



International Journal of Multidisciplinary Research in Science, Engineering and Technology

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 9.864

Volume 9, Issue 7, July 2026



Bioceramic Pulp Capping Agents: A Double-Edged Sword in Vital Pulp Therapy

**Dr. Ruchi Saluja¹, Prof. (Dr.) Harpreet Singh², Dr. Gursandeep Kaur Sandhu³, Dr. Harpreet Kaur⁴,
Dr. Simarpreet Singh⁵**

Postgraduate Student, Desh Bhagat Dental College and University, Mandi Gobindgarh, Punjab, India¹

Dean Research, Professor and Head of the Department, Desh Bhagat Dental College and University, Mandi
Gobindgarh, Punjab, India²

Professor, Desh Bhagat Dental College and University, Mandi Gobindgarh, Punjab, India³

Postgraduate Student, Desh Bhagat Dental College and University, Mandi Gobindgarh, Punjab, India^{4,5}

ABSTRACT: Bioceramic pulp capping agents have become central to modern vital pulp therapy because they combine bioactivity, sealing ability, and favorable pulp responses. Materials such as MTA, Biodentine, TheraCal LC, and related resin-modified or premixed products have been extensively studied for direct pulp capping in permanent teeth. However, not all materials marketed under the bioceramic category behave similarly, and resin-containing formulations may show more inflammation or less predictable outcomes than resin-free calcium silicate cements. This review summarizes the clinical merits, limitations, commercial formulations, and selected evidence supporting the concept that bioceramic pulp capping agents are a double-edged sword in vital pulp therapy.

KEYWORDS: Bioceramic, Biodentine, MTA, Pulp Capping, Vital Pulp Therapy.

I. INTRODUCTION

The preservation of pulpal vitality has become one of the principal objectives of contemporary restorative dentistry. Traditionally, teeth with deep carious lesions or pulp exposure were frequently treated with root canal therapy because the exposed pulp was considered incapable of predictable healing. Advances in pulp biology, regenerative dentistry, and biomaterial science have challenged this concept, leading to a paradigm shift toward vital pulp therapy (VPT), where preservation of the dentin–pulp complex is prioritized whenever the remaining pulp retains healing potential.¹

Vital pulp therapy encompasses indirect pulp capping, direct pulp capping, partial pulpotomy, and full pulpotomy, all of which aim to preserve the vitality and physiological function of the pulp. The success of these procedures relies on controlling bacterial contamination, maintaining pulp vitality, and providing a biologically favorable environment for tissue repair. Consequently, the choice of pulp-capping material plays a pivotal role in determining the biological response of the pulp.

For more than half a century, calcium hydroxide (CH) remained the material of choice for direct pulp capping because of its antibacterial activity and ability to induce hard tissue formation. However, despite its clinical popularity, calcium hydroxide exhibits several shortcomings, including poor adhesion to dentin, high solubility, dissolution over time, and the formation of porous dentinal bridges containing tunnel defects that may permit bacterial microleakage. These limitations prompted the search for biologically active alternatives capable of promoting more predictable pulp healing.¹

The introduction of calcium silicate-based bioceramics marked a significant milestone in regenerative dentistry. Unlike calcium hydroxide, bioceramic materials actively participate in tissue repair through sustained calcium ion release, hydroxyapatite formation, and stimulation of odontoblast-like cell differentiation. These properties have resulted in improved dentin bridge quality, superior sealing ability, and reduced pulpal inflammation, making bioceramics the preferred materials for many vital pulp therapy procedures.²



International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Nevertheless, describing bioceramics solely as "ideal" pulp-capping agents would be an oversimplification. Their biological activity is mediated through controlled inflammation, and the same mechanisms responsible for regeneration may also contribute to transient pulpal irritation, superficial necrosis, or excessive mineralization under certain clinical conditions. Furthermore, conventional mineral trioxide aggregate (MTA) is associated with prolonged setting time and tooth discoloration, while the long-term clinical evidence supporting several recently introduced bioceramic formulations remains limited.³

Therefore, this review critically evaluates the currently available bioceramic pulp-capping agents from both biological and clinical perspectives. Rather than merely highlighting their advantages, the review examines the evidence supporting their clinical application while discussing the limitations that justify describing these materials as a *double-edged sword* in contemporary vital pulp therapy.

