Mineral Trioxide Aggregate Obturation: A Review and Case Series

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Abstract

Mineral trioxide aggregate (MTA) has emerged as a reliable bioactive material with extended applications in endodontics that include the obturation of the root canal space. This article examines the literature supporting MTA as a canal filling material, suggests methods for its delivery and placement, and presents clinical cases that demonstrate its effectiveness in resolving apical periodontitis under a variety of circumstances. Case reports are presented documenting clinical outcomes after the application of MTA that include retreatment, obturation combined with root-end resection, apexification, internal resorption, dens in dente, and in conventional endodontic therapy. The review introduces clinicians to an alternative treatment strategy that might improve the healing outcomes for patients presenting with complex and challenging endodontic conditions. *(J Endod 2009;35:777–790)*

Key Words

Gutta-percha, mineral trioxide aggregate, obturation, periapical, retreatment

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The obturation of the prepared radicular space has been achieved by using a wide variety of materials selected for their intrinsic properties and handling characteristics. These core materials have been classified as cements, pastes, plastics, or solids (1). Gutta-percha, in its various forms, has remained the paragon as a root canal filling material during the course of the last century. The development of core materials and delivery techniques has generated carrier-based gutta-percha and resin-based systems. These filling materials are combined with sealers to provide an adequate obturation of the root canal space that ideally prevents the emergence of endodontic disease and encourages periapical healing when pathosis is present (2). This process can only succeed if the sealed root canal space prevents further ingress of bacteria, entombs remaining microorganisms, and prevents their survival by obstructing the nutrient supply (3).

The materials that can be used to fill the root canal space should exhibit certain characteristics that allow for predictable placement and prevent and resolve endodontic disease (1). For endodontic filling and sealing materials to fulfill these ideal requirements, they should be bacteriostatic, seal apically and laterally, be nonirritating to periapical tissues, resist moisture, and provide radiopacity. Furthermore, the material should be sterile, nonshrinking, nonstaining, and easily placed and removed from the root canal system. On the basis of recent advances in endodontic materials, some of these criteria might require considerable reexamination.

Because the obturation of the root canal system demands a material that actually provides a reliable and impervious hermetic seal, it might be a contradiction that the material should be easy to remove. Because restorative procedures that include core buildups and cuspal coverage restorations can be subject to restorative microleakage, it might be necessary to obturate the canal space with materials that demonstrate a greater resistance to leakage as an impediment against oral pathogens. Furthermore, if an obturation material can offer additional properties that decrease bacterial survival and promote bioactive mechanisms necessary for regeneration and healing, then some ideal requirements of the filling material might be viewed as less important when the distinct advantages are considered.

The development of alternative obturation materials can be attributed to multiple studies demonstrating that gutta-percha is highly susceptible to microleakage when a sealed coronal restoration is not provided. When gutta-percha canal obturations are tested *in vitro* by using dye penetration, fluid filtration, or bacterial leakage models, they show vulnerability. Bacterial challenges to exposed gutta-percha with sealer in various *in vitro* experimental models have shown leakage along the material within 3–30 days (4–7). Research indicates that no known method with various techniques of cold or warm compaction of gutta-percha can predictably produce a coronal bacterial-tight seal when the material is exposed to microorganisms and their by-products (8–10). Although gutta-percha presents important advantages in ease of use, handling properties, and biocompatibility, it exhibits inherent weaknesses that make it less than ideal. The ideal material for root canal obturation has yet to be developed.

Coronal microleakage has been identified as a major cause of persistent periradicular disease and failure in orthograde endodontic therapy (11–13). Furthermore, all contemporary provisional materials placed over gutta-percha in obturated teeth have limited effectiveness in protecting the material from microbial contamination for extended periods (14–16). The susceptibility of gutta-percha to contamination and microleakage has led to the recommendation that sealed coronal core materials be placed directly after the completion of orthograde root canal treatment when using gutta-percha (17). A current trend in endodontic research is to explore various alternatives to gutta-percha to identify suitable filling materials that can provide greater resistance against coronal and apical microleakage and thus protection from bacterial contamination.

Mineral trioxide aggregate (MTA) might have a profound advantage when used as canal obturation material because of its superior physiochemical and bioactive properties. The original material (ProRoot MTA; Dentsply Tulsa Dental, Tulsa, OK) was introduced to seal pathways of communication from the external surface of the tooth in perforation repair and as a root-end filling material in endodontic surgery (18). When early scientific observations and clinical outcomes demonstrated favorable biologic responses to the material, other uses for MTA were explored and investigated. MTA was found to be effective as a pulp capping and pulpotomy agent for the repair of internal and external resorptive defects and was also shown to promote root-end induction in teeth with immature apices (apexogenesis) (19, 20).

This recently introduced tricalcium silicate cement exhibits many important properties not available in other contemporary materials currently used in endodontics. In conjunction with being sterile, radiopaque, and nonshrinking, the material is not sensitive to moisture and blood contamination. MTA also provides an effective seal against dentin and cementum and promotes biologic repair and regeneration of the periodontal ligament (PDL) (21–26). Because perforation repair, root-end induction, and root-end filling are essentially forms of partial canal obturation, the orthograde filling of the apical region or the entire root canal system with MTA is the next logical progression in the evolutionary application of this material. The use of MTA as an obturation material might ultimately provide long-term benefits that enhance the prognosis and retention of the natural dentition in conventional and complex therapies.

