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Mineral Trioxide Aggregate: A Literature Review

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Abstract

MTA was developed in Loma Linda University in 1990's by Torabinejad as a root end filling material. It received acceptance by the US Federal Drug Administration in 1998. Since. Mineral Trioxide Aggregate (MTA) is a novel substance with a wide range of fascinating clinical uses. MTA has the potential to be one of the most adaptable materials used in dentistry today. Among MTA's notable qualities are its favourable physical characteristics, its capacity to promote tissue regeneration, and its favourable pulp response. This article provides a review of MTA's clinical applications in dentistry as well as its availability, composition, manipulation, setting reaction, and characteristics.

Keywords: *Mineral Trioxide Aggregate, MTA, Application of MTA*

Introduction

MTA is a root end filler substance that Torabinejad developed at Loma Linda University in the 1990s. The US Federal Drug Administration approved it in 1998. Since its clearance, MTA has been commercially accessible under the brand Pro Root MTA, and it is now available in two more forms with identical chemical and physical characteristics, namely the Grey and White MTA.[1,2]

Since Lee and colleagues' initial description of MTA in the dental literature in 1993, both surgical and nonsurgical applications, including as root end filling, direct pulp capping, pulpotomy, perforation repair, furcation repair, apexification, and obturation, have made use of it. Given its sealing qualities, blood-setting capacity, biocompatibility, and ability to create hard tissue, this material shows potential.[3]

MTA is a powder made up of calcium sulphate dehydrate, bismuth oxide, tricalcium silicate, dicalcium silicate, and tricalcium aluminate [1]. MTA is composed of ingredients designed to have the physical qualities, setting needs, and features of the perfect repair and medication material. With its outstanding long-term prognosis, relative ease of use, and interesting clinical applications, MTA has the potential to be one of the most adaptable materials of the century in dentistry.[4]

Composition of MTA: MTA comprises Portland cement (75%), Bismuth Oxide (20%), and gypsum (5%). Portland cement is a mixture of Tricalcium silicate $(CaO)_3SiO_2$, Dicalcium silicate $(CaO)_2SiO_2$, Tricalcium aluminate $(CaO)_3$ $Al2O_3$, and Tetracalcium aluminoferrite $(CaO)_4Al_2O_3Fe_2O_3$.[5]

Type of MTA: White and grey MTA are the two colours that are offered for MTA. The amount of FeO (black), MgO (white), and Al2O3 affects the MTA's colour. The colour of white MTA changes from grey to white when FeO is absent.[6,7] Grey MTA has a greater compressive strength than White MTA. MTA Fillapex (Angelus, Londrina, Brazil), for instance, is a resin found in several MTA formulations that are utilised as root canal sealing cements. The inclusion of resin has the goal of modifying or improving material flow, dentine bonding, and setting time, which reduces micro-leakage. However, it was discovered that adding resin to the MTA materials caused a decrease in the desirable amount of free Ca (OH)2, which is necessary for the development of roots in developing teeth. NeoMTA (Nusmile, Huston, USA) is a resin-free, pure form of MTA. It mostly aids in pulpotomies and increases MTA's cost-effectiveness.[8,9,10]

Manipulation of MTA: The powder is mixed with sterile water in a ratio of 3:1 (powder to liquid) to prepare MTA. A metal or plastic spatula can be used for mixing on a glass slab or paper pad to form a paste of putty-like consistency. Initial mixing of the material yields a colloidal gel that finally hardens to form a solid structure. Moisture from the surrounding tissues or wet cotton pellet supports the setting reaction. A paper point, plugger, ultrasonic condensation, or carriers with distinctive designs and messing guns can be used to deliver the MTA mix to the desired location.[10]According to reports, MTA materials create a porous matrix with internal capillaries and water channels, where a higher liquid to powder ratio produced more porosity and more solubility. The effects of mixing various liquids and additives with MTA powder have demonstrated how the selection of preparation liquid can affect setting time and compressive strength. Saline and 2% lidocaine anaesthetic solution preparation lengthened setting time but did not significantly alter compressive strength. Chlorhexidine gluconate gel was used to prepare MTA product, however it failed to set. It should also be obvious that the preparation liquid of choice must also contain water with the required ability for diffusion to be accessible for the hydration reaction.[11]

Physical Properties of MTA

Compressive Strength: MTA has a compressive strength of approximately 40 MPa at 24 hours and 67.3 MPa at 21 days. Additionally, according to the research, grey MTA has greater compressive strength than white MTA.[1]

Setting time and pH: According to Torabinejad and colleagues, grey MTA takes approximately 2 hours and 45 minutes to set (+5 minutes), however Islam et al. observed that grey MTA takes 2 hours and 55 minutes to set and white MTA takes 2 hours and 20 minutes. 11. One of the primary issues with MTA is its prolonged setting process. It has been proposed in the literature that the creation of a passivating trisulfate species layer, which might help to stop additional hydration and reaction, could lengthen the time that MTA materials take to set.[12]

Solubility: MTA becomes more soluble when combined with more water, as was found. Buding CG et al. (2008) discovered that when set MTA is exposed to water, $Ca(OH)_2$ releases. The cementogenesis-inducing property is caused by the release of $Ca(OH)_2$.[13]

