The Bioscan
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
20(4): 324-335, 2025 www.thebioscan.com

MTA Pulpotomy: An Evidence-Based Review

Dr. Yanina Singh[1*], Dr. Lidiane Fumiko Takeda[2], Dr. Suyash Pratap Singh[3], Dr. Garima Chaudhary[4], Dr. Mrunal Dave[5], Dr. Preeti Bhagwandas Vaprani[6]

[1]Assistant Professor, Department of Pediatric and Preventive Dentistry, School of Dental Sciences, Sharda University, Greater Noida, Uttar Pradesh, India

[2]Associate Dentist, Department of Orthodontics and Restorative Dentistry, Perfect Smiles Clinic, Chicago, Illinois, USA

[3]Senior Lecturer, Department of Conservative Dentistry and Endodontics, Institute of Dental Sciences, Bareilly, Uttar Pradesh, India

[4]Assistant Professor Department of Pediatric and Preventive Dentistry Sardar Patel Post Graduate Institute of Dental and Medical Sciences Lucknow Uttar Pradesh, India

[5]DDS, Associate Dentist, Bethlehem Smile Design, Bethlehem, Pennsylvania, USA.

[6]PhD Scholar, Assistant Professor, Department of Conservative Dentistry and Endodontics Tatyasaheb Kore Dental College and Research Centre, New Pargaon, Maharashtra, India

DOI: 10.63001/tbs.2025.v20.i04.pp324-335

Received on:
22-08-2025
Accepted on:
30-09-2025
Published on:
12-11-2025

ABSTRACT

Mineral Trioxide Aggregate (MTA) has transformed pulpotomy procedures in pediatric dentistry. This review assesses MTA's efficacy and safety compared to traditional materials like formocresol. Studies indicate MTA's superior biocompatibility and sealing ability, making it a preferred choice for both primary and permanent teeth pulpotomies. MTA not only preserves tooth vitality but also supports successful long-term outcomes.

Introduction: Dental caries continues to be one of the most common health issues affecting children globally, particularly in developing nations. Pediatric dentists often find themselves grappling with the challenge of managing deep carious lesions in children's primary teeth. A significant number of these cases involve pulpal exposure, stemming from the persistence of the carious lesions. Various treatment options, including direct pulp capping, pulpotomy, pulpectomy, and extraction, can be explored based on the severity of the decay and the dentist's expertise in handling

these situations. The success of these treatments largely hinges on a thorough evaluation of the pulp's condition, the technique employed, and the materials utilized in the process.[1]

Thanks to a better understanding of dental caries and advancements in materials, the old idea of "extension for prevention" has been replaced by a more conservative strategy for managing dental caries. For deep carious lesions that show pulpal exposure but lack significant signs or symptoms of extensive pulp damage, the pulpotomy procedure is used. Pulpotomy involves removing the coronal pulp while keeping healthy radicular pulp intact within the root canals. Afterward, a medicament is placed, and a strong seal is applied until the primary tooth naturally falls out. Despite its documented success over the years, the safety and effectiveness of various pulpotomy agents have faced scrutiny. However, the introduction of newer biocompatible materials like mineral trioxide aggregate (MTA), which shows better outcomes than older agents, suggests a bright future for this technique.[2,3]

Case Selection for Pulpotomy

Clinical Criteria

1. **Deep Caries with Restorability:** For deep carious lesions with a restorable crown, particularly proximal ones that penetrate more than half the dentine, a pulpotomy is often more effective than direct pulp capping due to the significant inflammatory response. Occlusal lesions with clear cavitation or extensive decay affecting over half the occlusal surface (ICDAS scores 5 or 6) should also undergo pulpotomy. This approach removes inflamed coronal pulp while preserving healthy radicular tissue, which can heal. A radiographic exam is crucial for assessing the extent of carious involvement, and there must be enough remaining tooth structure to retain a stainless steel crown for a secure coronal seal.[4,5]
2. **Systemic diseases or allergies:** No history of systemic diseases or allergies is essential to rule out any underlying conditions that could impact the success of the procedure.[6]
3. **Absence of obvious signs of pulpal degeneration is crucial:** symptoms like spontaneous pain, a sinus tract, nighttime pain, pathological mobility, and tenderness upon percussion make the tooth unsuitable for pulpotomy.

