

Assessment of Treatment Outcomes with Complete Orthograde Obturation with Bioceramic Materials: A Scoping Review

Murali H Rao¹, Rajkumar Krishnan², Mamatha Kumaraswamy³, Aditya Keshav⁴, Pavithra Gopal⁵, Elizabeth Thomas⁶

ABSTRACT

Aim: Bioceramic sealers are being used as obturation materials as they are known for hard tissue induction and facilitating periapical healing. Based on some *in vitro* studies, one can hypothesize that mineral trioxide aggregate (MTA) and biodentine used as the sole obturating material could reinforce the tooth and provide a better sealability than an MTA/biodentine apical plug with gutta-percha obturation. However, there are not many high-quality studies regarding outcomes of complete MTA/biodentine obturations compared with traditional obturation methods. The aim of this review is to organize findings of clinical outcomes and the quality of complete obturation of root canals from various *in vitro* studies and to identify the gaps in research done in this area.

Methods: The preferred reporting items for Systematic Reviews and Meta-analyses Extension for Scoping Reviews guidelines were followed to conduct a thorough literature search in June 2024 across PubMed, Google Scholar, Scopus, Science Direct, and Scielo. The research question was formulated using PICO: population: permanent dentition in adults or children; intervention: orthograde monoblock obturation; comparator: traditional orthograde root canal filling methods; outcome: success defined by asymptomatic, functional tooth, and radiographic evidence of healing.

Results: Out of 511 initially identified studies, 474 studies did not meet initial eligibility criteria for inclusion, and only 37 studies were selected. After full-text scrutiny, only 23 were subjected to qualitative assessment.

Conclusion: The findings of the data concluded that complete obturation with MTA and biodentine could be a viable alternative to an apical plug followed by gutta-percha obturation or bioceramic sealer with gutta-percha obturation. The lack of randomized controlled trials and long-term retrospective studies precludes clinicians from utilizing this technique.

Clinical significance: Bioceramic materials can be used for complete obturation of canals, both in primary and retreatment cases, bringing about periapical healing and regeneration of tissues. They are found to reinforce and improve the strength of radicular structure on account of the monoblock effect.

Keywords: Bioceramic materials, Biodentine, Mineral trioxide aggregate, Obturation, Treatment outcome.

The Journal of Contemporary Dental Practice (2024): 10.5005/jp-journals-10024-3764

INTRODUCTION

In the recent decade, there has been a rapid and enormous development in bioceramics used in endodontics owing to their promising biocompatibility with oral tissues. An ideal sealer must be nontoxic, biocompatible, insoluble in tissue fluids, dimensionally stable, and provide high-quality sealing ability.¹ However, current root canal sealers do not possess all of these qualities.² In the 1990s, for the first time in endodontics came the advent of a new root-end filling material called mineral trioxide aggregate (MTA) in order to overcome these drawbacks.³

The rationale for root canal filling is straightforward: to prevent coronal and apical leakage and to entomb the remaining bacteria in the canal.⁴ In traditional root filling methods, a standard gutta-percha cone is coated with the sealer as the core, and accessory cones are used to fill the spaces between the cones and the gutta-percha and dentin walls. The gutta-percha cones do not bond to each other, nor do they bond to the root canal dentin. Moreover, the sealer shrinks on setting. This causes a gap between the gutta-percha cones themselves and between the gutta-percha and root canal walls, leading to microbial leakage. In vertical heat condensation, the gutta-percha shrinks more than the sealer on setting and does not show much benefit over the lateral condensation method.⁵

^{1,3,5,6}Department of Conservative Dentistry and Endodontics, DA Pandu Memorial RV Dental College, Bengaluru, Karnataka, India

²Department of Oral Pathology, SRM Dental College, Chennai, Tamil Nadu, India

⁴Consultant Implant Dentist, DA Pandu Memorial RV Dental College, Bengaluru, Karnataka, India

Corresponding Author: Murali H Rao, Department of Conservative Dentistry and Endodontics, DA Pandu Memorial RV Dental College, Bengaluru, Karnataka, India, Phone: +91 9986577700/+91 9845605004, e-mail: drmuralihrao@yahoo.com

How to cite this article: Rao MH, Krishnan R, Kumaraswamy M, *et al.* Assessment of Treatment Outcomes with Complete Orthograde Obturation with Bioceramic Materials: A Scoping Review. *J Contemp Dent Pract* 2024;25(12):1190–1197.

