure complete polymerization. All samples were stored in deionized water at 37°C for 24 hours prior to testing to simulate intraoral conditions.

Shear Bond Strength (SBS) Testing

Shear bond strength was evaluated using a universal testing machine. Each sample was mounted in the machine such that a chisel-edge blade was aligned at the adhesive interface between the composite and enamel surface (figure 3). Load was applied at a crosshead speed of 1 mm/min until bond failure occurred. The maximum load at failure was recorded in Newtons (N), and SBS was calculated in Megapascals (MPa) using the formula:

$$\text{SBS (MPa)} = \frac{\text{Load at failure (N)}}{\text{Bonding area (mm}^2\text{)}}$$

where bonding area was taken as the cross-sectional area of the composite cylinder (πr^2).

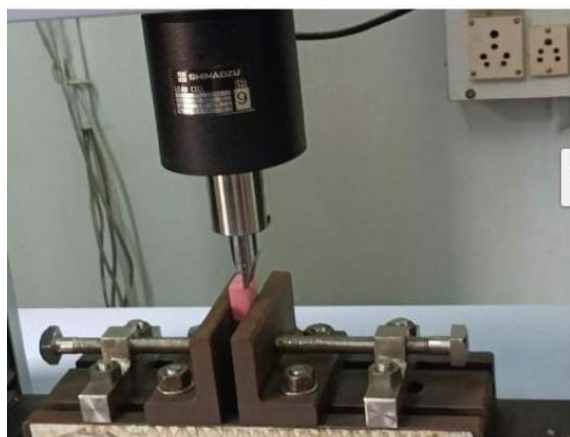


Fig 3: Shear bond strength test using UTM

Statistical Analysis

The obtained SBS values were subjected to statistical analysis using SPSS software (version 25.0). Descriptive statistics including mean and standard deviation were calculated for each group. Intergroup differences were analysed using one-way Analysis of Variance (ANOVA) followed by post hoc Tukey's HSD test for pairwise comparisons. A p -value < 0.05 was considered statistically significant.

Results

The results of this in vitro study demonstrated a clear positive effect of antioxidant treatment on the shear bond strength (SBS) of composite resin to bleached enamel. The mean SBS values (measured in Megapascals, MPa) for each group are summarized (Table 1).

Groups	Mean	Std. Deviation	95% Confidence Interval for Mean		P Value
			Lower Bound	Upper Bound	
Control	4.75	0.65	4.06	5.44	<0.001*
10% Sodium Ascorbate	8.3	0.23	8.06	8.55	
10% Grape Seed Extract	9.54	0.37	9.15	9.93	
10% Green Tea Extract	10.41	0.78	9.59	11.23	

Table 1; Mean shear bond strength of the groups.

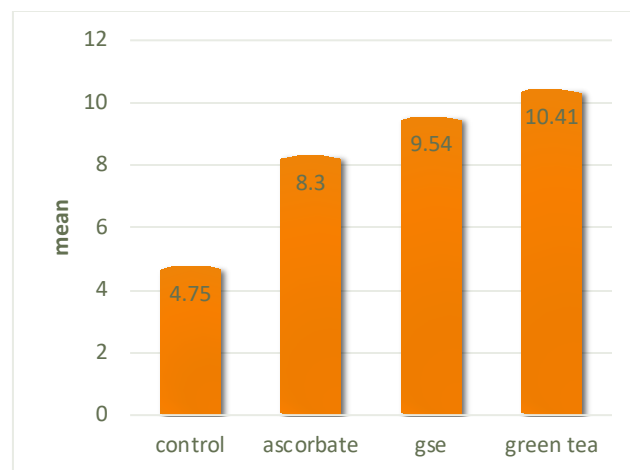
One-way Analysis of Variance (ANOVA) was performed to evaluate differences among the four groups. The test yielded a p -value < 0.001 , indicating that the differences in mean SBS values were statistically significant across the groups. To further identify specific intergroup differences, post hoc Tukey's Honest Significant Difference (HSD) test was applied:

- All antioxidant-treated groups (Groups 2–4) showed significantly higher SBS than the control group ($p < 0.001$).



- Green tea extract (Group 4) showed a significantly higher SBS compared to sodium ascorbate (Group 2) ($p < 0.01$).
- Although GSE (Group 3) showed a slightly lower SBS than GTE, the difference was not statistically significant ($p > 0.05$), suggesting comparable efficacy between GSE and GTE.
- Sodium ascorbate, while effective, yielded a significantly lower SBS than both GSE and GTE ($p < 0.01$).

The lowest mean SBS was observed in the control group (4.75 ± 0.65 MPa), reaffirming that bleaching without subsequent antioxidant treatment compromises bonding effectiveness due to residual oxygen inhibiting polymerization. Conversely, green tea extract produced the highest SBS (10.41 ± 0.78 MPa), indicating its superior ability to restore and even enhance bonding potential following bleaching. The standard deviations were relatively low across all groups, indicating consistency and reliability in the experimental measurements. (Graph 1)



Graph 1: Bar graph indicating that the differences in mean SBS values were statistically significant across the groups

Discussion

The findings of the present in vitro study provide compelling evidence that the application of antioxidants following dental bleaching can effectively reverse the reduction in shear bond strength (SBS) of composite resin to enamel. All three antioxidant groups—sodium ascorbate, grape seed extract (GSE), and green tea extract (GTE)—demonstrated significantly higher SBS values compared to the control group. This underscores the detrimental effect of residual oxidizing agents on the bonding process and the restorative potential of antioxidants. The control group, which received no antioxidant treatment post-bleaching, showed the lowest SBS value (4.75 ± 0.65 MPa). This is consistent with existing literature that demonstrates how residual oxygen and



peroxide byproducts interfere with the free-radical polymerization of adhesive resins, leading to compromised adhesion.^{3,5} The presence of this residual oxygen layer prevents optimal resin infiltration into enamel microporosities and can terminate the polymerization reaction prematurely, resulting in weakened bonding.^{4,6} Among the antioxidant groups, green tea extract yielded the highest mean SBS (10.41 ± 0.78 MPa), indicating its superior ability to counteract the oxidative effects of bleaching. Green tea is rich in catechins, particularly epigallocatechin gallate (EGCG), which exhibit strong antioxidant, anti-inflammatory, and antibacterial properties.^{9,10} These polyphenolic compounds effectively neutralize reactive oxygen species, restore the redox potential of the enamel surface, and enhance the hybrid layer formation during adhesive procedures.

Grape seed extract demonstrated the second-highest SBS value (9.54 ± 0.37 MPa), also significantly higher than the control and sodium ascorbate groups. The primary active components in GSE are oligomeric proanthocyanidins (OPCs), which have been reported to possess 20–50 times greater antioxidant potency than vitamins C and E.^{7,8} These compounds are capable of scavenging free radicals and stabilizing the oxidized enamel surface,

facilitating effective resin penetration and polymerization. Additionally, GSE is known for its collagen cross-linking ability, which strengthens the hybrid layer and may improve bond durability over time, though this effect is more commonly studied in dentin.¹¹ In enamel bonding, the antioxidant effect is primarily responsible for the improvement observed.

Sodium ascorbate (10%) also significantly improved the SBS (8.3 ± 0.23 MPa) compared to the control, corroborating earlier studies that established its utility as a post-bleaching antioxidant.^{2,3} As a water-soluble salt of ascorbic acid, sodium ascorbate neutralizes free radicals and restores the oxidized bonding substrate to a more favourable redox state for polymerization. However, its lower efficacy compared to GTE and GSE could be attributed to its relatively shorter half-life, lower permeability, or limited duration of action. Additionally, its lower antioxidant potential, compared to polyphenolic compounds found in GSE and GTE, may have contributed to the observed differences in bond strength recovery.

