



ORIGINAL ARTICALE

EVALUATION OF BIOCERAMIC BASED SEALERS IN REGENERATIVE ENDODONTICS OF IMMATURE PERMANENT TEETH

Sourav Chandra Bidyasagar Bal¹, Jana Ali Alnajim², Savita Singh³, Prashant Babaji⁴, Vardharajula Venkat Ramaiah⁵, PrabuMahin Syed Ismail⁶, ShubhraniBhowmick⁷, Alok Dubey⁸

¹Associate Professor, Department of Public Health Dentistry, Institute of Dental Science, SOA University, Bhubaneswar, Odisha, India.

²Consultant in Paediatric Dentistry, King Saud Hospital, Qassim Province, Unaizah, Saudi Arabia

³Department of Oral and Maxillofacial Pathology and Microbiology, Private Practitioner, T-265 B, Chirag Delhi.

⁴Professor, Department of Pediatric and Preventive Dentistry, Sharavathi Dental College, Shivamogga, Karnataka, India.

⁵Assistant Professor, Department of Public Health, College of Applied Medical Sciences, Qassim University, Buraydah 51542, PO Box 6666, Saudi Arabia

⁶Assistant Professor, Department of Conservative Dentistry, College of Dentistry, Qassim University, Kingdom of Saudi Arabia.

⁷Department of Pediatric and Preventive Dentistry, Kalinga Institute of Dental Sciences, KIIT, Deemed to be University, Patia, Bhubaneswar, Odisha, India.

⁸Associate professor, Department of Preventive Dental Sciences, College of Dentistry, Jazan University, Jazan, Saudi Arabia.

Corresponding author: Dr. Savita Singh Department of Oral and Maxillofacial Pathology and Microbiology, Private Practitioner, T-265 B, Chirag Delhi. E-mail: vidisaasingh@gmail.com

Received:Aug27.2025;**Accepted:**Sep 29, 2025;**Published:**Oct 21, 2025

ABSTRACT

Background:In dentistry, bioceramics have found extensive application, especially in endodontics. The goal of the current study was to assess the release of calcium ions (Ca²⁺) from apical plugs made of three distinct bioceramic cements in immature teeth models with open apices.

Materials and Methods: Three groups of ten samples each were created from a total of thirty lower premolar teeth. Dia-Root Bio MTA is in Group I; MTA Fillapex is in Group II; and Biodentine is in Group III. Every sample was made to resemble teeth that were still developing and had open apices. At the exposed apex region, a 4 mm apical stopper was placed. On days 8, 16, and 30, calcium ion release was quantified with an atomic absorption spectrophotometer. Mann-Whitney U and Kruskal-Wallis tests were used to analyse the data at a significance level of P < 0.05.

Result:All groups demonstrated the highest levels of Ca²⁺ release till day 30th. Dia-Root Bio MTA showed the highest calcium ion release.

Conclusion:Dia-Root Bio MTA showed the highest calcium ion release followed by biodentine. The tested materials can be used in regenerative endodontics for immature teeth development.

Keywords:Bioceramic sealers, calcium silicate, regenerative endodontics, immature permanent teeth

INTRODUCTION

The most common cause of pulpal non-vitality in children's immature permanent incisors, which range in age from 8 to 12, is traumatising dental injuries (TDIs). TDIs have the potential to cause pulpal necrosis and halt root growth if they harm the young teeth's Hertwig's epithelial root

sheath (HERS).¹ Any interference can result in a compromised crown-root ratio, thin root walls, and a wide-open apex without an apical stop because root growth is accomplished by the continuous deposition of dentine and cementum through stimulation and differentiation of HERS and surrounding progenitor cells.² Maintaining the tooth's sound structure and

absence of pathology is the foundation of an effective endodontic treatment. Apexification can be used to treat young teeth with non-vital pulp, and apogonosis can be used to treat immature roots with vital pulp. Apexification has historically been accomplished by applying non-setting calcium hydroxide (Ca(OH)₂) paste; however, this method necessitates frequent and prolonged root canal dressing. Apexification could be performed to create a root apex for the ensuing RCT if the dental pulp of young teeth experienced irreversible inflammation or necrosis. For open apical closure and periapical tissue repair, apexification and regenerative endodontic therapy are viable choices.³

