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Mineral Trioxide Aggregate: Technical Considerations and Clinical Applications.

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ABSTRACT

Mineral trioxide aggregate (MTA) in endodontics has been popularized due to a large amount of research indicating the beneficial properties of the material.Several in vitro and in vivo studies have shown that MTA prevents microleakage, is biocompatible, and promotes regeneration of the original tissues when it is placed in contact with the dental pulp or periradicular tissues. In present article, we review the current dental literature on MTA, discussing types, composition, manipulation, setting reaction, clinical implication and method of placement of MTA.

Keywords: Mineral trioxide aggregate, MTA, Biocompatible dental material

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INTRODUCTION

A considerable number of Endodontic procedures involve endodontic apical surgery, perforation repair, and apexification treatment [1]. Endodontic surgery may be performed to rectify any procedural errors that might have occurred during conventional endodontic therapy, such as root perforations over obturations or broken instruments that cannot be retrieved [2].

Surgical procedure may also be indicated for cases that cannot be successfully treated by non-surgical methods [3]. A Biocompatible material is usually placed to seal the root canal during surgical procedures [2]. Such material, along with providing a good seal against micro leakage, should also be non-toxic, non-absorbable, bactericidal, bacteriostatic and radiopaque [4]. A material that has all of these properties is Mineral Trioxide Aggregate (MTA) [5].

Mineral Trioxide Aggregate (MTA) was introduced by Mahmoud Torabinejad at Loma Linda University, California, USA in 1993.[6]The U.S. Food and Drug Administration approved it for Endodontic use in 1998 [7, 8].

TYPES OF MTA AND ITS CHEMICAL COMPOSITION

Based on the color, MTA is available as gray MTA and white MTA. Both the formulations consist of 75% Portland cement, 20% bismuth oxide, and 5% gypsum by weight. The gray-colored formula is mainly composed of tricalcium silicate, dicalcium silicate and bismuth oxide and small quantities of iron and aluminum. The white-colored preparation is more esthetic, and is primarily composed of tricalcium silicate and bismuth oxide and lacks iron [9]. Commercially available MTA is listed in Table 1.

Table 1: Commercially available MTA [10]

Trade name	Manufacturer
ProRoot MTA	Dentsply Tulsa Dental, Johnson City, USA
White ProRoot MTA	Dentsply Tulsa Dental, Johnson City, USA
MTA-Angelus (Grey)	Angelus, Londrina, Brazil
MTA (White)	Angelus, Londrina, Brazil
MM MTA	MicoMegha, Besancon, France
Ortho MTA	BioMTA, Seoul, Korea
Retro MTA	BioMTA, Seoul, Korea
EndoCem MTA	Maruchi, Wonju, Korea
MTA Plus	Avalon Biomed, Bradenton, USA
EndoCemZr	Maruchi, Wonju, Korea
EndoSeal	Maruchi, Wonju, Korea
MTA Fillapex	Angelus, Londrina, Brazil

MANIPULATION AND METHOD OF PLACEMENT OF MTA

MTA is obtained by mixing 3 parts of powder and 1 part of water into a putty consistency [11,12].Mixing is done using a plastic or steel spatula on a glass slab. It can be placed into the desired location using ultrasonic condensation, plugger, paper point or specially designed carriers like Dovegan carrier and messing gun. The mix should be cover with moistened cotton pellet to prevent dehydration of mix [13]. MTA has a pH of 10.2 immediately after mixing, and it increased to 12.5 after 3 hours[14]. Ideal manipulation should be less than 4 minute. Initial setting time for grey MTA is about 2 hours and 45 minutes and for white MTA 2 hours and 20.Minutes.MTA is hydrophilic, i.e. it requires moisture to set. Presence of moisture during setting helps improve the flexural strength of the set cement. Therefore, a wet cotton pellet is placed over the MTA in the first visit then the permanent restoration is done in the second visit[10].

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SETTING REACTION OF MTA

Initially, the particles of tricalcium silicate react with water to form calcium silicate hydrate[15].Calcium silicate hydrate is composed of calcium and silicon derived from MTA and hydroxyl ion which is supplied from mixing liquid16]. Later, tricalcium aluminatereacts with water and forms ettringite in the presence of gypsum, and eventually yield monosulfate once the gypsum is depleted [17].The quantities of tricalcium aluminate contained in MTA is much smaller than tricalcium silicate, therefore, this reaction product is reported to be produced in quite smaller quantities than calcium silicate hydrate gels[18].Calcium hydroxide is also formed during the hydration reaction of MTA, and it is believed to be a contributing factor in the hard tissue forming ability of MTA[19].