Clinical Implications

From a clinical standpoint, these findings advocate for the immediate application of antioxidant agents following in-office bleaching procedures when composite



restorations are planned. Delaying restorative procedures for 24–48 hours, as traditionally recommended, may be impractical in some clinical scenarios. Thus, antioxidant pre-treatment can serve as a reliable chairside solution to restore bonding efficacy. Importantly, natural antioxidants like GSE and GTE not only outperform synthetic agents in terms of antioxidative power but also offer additional therapeutic benefits, including antimicrobial activity, biocompatibility, and reduced cytotoxicity, which enhance their clinical appeal.^{7,11}

References

1. Joiner A. The bleaching of teeth: A review of the literature. *J Dent.* 2006;34(7):412–419. <https://doi.org/10.1016/j.jdent.2006.02.002>
2. Goldstein RE, Garber DA. Complete Dental Bleaching. Chicago: Quintessence Publishing Co; 1995.
3. Tezel H, Kemaloglu H. Susceptibility of enamel treated with bleaching agents to mineral loss after cariogenic challenge. In: Ming-yu Li, ed. *Contemporary Approach to Dental Caries*. Shanghai: InTech; 2012:75–92.
4. Kimyai S, Valizadeh H. The effect of hydrogel and solution of sodium ascorbate on bond strength in bleached enamel. *Oper Dent.* 2006;31(4):496–499.
5. Dabas D, Patil AC, Uppin VM. Evaluation of the effect of concentration and duration of application of sodium ascorbate hydrogel on the bond strength of composite resin to bleached enamel. *J Conserv Dent.* 2011;14(4):356–360.
6. Torres CR, Koga AF, Borges AB. The effects of antioxidant agents on bond strength of composites to bleached enamel. *J Esthet Restor Dent.* 2006;18(2):119–124.
7. Leigh JM. Health benefits of grape seed proanthocyanidin extract (GSPE). *Nutr Noteworthy.* 2003;6:1–5.
8. Perumalla AVS, Hettiarachchy NS. Green tea and grape seed extracts—Potential applications in food safety and quality. *Food Res Int.* 2011;44(4):827–839.
9. Mallepally JP, Aileni KR, Sugavasi GD, et al. Effect of grape seed and green tea on shear bond strength of brackets bonded to bleached enamel with and without Lase Peroxide Lite: An in vitro study. *J Orthod Sci.* 2022;11.
10. Badr YA, Ibrahim MA. Protective effect of green tea on the bonding of composite resin to bleached enamel. *Aust J Basic Appl Sci.* 2010;4(6):1448–1456.
11. Epasinghe DJ, Yiu CKY, Burrow MF, Tay FR. Effect of proanthocyanidin incorporation into dental adhesive on resin-dentin bond strength. *J Dent.* 2015;43(2):177–184.



Original article

COMPARATIVE EVALUATION OF EFFECT OF CONDITIONING AGENTS ON THE SHEAR BOND STRENGTH OF GLASS IONOMER CEMENT- AN INVITRO STUDY

*Sneha Chandran, **Chandini Raveendran, ***Elsy P Simon, ****Rohit Mathew, ****Nimmy Kurian.

Abstract

Background:

Adhesion between restorative materials and tooth structure plays a vital role in the clinical success of restorations. The presence of the smear layer on prepared dentin surfaces can compromise bonding. Surface conditioning agents are used to enhance bonding by modifying or removing the smear layer.

Aim:

To compare and evaluate the effect of different conditioning agents—10% polyacrylic acid, grape seed extract, and apple cider vinegar—on the shear bond strength of conventional glass ionomer cement (GIC).

Materials and Methods:

Twenty-four extracted human premolars were decoronated to expose flat dentin surfaces and were randomly assigned into four groups based on the conditioning agent used. Group 1: 10% polyacrylic acid, Group 2: No conditioning (control), Group 3: grape seed extract, and Group 4: apple cider vinegar. Conditioners were applied for 20 seconds and rinsed. GIC was placed and allowed to set. Shear bond strength was measured using a universal testing machine at 0.5 mm/min crosshead speed.

Results:

Statistical analysis ($p < 0.001$) showed that surface conditioning significantly improved bond strength. 10% polyacrylic acid demonstrated the highest bond strength, followed by grape seed extract. Apple cider vinegar showed the least improvement, while the unconditioned group had the lowest bond strength overall.

Conclusion:

Surface conditioning of dentin significantly enhances the shear bond strength of GIC. 10% polyacrylic acid remains the gold standard; however, grape seed extract offers a promising biocompatible alternative. Apple cider vinegar, while natural and biocompatible, showed lower efficacy and may require further investigation before clinical recommendation.



Keywords:

Shear bond strength, glass ionomer cement, grape seed extract, apple cider vinegar, polyacrylic acid, smear layer

Corresponding Author: Dr Sneha Chandran (snehachandran01@gmail.com)

** Post graduate student, **Associate Professor, ***Professor and Head, ****Assistant Professor,*

Department of Conservative Dentistry and Endodontics, KMCT Dental College, Kozhikode, Kerala.

Introduction

Bond strength between a restorative material and tooth structure is essential for the longevity and success of restorations. One of the primary challenges to achieving effective adhesion is the presence of a smear layer—a layer of debris composed of hydroxyapatite, collagen, and pulp tissue residues that forms during tooth preparation.¹ This smear layer obstructs dentinal tubules and compromises the micromechanical and chemical bonding of glass ionomer cement (GIC). To enhance bonding, various dentin conditioning agents are used to alter or remove the smear layer before the application of GIC. Traditionally, 10% polyacrylic acid has been widely used due to its ability to partially demineralize dentin and remove

loosely bound smear layer without excessively opening the dentinal tubules.²

In recent years, natural conditioning agents like grape seed extract and apple cider vinegar have gained attention due to their antimicrobial, antioxidant, and biocompatible properties.^{3,4} Grape seed extract contains proanthocyanidins, which stabilize collagen by promoting cross-linking, potentially enhancing the bonding substrate.⁵ Apple cider vinegar acts as a natural chelating agent and has demonstrated smear layer removal efficacy in some studies.⁶ This study was designed to compare the effect of three different conditioning agents—10% polyacrylic acid, grape seed extract, and apple cider vinegar—on the shear bond strength of GIC and evaluate their potential as effective dentin conditioners.

surfaces. Teeth were embedded in acrylic resin blocks for ease of handling during testing.

Materials and Methods

Sample Selection and Preparation

Twenty-four freshly extracted, non-carious human premolars were selected. The crowns were decoronated using a diamond disc to expose flat mid-coronal dentin

Grouping

Samples were randomly divided into four groups (n=6 each):

- **Group 1:** 10% Polyacrylic Acid(micron)
- **Group 2:** No Conditioner (Negative Control)
- **Group 3:** Grape Seed Extract
- **Group 4:** Apple Cider Vinegar

Conditioning Protocol

Each conditioning agent was applied to the dentin surface with a microbrush and left undisturbed for 20 seconds, followed by thorough rinsing with distilled water using a three-way syringe. Group 2 received no conditioning treatment.

Glass ionomer cement (Ketac Molar) was mixed according to manufacturer's instructions and condensed into a standard mold in contact with the treated dentin surface. After setting, the samples were stored in distilled water at 37°C for 24 hours before testing.

Shear Bond Strength Testing

Bond strength was tested using a universal testing machine (UTM) at a crosshead speed of 0.5 mm/min (figure 1). A chisel-edge blade was applied parallel to the bonded interface until failure. Shear bond strength values were recorded in Megapascal (MPa).

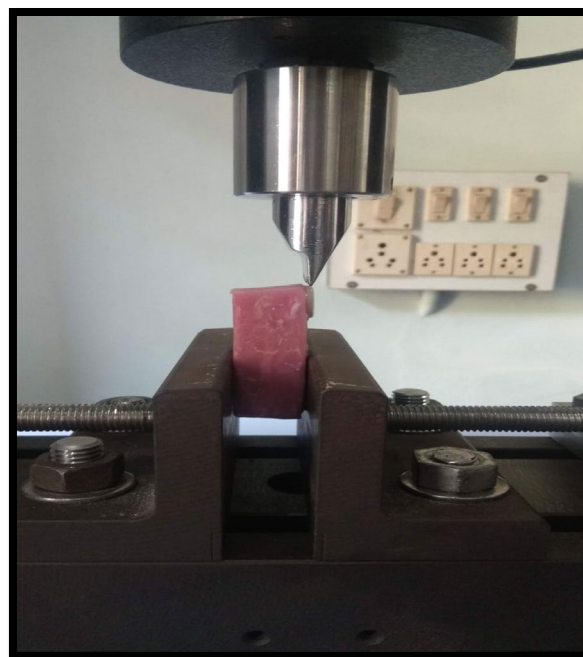


Fig 1: Specimen in universal testing machine

Statistical Analysis

Data were analysed using ANOVA and post hoc Tukey tests. A p-value of <0.05 was considered statistically significant.