With the advent of novel materials and methods that produce positive treatment outcomes, the field of dentistry is always evolving. Among the newly developed materials that have revolutionised dentistry are bio-ceramics.⁴ Bioceramics, a novel class of dental materials, were first used in the field of endodontics in the early 1990s. Alumina, zirconia, bioactive glass, glass ceramics, hydroxyapatite, calcium silicate, and resorbable calcium phosphate are examples of bioceramics, which are biocompatible ceramic materials or metal oxides. Based on their reaction with surrounding tissues, bioceramics can be categorised as bioinert, bioactive, or biodegradable materials. The most widely utilised bioceramics in endodontics are calcium silicate-based cements (CSCs), which are typically bioactive.^[3] Bioceramics can be synthetic or natural. Materials that are either bioactive or bioinert, such as aluminium, calcium, silicate, or carbon.⁴

Bioceramics work through the release of calcium ions, high alkaline pH, and diffusion of the sealer particles into the dentinal tubules. They are biocompatible, biomineralization-stimulating, have low porosity and solubility, moderate flow, high radiopacity, and compressive strength.⁴ The way bioceramics interact with surrounding tissues mostly reflects their biocompatibility and bioactivity. Stem cells, osteoblasts/osteoclasts, dental pulp cells (DPCs)/periodontal ligament cells (PDLCs), and immune cells are all impacted by bioceramics in terms of their migration, differentiation, proliferation, and apoptosis.⁵

Calcium silicate-based bioceramics, such as MTA, Biodentine, Bioaggregate, and iRoot BP Plus, have been extensively utilised in endodontic treatment because of their superior biocompatibility, bioactivity, and sealing capacity.⁶ A popular calcium-based sealer is MTA. MTA is very biocompatible and has good sealability. Through the release of calcium ions that react with phosphorus, MTA can promote the regeneration of hydroxyapatite.⁷ MTA products that are frequently used are ProRoot MTA and MTA. In addition to being successful CH replacements, MTA and Biodentine could also be utilised as efficient pulp capping materials.⁸ As a bioactive

dental alternative, biodentine cement (Septodont, Saint MaurdesFossés, France) is sold.⁹

sealers made of calcium hydroxide, calcium silicates, calcium phosphates, and zirconium oxide that are based on bioceramics. These sealers have hydrophilic qualities and come in pre-mixed syringes for convenient application.¹⁰

Nowadays, AH Plus (DentsplyDeTrey, Konstanz, Germany) is regarded by numerous studies as the gold-standard epoxy resin-based sealant. Epoxy resin-based root canal sealers are currently the most commonly utilised among the clinically available sealers. In 1957, Schroeder unveiled the AH series prototype, which had superior sealing capabilities and physical characteristics.¹¹

Both orthograde and retrograde filling, which strive for apical sealing, can be used to accomplish root-end filling. Bioactivity, biocompatibility, long-term sealing ability, good operational performance, and the capacity to encourage tissue healing are all desirable qualities in an apical sealing material.¹²

Long-term calcium hydroxide [Ca(OH)₂] treatment has historically been utilised to create an apical barrier in immature, non-vital teeth. Recent research, however, has revealed that long-term use of Ca(OH)₂ can weaken teeth's resistance to fracture, casting doubt on the efficacy of this treatment method. An alternative to this traditional method is the application of an apical barrier made of calcium phosphate, dentin chips, or freeze-dried cortical bone/dentin.¹³

The current research was done to evaluate the various bioceramic based sealers in calcium ion (Ca²⁺) release from apical plugs for regenerative endodontics of immature permanent teeth.

MATERIALS AND METHOD

The Paediatric and Preventive Dentistry department conducted this in vitro investigation. The study comprised a total of thirty single-rooted lower premolar teeth with any disease that had been excised for orthodontic purposes. Group I consisted of Dia-Root Bio MTA (Diadent, Cheongju, South Korea), Group II consisted of MTA Fillapex (Angelus Odontologicas), and Group III consisted of Biodentine (Septodont, Saint-Maur-des-Fosses, France). Each group contained ten samples following sterilisation. Every sample was made to resemble teeth that were still developing and had open apices. At the exposed apex region, a 4 mm apical stopper was placed. On days 8, 16, and 30, calcium ion release was quantified with an atomic absorption spectrophotometer. Mann-Whitney U and Kruskal-Wallis tests were used to analyse the data at a significance level of $P < 0.05$.