CLINICAL APPLICATIONS

MTA is an endodontic cement that is extremely biocompatible, capable of stimulating healing and osteogenesis, and is hydrophilic. Hence it is used in various clinical procedures.

Pulp Capping

Pulp capping is indicated for teeth with immature apices when the dental pulp is exposed and there are no signs of irreversible pulpitis[13]. According to recent studies, MTA stimulates dentin bridge formation adjacent to the dental pulp [20]. This material initially causes necrosis by coagulation in contact with pulp connective tissue, and later forms tubular dentin bridges. In addition to its mechanism of action being similar to that of calcium hydroxide, MTA provides a better seal against bacteria [21].

Apexification

Studies have shown that MTA is an ideal material to promote the formation of an apical barrier in immature pulpless teeth[22]. MTA induces the same amount of apical hard tissue formation as calcium hydroxide, and tissues don't show any inflammatory response to MTA [23].MTA should now be considered the material of choice for the apical barrier technique taking into consideration its sealing ability, antimicrobial properties, hydrophilic properties and biocompatibility.

Perforation Repair

MTA can be considered an ideal material for perforation repair mainly because it does not require a dry field, and it promotes new tissue formation. When MTA was used for perforation repair, cementum has been found to grow over the material, facilitating the normal attachment of the periodontal ligament[24].

Root End Filling

During endodontic surgery, MTA can be used to fill the root end, even in the presence of blood [25].When MTA was used as a root-end filling material, healing of the surrounding tissues was observed [26-28].Presence of connective tissue was the characteristic tissue reaction of MTA after the first postoperative week. The drawback of MTA as a root end filling material is the difficulty in manipulation and long setting time[29].

Root Fracture Repair

MTA has also been used for repair of Horizontal root fracture and showed complete healing and regeneration of bone after a one year follow up[30]. MTA can be a good material for repairing root fractures as it can induce the release of growth factors such as bone morphogenetic proteins (BMPs), platelet derived growth factor (PDGF), fibroblast growth factor (FGF), transforming growth factor (TGF), insulin-like growth factor-1 (IGF-1), epidermal growth factor (EGF), cementum derived growth factor (CGF) from cementum matrix along with IGFs, TGF-β, BMPs, FGF, and PDFG from alveolar bone matrix and signal progenitor/stem cells in the periodontal ligament and alveolar bone marrow to differentiate into cementoblast-like cells and osteoblasts[31]. It also increases the fracture resistance of the thin dentinal wall[32].

Regenerative Endodontics

Regenerative endodontic procedures evoke bleeding into the root canal, which delivers undifferentiated mesenchymal stem cells in the root canal space[33].Restorative materials like amalgam, composite resins, or glass ionomers is not recommended without a thin coronal barrier of MTA over the coronal pulp tissue, root canal blood clot, orregenerating tissues[34].

MTA Obturation

Due to the good biological and physical properties responses there is interest in intensifying the applications of MTA as a root canal filling material[35].Canal obturation with MTA requires the same preparation and irrigation normally carried out using gutta-percha placement but the removal or retention of the smear layer before canal obturation still remains controversial[36].The drawback is that the obturation of entire root canals with MTA is expensive.

Root Canal Sealer

MTA sets hard and its setting time is long enough (165 ± 5 min) to be used as a sealer[37].MTA mixed with propylene glycol was used as a root canal sealer. Study conducted by S Thakur et al showed MTA could be used as a root canal sealer with equal effectiveness compared with epoxy resin and zinc oxide eugenol sealers. Further long-term studies should be carried out to prove the effectiveness [38].

CONCLUSION

MTA has become the material of choice for a number of endodontic procedures due to its biocompatibility and excellent sealing ability. The sealing ability of MTA is due to the formation of interfacial layers between MTA and dentin from Calcium silicate hydrate, calcium hydroxide and calcium deficient hydroxyapatite[CDHA]. Another major advantage of MTA is that it does not require a dry field and can be used in Endodontic surgeries. Therefore MTA has multiple qualities for an ideal dental material with various clinical applications. Further clinical studies have to be conducted to assess the long term benefits of MTA in endodontics.

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