Source of support: Nil

Conflict of interest: None

In the early 2,000s, there was increased interest in bondable root canal filling materials, which led to the development of the Resilon Monoblock System (RMS). Resilon is a polycaprolactone-based dimethacrylate resin composite used with a methacrylate-based

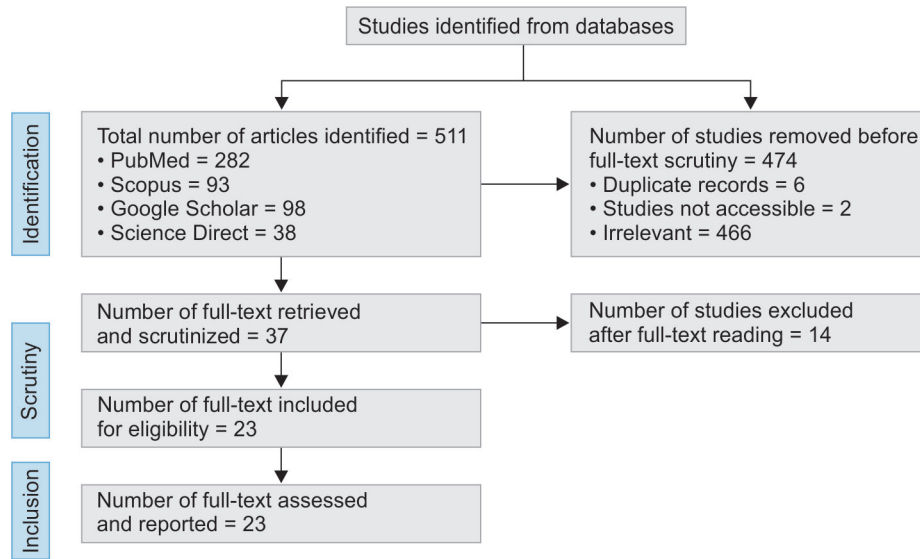


Fig. 1: Flowchart describing the search strategy

sealer. All adhesive restorations inherently cause volumetric shrinkage on polymerization. Additionally, the configuration-factor in root canals can be well over 1,000, leading to debonding and gap formation. Although the RMS showed positive outcomes compared to traditional filling methods, it still lacked adequate dimensional stability and bond strength and was technique sensitive.^{5,6}

Many uses have been described for MTA in the literature: Root-end filling, perforation repair, filling resorptive defects, vital pulp therapy, and apexogenesis in teeth with immature apices.³ Of late, the use of MTA as a sole obturating material is being explored due to its three most important characteristics, namely, potential bactericidal effect, insolubility in oral fluids, and biocompatibility.⁷ Clinical data on bioceramic materials used for complete orthograde obturations of root canals appear to be limited. This scoping review aims to map the type of evidence available and to explore the gaps in existing knowledge regarding the use of MTA/biodentine for orthograde obturation of the entire root canal.

METHODS

Protocol

This scoping review was undertaken as per the preferred reporting items for Systematic Reviews and Meta-analyses Extension for Scoping Reviews using the standard population, intervention, comparator, outcome (PICO) protocol as follows:⁸

Population: Permanent dentition in adults or children.

Intervention: Orthograde monoblock obturation using MTA or biodentine.

Comparator: Traditional orthograde root canal filling methods: gutta-percha obturation (warm vertical or lateral condensation techniques), MTA or biodentine apical plug with gutta-percha obturation.

Outcome: Success defined by asymptomatic, functional tooth and radiographic evidence of healing.