Physiochemical Properties

MTA exhibits unique physiochemical properties that can provide exceptional outcomes when used for complete or partial canal obturation. Both gray and white MTA can be used for this procedure, despite the fact that the materials vary slightly in composition and characteristics (27). Some of these characteristic properties can be first observed during the hydration process, when calcium silicates react to form calcium hydroxide and calcium silicate hydrate gel, producing an alkaline pH (28). A further reaction forms a high-sulfate calcium sulfoaluminate during the reaction with tricalcium aluminate and calcium phosphate (29). The release of calcium from setting MTA diffuses through dentinal tubules, and the concentration of the calcium ions increases with time as the material cures (30). It appears that the biocompatibility of the cement might be attributable to the release of hydroxyl ions and formation of calcium hydroxide during the hydration process (31).

When mixed MTA is compacted against dentin, a dentin-MTA interfacial layer forms in the presence of phosphates (32). This adherent interstitial layer resembles hydroxyapatite in composition and structure when examined under x-ray diffraction and scanning electron microscopy (SEM) analysis; however, the calcium to phosphorus ratio varies slightly from that reported in actual hydroxyapatite (33). This interface between dentin and MTA has demonstrated superior marginal adaptation compared with amalgam, intermediate restorative material, or Super-EBA under SEM in resin models (34). Moreover, the particle size and dimensional shape of MTA can occlude and penetrate dentinal tubules that might harbor microorganisms after cleaning and shaping (35).

MTA not only fulfills the ideal requirement of being bacteriostatic, but it might have potential bactericidal properties. The release of hydroxyl ions, a sustained high pH for extended periods (36), and the formation of a mineralized interstitial layer might provide a challenging environment for bacterial survival (37). These antibacterial properties can be a potent inhibitor of bacterial growth against species such as *Entercoccocus faecalis* (38), a microorganism prevalent in root canal failures (39–42). Moreover, *Candida albicans*, commonly present in refractory endodontic disease (43), is susceptible to the antifungal activity of freshly mixed MTA (44–46).

The cured cement creates a potentially impervious seal that might be difficult for microorganisms to penetrate. This unique sealing property, combined with an initially high pH that increases to 12.5 after curing, might provide a suitable mechanism for bacterial entombment, neutralization, and inhibition within the canal system. These factors are important when considering nonsurgical treatments for patients with large periapical lesions associated with initial root canal treatment or in cases presenting with refractory endodontic disease diagnosed for retreatment. Orthograde retreatments with MTA might provide comparable or superior healing rates and less morbidity when contrasted against conventional retreatment paired with surgical endodontics (47, 48).

Case #1: MTA Obturation

A 34-year-old male patient presented to a private endodontic office for evaluation of tooth #30, which had received nonsurgical endodontic treatment 18 months before and was restored with a porcelain fused to metal (PFM) crown (Fig. 1*A*). The presenting symptoms included swelling in the buccal vestibule and pain overnight. His medical health history was unremarkable, and radiographic examination revealed a poor quality obturation of the distal canal, extrusion of gutta-percha associated with both apices, absence of a discernible core material, and extensive periapical and furcation bone loss. Clinical examination disclosed fluctuant swelling in the vestibule proximal to the molar, grade 1 mobility, and pain on percussion. The clinical diagnosis was acute periapical abscess, and the patient elected retreatment with MTA obturation after discussion of treatment options. Written consent was obtained.

After anesthesia and rubber dam isolation, the molar was accessed through the crown, and inspection affirmed that no restorative core material was present. After the remaining Cavit (3M ESPE, St Paul, MN) and cotton pellet were removed, 3 canals were located. The previous obturating materials were removed with Gates-Glidden drills and barbed broaches without chloroform irrigation. The canals were chemomechanically debrided with Profile .04 Taper (Dentsply Tulsa Dental) sizes 20–60 to a master apical file (MAF) size 40 in conjunction with 5.25% sodium hypochlorite (NaOCl) irrigation. The canals were flushed with sterile water and dried with paper points, and the canals were filled with vertically compacted gray MTA by using a size 30 stainless steel K-file and 1/3 and 5/7 endodontic pluggers (Fig. 1*B*). After provisionalization, the patient received incision and drainage at the site and was given analgesics and antimicrobial therapy. He returned for follow-up 30 days after a bonded core was placed by the general dentist (Fig. 1*C*) and at 4 years, with healing evident radiographically (Fig. 1*D*). Clinical examination revealed normal mobility, probings, and normal function without symptoms.

This case illustrates the concept of MTA obturation of the entire canal system. In particular, previously endodontically treated teeth that have been subjected to long-term microleakage and bacterial contamination can show improved healing rates without surgical intervention by using MTA obturation, when compared with gutta-percha reobturated teeth under the same clinical conditions.

Recent research has demonstrated that root canal treated teeth obturated with MTA exhibit higher fracture resistance than their untreated counterparts (49). Furthermore, it appears that long-term placement of MTA in the canal system not only provides increased resistance to