Results

The shear bond strength values (mean $\pm$ SD) for each group were as follows:

- Group 1 (Polyacrylic Acid): Highest bond strength
- Group 3 (Grape Seed Extract): Slightly lower than Group 1 but significantly higher than Group 2
- Group 4 (Apple Cider Vinegar): Lower bond strength than Group 3
- Group 2 (Control): Lowest bond strength

Statistical analysis revealed a highly significant difference ($p < 0.001$) among all groups. Group 1 outperformed all other



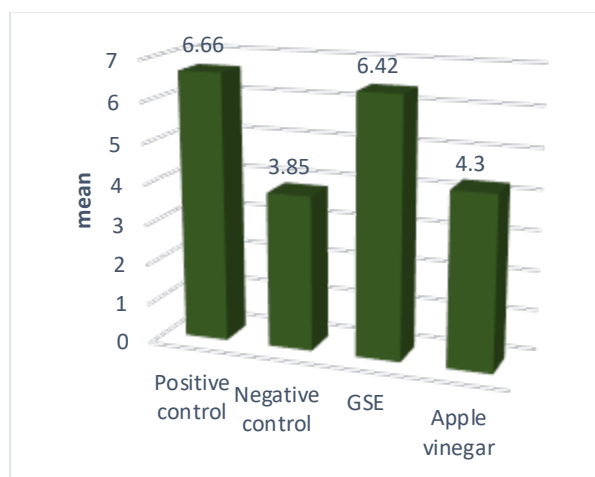
groups, with grape seed extract showing comparable performance and apple cider vinegar showing limited effectiveness (table 1, graph 1).

Graph 1: Comparison of shear bond strength between groups.

Groups	Mean	Std. Deviation	95% Confidence Interval for Mean		P value
			Lower Bound	Upper Bound	
Positive control	6.6 ^{ab}	0.31	6.34	6.99	<0.001*
Negative control	3.8 ^{acd}	0.41	3.41	4.28	
GSE	6.4 ^{ce}	0.25	6.15	6.70	
Apple vinegar	4.3 ^{bde}	0.14	4.15	4.45	

Table 1: Comparison of shear bond strength between groups.

One way ANOVA: * statistically significant; #same alphabets indicate significant difference using LSD post hoc test



Discussion

Bonding restorative materials to dentin is a complex process influenced by the condition of the dentin surface and the properties of the bonding agents and materials used. One of the primary impediments to effective adhesion is the presence of the smear layer, which forms during cavity preparation and consists of organic and inorganic debris, including hydroxyapatite, collagen, pulp remnants, and bacteria.¹ The smear layer not only obstructs the dentinal tubules but also interferes with the penetration of restorative materials, compromising both micromechanical interlocking and chemical bonding.

In recent years, there has been a growing interest in the use of natural agents as dentin conditioning agents due to increasing concerns regarding the cytotoxicity, environmental impact, and long-term safety of conventional synthetic chemicals. Traditional conditioners like polyacrylic acid and EDTA, while effective at smear layer removal, can sometimes cause excessive demineralization, collagen network disruption, or adverse pulpal responses, especially in deep cavities.⁷ To overcome these limitations, researchers have turned to plant-derived bioactive compounds that offer biocompatibility, sustainability, and additional therapeutic benefits. Natural agents such as grape seed extract (GSE) and apple cider vinegar (ACV) have shown promising results in modifying or partially removing the smear



layer while promoting collagen stability and antimicrobial action, which are beneficial for bonding and pulpal health.⁸ The current study aimed to evaluate and compare the effect of different dentin conditioning agents—10% polyacrylic acid, grape seed extract, and apple cider vinegar—on the shear bond strength of GIC. The results clearly indicate that surface conditioning significantly enhances bond strength compared to unconditioned dentin surfaces ($p < 0.001$). Among the tested agents, 10% polyacrylic acid showed the highest bond strength, closely followed by grape seed extract, while apple cider vinegar resulted in the lowest among the conditioned groups.

Effect of 10% Polyacrylic Acid

10% polyacrylic acid is the conventional and most widely used conditioning agent in conjunction with GIC. It has been shown to partially remove the smear layer, clean the dentin surface, and modify the surface energy without causing excessive demineralization or tubular opening.⁹ This partial removal enhances the chemical interaction between the carboxylic groups in the GIC and the calcium ions in hydroxyapatite, a mechanism known as chelation bonding.¹⁰

Rai et al. (2017) demonstrated that conditioning with 10% polyacrylic acid significantly improves bond strength when compared to unconditioned surfaces and natural alternatives.² The results of the present study are consistent with these findings and confirm the efficacy of polyacrylic acid in preparing dentin surfaces for optimal GIC adhesion.

Effect of Grape Seed Extract

Grape seed extract (GSE), rich in proanthocyanidins, has emerged as a promising biocompatible alternative for dentin conditioning. Proanthocyanidins have been shown to induce collagen cross-linking, increase dentin matrix stiffness, and inhibit matrix metalloproteinases (MMPs), which are responsible for collagen degradation.¹¹ By stabilizing the collagen matrix, GSE enhances the structural integrity of the demineralized dentin and potentially improves the interface with restorative materials.

Studies by Aref and Abdallah (2021) and Cai et al. (2021) demonstrated that grape seed extract can improve the mechanical properties and long-term durability of GIC-dentin bonds, supporting its use as a dentin biomodifier and conditioner.⁵ In the current study, GSE showed a shear bond strength that was slightly lower than polyacrylic acid but significantly higher than the unconditioned group, suggesting it may be used as an effective natural alternative, particularly for patients requiring biomimetic or minimally invasive options.

Effect of Apple Cider Vinegar

Apple cider vinegar (ACV), a natural product with mild acidity, contains acetic acid, known for its chelating and antimicrobial properties. In endodontics and restorative dentistry, it has been explored as a natural etchant or irrigant capable of removing the smear layer. However, its relatively low pH (~3–3.5) and weak buffering capacity may result in inadequate smear layer removal or inconsistent dentin surface modification compared to established agents like polyacrylic acid.

In the present study, ACV resulted in the lowest bond strength among the



conditioned groups, indicating that while it may possess some smear layer removal potential, it does not sufficiently enhance the bonding substrate for GIC. DeShmukh et al. (2022) also noted that although ACV has some chelating ability, its efficacy is limited and not comparable to standard chemical conditioners or other natural agents like citric acid or GSE.⁶

Significance of Conditioning

Surface conditioning is crucial because it promotes intimate contact between the restorative material and the tooth substrate, creating a more receptive surface by removing debris and enhancing wettability. The effectiveness of a conditioner depends on its pH, application time, and the degree of smear layer removal. Over-conditioning, however, can cause excessive demineralization and exposure of collagen fibrils, leading to collapse and reduced bond strength if not properly managed.¹²

The results of this study support the concept that modifying the dentin surface before GIC application significantly increases the bond strength, with the potential for natural conditioners like grape seed extract to serve as clinically viable alternatives to synthetic agents.

Conclusion

Within the limitations of this in vitro study, it can be concluded that dentin surface conditioning significantly influences the shear bond strength of glass ionomer cement (GIC). The results demonstrated that conditioning with 10% polyacrylic acid produced the highest bond strength, affirming its status as the gold standard for pre-treatment prior to GIC application. Its

ability to partially remove the smear layer and increase surface energy allows for enhanced chemical bonding between the polyacrylate chains in GIC and calcium ions in dentin.

References

1. Violich DR, Chandler NP. The smear layer in endodontics—a review. *Int Endod J*. 2010;43(1):2–15.
2. Rai N, Naik R, Gupta R, Shetty S, Singh A. Evaluating the effect of different conditioning agents on the shear bond strength of resin-modified glass ionomers. *Contemp Clin Dent*. 2017;8(4):604.
3. Aref NS, Abdallah RM. Could different formulations of grape seed (*Vitis vinifera*) influence the physical properties of conventional glass ionomer cement? *Contemp Clin Dent*. 2021;12(4):383–388.
4. Motwani NM et al. Dentinal Pre-Treatment in Restorative Dentistry. *J Clin Diagn Res*.
5. Cai J, Burrow MF, Manton DJ, Palamara JEA. Using Proanthocyanidin as a root dentin conditioner for GIC restorations. *J Dent Res*. 2021;100(10):1072–1080.
6. Deshmukh S, Devraj IM, Banerjee A. Smear Layer Removal Efficacy of Natural Root Canal Irrigants - A Literature Review. *J Clin Diagn Res*. 2022;16(9).
7. Van Meerbeek B, De Munck J, Yoshida Y, et al. Adhesion to enamel



and dentin: current status and future challenges. *Oper Dent.* 2003;28(3):215–235

8. Bedran-Russo AK, et al. Dentin biomodification: strategies, renewable resources and clinical applications. *Dent Mater.* 2014;30(1):62–76.
9. Manksar M, et al. Influence of polyacrylic acid conditioning on GIC-dentin adhesion: A scanning electron microscope study. *J Conserv Dent.* 2018;21(3):290–294.
10. Ngo HC, Mount G, McIntyre J. Chemical bonding of glass ionomer cements to dentin and enamel. *Oper Dent.* 2006;31(1):33–39.
11. Epasinghe DJ, Yiu CKY, Burrow MF, et al. Effect of proanthocyanidin incorporation into dental adhesive resin on bond strength to dentin. *J Adhes Dent.* 2012;14(5):471–478.



