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APPLICATION OF MINERAL TRIOXIDE FILLER IN ENDODONTICS (REVIEW ARTICLE)

Ishniyazova G. B.
Tashkent State Dental Institute
Department: "Propaedeutics of Therapeutic Dentistry"

Abstract

The purpose of this article is to investigate the characteristics of mineral trioxide aggregate (MTA) from a clinical point of view, even in comparison with other biomaterials. All clinical data regarding this dental material will be evaluated in this review article. Data obtained from a review of the literature over the past 10 years identified 19 articles that could address the clinical aspects of MTA. The results obtained in this article are an important step to demonstrate the safety and predictability of oral rehabilitation with these biomaterials and advance the path to improve their properties in the future.

Keywords: dental materials, mineral trioxide aggregate, MTA, Portland cements, dentin, pulp exposure, pulp capping, root canal filling.

Introduction

Mineral trioxide aggregate (MTA) is a hydrophilic and biocompatible endodontic cement capable of promoting healing and osteogenesis. It consists of a powder of fine trioxides (tricalcium oxide, silicon oxide, bismuth oxide) and other hydrophilic particles (tricalcium silicate, tricalcium aluminate, responsible for the chemical and physical properties of this filler), which hardens in the presence of moisture [1,2,3,4,5].

Hydration of the powder results in the formation of a colloidal gel with a pH of 12.5, which hardens into a structure in approximately 3-4 hours [6,7,8,9].

Over the past 10 years, MTA has found its application in the field of dentistry, especially in the context of conservative and endodontic treatment. Dental trauma is an event that cannot be predicted and is usually not easy for doctors to deal with. Therefore, the dentist must be prepared to intervene in a patient who has suffered dental trauma. Early intervention is often critical to improving the prognosis of the injury itself. In the presence of a coronal fracture exposing dentin, the primary goal should be to close the dentinal tubules. Especially in young patients, the size and number of dentinal tubules are large: therefore, even a small amount of exposed dentin allows large amounts of plaque bacteria and their metabolites to migrate into the underlying pulp and cause inflammation. The occurrence of this type can sometimes lead to necrosis in a short time. When tooth trauma has exposed the pulp, emergency intervention is to treat the exposed pulp. One treatment option other than endodontic treatment is direct plating or partial pulpotomy. A partial pulpotomy can be performed using an MTA. MTA can be used as a cement due to its high compatibility, which has a mechanism similar to calcium hydroxide (Ca(OH)2) (extremely basic) and is therefore a powerful antibacterial agent. However, unlike Ca(OH)2, MTA hardens to a good consistency; it is therefore extremely suitable for any restoration. Thus, rapid curing allows definitive restoration of partial pulpotomy performed with MTA [7].

Pulp, consisting of a cellular component, vessels and nerves; this tissue is called mature mucosal connective tissue. Endodontic treatment is used if carious or traumatic damage to the tooth has caused an irreversible change in the pulp tissue and its necrosis. It is also possible to use this method if the dental element is involved in orthopedic rehabilitation, which, due to significant reduction of dental tissue, will most likely cause irreversible alteration of the pulp. During endodontic treatment, blood contamination should be completely avoided and the root canal system should be kept dry to ensure successful root canal filling. During direct pulp capping or perforation sealing, it is critical to control bleeding as well as achieve a dry field. The mechanism of action of MTA is associated with the clinical characteristics of the human oral cavity. MTA, in direct contact with human tissue, is capable of releasing calcium ions for cell proliferation. In addition, it creates an antibacterial environment due to its alkaline pH, regulating the production of cytokines. Consequently, it promotes the migration and differentiation of hard tissue-producing cells, forming hydroxyapatite on the surface of MTA and providing biological insulation. Finally, during a surgical endodontic procedure, the retrograde cavity must be completely dry. This cement differs from all other materials currently available due to its biocompatibility, its antibacterial properties, its edge adaptation and sealing ability, and finally due to its hydrophilic nature. It is important to understand the functioning of this biomaterial, its behavior in contact with other materials used in dentistry and, above all, over time or from a clinical and radiological point of view [10,11,12]. Studying these topics requires international literature research, which also includes the use of advanced technologies for study [13,14,15,16].

The results obtained from the literature search were filtered using software and manual screening according to the following inclusion and exclusion criteria:

Inclusion criteria are: humanities research; information on the clinical use of MTA; information about MTA and other biomaterials in endodontics; in vitro and in vivo studies of MTA; last 10 years of study.

Exclusion criteria were: in silica studies; does not apply to human studies; not in English; unavailable title or abstract; insufficient information on the main issue; information sources.