Inclusion Criteria

Treatment in permanent dentition in adults or children, orthograde monoblock obturations using MTA/biodentine assessing treatment

outcomes such as asymptomatic and restored functional teeth and evidence of healing were included.

Exclusion Criteria

Traditional obturation methods with gutta-percha, bioceramic sealers, deciduous teeth, animal studies, and laboratory studies were excluded from the review.

Search Strategy

The search was made in the month of June 2024 on PubMed, Google Scholar, Scopus, ScienceDirect, and Scielo databases using MeSH terms “bioceramic,” “mineral trioxide aggregate,” “biodentine,” “calcium silicate,” and “complete obturation.” Articles from January 2009 till October 2024 were sought. The search also included journals of repute: Journal of Endodontics, International Endodontic Journal, Australian Endodontic Journal, European Endodontic Journal, Journal of Dentistry, and Odontology. Articles and abstracts were provisionally included and then assessed individually by full-text reading by all reviewers. The references from each of the finalized articles were further examined for relevance, and duplicates were eliminated. The differences in opinions about inclusion were fully debated, and a common agreement was arrived at. Only resources meeting the inclusion criteria were chosen for final assessment.

Data Extraction and Synthesis

The relevant data were extracted with the help of a customized table for this purpose. The data table mandatorily included the details of authorship and year, region of origin, study design, study samples and size, bioceramic materials used (either MTA or biodentine for complete obturation), control (applicable for randomized controlled trials and retrospective studies), outcomes, and interpretations.

RESULTS

The selection of studies is elucidated in Figure 1. A total of 511 were retrieved from the initial search. Thirty-seven relevant studies were provisionally selected. Fourteen studies that did not meet the inclusion criteria were removed. Only 23 studies that met the inclusion criteria for qualitative analyses were considered after full text reading as stated before. The majority of the studies identified

were case reports. There were only 2 randomized controlled trials and retrospective observational studies each. The main features of the selected studies are reported in Table 1.

Characteristics of Selected Studies

The majority of the authors in the selected case report studies were from India. As the studies were mostly case reports, there were no controls to compare the treatment with gutta-percha obturations. Some of them did not have sufficient follow-up periods (up to 6 months only).^{9–12}

Significant Findings

The selected clinical studies assessed the periapical healing, obturation quality, and success in the retreatment of bioceramic materials. The size of the baseline lesion was found to be a significant predictor in determining the success of retreatment cases. Large lesions eventually required surgical intervention.¹³ Complete obturation with MTA showed significant regeneration of periapical tissue in certain retreatment and resorption cases.^{14,15} One study using OrthoMTA and ProRoot MTA demonstrated 87.5% periapical healing compared to conventional obturation.¹⁶ There is no negative impact found in the extrusion of MTA beyond the apex owing to its bioactive nature, and this induces hard tissue regeneration in the periapical region.¹³ Monoblock obturation using MTA perhaps also helps in strengthening and reinforcing the tooth structure while maintaining the sealing properties, especially in cases of immature teeth.¹⁷

DISCUSSION

The clinical success of a root canal treatment may have different meanings to the practitioner, the patient, and the clinical condition of the tooth itself.¹⁸ A successful outcome may be strictly defined by the complete absence of radiolucency and clinical signs and symptoms.¹⁹ Many consider that a functional tooth without an associated sinus, swelling, pain, or discomfort is a success, even though the radiographic appearance is unsatisfactory. Others maintain that in addition to the absence of clinical signs or symptoms, there must be evidence of complete bony repair, or reduction in the size of the periapical lesion, or absence of formation of a new periapical lesion, demonstrated radiographically.²⁰ In a systematic review by Ng et al., the two most important conditions to significantly improve tooth survival were placement of a crown following root canal treatment and a tooth having both mesial and distal proximal contacts.²¹ Nevertheless, in another systematic review by Ng et al., the absence of preoperative periapical radiolucency, root canal filling without voids and extending up to 2 mm within the radiographic apex, and a satisfactory coronal restoration were the main factors that influenced tooth retention.²²