RESULT

At days 8, 16, and 30, Group I displayed the highest amounts of calcium ion (Ca²⁺) release, followed by Group III, while Group II displayed the lowest levels (Table 1). All three evaluation points had significant differences between groups, according to the Kruskal-

Wallis test results ($P < 0.001$). On days 7 and 15, the three groups showed significant differences ($P < 0.05$) according to the Mann-Whitney U test.

Table 1. Comparison of the groups' Ca²⁺ release (ppm) profiles

Evaluation Day	Materials group	Mean $\pm$ SD	IQR
8th	Group I	17.05 $\pm$ 0.43	0.73
	Group II	08.24 $\pm$ 0.32	0.64
	Group III	13.11 $\pm$ 0.48	0.80
16 th	Group I	17.36 $\pm$ 0.71	1.12
	Group II	07.12 $\pm$ 0.42	0.54
	Group III	11.67 $\pm$ 0.48	0.68
30 th	Group I	2.43 $\pm$ 0.32	0.32
	Group II	1.75 $\pm$ 0.31	0.22
	Group III	2.01 $\pm$ 0.04	0.24

SD: Standard deviation, IQR: Interquartile range

DISCUSSION

Achieving a "closed apex" by apexification using biocompatible materials is crucial since it promotes the development of mineralised tissues like bone or osteodentin. For apexification or apexogenesis to be successful, the calcium release profile is essential. Calcium promotes the growth of dental pulp cells by assisting in cell differentiation, hard tissue mineralisation, and the control of osteopontin and bone morphogenetic protein 2 (BMP-2) levels.¹³

Ca²⁺ release in the deionised water around the root-end filling materials was verified in this investigation. In this investigation, Dia-Root Bio MTA showed the maximum Ca²⁺ release. The outcome is related to Sahiba et al. In simulated immature teeth with open apices, Sahiba et al. assessed the release of calcium ions (Ca²⁺) from apical plugs made by three distinct bioceramic cements. When compared to ProRoot MTA, Dia-Root Bio MTA displayed the maximum calcium ion release after 15 days.¹³

The best bio-ceramic materials for endodontic hole sealing and repair are EndoSequence and Biodentine.¹⁴ At a twelve-month follow-up, Ghaly et al. found that the Well-Root PT group had a higher mean periapical bone radiodensity than the MTA group.¹⁵ Donnell et al. came to the conclusion that MTA, Biodentine, and TotalFill Putty are great clinical outcomes and very effective apexification materials.¹ According to Vyas et al., GuttaFlowBioseal and Biodentine apexification groups displayed the highest fracture resistance

values.¹⁶ Biodentine exhibited a higher compressive strength than MTA Repair HP and Bio-C Repair, according to Morais Rodrigues et al.⁹ Pallavi et al. claim that among the experimental groups, the MTA Fillapex sealer applied with lentulospiral produced the best apical seal.¹⁷ By eliminating the need for numerous temporary coronal restorations, the substantial reduction in treatment duration for bioceramics has decreased the danger of microleakage and reinfection of the canal.^[1]

The MTA and biodentine groups that were examined in this study are efficient in the apexification or apexogenesis process.

CONCLUSION

The greatest calcium ion release was demonstrated by Dia-Root Bio MTA, which was followed by biodentine. The materials under test can be applied to the growth of immature teeth in regenerative endodontics.

DECLARATION

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no conflict of interest.

Funding

This research received no external funding.