Biocompatibility: MTA is more biocompatible than silver amalgam, Super EBA, and IRM and comparable to chemically inert titanium. MTA crystallises calcium hydroxide, often known as Portlandite, after setting. Rich in calcium oxide, MTA and Portland cement combine to generate calcium hydroxide when water is present. Calcium ions and alkaline pH values in the surrounding fluid make conditions unfavourable for bacterial growth. Calcium silicate-based cements are active biomaterials, meaning they can encourage the host tissue to respond favourably.[10]

Radiopacity: The mean radiopacity for MTA has been reported at 7.17 mm of an equivalent thickness of aluminium. This value is higher than that reported for Super EBA or IRM in a separate investigation.[14]

Antibacterial efficacy: It has been suggested in literature that MTA has an antibacterial property especially against Enterococcus faecalis and Streptococcus sanguis in vitro. But Torabinejad et al reported that MTA shows no antimicrobial activity against any of the anaerobes but did have some effect on five (S.mitis, S.mutans, S.salivarius, Lactobacillus and S.epidermidis) of the nine facultative bacteria.[15]

Clinical Application of MTA

Pulp Capping: When large, big carious lesions, pulpal exposures are occasionally unavoidable. Despite the established unpredictability of direct pulp capping as a therapeutic option, some dentists are reluctant to do these treatments. However, MTA may assist to enhance the outcome of this technique in the future. Compared to calcium hydroxide, MTA has the benefit of being less soluble. It also provides a better seal because of its setting expansion, which hermetically seals the pulp area and stops bacterial contamination from the outside. Studies have revealed that MTA pulp capping can be an effective therapeutic option for instances that are asymptomatic or have reversible pulpits (where the infection has not entered the pulp chamber itself).[16,17] Histological studies also demonstrate that using MTA as opposed to traditional calcium hydroxide pulp capping results in less inflammation and greater dentinal bridging.[18]

Apexification: Due to the absence of an apical stop, treating a necrotic pulp in an immature root has always been difficult for clinician. Long-term calcium hydroxide therapy has traditionally been used to treat this, but it can take years of treatment, require several visits, and, at the very least, raise the risk of the affected root breaking. By producing a biocompatible apical plug in just one visit, MTA has developed as an excellent, reliable approach to handle these problems.[25]

In recent times, mineral trioxide aggregate (MTA) has gained widespread popularity for the apexification procedure. It produces apical hard tissue formation with significantly greater consistency than calcium hydroxide. MTA, a biocompatible material, can be used to create a physical barrier. It also helps in the formation of bone and periodontium around its interface.[19]

Clinical Procedure: A collagen/gelatin sponge, such as Gelfoam®, can be inserted apically if apical bone loss is present in order to deliver the MTA to the required working length. By using an endodontic file to drive a small piece of Gelfoam® down to and through the root apex, this is accomplished. Following completion of this, MTA is pushed with a specially fitted cone down the canal. The clinician can measure the length of MTA implanted in the apical third using a rubber stopper on his gutta percha cone (Figure 2B). The remaining coronal canal space can be backfilled using a warm gutta-percha method after the apical third is sealed with 3-5mm of MTA.[20]

Perforation Repair: Endodontic treatment failure may result from substantial iatrogenic consequences called furcation perforations. Perforations can develop during access cavity preparation, post-space preparation, or as a result of an internal resorption spreading into the periradicular tissues.[21] The therapeutic uses of MTA have demonstrated that it is effective at addressing issues brought on by perforation. MTA is a good material for healing the root and furcal holes because of its appealing qualities. In addition to providing a biologically active substrate for bone and cells, MTA has also been demonstrated to be well-tolerated by osteoblasts.[22]

Clinical Procedure: When a perforation appears, one must determine how large it is. If there is a nearby bony deficiency, it is first necessary to fill the defect with an osteoconductive or osteoinductive substance. A bone transplant, calcium sulphate, or collagen/gelatin sponge can be used for this. After that, MTA is used to restore the tooth's punctured dentinal area.[20]

Regenerative Procedure: Regenerative endodontic treatment is a treatment procedure designed to replace damaged pulp tissue with viable tissue which restores the normal function of the pulp-dentin structure. After regenerative endodontic treatment, continued root development and hard tissue deposition on the dentinal wall can occur under ideal circumstances.[23]

MTA as Obturating material: MTA is suggested as a pulpectomy material alternative for main teeth that are no longer viable and have no long-term replacements. Recently, O'Sullivan and Hartwell demonstrated the successful use of MTA as a root canal filling material to treat a primary molar that lacked a successor permanent tooth. But no long-term outcomes were reported.[24]

Table no 1: Pros and Cons of MTA

Pros	Cons
• Biocompatible with peri-radicular tissues • Non cytotoxic • Possesses antimicrobial activity • Non resorbable • Excellent Sealing properties • Very basic alkaline (high pH when mixed with water) • Facilitate regeneration of periodontal ligament	• Treated area needs to be infection free when applying MTA, because an acidic environment will prevent MTA from setting. • Requires operator expertise. • Difficult to handle MTA as a pulp capping material due to its granular consistency, low strength and initial looseness. • Expensive

Conclusion

MTA is a powdered combination of gypsum, bismuth oxide, and Portland cement clinker. In recent years, it has grown significantly in significance in dentistry. MTA is a superb material that possesses a plethora of desirable traits. The tooth becomes less resistant to breakage and more unpredictable after apexification with calcium hydroxide. MTA apical plug implantation performed in a single visit has proven to be an effective substitute in these circumstances. MTA is also successful in creating thicker dent in bridge with less flaws and adverse effects. Clinicians should investigate MTA to determine its therapeutic benefits.

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