In recent times, the interest in calcium-silicate-based materials evolved from MTA for root canal filling has peaked and resulted in the development of different root canal obturation materials and techniques to facilitate enhanced periapical healing.²³ Mineral trioxide aggregate is found to have excellent biocompatibility when used as a root-end filling material. It induces apical hard tissue formation and almost complete regeneration of periapical periodontium. When used as a vital pulp therapy agent, it induces dentin barrier formation with minimal signs of inflammation.²⁴ When MTA is proven to be biocompatible, can it not be used for complete obturation of teeth? Does it reinforce the roots and improve long-term tooth retention? *In vitro* studies have claimed that the root-reinforcing ability of MTA, flowable composite, and

hybrid composites were almost equal and the differences were statistically insignificant.²⁵ Another *in vitro* study by Elnaghy and Elsaka was done to assess the difference in fracture resistance when Biodentine or white MTA was used, and the result was not statistically significant.²⁶ Good quality *in vitro* studies in this regard were found to be lacking, but the current studies do not show any reduction in the fracture resistance of roots filled with MTA or Biodentine alone.^{25–27} The quality of obturation using different obturation techniques did not show any statistically significant differences.^{28–31} Yoo et al. demonstrated entombment of *E. faecalis* bacteria due to intratubular mineralization of dentin following orthograde MTA obturation. This entombment of bacteria has not been achieved by gutta-percha or Resilon with sealer, suggesting that the use of complete obturation of canals with MTA may be beneficial compared to an apical plug of MTA followed by gutta-percha obturation.³² Furthermore, this property of MTA could help entomb bacteria in small lateral canals not accessible to cleaning and shaping. In a way, the interface between the prepared radicular dentin and the MTA/Biodentine without a sealer interface could be called a “monoblock,” as there appears to be a biological bonding between the dentin–bioceramic interface.³³ One of the byproducts of MTA setting reaction is the formation of calcium hydroxide, which, as we are aware, exhibits antibacterial properties due to its highly alkaline pH. Mineral trioxide aggregate also stimulates differentiation and migration of hard tissue-forming cells to the area of repair.³⁴ The above-mentioned properties of MTA can be used to advantage in different clinical indications such as refractory primary root canal treatment, nonhealing periapical lesions, open apices, and root resorption.¹³

The majority of the studies included in this review were case reports, and only four studies were randomized controlled trials (RCTs) or retrospective studies.^{13,16,35,36} Unfortunately, the lack of high-quality studies indicates that there is not as much awareness about the potential uses of MTA as the sole obturating material. Eighty-four percent of included studies were case reports that are considered as one of the lowest levels of evidence, whether the treatment delivered was successful or not.³⁷ None of the randomized controlled studies assessed the outcome longer than 5 years, and the tooth retention beyond this time frame is not known. The studies that were included, however, showed no detrimental effect of complete bioceramic obturations on the success of the treatment. Some *in vitro* studies have also indicated that this type of obturation could actually reinforce the tooth root, but the authors were unable to find *in vivo* studies that supported the hypothesis. An observational study by Terauchi et al. revealed that teeth with overfilled or flush-filled MTA had better periapical healing than underfilled teeth;¹³ however, follow-up lasted for 48 months only. Even in teeth where the MTA was extruded beyond the apex, the periapical lesion showed satisfactory healing, and outcomes were favorable after 54 months, possibly because it was in direct contact with periapical tissues.^{34,38} One of the drawbacks was that not only were the methodologies of each of these RCTs non-uniform but also the technique of treatment delivery within the study group itself differed, and presented difficulties in synthesizing any conclusive data; hence, a systematic review was deemed unfit to accomplish. There were other ambiguities additionally, such as the teeth included had different preoperative pathologies, some cases were posted for periapical surgery a few months after, and attrition rates for long-term follow-up were on the higher side. This implies that more RCTs and retrospective studies must be executed to assess tooth retention over long periods of perhaps 10 years or more. Unless these are undertaken, we might not be able to appreciate the full potential of bioceramic materials.^{38–49}