Spontaneous and nocturnal pain are classic indicators of irreversible pulpitis with significant pulp damage, while the presence of a fistula, sinus tract, or mobility suggests infection has spread to the periradicular tissues.[6]

4. **Carious or iatrogenic pulpal exposure:** Vital pulp therapy is recommended for teeth with carious, mechanical, or traumatic pulp exposures. Razlan and Wetzel (2006) suggested that the cause of the pulpal exposure may influence the post-treatment response.[7] However, Çelik and Sari found that both carious and mechanical exposures had a 100% success rate after 18 months, even though pulpal response was slightly higher for carious exposures compared to mechanical ones.[4]
5. **Successful Haemorrhage Control:** Successful control of hemorrhage should occur within 5 minutes, according to Ozdemir et al., while Aeinehchi et al. suggest within 3 minutes, and Cohenca et al. recommend 1-2 minutes. If bleeding persists after placing a moistened cotton pellet in this timeframe, it indicates irreversible pulpitis and the need for nonvital pulp therapy.[8-10]
6. **Colour of Bleeding:** The color of the hemorrhage is also significant: bright red indicates inflamed pulp, while dull red or brownish-red suggests extensive infection and pulpal degeneration. Pulpotomy should be performed when the intracanal hemorrhage is bright red, as this color indicates active inflammation from red blood cell breakdown.[3]

Radiographic Criteria: Remaining dentin thickness in deep carious lesions (ICDAS scores 5 or 6) is best evaluated using a quality bitewing radiograph, aiding clinicians in determining the appropriate treatment. If physiological root resorption is more than one-third of the total root length, vital pulp therapy is usually unnecessary, as the tooth is likely to exfoliate soon. Additionally, a widened lamina dura visible on radiographs indicates irreversible changes in the supporting tissues, suggesting that nonvital pulp therapy is more appropriate than vital pulp therapy.

The presence of periradicular or furcal radiolucency in primary teeth is a key indicator of irreversible pulpal degeneration, typically first seen in the interfurcal region. Such radiolucencies

result from bacterial invasion of surrounding tissues and suggest the need for more invasive endodontic therapy. Additionally, any evidence of external or internal root resorption on radiographs indicates inflammatory changes and infection of the radicular pulp, making vital pulp therapy contraindicated.[11-13]

Clinical Procedure

Isolation: Complete isolation with a rubber dam is essential for any endodontic procedure; pulpotomy should not be performed if this cannot be achieved. The choice between quadrant or single tooth isolation is subjective, but quadrant isolation is preferred, whenever possible, to aid in crown preparation under the rubber dam.[6,14]

Caries Removal: Carious tissue is removed using a large, slow-speed round bur after assessing the extent of the lesion. The pulp chamber roof is then carefully eliminated, which can be done using a large, low-speed round bur or a #330 carbide bur. Some experts recommend using a safe-end or non-cutting end taper fissure bur for this purpose. Once the chamber is accessed, the coronal pulp is amputated to complete the procedure. [6,14]

Deroofing of Pulp Chamber: To eliminate the roof of the pulp chamber, a large, low-speed round bur or a #330 carbide bur is used. Some practitioners also recommend utilizing a safe-end or non-cutting end taper fissure bur for this process. Once the chamber is accessed, the coronal pulp is amputated with a large, low-speed round bur (#6 or #8) or a sharp spoon excavator. [6,14]

Disinfection: For disinfection of the pulp chamber, studies suggest using a 3%–5% sodium hypochlorite (NaOCl) solution prior to drying the chamber. This solution helps dissolve and remove any residual tissue, debris, or dentinal chips that could lead to infection of the radicular pulp. Research by Akcay et al. compared the effectiveness of 5% NaOCl with physiological saline for pulp chamber disinfection before placing pulpotomy medicament, reporting successful treatment outcomes in both scenarios.[15]

Haemorrhage Control: To control pulp haemorrhage, gentle pressure should be applied with a moist, sterile cotton wool pellet against the canal orifices. Bleeding should be managed within 3-5 minutes, as a dry pellet can leave fibers behind in the clot, leading to renewed hemorrhage upon removal.[6,14]

Mixing of MTA and Its Placement: When mixing MTA, follow the manufacturer's guidelines using sterile water on a clean glass slab with a spatula. The final mixture should achieve a wet, sand-like consistency.