Review Article

DENTAL IMPLANT SURVIVAL IN MEDICALLY COMPROMISED PATIENTS

*Dr Adhila Nihal **Dr Sheejith.M ***Dr Namitha AP

Abstract

Dental implants are a scientifically validated and widely accepted treatment modality for replacing missing teeth, offering high long-term success rates due to their effectiveness, durability, and predictability. Despite these advantages, implant failures—categorized as early (during the osseointegration phase) or late (post-osseointegration)—can occur, particularly in patients with underlying systemic conditions. While implant placement is generally straightforward in healthy individuals, medically compromised patients, such as those with cardiovascular disease, diabetes mellitus, hypothyroidism, osteoporosis, and other chronic conditions, present unique challenges that can significantly influence treatment outcomes. These patients often require comprehensive preoperative assessment, tailored surgical protocols, and meticulous postoperative care to mitigate risks and enhance outcomes. This review critically examines the survival rates of dental implants in medically compromised populations, highlighting the importance of interdisciplinary collaboration and evidence-based clinical protocols to optimize implant success and ensure safe, effective care for vulnerable patient groups.

Keywords: *Medical conditions, Implant survival*

Corresponding Author: Adhila Nihal (adhi2233@gmail.com)

** Post Graduate student, ** Professor and HOD, Department of Prosthodontics and Crown & Bridge KMCT Dental College, *** Assistant Professor, Department of Prosthodontics and Crown & Bridge KMCT Dental College.*

Introduction

In recent times, dental implants have evolved as a common therapy to solve

problems related to stability and retention of dentures as well as to replace failing teeth. Although dental implants are applied in



medically compromised patients, prognosis is not predictable, it is not known if the risk of implant failure and developing peri-implantitis is increased in the presence of comorbidities, and what specific preventive measures, if any, have to be taken when placing dental implants in these patients.



Fig:1 Osseointegration of Dental implants

One of the factors for the clinical success of dental implants is osseointegration, which is a biological process consisting of the strict contact of living bone with an endosseous implant and lasts approximately 3-4 months in the mandibular arches and 4-6 months in the maxillary arches. However, several factors can influence implant placement and the osseointegration process, such as patient's overall health, oral hygiene, bone quality and quantity, the implant's design

and placement, surgical technique, and post-operative care. Most common medical conditions that pose a challenge to dental implant treatment are hypothyroidism, diabetes, mellitus, bleeding disorders, thyrotoxicosis, xerostomia, osteoporosis, cardiovascular diseases etc. Absolute contraindications for implant placement are myocardial infarction and cerebrovascular accident, cardiac transplant, immunosuppression active treatment of malignancy, drug abuse, and psychiatric disorders.¹

Cardiovascular Disease (CVD)

Patients with cardiac diseases face significant risks when undergoing dental implant therapy due to the high potential for developing infective endocarditis and other complications. Reduced blood flow from cardiovascular disorders can hinder bone healing, and chronic hypoxia can weaken the immune system, increasing infection risk.

According to American Heart association, meticulous medication management and prophylactic antibiotics are essential, along with careful monitoring of bleeding time and INR for those on anticoagulants and for patients who have prosthetic heart valves, heart transplants,



and congenital heart diseases. Antibiotics should be administered 30-60 minutes before invasive dental procedures that may include surgeries and piercing oral soft tissues. The normal INR in these kinds of patients should be 2.2 or less for surgical procedures and the normal platelet count is between 100,000 and 500,000/m³. Surgical risks such as bleeding or cardiac ischemia necessitate thorough consultation with a cardiologist before proceeding with implant surgery.²

Kaura et al. found in their clinical study that it's safe to place dental implants in patients taking single anti-platelet drugs like aspirin and clopidogrel without stopping them but when a couple of anti-platelet drugs are used, the bleeding risk would be mild to moderate.³

A review published by Aghaloo et al. showed that cardiac disease and hypertension did not adversely affect early implant failures.³ Furthermore, it appears that antihypertensive drugs, such as beta blockers or ACE inhibitors, may even positively influence the implant failure rate, as shown in reviews by Chappuis and Aghaloo.^{3,4} Antihypertensive drugs such as ARBs can significantly increase bone mineral density (BMD) by inhibiting the

activity of tartrate-resistant acid phosphatase, an enzyme responsible for bone resorption. Wu also demonstrated a lower implant failure rate in patients taking antihypertensive drugs, showing a failure rate of 0.6% in patients taking antihypertensive drugs compared with 4.1% in patients not taking such drugs.⁵

In patients with prosthetic valve replacement, stability occurs at least 6 months to 1 year after cardiac surgery compared to 3 – 4 months in normal healthy individuals. Avoidance of invasive periodontal procedures is mandatory in order to prevent bacteremia and possible subsequent valve loss.

However existing evidence regarding the effect of cardiovascular disease and its biological complications on dental implants is still debatable and inconclusive.

Diabetes Mellitus

Diabetes mellitus is a chronic metabolic disorder characterized by a high blood glucose level, either because of impaired insulin secretion or insulin resistance by the cells. Type 1 diabetes is due to a deficiency in insulin secretion because of destroyed pancreatic-producing



cells. Type 2 diabetes occurs in most cases due to insulin resistance, but impaired insulin secretion may appear with time. Prediabetes is a condition where there is an abnormal blood glucose level, where it is higher than normal but not to the level that can be diagnosed as diabetes.

The important oral manifestations and complications related to diabetes include xerostomia, dental caries, gingivitis, periodontal disease, increased tendency to oral infections, burning mouth, taste disturbance, and poor wound healing.⁶

Under stable conditions, when an implant is placed, blood clot forms and vascularizes, mesenchymal stem cells (MSCs) multiply and differentiate into osteoblasts, and bone remodeling occurs. Diabetes may alter bone cell metabolism, interfering with bone healing and reducing bone matrix strength, leading to reduced bone density and decreased bone quality, thus increasing the possibility of osteoporosis and fractures.²

It has been reported that long-term bone loss is more severe among patients with type 1 diabetes than among those with type 2 diabetes and that bone mineral density in patients with type 1 diabetes is at least 10% lower than among sex- and age-matched healthy people

When the blood sugar levels are well-controlled, implant survival is comparable to that of healthy subjects; peri-implant health is good and peri-implant bone loss is comparable to controls. In subjects with uncontrolled diabetes, the risk of developing peri-implantitis has been shown to be increased. Antibiotic prophylaxis is recommended in diabetic patients, in particular for patients with higher glycemic levels.⁷

Studies performed with untreated type 1 diabetic animal models showed evidence of lower numbers of osteoblasts, less osteoid surface, and lower plasma osteocalcin levels, consistent with decreased rates of bone formation.⁸

Glycemic Control:

Research shows that higher hemoglobin A1c (HbA1c) levels, particularly above 8%, are associated with reduced implant survival. Effective glycemic control is crucial for improving implant outcomes. Oates et al found that osseointegration during the first 4 months postoperatively was poor in people with higher HbA1c levels. Only 57.1% implants of poorly controlled diabetes mellitus returned to exceeded baseline stability level after 16



week, compared with 80% in well-controlled group.⁹

In uncontrolled diabetes mellitus, hyperglycemia reduces clot quality, number of osteoclasts, and collagen production, which are the keys of bone regeneration. In this regard, we strongly emphasize that glycemic control/maintenance plays an essential role in the overall success and survival of dental implants, and also helps to improve the quality of life for patients with diabetes.

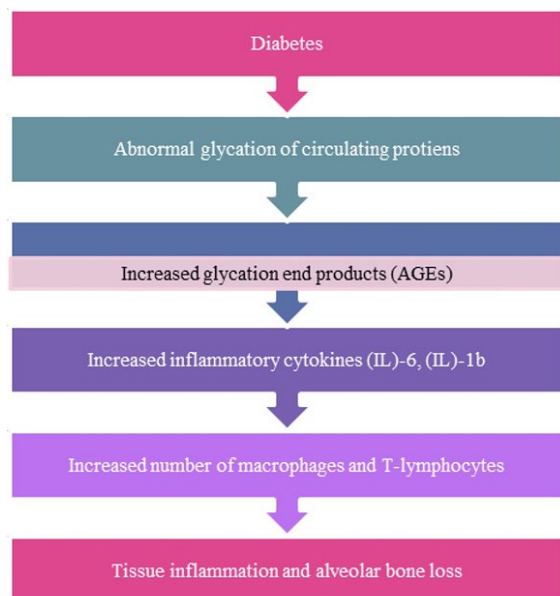


Fig 2: A possible mechanism of diabetes-related alveolar bone loss in dental implant therapy²

Hypothyroidism

Hypothyroidism is a common endocrine disorder, with an increased prevalence in women and in advanced age. Since most organs have receptors for thyroid hormone, its deficiency interferes with many of the body's metabolic processes. In addition to regulating temperature, generalized energy, metabolism, skin moisture, gastrointestinal motility, muscle metabolism, mental and memory ability, libido, and menstrual cycle, thyroid hormone affects bone metabolism. Thyroid hormone helps maintain adult bone mass and stimulates production of insulin-like growth factor-1 (IGF-1), which increases osteoblast formation and differentiation, and bone remodeling.³

For the treatment of hypothyroidism (oral) an initial dose of 1.6 mcg/kg/day levothyroxine with a 12.5 to 25 mcg/day dose adjustment every 6 to 8 weeks is needed.

