REVIEW ARTICLE

Mineral Trioxide Aggregate (MTA) 'A versatile Endodontic Material'

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Abstract

Mineral Trioxide Aggregate (MTA) has become such an important material in armamentarium of endodontic practice that at present it is virtually inseparable from endodontics. MTA was introduced in 1993 with original intent to use mainly for perforation repair. MTA is derived from Portland cement it is composed mainly of Tricalcium silicate and Dicalcium silicate. However because of its superior physicochemical characteristics such as, low shrinkage and good sealing ability, its use gradually expanded in the endodontic practice. Its use ranges from pulpotomy in primary teeth, vital pulp capping agent in permanent teeth, to root end fillings, perforation, as well as repair material in tooth resorption and apexifications. This review article explores scope of MTA in endodontic practice.

Key words: *Endodontics, MTA: Mineral Trioxide Aggregate*

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Introduction

Mineral Trioxide Aggregate was introduced in early 1990s it was first used by Torabinejad for repair of Lateral Root perforations. MTA is a product of complex compounds major component of which includes Tricalcium Silicate and Dicalcium Silicate [1-3]. In addition, MTA contains relatively small amount of Tricalcium Aluminate and Tetracalcium Aluminoferrite. To increase radiopacity, bismuth oxide was added in MTA [4, 5] initially only grey colored MTA (GMTA) was available however due to potential for causing tooth discoloration in 2002 a tooth colored MTA also called as white MTA (WMTA) was introduced.

Chemistry

Mineral Trioxide Aggregate is derived from Portland cement. MTA and Portland cement are very similar in composition. MTA powder contains fine hydrophilic particles that set in the presence of moisture. MTA is composed mainly of lime (CaO), silica (SiO_2) and bismuth oxide (Bi_2O_3). White MTA (WMTA) contained significantly lesser amount of aluminum oxide (Al_2O_3), magnesium oxide (MgO) and ferric oxide (Fe_2O_3) than grey MTA (GMTA) [6].It is of interest to know that MTA contains considerably lesser heavy metals such as Arsenic, Lead, Iron, and Chromium than Portland cement [7] Proroot MTA (Dentsply Tulsa Dental) appears to be safe in terms of its heavy metal content [8]. When MTA powder is mixed with water calcium hydroxide and calcium silicate hydrate are formed which transform into a poorly crystallized amorphous gel. It is because of calcium hydroxide formation the pH of MTA is alkaline. The pH value of MTA is 10.2 after mixing. This value rises to 12.5 at 3 hours [9]. Calcium hydroxide is also responsible for formation of a hard tissue barrier calcium hydroxide eventually also react with phosphate ion to form amorphous calcium phosphate which ultimately yields hydroxapatite. [10-13] As the MTA matures in phosphate of body fluids the calcium deficient hydroxapatite is formed at the surface of MTA [14].

Physical Characteristics

Standard MTA is prepared by mixing power with sterile water in a ratio of 3:1 [15] The mean setting time of MTA is 165 + 5 minutes [16] Setting Expansion of both GMTA and WMTA varied considerably WMTA expands slightly more than GMTA [17, 18]. Solubility of MTA Most investigations reported low or no solubility for MTA [19 -21]. However, increased solubility is reported in a long-term study [22]. The compressive strength of MTA is significantly less than that of amalgam and IRM, after 24 hours. However, after 3 weeks, there is no significant difference between Super EBA, IRM, and MTA in terms of compressive strength. [10] Biocompatibility studies of MTA have shown that MTA is a biocompatible material and its biocompatibility is superior to IRM and silver Amalgam [23].