Table 1: Summary and findings of full-text articles after data analysis

No.	Author, year, country	Study design	Population	Bioceramic material	Control	Method	Outcome	Main interpretations
1	Yoshi Terauchi et al., 2023; Japan ¹³	Retrospective	264 previously endodontically treated teeth	MTA	No specific control group with gutta-percha obturation	264 teeth divided into 3 groups based on cone-beam computed tomography measurements Overfills: >0.3 mm beyond the major apical diameter (n = 108). Flush fills: at or less than 0.3 mm (n = 103) Underfills: 0.3 mm or short of major apical diameter	Success at 6-month follow-up: Overfilled: 65.7% Flush-filled: 67% Underfilled: 35.3% Success at 48-month follow-up: Overfilled: 91.7% flush-filled: 87.4% Underfilled: 18.9%	With surgical intervention, the combined healed proportion was 93.2%. Under-filling: Three-fold increase in need for surgery.
2	Karp et al., 2006; USA ³⁹	Case report	Immature permanent left central incisor: External inflammatory resorption secondary to replantation after avulsion	MTA	NA	Avulsed tooth replanted, external root resorption noted after 47 days. Apexification attempted with calcium hydroxide. Continued resorption after 75 days. Calcium hydroxide dressing changed after 166 and 257 days: Cessation of resorption change dressing 347 days Obtured with MTA after 422 days	Cessation of root resorption and regeneration of periodontal ligament. Space at 166 days Normal clinical mobility at 865 days.	Apexification was complete with monoblock MTA obturation, without MTA apical plug and gutta-percha obturation.
3	Alsulaimani 2016; Saudi Arabia ¹⁶	Randomized controlled trial	36 restorable, teeth with closed apices, sinus tracts and periodical radiolucency of diameter >3 mm	MTA	Gutta-percha with root canal sealer	36 teeth randomly divided: Treatment (T): Mineral trioxide aggregate obturation Control (C): gutta-percha with sealer	Survival rate of MTA-treated teeth was 100% at 2.5, 3, and 5 years. Survival rate of gutta-percha-treated teeth was 100% at 2.5 years but 83.3% at 3, and 5 years.	There was no significant difference between the groups in terms of periapical healing, survival rate, obturation length, or resorption of extruded material.
4	Witherspoon et al., 2008; USA ³⁵	Retrospective	144 immature permanent teeth	MTA	No specific control group with gutta-percha obturation	Complete obturation with MTA following disinfection	78 teeth were available for recall. Of the cases recalled for period of 1 year or longer, 93.5% of 1 visit treatments healed, and 90.5% of 2-visit treatments healed with normal periodontal ligament space and lamina dura	MTA obturation of canals with open apices is a feasible alternative to the use of calcium hydroxide for apexification.
5	Srinivasan et al., 2021; India ⁹	Case report	Maxillary right central incisor	Biodentine	NA	First visit: Triple antibiotic paste dressing following access opening Second visit: Three weeks later, triple antibiotic mixture removed from the canal, obturated with biodentine.	6-month follow-up: satisfactory periapical healing demonstrated radiographically	Biodentine can be used instead of MTA as an obturation material due to its favorable handling properties, faster setting time, lesser discoloration.

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Table 1: (Contd...)