Verhaeghe et al in an animal study found that long-term levo thyroxine treatment has been associated with increased risk for osteoporosis and delayed fracture recovery making the condition and its therapy a cause for concern in patients seeking dental implants.¹⁰



According to Aghaloo et al.'s study, hypothyroidism has been linked to a higher risk of fracture as well as a delayed rate of bone regeneration; however, results didn't show statistically significant variations in the rate of implant failures in hypothyroid patients compared to healthy subjects.¹¹

Osteoporosis

Osteoporosis is a metabolic bone disorder associated with an excessive decrease in bone density and impaired bone structure. The National Osteoporosis Foundation (NOF) estimates there are 9.1 million women with osteoporosis and an additional 26 million with low bone mass, which far exceeds the estimated 2.8 million men with osteoporosis and 14.4 million men with low bone mass. It is identified as a relative contraindication for dental implant therapy due to impaired quality of bone and alveolar ridge atrophy caused by osteoporosis, as the main negative side effect is the high risk of fractures. It's been strongly advised that antibiotics should be considered before the operation for patients who are taking, anti resorptive drugs, thus, more healing interval time should be given before inserting the implant prosthesis inside. There is evidence that the use of bisphosphonates (BP), especially parenteral

bisphosphonates, which are the most frequently prescribed pharmacologic agents for the treatment of osteoporosis, may accelerate the rate of failure of the osseointegration of implants.²

A problem with regard to the risks accompanying dental implant treatment are drugs used to treat osteoporosis or bone metastasis. According to Giovannacci et al. the use of antiresorptive drugs, such as bisphosphonates and denosumab, is accompanied by an increased risk of developing so-called medication-related osteonecrosis of the jaws (MRONJ), in particular when given intravenously or combined with glucocorticoids.¹² The risk of MRONJ in osteoporosis patients on low-dose bisphosphonates is estimated to be 0.7 per 100,000 per son-years of exposure, and fewer than 100 cases of MRONJ after implant therapy in this group of patients have been reported by Ata Ali et al.¹³

Surgery is not contraindicated with use of oral bisphosphonate, but the dental provider must exercise caution. In the case of IV bisphosphonates, on the other hand, elective surgery is not allowed.¹⁴

Immunocompromised patients



Studies published by Albrecht et al; Donos & Calciolari ; Korfage et al ; Kotsakis et al ; Krennmair, Seemann, & Piehslinger ; Weinlander, Krennmair, & Piehslinger, have shown that implant treatment is feasible in immunocompromised patients when proper precautions are taken, mostly being antibiotic prophylaxis.⁷

The HIV virus causes acquired immune deficiency syndrome (AIDS), which is an infectious disease caused by the HIV virus; it attacks and weakens the immune system. HIV-positive individuals have impaired bone metabolism caused by impaired calcium/vitamin D absorption, lower testosterone levels, and highly active antiretroviral therapy (HAART)

Oliveira et al showed that patients infected with HIV and on HAART do not have success and survival rates for dental implants that are very different from those who do not have this pathology or are on HAART . A recent systematic review, conducted by Ambrosio et al. pointed out that the failure of dental implants was comparable between HIV-positive patients and healthy patients.¹¹

In a clinical report by Altin et al, success of dental implants has been mentioned for patients with autoimmune diseases like

pemphigus vulgaris, as they are treated by corticosteroids, although it's believed that these drugs, in the long run, can lower immunity and affect bone healing. However, it's important to highlight that these patients should be covered by additional corticosteroids before operations like oral surgery due to their effect on the adrenal gland.¹⁵

Based on findings by Ouanounou et al 2016, on the influence of immunosuppressive drugs on bone, they should be carefully considered when it is related to the survival of implants . NSAIDs are one of the most used medications. NSAIDs such as cyclooxygenase-2 (COX-2) and selective inhibitors (selective NSAIDs) have antipyretic, analgesic, and anti-inflammatory effects, while aspirin has remarkable antiplatelet aggregating activity. Some NSAIDs, including ibuprofen and flurbiprofen, are commonly used for relieving pain after implant surgery due to their anti-inflammatory and analgesic effects. Most of the recent literature believes that the level of NSAIDs' negative impact on bone healing and osseointegration relies on how much they can inhibit cyclooxygenase enzyme activity, as this only can be done by some types of NSAIDs. A 2016 retrospective study by Winnet et al.



showed that 50% of patients treated with NSAIDs had the lowest success rates of dental implants, though it is worth saying that differences in types and number of drugs could affect these results. Furthermore, results showed that patients who received NSAIDs before implant surgery had more failures and increased bone loss around implants.¹⁶

Bleeding disorders

In patients with bleeding disorders, haemorrhage associated with implant surgeries is more common and can be prolonged, particularly with warfarin or acenocoumarol. In these patients, the current recommendation is to undertake the implant surgical procedure without modifying the anticoagulation, provided the INR is less than 3 or 3.5.¹⁷

Haemorrhage can complicate implant placement, but is not a contraindication. According to Diz et al even in haemophiliacs, dental implants can be placed with a high success.¹⁸

In a recently published case series by Bacci et al, involving 50 consecutive patients receiving oral anticoagulant therapy (warfarin) without interruption or modifications to their therapy, it was shown

that a standard protocol of local haemostasis in dental implant surgery is able to prevent bleeding complications in patients on oral anticoagulants, allowing these surgical procedures to be performed on an outpatient basis.¹⁹

A common consideration in all reviews is to take extreme care not to perforate the lingual cortical during surgery, as bleeding of the vasa plexus in that area would result in major bleeding that would be difficult to resolve. The only article that advised against implant therapy in patients with congenital coagulation defects was that of Hwang et al.²⁰ According to the authors, elective procedures such as implant rehabilitation should not be performed unless haemostasis can be assured with certainty at the end of the procedure.²¹

According to a review by Pedro Diz et al, there is no evidence that any bleeding disorders are an absolute contraindication to dental implant surgery, although these patients may be at risk of prolonged haemorrhage and blood loss, and medical advice should be taken first especially in congenital bleeding disorders.¹⁸



Cancer Therapy

While needed to destroy rapidly dividing malignant cells, both ionizing radiation and chemotherapy disrupt host defense mechanisms and hematopoiesis. Because the patient on such regimens cannot mount an appropriate response to wounding from surgery, implantation is prohibited. The total dose of ionizing radiation for cancer treatment ranges from 50 to 80 Gy. This is given in fractions of 1–10 Gy per week in order to maximize death of neoplastic cells and minimize injury to host cells.

Studies conducted by Ernst et al ; Heberer et al ; Korfage et al ; Sammartino et al, reported a time lapse between radiotherapy and implant placement of more than 12 months.²² Survival rates were reported to range between 57.1% for immediately placed implants into vascularized grafts with subsequent radiotherapy (Fenlon et al.) and 97.9% (Heberer et al.).^{23,24}

Discussion & Conclusion

The provision of implant-supported/retained prostheses in geriatric subjects is a predictable treatment option with a high rate of implant survival. The functional and psychosocial benefits of an

implant restoration should outweigh the reported relative risks associated with common medical conditions and their respective treatments. Commonly, a high level of follow-up care must be present in medically compromised patients, as these patients are prone to develop peri-implant health problems. Dental implants can safely be applied in most medically compromised patients when (i) the required precautions are taken for the disease the patient is suffering from or treated for, (ii) immediate implant complications are quickly recognized and treated when needed, and (iii) follow-up care is strict and peri-implant health problems are recognized and treated promptly.