REFEREN

1. Donnell CC, Kandiah P. Comparing the technical quality and clinical outcomes of root canal treatment

- on immature permanent incisors in children: a retrospective evaluation of three bioceramic plug materials. *European Archives of Paediatric Dentistry* (2024) 25:821–835. <https://doi.org/10.1007/s40368-024-00941-3>
2. Duggal M, Tong HJ, Al-Ansary M, Twati W, Day P, Nazzal H. Interventions for the endodontic management of non-vital traumatised immature permanent anterior teeth in children and adolescents: a systematic review of the evidence and guidelines of the European Academy of Paediatric Dentistry. *Eur Arch Paediatr Dent*. 2017;18:139–51. <https://doi.org/10.1007/s40368-017-0289-5>.
3. Dong X, Xu X. Bioceramics in Endodontics: Updates and Future Perspectives. *Bioengineering* 2023;354:1-30. <https://doi.org/10.3390/bioengineering10030354>
4. Rawat A, Geogi C, Dubey S, Singh P. Bioceramics in endodontics – A review. *IP Indian Journal of Conservative and Endodontics* 2022;7(4):163–171. <https://doi.org/10.18231/j.ijce.2022.037>
5. Song, W.; Li, S.; Tang, Q.; Chen, L.; Yuan, Z. In vitro biocompatibility and bioactivity of calcium silicate-based bioceramics in endodontics (Review). *Int. J. Mol. Med*. 2021, 48, 128
6. Parirokh, M.; Torabinejad, M. Mineral trioxide aggregate: A comprehensive literature review—Part I: Chemical, physical, and antibacterial properties. *J. Endod*. 2010, 36, 16–27
7. Song W, Sun W, L, Yuan Z. In vivo biocompatibility and bioactivity of calcium silicate-based bioceramics in endodontics. *FrontBioengBiotechnol*. 2020;8: 580954.
8. Stringhini Junior E, et al. MTA and biodentine for primary teeth pulpotomy: a systematic review and meta-analysis of clinical trials. *Clin Oral Investig*. 2019;23(4):1967–76.
9. Morais Rodrigues MN, Bruno KF, de Alencar AHG, Santos Silva JD, de Siqueira PC, de Almeida Decurcio D et al . Comparative analysis of bond strength to root dentin and compression of bioceramic cements used in regenerative endodontic procedures. *Restor Dent Endod*. 2021 Nov;46(4):e59. <https://doi.org/10.5395/rde.2021.46.e59>
10. Raghavendra SS, Jadhav GR, Gathani KM, Kotadia P. Bioceramics in endodontics - a review. *J Istanbul Univ Fac Dent*. 2017 2;51(Suppl 1):S128–37. <https://doi.org/10.17096/jiufd.63659>
11. Lim M, Jung C, Shin DH, Yong-bum Cho , Song M. Calcium silicate-based root canal sealers: a literature review. *Restor Dent Endod*. 2020 Aug;45(3):e35. <https://doi.org/10.5395/rde.2020.45.e35>
12. Parirokh M, Torabinejad M, Dummer PMH. Mineral trioxide aggregate and other bioactive endodontic cements: an updated overview - part I: vital pulp therapy. *IntEndod J*. 2018;51(2):177–205
13. Sahiba U, Sree Gowri, Prathap MS, Aphiya A, Aleemuddin M. Comparative evaluation of calcium ion release from three bioceramic cements in simulated immature teeth with open apices. *J Dent Mater Tech* 2024; 13 (3): 103-10. <https://doi.org/10.22038/jdmt.2024.79814.1635>
14. Guajardo DIG, Coronado JEA, Longoria JAG, Gutierrez RC, Bernal MAM, Cepeda MAAN, et al. Comparative evaluation of four bioceramic-based endodontic sealers. *International Journal of Applied Dental Sciences* 2021; 7(2): 328-331 DOI: <https://doi.org/10.22271/oral.2021.v7.i2e.1229>
15. Ghaly MS, Abozena NI, Ghouraba RF, Kabbash IA, EL-Desouky SS. Clinical and radiographic evaluation of premixed bioceramic putty as an apical plug in nonvital immature anterior permanent teeth. *Scientific Reports*. 2025;15:26487. <https://doi.org/10.1038/s41598-025-11407-x>
16. Vyas A, Shah S, Patel NK, Yagnik K, Hirpara V, Shah R. An in vitro comparison of fracture resistance of immature teeth subjected to apexification using three different bioactive materials. *IP Indian Journal of Conservative and Endodontics* 2022;7(4):172–176 <https://doi.org/10.18231/j.ijce.2022.038>
17. Pallavi S, Devadathan A, James B, et al. Comparative Evaluation of the Apical Sealing Ability of Two Root Canal Sealers Using the Two Different Placement Techniques: An *In Vitro* Study. *Cons Dent Endod J* 2020;5(1):11–14.