No.	Author, year, country	Study design	Population	Bioceramic material	Control	Method	Outcome	Main interpretations
6	Parolia et al., 2021; Malaysia, ⁴⁰ Lebanon	Case report	3 patients, 5 teeth	MTA	NA	Case I: MTA with thermoplasticized gutta-percha Case II: Complete obturation with MTA. Case III: Complete obturation with MTA.	30-month follow-up: Satisfactory healing of the periapical lesions and functional teeth	Complete resolution of pain and healing of periapical lesion radiographically.
7	Aggarwal et al., 2010; India ¹⁴	Case report	Mobile upper right central incisor	MTA	NA	Entire canal filled with MTA after complete disinfection	48-month follow-up: Arrest of root resorption.	Successful arrest of root resorption in severely resorbed, previously avulsed tooth. Longevity of treatment: Over a 48-month follow-up period, the treated tooth demonstrated stability, reduced mobility, and functional integration in the arch.
8	El Backly et al., 2020; Egypt ¹⁷	Case report	Supernumerary tooth fused to the left maxillary central incisor with periapical lesion	MTA	NA	Complete MTA obturation of the maxillary central incisor and removal of supernumerary tooth	4-year follow-up: satisfactory healing	Mineral trioxide aggregate offers reliable long-term outcomes, even when adjacent to graft materials and bone tissue.
9	Hayashi et al., 2004; Japan ¹⁵	Case report	Mandibular central incisors	MTA	NA	Re-obtured with MTA, followed by post-core	2 years follow-up: Satisfactory regeneration of periapical tissue	Mineral trioxide aggregate is an effective orthograde obturation material for apexification and retreatment cases as well.
10	Raidi et al., 2009; Brazil, Canada ⁴¹	Case report	Teeth with open apices and periapical lesions	MTA	NA	Case I: Calcium hydroxide dressing followed by gutta-percha and sealer obturation. Case II: An MTA apical plug followed by obturation with gutta-percha and sealer Case III: Complete MTA obturation	Signs of bone healing present, regardless of the treatment protocol used after 2 years, 5 years and 9 months follow-up, respectively	Mineral trioxide aggregate may be an alternative to calcium hydroxide apexification for managing open apices and large periapical lesions, especially when reduced treatment time is desired
11	Panda et al., 2024; India ¹⁰	Case report	Maxillary right lateral incisor	MTA	NA	Complete obturation with MTA followed by apicoectomy, placement of bone graft material, a platelet-rich fibrin (PRF) membrane, and sutures	6-month follow-up: lesion resorbed satisfactorily	Mineral trioxide aggregate can be used for complete orthograde obturation in chronic inflammatory cyst

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Table 1: (Contd...)

No.	Author, year, country	Study design	Population	Bioceramic material		Method	Outcome	Main interpretations
				Biodentine	Control			
12	Thiyagarajan et al., 2023; India ⁴²	Case report	Maxillary left central incisor	Biodentine	NA	Monoblock obturation using Biodentine	Six-month follow-up: Substantial bone healing and regeneration	Biodentine could be an alternative for non-surgical particularly for cases with parallel walls
13	Adiga et al., 2010; India ⁴³	Case report	Left and right mandibular first molar	MTA	NA	Only canals with strip perforation were filled with MTA; rest of the canals were obturated using GP with AH Plus sealer	6-month and 2-year follow-up: tooth was asymptomatic, radiographic healing evident	Mineral trioxide aggregate can be used as an alternative root canal obturation material for the treatment of strip perforation.
14	Jaiswal et al., 2013; India ¹¹	Case report	Maxillary central incisors	Biodentine	NA	Absorbent gelatin sponge was placed as apical barrier and complete obturation of the canals done using Biodentine	6-month follow-up asymptomatic tooth and a healed periapical lesion	Biodentine can be used for apexification, obturation, and reinforcement
15	Nikhil et al., 2012; India ⁴⁴	Case report	Maxillary right lateral incisor	Biodentine	NA	Complete canal obturation with Biodentine	15-month follow-up: Arrest of root resorption and progressive healing of the defect	Biodentine can be used for treating external cervical resorption, external apical resorption and obturating root canal.
16	Al-Kahtani 2013; Saudi Arabia ⁴⁵	Case report	Avulsed immature permanent maxillary central incisors	MTA	NA	External root resorption controlled by using calcium hydroxide intracanal medicament 46 days later: dressing was removed, and canal was completely obturated with MTA	1-year follow-up: symptom-free teeth, the clinical and radiographic evidence of healthy periodontium	Mineral trioxide aggregate can be used to completely obturate replanted avulsed teeth, provided there is no sign of external root resorption
17	Seok-Woo Chang et al., 2013; South Korea ³⁸	Case report	Maxillary central incisors	MTA	NA	Unintentional extrusion into the periapical area during complete obturation with MTA	36-54-month follow-up: Extruded material does not negatively affect healing of the periapical tissues	Radiographic follow-ups showed that the extruded MTA gradually became surrounded by bone-like tissue, with a reduction in periapical radiolucency
18	Agrawal et al., 2013; India ¹²	Case report	Maxillary right Canine: Middle third fracture	MTA	NA	Mineral trioxide aggregate was used for complete obturation and intra-radicular splint	4-month follow-up: Teeth were asymptomatic and responded normally to percussion, palpation, and pressure 1-year follow-up: Satisfactory radiographic healing	There is potential for MTA to improve the prognosis of horizontal root fractures
19	Teja KV and Ramesh S, 2021; India ⁴⁶	Case report	Mandibular Left First molar: Strip perforation	MTA	NA	Autologous PRF used as apical matrix, followed by complete obturation with MTA	One year follow-up: Normal clinical function and periradicular healing	Platelet-rich fibrin and MTA can be used concurrently managing strip perforations
20	Kapoor et al., 2016; India ⁴⁷	Case report	Two patients: Maxillary Premolars	MTA	NA	Mineral trioxide aggregate was incrementally placed in the canals, using ultrasonic agitation and compaction		MTA highly effective clinically for apexification, regeneration, and strengthening immature teeth, supporting both rapid healing and long-term durability