Meta-analyses indicate that while healthy individuals show implant survival rates of approximately 95–98%, medically compromised patients such as those with diabetes, osteoporosis, or cardiovascular conditions tend to exhibit slightly lower rates, typically around 85–95%.²⁵ These variations are influenced by factors such as systemic disease control, medication use, and oral hygiene practices. Despite the generally favourable outcomes, medically compromised patients may require more rigorous preoperative assessment and postoperative care. Future research should



focus on long-term, disease-specific outcomes and the development of tailored protocols to optimize implant success in high-risk groups.

References

1. Parihar A, Madhuri S, Devanna R, Sharma G, Singh R, Shetty K. Assessment of failure rate of dental implants in medically compromised patients. *J Fam Med Prim Care*. 2020;9(2):883.
2. Samara W, Moztarzadeh O, Hauer L, Babuska V. Dental Implant Placement in Medically Compromised Patients: A Literature Review. *Cureus* [Internet]. 2024 Feb 14 [cited 2025 Mar 27]; Available from: <https://www.cureus.com/articles/213056-dental-implant-placement-in-medically-compromised-patients-a-literature-review>
3. Aghaloo T, Pi-Anfruns J, Moshaverinia A, Sim D, Grogan T, Hadaya D. The Effects of Systemic Diseases and Medications on Implant Osseointegration: A Systematic Review. *Int J Oral Maxillofac Implants*. 2019;34:s35–49.
4. Chappuis V, Avila-Ortiz G, Araújo MG, Monje A. Medication-related dental implant failure: Systematic review and meta-analysis. *Clin Oral Implants Res*. 2018 Oct;29(S16):55–68.
5. Wu X, Al-Abedalla K, Eimar H, Arekunnath Madathil S, Abi-Nader S, Daniel NG, et al. Antihypertensive Medications and the Survival Rate of Osseointegrated Dental Implants: A Cohort Study. *Clin Implant Dent Relat Res*. 2016 Dec;18(6):1171–82.
6. Rohani B. Oral manifestations in patients with diabetes mellitus. *World J Diabetes*. 2019 Sep 15;10(9):485–9.
7. Vissink A, Spijkervet F, Raghoobar G. The medically compromised patient: Are dental implants a feasible option? *Oral Dis*. 2018 Mar;24(1–2):253–60.
8. Verhaeghe J, van Herck E, Visser WJ, Suiker AM, Thomasset M, Einhorn TA, et al. Bone and mineral metabolism in BB rats with long-term diabetes. Decreased bone turnover and osteoporosis. *Diabetes*. 1990 Apr;39(4):477–82.
9. Oates TW, Dowell S, Robinson M, McMahan CA. Glycemic Control and Implant Stabilization in Type 2 Diabetes Mellitus. *J Dent Res*. 2009 Apr;88(4):367–71.
10. Tsourdi E, Rijntjes E, Köhrle J, Hofbauer LC, Rauner M. Hyperthyroidism and Hypothyroidism in Male Mice and Their Effects on Bone Mass, Bone Turnover, and the Wnt Inhibitors Sclerostin and Dickkopf-1. *Endocrinology*. 2015 Oct 1;156(10):3517–27.
11. D'Ambrosio F, Amato A, Chiacchio A, Sisalli L, Giordano F. Do Systemic Diseases and Medications Influence Dental Implant Osseointegration and Dental Implant Health? An Umbrella Review. *Dent J*. 2023 Jun 5;11(6):146.
12. Giovannacci I, Meleti M, Manfredi M, Mortellaro C, Greco Lucchina A, Bonanini M, et al. Medication-Related Osteonecrosis of the Jaw Around Dental Implants: Implant Surgery-



- Triggered or Implant Presence-Triggered Osteonecrosis? J Craniofac Surg. 2016 May;27(3):697–701.
13. Ata-Ali J, Ata-Ali F, Peñarrocha-Oltra D, Galindo-Moreno P. What is the impact of bisphosphonate therapy upon dental implant survival? A systematic review and meta-analysis. Clin Oral Implants Res [Internet]. 2016 Feb [cited 2025 Mar 31];27(2). Available from: <https://onlinelibrary.wiley.com/doi/10.1111/clr.12526>
 14. Hwang D, Wang HL. Medical Contraindications to Implant Therapy: Part I: Absolute Contraindications: Implant Dent. 2006;15(4):353–60.
 15. Altin N, Ergun S, Katz J, Sancakli E, Koray M, Tanyeri H. Implant-Supported Oral Rehabilitation of a Patient with Pemphigus Vulgaris: A Clinical Report. J Prosthodont. 2013 Oct;22(7):581–6.
 16. Winnett B, Tenenbaum HC, Ganss B, Jokstad A. Perioperative use of non-steroidal anti-inflammatory drugs might impair dental implant osseointegration. Clin Oral Implants Res [Internet]. 2016 Feb [cited 2025 Mar 27];27(2). Available from: <https://onlinelibrary.wiley.com/doi/10.1111/clr.12493>
 17. Scully C. Medical problems in dentistry. 6th ed. London: Elsevier; 2010.
 18. Diz P, Scully C, Sanz M. Dental implants in the medically compromised patient. J Dent. 2013 Mar;41(3):195–206.
 19. Bacci C, Berengo M, Favero L, Zanon E. Safety of dental implant surgery in patients undergoing anticoagulation therapy: a prospective case-control study: Dental implant therapy in anticoagulated patients. Clin Oral Implants Res. 2011 Feb;22(2):151–6.
 20. Hwang D, Wang HL. Medical Contraindications to Implant Therapy: Part I: Absolute Contraindications: Implant Dent. 2006;15(4):353–60.
 21. Bacci C, Schiazzano C, Zanon E, Stellini E, Sbricoli L. Bleeding Disorders and Dental Implants: Review and Clinical Indications. J Clin Med. 2023 Jul 18;12(14):4757.
 22. Ernst N, Sachse C, Raguse JD, Stromberger C, Nelson K, Nahles S. Changes in Peri-Implant Bone Level and Effect of Potential Influential Factors on Dental Implants in Irradiated and Nonirradiated Patients Following Multimodal Therapy Due to Head and Neck Cancer: A Retrospective Study. J Oral Maxillofac Surg Off J Am Assoc Oral Maxillofac Surg. 2016 Oct;74(10):1965–73.
 23. Fenlon MR, Lyons A, Farrell S, Bavisha K, Banerjee A, Palmer RM. Factors Affecting Survival and Usefulness of Implants Placed in Vascularized Free Composite Grafts Used in Post-Head and Neck Cancer Reconstruction. Clin Implant Dent Relat Res. 2012 Apr;14(2):266–72.
 24. Heberer S, Kilic S, Hossamo J, Raguse JD, Nelson K. Rehabilitation of irradiated patients with modified and conventional sandblasted acid-etched implants: preliminary results of a split-mouth study: SLA and modSLA implants in irradiated patients. Clin



Oral Implants Res. 2011
May;22(5):546–51.

25. Schimmel M, Srinivasan M, McKenna G, Müller F. Effect of advanced age and/or systemic medical conditions on dental implant survival: A systematic review and meta-analysis. Clin Oral Implants Res. 2018 Oct;29(S16):311–30.



Original article

STEREOMICROSCOPIC EVALUATION OF INTRA CANAL SMEAR LAYER FOLLOWING SYRINGE IRRIGATION AND CONTINUOUS IRRIGATION

*Vibin V K, **Elsy P Simon, ***Ravi SV, ****Sarin Korothe, ****Bizenah CP.

Abstract

Introduction:

Effective removal of the intra-canal smear layer is critical for successful endodontic therapy. The smear layer, formed during mechanical instrumentation, consists of organic and inorganic debris, including dentin particles, pulp tissue remnants, microorganisms, and irrigant residues. Its presence can hinder the penetration of irrigants and sealers into dentinal tubules, negatively affecting disinfection and the sealing ability of obturation materials.

Aim:

This study aimed to evaluate and compare the amount of residual smear layer in the apical third of root canals following two different irrigation protocols: conventional syringe irrigation and a novel continuous irrigation technique using a physio-dispenser system.

Methods:

Thirty-two freshly extracted single-rooted human premolars were selected and randomly divided into two groups (n=16 each): Group 1 – continuous irrigation using a physio-dispenser handpiece, and Group 2 – syringe irrigation. Each group was further subdivided into two subgroups based on the use of sonic activation (1A, 1B, 2A, 2B). Root canal preparation was standardized to size 30, 0.06 taper. Irrigation protocols included 3% sodium hypochlorite (NaOCl) during instrumentation and final irrigation with 17% EDTA followed by NaOCl. In subgroups 1A and 2A, sonic activation was used during the final irrigation. The apical third of each sample was evaluated under a stereomicroscope to assess the presence of the smear layer using a scoring system.