After preparing the MTA, the cotton pellet in the pulp chamber should be carefully removed to allow for placement. The increments of MTA should be compacted against the floor and walls of the chamber using a cotton pellet moistened with sterile water. The thickness of the compacted bulk of material should be 3–4 mm and should cover all of the root canal orifices and the floor. No voids should be seen. It is advisable to make a radiograph at this stage to check for adequate thickness of the MTA layer and proper compaction of the material.[6,14]

Restoration and stainless steel crown: After confirming the acceptability of the MTA layer, the pulp chamber should be immediately filled with glass ionomer cement. Some authors advocate for this immediate restoration, while others recommend covering the MTA with a moist cotton pellet and temporizing, with the patient returning after 24 hours to fill the chamber with glass ionomer cement. However, this step is unnecessary with newer MTA materials that have shorter setting times compared to traditional ProRoot MTA or Portland cement. Once the pulp chamber is restored, the appropriately sized stainless steel crown (SSC) should be cemented using glass ionomer luting cement.

Follow up: The pulpotomized tooth requires regular follow-up. During recall visits, the clinician should check for signs and symptoms of clinical outcomes, such as:

Successful Outcomes:

- Asymptomatic
- Natural exfoliation
- Physiologic mobility
- Short-lasting chewing sensitivity
- Normal taper of root canals
- Normal width of periodontal ligament space
- No trabecular changes
- Dentin bridge formation

Failures:

- Exfoliation due to ectopic eruption
- Gingival inflammation from poor oral hygiene
- Long-lasting chewing sensitivity
- Spontaneous pain
- Gingival swelling near the furcation area
- Pathologic mobility >2 mm
- Sinus tract or fistula formation
- Premature tooth loss due to pathology
- Widened periodontal ligament space
- External root resorption
- Perforating internal resorption
- Osseous radiolucency involving the area

Monitoring these outcomes helps assess the success of the pulpotomy and ensure proper management.

Evidence Based Success of MTA Pulpotomy

Vital pulp therapy aims to maintain the health and integrity of a tooth, its supporting structures, and the overall arch. One common technique used to prevent the extraction of a decayed primary tooth is pulpotomy. This procedure involves removing the affected coronal pulp while preserving the vital radicular pulp, particularly in teeth with deep caries that show no signs of radicular pulpitis.[16]

Ranly classifies pulpotomy procedures into three categories based on the type of medicament used: devitalization, preservation, and regeneration. Among these, formocresol, introduced by Buckley in 1904, is often considered the "gold standard" for pulpotomy agents. Despite its widespread use, formocresol has several disadvantages, including cytotoxicity, potential for pulp inflammation and necrosis, systemic effects, mutagenicity, carcinogenic potential, and immunological responses. Nonetheless, it remains one of the most commonly used medicaments in pulpotomy procedures.[17]

In the pursuit of more biocompatible pulpotomy agents, mineral trioxide aggregate was introduced by Torabinejad in the mid-1990s as an innovative material for pulpotomy procedures in both primary and permanent teeth. MTA is known for its excellent biocompatibility, ability to promote tissue regeneration, and good marginal integrity with no microleakage.[18,19]

Despite these advantages, MTA does have some drawbacks. It can be challenging to manipulate, has a long setting time, and its high pH can be a concern. Additionally, MTA has a short shelf life, may cause discoloration of the teeth, and exhibits low compressive strength compared to other materials. These factors can limit its practical application in certain scenarios.

MTA vs Formocresol: In a study by Ghoniem N et al., the effectiveness of MTA versus formocresol (FC) in primary molar pulpotomies was evaluated at both a teaching institution and a pediatric dental practice. At the teaching institution, 206 primary molars from 122 children were included, and after 48 months, 20 teeth treated with MTA and 25 treated with FC were available for assessment. In the private practice, dental records of 245 primary molars from 68 patients were examined, and again, after 48 months, findings from both locations revealed a radiographic success rate of 80% for FC and 95% for MTA. The results indicate that MTA is a viable alternative for pulpotomy in primary molars.[20]

In a study by Biedma Perea M et al., 212 molars were treated—74 with formocresol

and 138 with white mineral trioxide aggregate (MTA). The clinical success rate was similar between groups, with 89.9% for white MTA and 82.5% for FC. However, the radiographic success rate was significantly higher for white MTA, with a failure rate of 7.9% compared to 18.9% for FC. In terms of eruption timing, minor variations were noted, with early and delayed eruptions occurring in 7.24% and 8.69% of the MTA cases, and 9.45% and 4.05% in the FC cases, indicating no relevant impact on eruption. Overall, MTA demonstrated a significantly better radiographic success rate than FC for pulpotomy in primary teeth over a follow-up period of 6 to 48 months.[21]

Agamy et al. found that clinical, radiographic, and histological evaluations of pulpotomized teeth over 12 months showed better outcomes with MTA compared to formocresol.[22] Similarly, Stringhini Junior et al. also reported superior results for MTA over formocresol.[23] In a study by Jayam et al., the success rates for primary tooth pulpotomy after 24 months were 90.48% for formocresol and 100% for MTA.[24] These studies highlight the excellent biocompatibility and effectiveness of MTA in pulpotomy procedures.