(Contd...)

Table 1: (Contd...)

No.	Author, year, country	Study design	Population	Bioceramic material	Control	Method	Outcome	Main interpretations
21	Subay et al., 2019; Turkey ⁴⁸	Case report	Maxillary right central incisor: perforating internal root resorption	MTA, Biodentine	NA	First visit: Canal disinfection and calcium hydroxide dressing due to canal exudation. Second visit: 3 months later, complete obturation with MTA	4-year follow-up: Symptom-free, patient received orthodontic treatment followed by ceramic crowns. 6-year follow-up: Hard tissue barrier seen radiographically	Mineral trioxide aggregate can be used for repair of the internal root resorption defects
22	Sinha et al., 2024; India ⁴⁹	Case report	Maxillary central incisors	MTA	NA	Decalcified freeze-dried bone allograft DFDBA and PRF as apical barrier followed by complete MTA obturation.	3- and 12-month follow-up: Symptomatic and functionally normal, with radiographic evidence of osseous repair and complete apical closure.	Scaffold materials along with MTA resulted in satisfactory outcome
23	Al Jasser et al., 2021; Saudi Arabia ³⁶	Randomized controlled trial	120 maxillary anterior teeth	MTA	Gutta-percha with sealer	Group I: Gutta-percha (control), n = 30 Group II: Complete MTA, n = 30 Group III: Gutta-percha + grafting for osseus defect. Group IV: Mineral trioxide aggregate + grafting.	1, 3, 6, and 12-month follow-up: pocket depth and clinical attachment levels were optimum for Groups II and IV	Complete MTA with grafting showed highest resolution of true combine endo-perio lesions.

CONCLUSION

To use bioceramic materials for complete, standalone obturation, very few studies with limited data in terms of outcomes and time span exist. This dearth of research includes the absence of long-term clinical longitudinal studies and *in vivo* randomized controlled trials, resulting in a lack of evidence over the efficacy of this material for complete obturation of the root canal. Hence, this scoping review has tried to bridge this gap between existing literature and relevance in current dental practice.

ORCID

Murali H Rao  <https://orcid.org/0000-0001-6310-6425>
 Rajkumar Krishnan  <https://orcid.org/0000-0002-6875-0663>
 Aditya Keshav  <https://orcid.org/0000-0002-4943-9888>
 Pavithra Gopal  <https://orcid.org/0009-0005-7505-1616>
 Elizabeth Thomas  <https://orcid.org/0009-0002-8185-3912>

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