Results:

Statistical analysis revealed that continuous irrigation with sonic activation (Group 1A) resulted in significantly less smear layer compared to syringe irrigation with activation (Group



2A). Similarly, among non-activated groups, continuous irrigation (1B) demonstrated better smear layer removal than syringe irrigation (2B). The overall findings showed a significant reduction in smear layer with continuous irrigation, especially when combined with sonic activation.

Conclusion:

Within the limitations of this in vitro study, continuous irrigation combined with sonic activation was more effective in removing the smear layer from the apical third of root canals compared to syringe irrigation. This technique may offer a more efficient clinical alternative for improving canal cleanliness and enhancing endodontic treatment outcomes.

Keywords: Irrigation, continuous irrigation, syringe irrigation, smear layer.

Corresponding Author:

Name: DR VIBIN VK (vkvibin87@gmail.com)

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

Introduction

Successful endodontic therapy depends on the complete debridement and disinfection of the root canal system. During mechanical instrumentation of root canals, a smear layer is formed on the canal walls, composed of dentin debris, remnants of pulp tissue, microorganisms, and chemical residues from irrigants. This layer, typically 1–2 µm thick, can extend up to 40 µm into the dentinal tubules and acts as a physical barrier that may inhibit the penetration of disinfecting agents and the adaptation of obturation materials, potentially compromising the long-term success of root

canal treatment.^{1,2} The removal of the smear layer is therefore considered essential for enhancing the sealing ability of root canal filling materials and improving the adhesion of endodontic sealers to dentin.³ Irrigants such as sodium hypochlorite (NaOCl) and ethylenediaminetetraacetic acid (EDTA) are commonly used for their tissue dissolution and chelating properties, respectively.⁴ However, the effectiveness of these irrigants depends largely on their ability to be adequately delivered and agitated within the canal, particularly in the



apical third, which is often anatomically complex and less accessible.⁵

Conventional syringe irrigation, although widely used, is limited by its inability to reach the apical third effectively and often results in inadequate removal of the smear layer.⁶ Recent advancements have introduced continuous irrigation systems, such as physio-dispenser-based handpieces, which provide simultaneous irrigation and instrumentation. These systems offer constant fluid replenishment and better debris removal, potentially improving canal cleanliness and reducing smear layer formation.⁷ Additionally, the use of irrigant activation techniques such as sonic or ultrasonic agitation has shown promising results in enhancing the effectiveness of irrigants by improving their penetration and flow within the canal system.⁸ This study aims to evaluate and compare the smear layer removal efficacy of continuous irrigation and conventional syringe irrigation, both with and without sonic activation, using stereomicroscopic analysis.

Materials and Methods

Study Design

This in vitro experimental study was conducted to evaluate and compare the amount of residual smear layer in the apical

third of root canals after using two irrigation techniques: syringe irrigation and continuous irrigation with a physio-dispenser. Ethical approval was obtained prior to sample collection and preparation.

Sample Selection

A total of 32 freshly extracted human single-rooted premolars with mature apices and similar root lengths were selected for the study. Teeth with caries, cracks, calcified canals, or previous endodontic treatment were excluded. The selected teeth were stored in 0.9% saline solution until further use to prevent dehydration.

Grouping of Samples

The teeth were randomly divided into two main groups based on the irrigation technique used:

- Group 1: Continuous Irrigation (n = 16)
 - Group 1A: With sonic activation (n = 8)
 - Group 1B: Without activation (n = 8)
- Group 2: Syringe Irrigation (n = 16)
 - Group 2A: With sonic activation (n = 8)
 - Group 2B: Without activation (n = 8)

Access Opening and Canal Preparation

Standard endodontic access cavities were prepared using Endo Access and Endo-Z burs. Working length was determined by inserting a size 10 K-file into the canal until it was visible at the apical foramen, then subtracting 1 mm.

All canals were prepared using rotary nickel-titanium (NiTi) files up to size 30/.06 taper. Instrumentation was done using:

- Group 1: A physio-dispenser with 20:1 reduction gear handpiece for simultaneous instrumentation and irrigation (figure 1).
- Group 2: Standard rotary files with syringe irrigation using side-vented 30-gauge needles.

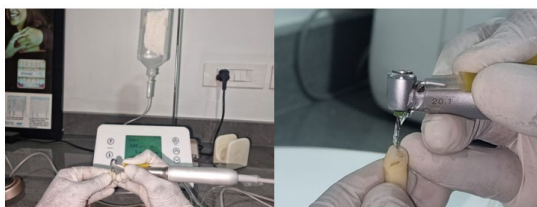


Figure 1: Continuous irrigation and instrumentation with hypochlorite using physiodispenser

Irrigation Protocol

During canal preparation, 3% sodium hypochlorite (NaOCl) was used for irrigation in all groups. Following

instrumentation, final irrigation was done with:

- 2 ml of 17% EDTA followed by
- 2 ml of 3% NaOCl

In subgroups with activation (1A and 2A), a sonic activation device (EndoActivator, Dentsply) (figure 2) was used for 30 seconds per canal to enhance irrigant agitation. In non-activated groups (1B and 2B), irrigation was performed passively.



Figure 2: Sonic activation of irrigant

Smear Layer Evaluation

Following irrigation, the roots were longitudinally sectioned using a diamond disc under water cooling. Each section was examined under a stereomicroscope at 40× magnification (figure 3,4). Area of dye penetration is calculated using image j software.

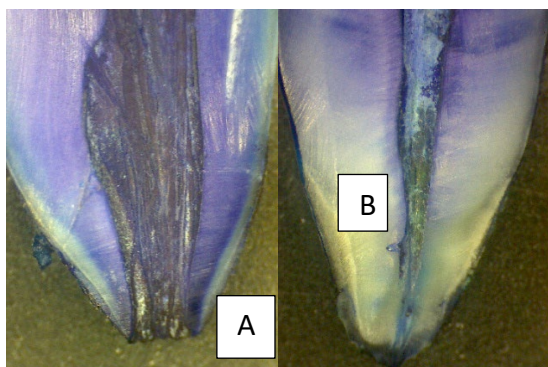


Figure 3: Stereomicroscopic image of group 1, A- with activation, B- without activation

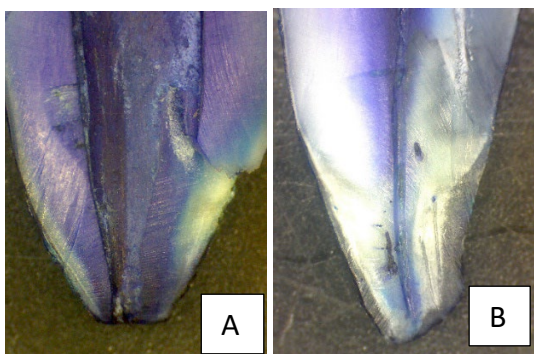


Figure 4: Stereomicroscopic image of group 2, A- with activation, B- without activation

Statistical Analysis

The data were subjected to statistical analysis using SPSS software. Intergroup comparisons were made using the Kruskal-Wallis test, followed by Mann-Whitney U test for pairwise comparisons. A p-value < 0.05 was considered statistically significant.

Results

The stereomicroscopic evaluation revealed that the continuous irrigation group with sonic activation (Group 1A) exhibited the least amount of residual smear layer in the apical third, followed by continuous irrigation without activation (Group 1B). Among the syringe irrigation groups, those with activation (Group 2A) showed better smear layer removal compared to those without activation (Group 2B), although both were less effective than their continuous irrigation counterparts (tables, graphs). Statistical analysis using the Kruskal-Wallis and Mann-Whitney U tests confirmed a significant difference between Group 1A and all other groups ($p < 0.05$), indicating that continuous irrigation combined with activation significantly enhances smear layer removal.

Tables

	mean	Std. deviation
Group 1a	60.035	.1029
Group 1b	56.728	.3860
Group 2a	58.898	.5597
Group 2b	56.700	.4041

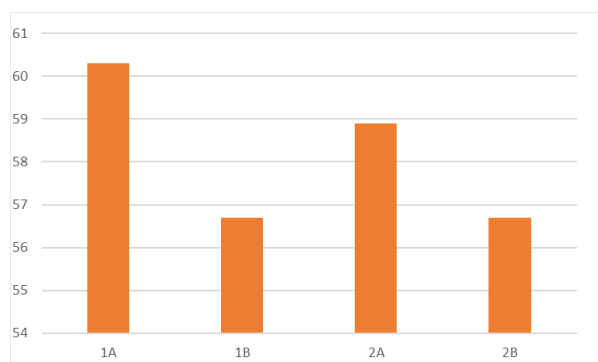
Table 1: mean and standard deviation of area of die penetration



Group 1a	Group 2a	P value
60+/- 0.1	58.9+/- 0.55	P < 0.05

Group 1b	Group 2b	p-value
58.7+/- 0.4	56.7+/- 0.38	0.825

Table 2: Comparison between both activated group



Graph 1: Bar diagram showing area of dye penetration

Discussion

The effective removal of the intra-canal smear layer is essential for optimal root canal disinfection and the long-term success of endodontic therapy. The smear layer, composed of organic and inorganic

debris, not only blocks dentinal tubules but can also harbour bacteria and impede the penetration of irrigants and sealers, compromising the seal of the root canal filling.¹ Therefore, developing effective irrigation protocols that target this smear layer is a priority in endodontics.