Celik et al. [20] analyzed the differences between two groups of patients who underwent pulpotomy. In the MTA groups, the success rate at 24 months was 100%, rather than 89.4% with Biodentine. According to Erfanparast et al. [21] there are no significant differences between resin modified Portland cement and MTA based materials for direct pulp capping. After 12 months, the effectiveness of MTA and the resin-modified method was 94.5 and 91.8%, respectively. Koc Vural et al. [22] assessed the differences between Ca(OH)2 and MTA. The observation period for 100 samples was 24 months. Four teeth with Ca(OH)2 caps and two teeth with MTA caps underwent emergency endodontic treatment. But there are no significant differences between the groups.

Kang et al. [23] examined the clinical differences between three MTA groups (ProRoot MTA, Ortho MTA and RetroMTA). Success rates at 1 year were high with no significant differences; success rates were 96, 92.8, and 96%, respectively (as reported in parentheses). Bakhtiar et al. [24] examined differences in third molar pulpotomy between three different materials (TheraCal, Biodentine and ProRoot). They showed no clinical signs in the ProRoot MTA and Biodentine groups, as two patients reported severe pain in the TheraCal group. Pulp reorganization was observed in 33.33% of the ProRoot MTA groups, 11.11% of the TheraCal groups, and 66.67% of the Biodentine groups.

Moreover, dentin bridge formation was observed in 11% TheraCal and 56% ProRoot MTA. Asl Aminabadi et al. [25] tested clinical differences between four groups in direct pulp capping. Non-

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carious areas of the pulp were treated with simvastatin, 3Mix, 3Mixtatin or MTA. At the end of the 12-month follow-up period, overall success rates were 93.8% (MTA), 91.9% (3Mixatin), 62.5% (3Mix) and 57.1% (Simvastatin). According to the authors, there were no significant differences (p=0.05) between the MTA and 3-Mixtatin groups. The 3 mixtatin groups had a statistical difference in the simvastatin and 3 mix groups (p<0.01). Another study conducted by [26] confirmed the effectiveness of 3Mixtatin in pulp capping. The authors studied MTA versus 3Mixtatin in direct pulp capping with a success rate of 96.8% versus MTA with 48.6% referred pain. Nowicka et al. [27] assessed differences in direct pulp coverage between four groups: Ca(OH)2, MTA, Biodentine and Single Bond Universal. The reparative dentin formed in Ca(OH)2, MTA and Biodentine was better than that in the Single Bond Universal group. Moreover, dentin bridge density was highest in the MTA group and lowest in the Single Bond Universal group. At 12 months, radiographic success rates in these groups were 100% (RetroMTA), 97.4% (Ortho MTA), and 100% (ProRoot MTA).

The Kaplan-Meier survival function in relation to clinical and radiological parameters did not differ between groups. According to Bonte et al., [29] MTA formed a mineralized barrier in 82.4% of cases instead of Ca(OH)2 (50%) after 12 months. Pain and tenderness on percussion disappeared in both groups.

In a randomized controlled trial, Petrou et al. [30] demonstrated after ~6.3 months in 86 patients that Ca(OH)2 compared with medicinal Portland cement versus white MTA showed no statistical difference. The overall success rate was 90.3%. Hilton et al. [31] recently published a study on the clinical and radiological differences of two groups of direct coating materials, Ca(OH)2 compared with MTA. MTA showed a lower failure rate (p=0.046). Gandolfi et al [32] analyzed, using three-dimensional micro-computed tomography (3D micro-CT) analysis, the differences between AH Plus and MTA flows in their microstructure. Bernabé et al [33] tested the sealing ability of MTA during apicectomy. They are filled with MTA plus with sound, ultrasound or without vibration. Sonic vibration can improve compaction level.

Sönmez et al [34] showed differences in apical microleakage between AH Plus, Fillapex MTA and ProRoot MTA. Fillapex had better results for microleakage and there was no statistical difference between AH Plus and MTA.

Leye Benoist at all [35] highlighted the differences between Ca(OH)2 and MTA for indirect pulp capping. After 3 months, the effectiveness of MTA was 93% instead of 73% for Ca(OH)2. After 6 months, the MTA success rate was 89.6% instead of 73%. The average initial residual dentin thickness was 0.23 mm, this value increased to 0.121 mm with MTA and to 0.136 mm with Ca(OH)2 after 3 months.

According to Ghoddusi et al. [36] there is no statistical difference between MTA and zinc oxide eugenol (ZOE) in pulpotomy after carious or traumatic pulp exposure. Hansen et al [37] looked at the pH level when using different biomaterials for pulp capping. The authors studied MTA, endodontic seal (ES); control pairs were filled with Ca(OH)2 (positive group) and saline (negative group). pH was measured after 20 minutes, 3 hours, 24 hours and after 1–2–3–4 weeks. The pH of MTA was significantly higher than that of ES (at 1 week, p<0.0001).

Yildirim et al [38] found differences in gutta-percha filling between two methods and MTA.

