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Review Article

Mineral Trioxide Aggregate: A Comprehensive Review

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Abstract

MTA was created in the 1990s at Loma Linda University by Torabinejad as a root end filling substance. In 1998, the US Federal Drug Administration approved it. Since. The innovative material known as Mineral Trioxide Aggregate (MTA) has a variety of exciting clinical applications. MTA has the potential to rank among the materials used in dentistry today that are most versatile. Its good physical properties, ability to encourage tissue regeneration, and beneficial pulp response are just a few of MTA's noteworthy attributes. In addition to a discussion of MTA's availability, composition, manipulation, setting reaction, and features, this article also discusses some of its clinical applications in dentistry.

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

Introduction

As a root end filler substance, MTA was created in the 1990s at Loma Linda University by Torabinejad. In 1998, it was approved by the US Federal Drug Administration. Since its approval, MTA has been commercially accessible under the brand Pro Root MTA. Today, two MTA products with comparable chemical and physical features, the Grey and White MTA, are also offered. [1,2]

Since Lee & colleagues' initial description of MTA in the dental literature, both surgical and nonsurgical uses, such as root end filling, direct pulp capping, pulpotomy, perforation repair, furcation repair, apexification, and obturation, have made use of it. This material shows promise due to its ability to seal, its propensity to set up in the presence of blood, its biocompatibility, and its capacity to trigger the creation of hard tissue.[3]

In addition to a discussion of MTA's availability, composition, manipulation, setting reaction, and features, this article also discusses some of its clinical applications in dentistry.

MTA: Tricalcium silicate, tricalcium aluminate, tricalcium oxide, and silicate oxide are all present in trace amounts in MTA's powder form. Additionally, it has trace amounts of other mineral oxides, which alter its chemical and physical composition. Hydration of the powder creates a colloidal gel with a pH of 12.5, which solidifies to create a strong, impenetrable, hard solid barrier in three to four hours.[4-6]

MTA comprises Portland cement (75%), Bismuth Ox-ide (20%), and gypsum (5%). Portland cement is a mixture of Tricalcium silicate $(CaO)_3SiO_2$, Dicalcium silicate $(CaO)_2SiO_2$, Tricalcium aluminate $(CaO)_3Al_2O_3$, and Tetracalcium aluminoferrite $(CaO)_4Al_2O_3Fe_2O_3$.[7]

Type of MTA:

MTA is offered in two distinct colours: white MTA and grey MTA. Depending on the amount of FeO (black), MgO (white), and Al2O3, the MTA will have a particular colour. Grey MTA turns white when FeO is absent, and vice versa.[8,9]

Grey MTA has more compressive strength than White MTA. For instance, MTA Fillapex (Angelus, Londrina, Brazil) resin is present in some MTA formulations, which are utilised as root canal sealing cements. The addition of the resin has the goal of modifying or improving material flow, dentine bonding, and setting time, which will reduce micro-leakage. [8,9]

NeoMTA (Nusmile, Huston, USA) is a completely unreinforced MTA. It mostly is utilised in pulpotomies and improves the MTA's cost-effectiveness. [10-12]

Manipulation of MTA: Powder water ratio for MTA should be 3:1, according to Sluyk et al. (1998)[13], Torabinejad et al. (1999)[14], and Schmitt et al. (2001)[15]. To achieve a putty-like paste consistency, mixing can be done on a paper pad or on a glass slab using a plastic or metal spatula. To stop the mix from drying out, cover it with moistened cotton pellets. The duration of the mixing process is crucial because if it is too long, the mixture will get dehydrated. After mixing, it is recommended covering the mixture with moistened cotton pellets since, if left exposed, it would suffer dehydration and turn into a sandy mixture [14]. Using an ultrasonic condensation device, a plugger, a paper point, a specially made carrier, or a messing gun, MTA can be placed in the desired spot.

Aminoshariae et al. (2003) compared the hand condensation and ultrasonic methods and discovered that the hand condensation approach had a better MTA adaption to the walls with fewer cavities than the ultrasonic method.[16]

After mixing, MTA has a pH of 10.2, which rises to 12.5 after three hours of setting and is essentially identical to calcium hydroxide.[2] In comparison to other materials, MTA requires more time to set. Torabinejad and colleagues claim that the grey MTA sets in roughly 2 hours and 45 minutes (+5 minutes), while Islam et al claim that the grey MTA sets in 2 hours and 55 minutes and the white MTA sets in 2 hours and 20 minutes. One of the primary issues with MTA is its prolonged setting process. Numerous researchers have proposed that adding accelerators like calcium chloride (CaCl2) and sodium phosphate dibasic (Na2HPO4) may shorten the setting time. [17,18]

Properties of MTA: 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]