The present study was undertaken to compare the smear layer removal efficacy of two irrigation techniques—continuous irrigation using a physio-dispenser and traditional syringe irrigation—both with and without sonic activation. This was motivated by the clinical limitation that irrigants delivery and replenishment fails during the time of instrumentation of the root canal system due to its limited flow dynamics and inability to overcome apical vapor lock.^{2,3} This limitation is especially problematic in anatomically complex root canal systems, where the risk of residual debris and microorganisms is higher.⁴

Our results demonstrated that continuous irrigation with sonic activation (Group 1A) produced the least amount of residual smear layer, followed by continuous irrigation without activation. This supports the hypothesis that continuous irrigant replenishment, when combined with energy-driven activation, enhances smear layer removal. The physio-dispenser used in this study allowed constant irrigant flow during canal preparation, maintaining



lubrication, reducing debris accumulation, and improving chemical contact time. Similar findings were reported by Lopes et al., who emphasized the importance of continuous flow irrigation in achieving more uniform debridement across the canal walls.⁵

In contrast, syringe irrigation even with activation was found to be less effective. Although sonic activation improved the smear layer removal compared to non-activated syringe groups, it still fell short of the results obtained by the continuous irrigation system. This can be attributed to the intermittent and limited irrigant replenishment and the inability to maintain consistent flow during instrumentation.⁶ Moreover, syringe irrigation typically delivers irrigants only up to 1–2 mm beyond the needle tip, which may leave the apical third inadequately irrigated.⁷ Sonic activation, regardless of irrigation type, improved the effectiveness of smear layer removal. This can be explained by the acoustic streaming effect generated by sonic devices, which increases the flow and turbulence of irrigants, allowing better penetration into lateral canals and dentinal tubules.⁸ However, its efficacy is closely linked to the efficiency of the base irrigation method; thus, it is most beneficial when combined with continuous irrigation.

The methodology adopted in this study reflects current attempts to bridge the gap between technological advances and clinical limitations. The use of a physio-dispenser with a 20:1 reduction gear handpiece provided a novel approach by allowing simultaneous shaping and irrigant delivery, a technique that is less explored in the literature. The sample size, standardization of canal preparation, use of validated irrigants (NaOCl and EDTA), and evaluation of the apical third under stereomicroscopy all contribute to the reliability and reproducibility of the study.

Importantly, the need for this study is justified by the lack of sufficient clinical data comparing physio-dispenser-based irrigation with conventional techniques. Most previous studies have focused on syringe irrigation or ultrasonic activation, with limited evidence on the clinical utility of continuous handpiece-driven irrigation systems. Our findings add to the growing body of evidence supporting dynamic irrigation protocols that combine mechanical action with chemical efficacy.

Conclusion

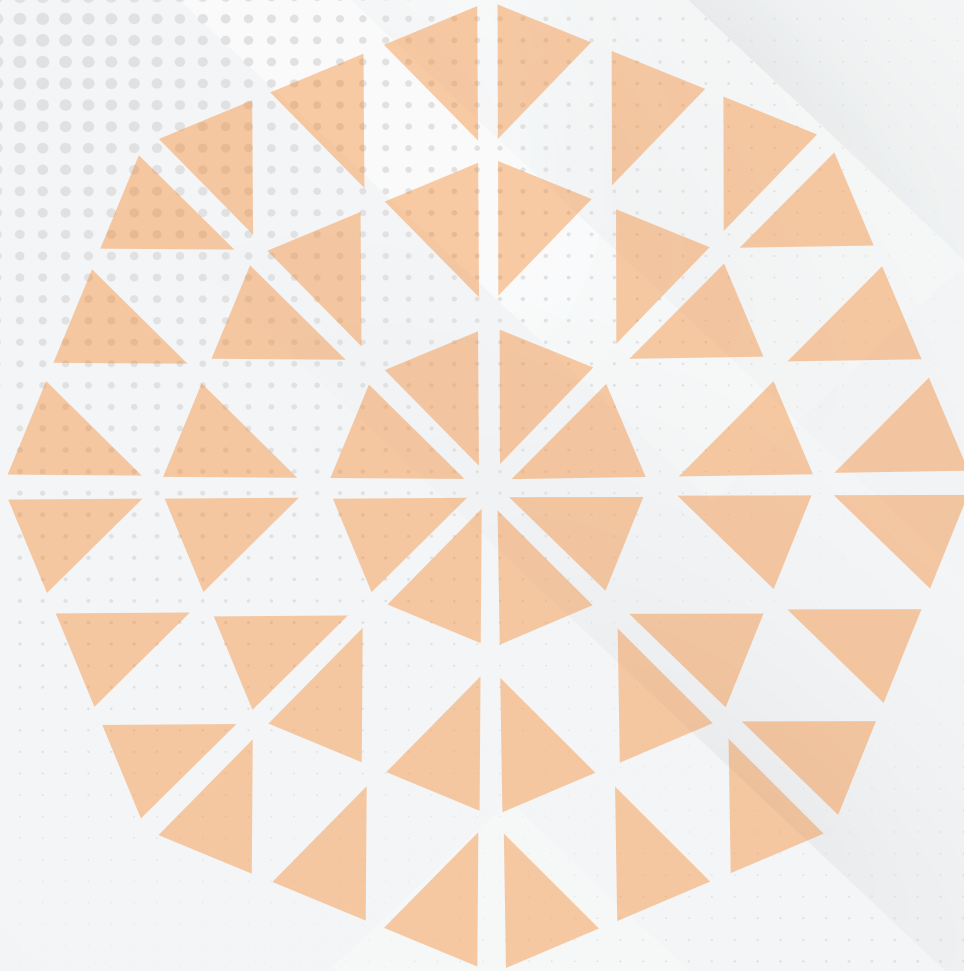
Within the limitations of this in vitro model, our results suggest that continuous irrigation with activation can significantly improve smear layer removal, especially in the apical third, where mechanical and



chemical cleaning are most challenged. Further in vivo studies and clinical trials are warranted to confirm these findings and assess their impact on long-term treatment outcomes.

References

1. Okşan T, Aktener BO, Sen BH, Tezel H. The penetration of root canal sealers into dentinal tubules. A scanning electron microscopic study. *Int Endod J*. 1993 Sep;26(5):301-5.
2. Haralur SB, Al-Qahtani AS, Al-Qarni MM, Al-Homrany RM, Aboalkhair AE. Influence of remaining dentin wall thickness on the fracture strength of endodontically treated tooth. *J Conserv Dent*. 2016 Jan-Feb;19(1):63-7.
3. Tay FR, Gu LS, Schoeffel GJ, Wimmer C, Susin L, Zhang K, Arun SN, Kim J, Looney SW, Pashley DH. Effect of vapor lock on root canal debridement by using a side-vented needle for positive-pressure irrigant delivery. *J Endod*. 2010 Apr;36(4):745-50.
4. de Gregorio C, Estevez R, Cisneros R, Paranjpe A, Cohenca N. Efficacy of different irrigation and activation systems on the penetration of sodium hypochlorite into simulated lateral canals and up to working length: an in vitro study. *J Endod*. 2010 Jul;36(7):1216-21.
5. Lopes HP, Elias CN, Siqueira JF Jr, et al. Mechanical behavior of three nickel-titanium rotary instruments tested with repetitive axial movements. *J Endod*. 2008;34(7):858-61.
6. Castelo-Baz P, Martín-Biedma B, Cantatore G, Ruíz-Piñón M, Bahillo J, Rivas-Mundiña B, Varela-Patiño P. In vitro comparison of passive and continuous ultrasonic irrigation in simulated lateral canals of extracted teeth. *J Endod*. 2012 May;38(5):688-91.
7. Chow TW. Mechanical effectiveness of root canal irrigation. *J Endod*. 1983 Nov;9(11):475-9.
8. van der Sluis LW, Versluis M, Wu MK, Wesselink PR. Passive ultrasonic irrigation of the root canal: a review of the literature. *Int Endod J*. 2007;40(6):415-26.



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