Several published articles have emphasized the clinical features of MTA with only evaluation of clinical and radiological findings. Nowicka et al [27] demonstrated how reparative dentin bridges depend on the material used. Biodentine and MTA showed the highest volumes after cone beam radiography. According to Kang et al., [28] the success rates of RetroMTA, Ortho MTA and

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webofjournals.com/index.php/5

ProRoot MTA were not different and indistinguishable, and these results indicate that pulpotomy can be performed with a high degree of success with all biomaterials evaluated.
Bonte et al [29] showed that there is no statistical difference between Ca(OH)2 and MTA, but MTA provides better dentin healing, apexification using MTA can give better results than Ca(OH)2.
Petrou et al. [30] concluded that MTA or medicinal Portland cement is preferable to Ca(OH)2 for indirect pulp capping because these materials are non-absorbable. Hilton et al.31 showed that MTA was superior to Ca(OH)2 for direct pulp capping. Gandolfi et al [32] concluded in their study after 3D micro-CT analysis that MTA flow created an apatite layer after 7 days and AH Plus even after 28 days.
Bernabé et al [33] showed how MTA can be useful for filling root canals after apicectomy; In addition, sound vibration can improve the sealing performance. Sönmez et al [34] concluded that the sealing ability of AH Plus and ProRoot was similar, but MTA Fillapex showed microleakage compared to the other two materials.
Some studies report how results may change if assessments are performed 3, 6 months, or 1 year after treatment. This clinical condition demonstrated that patient response can be individual and independent of the materials or technique used. According to Leye Benoist et al [35], a higher success rate was observed in the MTA group instead of Ca(OH)2. Differences were significant at 3 months but not at 6 months, with no difference in dentin thickness, suggesting that time is important in the assessment.
Ghoddusi et al [36] concluded that there was no statistical difference between ZOE or MTA treatment, but MTA was successful, expensive and, due to dentinal bridges, could complicate future root canal treatment. Data presented by Hansen et al. [37], demonstrated how MTA produces a higher intracanal pH than ES. The same result was demonstrated by Yildirim et al. [38] MTA can be used in root canals as an apical filling material, particularly in teeth with a post indication.
From the above scientific studies, the superiority of MTA is proven, which has superior capabilities in terms of biocompatibility as seen from studies as well as stability over time [39,40,41]. The nanocharacteristics of MTA may be related to its interaction with human tissues during endodontic treatment. Remineralizing potential to inhibit early lesion progression in the form of nano-sized calcium phosphate, hydroxyapatite carbonate nanocrystals, nano-amorphous calcium phosphate and bioactive glass nanoparticles, especially with the provision of self-assembling protein, which plays an important role in biomimetic repair even in dentistry. The unique size of nanomaterials makes them excellent carriers for dental products [42,43, 44, 45, 46, 47,48,49].
Thus, it has recently been stated that enriching adhesives with nanomaterials with biological properties not only improves the mechanical and physical properties of adhesives, but also helps to achieve and maintain a strong adhesive bond and increase service life. It is also important to convey that these conservative treatments often do not expose patients to invasive surgery or risks that would be difficult to implement in patients with unfavorable systemic diseases. Accordingly, this review will focus on the current status and future implications of nanotechnology in preventive and adhesive dentistry.
In dental materials, the main applications of nanotechnology have been to achieve better mechanical properties, higher abrasion resistance, less shrinkage, improved optical and aesthetic properties, and to provide antimicrobial properties. Antimicrobial activity is an important property

of nanomaterials used in dentistry due to the lack of this property in resin-based materials. MTA is a biomaterial that has many potential applications in endodontic treatment, with animal studies and clinical results being very encouraging. Can also be used in primary teeth, with deep carious lesions or exposure of traumatic pulp intended for endodontic treatment [51, 52, 53, 54, 55,56,57,58,59,60,61].

MTA could not be used to save all teeth with pulp involvement; however, with careful technique, it can serve as a pulp drug in advance to add to clinical use. Modern nanotechnology is used in the production of various dental materials, such as light-curing composite resins, adhesive systems, impression materials, ceramics, dental implant coatings and bioceramics. A number of malocclusions can occur in childhood. There can be different types of malocclusions: some are genetic and others are caused by external factors; The big difference in treating these malocclusions in children and adults is that in children, treatment is generally much less invasive since the bones have not yet fully developed and it is easier to intervene to correct their shape. Therefore, it should be understood how the absence of a dental element, removed rather than preserved, thanks to endodontic treatment, even in marginal conditions, thanks to the use of these cements, can have consequences for the entire stomatognathic system [62, 63].

MTA is versatile, guaranteeing a variety of uses and has excellent performance in contact with reconstruction materials [64,65,66].

Conclusions. The results of this review will certainly be helpful in fully understanding the characteristics and benefits of this biomaterial from a clinical point of view; our structural analysis of the material explains its clinical behavior; and the studies studied are the proof. Numerous clinical, histological and radiographic tests make this material a safe and predictable material in the field of endodontics and conservative dentistry. Some studies have shown better performance than MTA, primarily from an antibiotic perspective. This could serve as a starting point for improving this material and creating even better materials.

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