MTA vs Ferric Sulphate: In 1991, Fei introduced 15.5% ferric sulfate as an alternative to formocresol for pulpotomy, reporting promising clinical results in primary teeth.[25] A systematic review and meta-analysis by Asgary S evaluated the success rates of pulpotomy in primary molars using mineral trioxide aggregate (MTA) versus ferric sulfate (FS). Out of 620 articles, four randomized controlled trials (RCTs) were selected, involving 264 teeth with follow-ups of 12 and 24 months. Results showed similar outcomes after 12 months (RR=0.642, P=0.407). However, at the two-year mark, MTA demonstrated significantly better outcomes (RR=0.300, P=0.004). Consequently, MTA showed superior long-term effectiveness for pulpotomy.[26]

MTA vs Calcium Hydroxide: Liu H et al. effects of mineral trioxide aggregate and calcium hydroxide (CH) for pulpotomy in primary molars. randomised, bilateral self-controlled clinical trial was designed to compare the clinical effect of MTA and CH in pulpotomies in primary molars in 4- to 9-year-old children. Seventeen pairs of self-controlled contralateral teeth were available for follow-up evaluations. The success rate of MTA was 94.1% (16/17), while the success rate of CH was 64.7% (11/17). Internal root resorption was the most frequent reason for failure in the CH group. Crown discolouration was common in the MTA-treated group. MTA was more

successful than CH for pulpotomies in primary molar teeth, and may be a suitable replacement for CH in primary molar pulpotomies.[27,28]

MTA vs Electrosurgery: Electrosurgery has been proposed as an alternative treatment to avoid the toxic effects of chemical drugs applied over the pulp. In this context, Girish MS et al. conducted a study to compare the outcomes of mineral trioxide aggregate and electrosurgical pulpotomies in 60 carious mandibular primary molars from 46 children. The teeth were randomly assigned to either MTA or electrosurgical pulpotomy and subsequently fitted with stainless steel crowns. Follow-ups were conducted at 1, 3, 6, 9, and 12 months for evaluation. After 12 months, the success rate for MTA was 96.7%, while the electrosurgery group had a success rate of 90%. Although MTA showed a higher success rate than electrosurgery, the difference was not statistically significant, indicating that both methods are effective for pulpotomy in primary molars.[29]

MTA vs Biodentine: Stringhini Junior E et al. conducted a systematic review and meta-analysis of clinical trials to assess the clinical and radiographic success rates of pulpotomy in primary teeth using Biodentine compared to MTA. Out of 233 initial publications, only 9 studies met the inclusion criteria. The results showed that at 6 months, the overall clinical success rates were similar between Biodentine and MTA (RR = 0.99; 95% CI = 0.96-1.02, p = 0.92). Radiographic success rates also did not differ significantly (RR = 0.96; 95% CI = 0.92-1.00, p = 0.28). While MTA is the gold standard for pulpotomy, it has drawbacks like poor handling and long setting times, making it important to evaluate alternatives like Biodentine.[30]

Future Prospective of MTA Pulpotomy: The future of MTA pulpotomy is promising due to advancements in materials and techniques, which may enhance its effectiveness and biocompatibility. Its application is expanding beyond pediatric dentistry, with increasing interest in treating adult cases. Research is ongoing to better understand long-term outcomes, and there's potential for integration with regenerative dentistry. The trend towards minimally invasive practices aligns well with MTA procedures, promoting the preservation of tooth structure. As education and public awareness grow, demand for MTA pulpotomy is expected to increase, making it a mainstay in both pediatric and adult dental care.

Conclusion: MTA pulpotomy has emerged as a promising treatment option for

managing primary and permanent teeth with vital pulp exposure due to caries or trauma. The utilization of MTA in pulpotomy procedures shows several advantages, including excellent biocompatibility, superior sealing abilities, and the capacity to promote pulp regeneration. Evidence from clinical studies indicates that MTA pulpotomies yield high success rates, often surpassing those of traditional methods such as formocresol pulpotomy.

Future research should focus on long-term follow-up studies assessing the outcomes of MTA pulpotomy in diverse patient populations, as well as comparisons with other modern materials and techniques. As practitioners continue to advocate for evidence-based approaches, MTA pulpotomy stands as a significant advancement in pediatric and endodontic dentistry, ultimately enhancing patient care and improving tooth retention.

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