BIOCERAMIC MATERIALS IN PERSPECTIVE

Bioceramic pulp capping materials include ProRoot MTA, MTA Angelus, Biodentine, RetroMTA, NeoMTA Plus, TotalFill / EndoSequence Root Repair Material, TheraCal LC, TheraCal PT, ACTIVA BioACTIVE Base/Liner, and ApaCal ART. Their actions are generally based on calcium ion release, alkalinity, and stimulation of hard-tissue formation. Resin-free calcium silicate cements are usually regarded as the most biologically favorable group, while resin-modified products are more controversial because resin may affect pulp response. For this reason, product composition matters as much as the bioceramic label itself.⁴

CLINICAL MERITS

The strongest merit of bioceramic materials is their ability to support pulp healing and dentin bridge formation. In the study by Jalan et al.⁵, Biodentine produced a more favorable response than calcium hydroxide in human direct pulp capping. In the pilot retrospective study by Linu et al.⁶, direct pulp capping with bioceramic materials in mature permanent teeth showed a high overall success rate, and Biodentine performed particularly well clinically. In the in vivo study by Ahlawat et al.⁷, MTA and Biodentine maintained pulp vitality after direct capping of cariously exposed molars. A systematic review and meta-analysis by Alsubait and Aljarbou⁸ found Biodentine to have clinical and radiographic success comparable to MTA in mature permanent teeth.

LIMITATIONS AND BIOLOGICAL CONCERNS

Despite their advantages, bioceramic agents also have important limitations. Conventional MTA may be difficult to handle, may set slowly, and may discolor teeth. Some newer products have improved handling but still lack long-term independent evidence. Resin-containing formulations deserve special caution because their local biologic effects may be less favorable than those of resin-free materials. The literature also shows that favorable dentin bridge formation does not always mean minimal inflammation, so clinical success should be interpreted together with histologic and biologic behavior.⁹

COMMERCIAL FORMULATIONS AND CLINICAL APPLICATIONS

ProRoot MTA and MTA Angelus are widely used for direct pulp capping, pulpotomy, perforation repair, and root-end procedures. Biodentine is used for direct and indirect pulp capping and as a dentin substitute, with strong evidence supporting its regenerative performance. TotalFill and NeoMTA Plus have shown favorable histologic healing and complete dentin bridge formation in human tooth culture studies. TheraCal LC is a resin-modified calcium silicate pulp-capping material that is easy to handle and has good physical properties, but several studies suggest it is less reliable than MTA or Biodentine in direct pulp capping. ApaCal ART is a photo-cure resin-modified calcium hydroxide / tri-calcium phosphate pulp protectant and liner, and it is better placed among resin-modified protectants rather than among classical resin-free bioceramic cements.¹⁰

EVIDENCE FROM SELECTED STUDIES

The study by Jeanneau et al.¹¹ showed that tricalcium silicate-based materials modulate the balance between inflammation and regeneration, with resin-containing materials such as TheraCal shifting the pulp response toward inflammation, while resin-free Biodentine showed more favorable anti-inflammatory and regenerative behavior. In the trial by Mahapatra et al.¹², TheraCal LC, MTA, and Biodentine all showed clinically acceptable performance at 12 months, though the authors noted meaningful differences among the materials.