Clinical Performance Studies

As a pulp capping Agent in primary teeth: studies conducted with MTA used as pulp capping material in animal have found that all the pulps capped with MTA showed dentin bridge formation and the bridge formed adjacent to MTA was thick and continuous with original dentin. [24]

Direct pulp capping in Permanent teeth: The material of choice since many years for Vital Pulp Therapy (VPT) was calcium hydroxide $Ca(OH)_2$ [25]. Despite its apparent success in VPT calcium hydroxide has shown toxic effects on vital pulp tissue apparently because of its high pH. [26] Therefore, an ideal VPT material should be biocompatible and stimulates dentin formation and apical development of immature teeth. MTA provides a non-resorbable seal over the vital pulp. Accorinte *et al;* reported that pulp healing with MTA is faster than with $Ca(OH)_2$. Previous investigations showed favorable outcomes in human teeth with MTA pulpotomy treatment [27 -30].

Perforation closure: Sluyk SR *et al;* demonstrated that perforation defects repaired with MTA showed that periradicular moisture was advantageous in adapting the material to the walls of the perforation. Further its retention and physical characteristics were not altered by placement of either a moist or dry cotton pellet over the material [31]. Most of studies of furcation perforations [32, 33] showed significant cementum was generated underneath material and less inflammation in perforation sites with MTA were as in Lateral Perforation repairs by Holland *et al* [34] showed no inflammation and cementum formation. This shows that MTA is versatile perforation repair material.

Apexification: Treatment of apexification prior to introduction of MTA was confined to Calcium hydroxide, however the drawback of calcium hydroxide was multiple visits that were required and weakening of tooth structure. Now it has been shown that MTA has cementogenic properties, not only when used as a root-end filling material and in perforation repair but also in the induction of root-end closures [34]. MTA also induces the formation of apical calcific barriers and resolution of periapical disease of open apices in teeth with necrotic pulps, as demonstrated in numerous case reports [35-39]. MTA obturations in teeth with immature apices can induce apexo-genesis by stimulating the mesenchymal stem cells from the apical papilla to promote complete root maturation in the presence of periapical pathosis or abscesses [40].

Resorption : It has been shown that intracanal application of MTA can also cause release of calcium ions through dentinal tubules into External Resorption defect, which may halt the progress of resorption and favour repair potential of the surrounding tissues [41]. Recent research has demonstrated that root canal treated teeth obturated with MTA exhibit higher fracture resistance than their untreated counterparts [42]. This could be attributed to the ability of MTA to prevent the destruction of collagen by inducing the expression of a tissue inhibitor of metalloproteinase 2 in the dentin matrix [43]. Very satisfactory results were also observed by Meire & De Moor [44] when treating a perforating Internal Resorption in the mesial root of a mandibular second molar using MTA, observed a complete recovery of the alveolar bone and periodontal ligament. Sari & Sonmez [45] published a study about the treatment of an Internal Resorption with MTA in deciduous

molars. Based on the obtained results the authors state that the MTA seems to be an adequate material for the treatment of Internal Resorptions of deciduous teeth too.

For root canal Obturation: Mineral trioxide aggregate (MTA) might have a profound advantage when used as canal obturation material because of its superior physiochemical and bioactive properties. Based on clinical performance MTA might become a viable alternative treatment option compared with gutta-percha–based materials and sealers. MTA exhibits superior sealability against bacterial microleakage, while demonstrating antibacterial and bioinductive properties that can improve treatment outcomes. Furthermore, the material is sterile, radiopaque, resistant to moisture, and nonshrinking and stimulates mechanisms responsible for the bioremineralization and resolution of periapical disease [46].

Conclusion

On the basis of available information, it appears that MTA is the material of choice for some clinical applications and especially it can be used for root-end filling, VPT, Perforation Repair, and Apical Barrier formation for teeth with necrotic pulps and immature apex. Hydroxyapatite crystals form over MTA when it comes in contact with tissue fluid. This can act as a nidus for the formation of calcified structures after the use of this material in endodontic treatments. However MTA has some known drawbacks such as a long setting time, high cost, and potential for discoloration. More clinical studies are needed to confirm its long term efficiency when compared with other materials.

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