There are no indicators of solubility in the set MTA. However, if more water is added when mixing the MTA, this could lead to more solubility. Set MTA releases calcium hydroxide ($CaOH_2$) when it is in contact with water. Its ability to promote cementogenesis may be due to $CaOH_2$. If the mixture is exposed to an acidic environment throughout the setting reaction, this has no effect on the setting.[19]

MTA has been proven to be superior to the other conventional root-end filling materials [20]. MTA has great sealing ability, which may be because MTA expands during the setting reaction [22]. It has been recommended that a moistened cotton pellet be placed in touch with MTA before to placing the permanent restoration because the sealing capacity of MTA is strengthened in the presence of a damp environment due to the setting expansion. According to Valois et al. (2004)[23], a 4-mm thickness of MTA is adequate to ensure a satisfactory seal.

MTA is neither mutagenic and less cytotoxic than Super EBA and IRM.[25] MTA is biocompatible and well tolerated by the tissues.[26] MTA was used by Arens and Torabinejad (1996)[27] to treat osseous repair and furcation holes. Osteoblast-like cell response to MTA was examined by Pelliccioni et al. in 2004[28], and the results revealed that MTA had positive interactions with periapical and periradicular tissues.

MTA may have an impact on the collagen release pathway in cells. According to Koh et al. (2001)[29], MTA has the ability to create interleukin and also provides bone cells with a physiologically active substrate.

Clinical Application of MTA

Pulp capping: Due to its superior tissue compatibility, MTA has been considered as a viable treatment for pulp capping with reversible pulpitis. On the basis of tissue reaction and the quantity of dentine bridge created, it is significantly superior than frequently utilised calcium hydroxide-based cements. With MTA, there isn't any tissue necrosis or inflammation like there is with calcium hydroxide. With MTA, dentin bridge formation following pulp capping was noticed at around one week, and within three months of capping, it rapidly increased in length and thickness. The dentin bridge, in contrast, showed numerous tunnel flaws and less consistent pulp capping with calcium hydroxide.[30]

Root-End Filling of Immature Permanent Teeth: When normal endodontic treatment is not an option, endodontic surgery followed by root-end filling may occasionally be required. In this procedure, the root apex is surgically exposed, the root is cut, and the apical foramen is sealed completely using a substance that is nontoxic, non resorbable, dimensionally stable, and radio opaque. Teeth treated with MTA showed noticeably decreased inflammation, greater cementum production, and periradicular tissue regeneration.[2]

Obturation of the Canal: When the next permanent tooth is missing, mineral trioxide aggregate might be utilized to seal the root canal of a retained primary tooth. O'Sullivan and Hartwell reported one such application on a main mandibular second molar that was still in place. Since it is predicted that Mineral Trioxide Aggregate would be absorbed slowly, if at all, this procedure is not advised for the obturation of primary teeth that are anticipated to exfoliate.[31]

Perforation Repair: Iatrogenic root perforation or a significant expansion of internal resorption that allows connection between the root canal and the periodontium are both possible causes. With significant hemorrhage, there may be severe inflammation and the production of granulation tissue. Such a communication needs to be repaired using a material that is biocompatible, can endure moisture without dissolving, and has strong sealing capabilities. When compared to amalgam and IRM, Lee

and colleagues discovered that MTA had much less leakage and a lower propensity for overfilling or underfilling.

Regenerative Endodontic therapy: Regenerative endodontic therapy is a process aimed to replace diseased pulp tissue with healthy tissue, hence restoring the pulp-dentin structure's natural function. Ideal conditions can result in ongoing root development and hard tissue deposition on the dentinal wall following regenerative endodontic therapy.[31]

Pulpotomy: For deciduous teeth, formocresol has traditionally been employed as a pulpotomy agent. However, this substance has come under fire for its mutagenic, cytotoxic, and tissue-irritating effects. MTA was examined and shown to be an excellent substance with minimal toxic effects, enhanced tissue-regenerating abilities, and positive clinical outcomes.[33-35] When compared to hydroxyapatite and formocresol, MTA was determined to be a better option as pulpotomy material in a histology investigation by Jabbarifar et al [36].

Advantage and Disadvantage of MTA:

MTA is a great biocompatible material, according to the current literature evaluation. MTA has many fascinating clinical uses since it possesses several essential characteristics of the ideal dental material. Clinicians need to research MTA more to take advantage of its beneficial qualities. The long setting time, high cost, and risk for discoloration of MTA are some of its known downsides. When MTA comes into touch with tissue synthetic fluid, hydroxyapatite crystals start to grow on top of it.[32]

Conclusion

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. Additionally, MTA is successful in creating thicker bridge dents with fewer flaws and adverse effects. Clinicians must research MTA in order to uncover its therapeutic benefits.

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