International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

CLINICAL INTERPRETATION

Taken as a group, bioceramic pulp capping agents are among the most important advances in conservative dentistry. Resin-free materials such as MTA and Biodentine remain the most validated options for direct pulp capping because they combine biologic activity with better long-term support in the literature. Resin-containing formulations may offer easier handling and favorable physical properties, but their inflammatory potential and weaker evidence base limit their status as first-line choices. Thus, the clinician should select the material based on case selection, isolation, restoration quality, and the biologic profile of the product rather than on the broad term bioceramic alone.¹³

II. CONCLUSION

Bioceramic pulp capping agents represent a major step forward in vital pulp therapy, but their effects depend strongly on formulation. MTA and Biodentine are the most reliable and well-supported materials for direct pulp capping, while resin-containing products such as TheraCal LC and ApaCal ART require more cautious interpretation because of their biological and inflammatory concerns. Their usefulness is real, but so are their limitations, which is why they can rightly be described as a double-edged sword in vital pulp therapy.

REFERENCES

1. Al-Saudi KW. A paradigm shift from calcium hydroxide to bioceramics in direct pulp capping: A narrative review. *J Conserv Dent Endod.* 2024 Jan;27(1):2-10.
2. Sharma DK, Kumar RSM, Singh S, Bhullar KK, Manigandan K, Mazumdar P, Shenoi P, Kumar AA, Vandekar M, Patel P, Kaur G. Indian Association of Conservative Dentistry and Endodontics consensus statement on bioceramics in conservative dentistry and endodontics. *J Conserv Dent Endod.* 2026 Jun;29(6):574-581.
3. Mustafa Tariq Mutar, Anas F Mahdee. Different pulp capping agents and their effect on pulp inflammatory response: A narrative review. *The Saudi Dental Journal.* 2024;36(1):1295-1306.
4. Chen L, Suh BI. Cytotoxicity and biocompatibility of resin-free and resin-modified direct pulp capping materials: A state-of-the-art review. *Dent Mater J.* 2017 Jan 31;36(1):1-7.
5. Jalan AL, Warhadpande MM, Dakshindas DM. A comparison of human dental pulp response to calcium hydroxide and Biodentine as direct pulp-capping agents. *J Conserv Dent.* 2017;20(2):129-133.
6. Linu S, Lekshmi MS, Varunkumar VS, Joseph VS. Treatment outcome following direct pulp capping using bioceramic materials in mature permanent teeth with carious exposure: a pilot retrospective study. *J Endod.* 2017;43(10):1635-1639.
7. Ahlawat M, Grewal MS, Goel M, Bhullar HK, Saurabh, Nagpal R. Direct pulp capping with mineral trioxide aggregate and Biodentine in cariously exposed molar teeth: 1-year follow-up – an in vivo study. *J Pharm Bioallied Sci.* 2022;14(Suppl 1):S983-S985.
8. Alsubait S, Aljarbou F. Biodentine or mineral trioxide aggregate as direct pulp capping material in mature permanent teeth with carious exposure? A systematic review and meta-analysis. *Oper Dent.* 2021;46(6):631-640.
9. Dong X, Xu X. Bioceramics in endodontics: updates and future perspectives. *Bioengineering (Basel).* 2023;10(3):354.
10. Peskersoy C, Lukarcanin J, Turkun M. Efficacy of different calcium silicate materials as pulp-capping agents: Randomized clinical trial. *J Dent Sci.* 2021 Mar;16(2):723-731.
11. Jeanneau C, Laurent P, Rombouts C, Giraud T, About I. Light-cured Tricalcium Silicate Toxicity to the Dental Pulp. *J Endod.* 2017 Dec;43(12):2074-2080.
12. Mahapatra J, Nikhade PP, Patel A, Mankar N, Taori P. Comparative evaluation of the efficacy of TheraCal LC, mineral trioxide aggregate, and Biodentine as direct pulp capping materials in patients with pulpal exposure in posterior teeth: A triple-blinded randomized parallel group clinical trial. *Cureus.* 2024;16(2):e55022.
13. Islam R, Islam MRR, Tanaka T, Alam MK, Ahmed HMA, Sano H. Direct pulp capping procedures - Evidence and practice. *Jpn Dent Sci Rev.* 2023 Dec;59:48-61.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

| Mobile No: +91-6381907438 | Whatsapp: +91-6381907438 | ijmrset@gmail.com |

www.ijmrset.com