

REVIEW ARTICLE

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The Composition and Biologic Actions of Mineral Trioxide Aggregate: A Review

SUMMARY

Aim: Mineral Trioxide Aggregate (MTA) is widely used in clinical application such as pulp capping, perforation repair, root-end sealing, canal filling at internal and external root resorption and pulpotomies in primary and permanent teeth. In endodontic field when using a material such as MTA the interaction between material and periapical tissue is so important for healing and life time of endodontic therapy. Although it is sealing ability, the interaction with cells or tissues and their replay to this material play major role for endodontic success.

Methods: Literature review was performed using electronic and hand-searching methods for the clinical applications, experimental studies and cellular studies of MTA between 2000 and 2010.

Results: MTA is a bioactive material when using vital pulpotomies, apical barrier formation for necrotic pulps and open apices. Numerous study and case reports show MTA is more effective material than other materials in these cases. Many studies have shown the effects of MTA on cementoblasts and odontoblasts.

Conclusion: This review shows its composition, biologic action when used different endodontic procedure and interaction between cell and tissues.

Key Words: Biologic Action, Mineral Trioxide Aggregate, MTA, Cell.

Mineral Trioksit Agregat'ın Kompozisyonu ve Biyolojik Etkileri: Derleme

ÖZET

Amaç: Mineral trioksit Agregat pulpa kapamasında, perforasyon tedavisinde, apeksogenezisin stimülasyonunda, iç ve dış rezorpsiyonlarda ve pulpotomilerde kanal dolgu materyali olarak kullanılmaktadır. Endodontide MTA gibi bir materyal kullanıldığı zaman, materyal ve doku etkileşimi sonrasında iyileşme ve endodontik tedavinin ömrü açısından çok önemlidir. Kapama yeteneği hücre ve dokularla etkileşimleri ve bu materyale gösterdikleri yanıtlar endodontik başarıda önemli rol oynar.

Gereç ve Yöntem: MTA ile ilgili literatür taraması 2000-2011 arasında yapılmış klinik, deneysel ve hücresel çalışmalar için elektronik tarama ve dergi taraması yapılmıştır.

Bulgular: MTA vital pulpotomilerde, nekrotik pulpaların apikal bariyerini oluşturmak için, açık apeksleri kapamak için kullanılan biyoaktif materyaldir. Pek çok yayında ve olgu sunumlarında MTA'nın diğer materyallerden daha etkili olduğu gösterilmiştir. MTA'nın sementoblast ve odontoblastlara etkili olduğunu gösteren yayınlarda mevcuttur.

Sonuç: Bu yayında MTA'nın kompozisyonu, farklı endodontik uygulamalarda kullanımında biyolojik etkisi ve hücre ve dokularla etkileşimi gösterilmektedir.

Anahtar Kelimeler: Biyolojik Etki, Mineral Trioksit Agregat, MTA, Hücre.

INTRODUCTION

Mineral trioxide aggregate (MTA) was introduced to endodontics by Torabinejad et al as a root-end filling material in 1993 at Loma Linda University (1,2). But it took acceptance of U.S. Food and Drug Administration in 1998. Several reviews have been published about MTA's chemical properties, biocompatibility, and clinical applications (3,4). Mineral trioxide aggregate (MTA) is the most commonly recommended material for sealing communications between the root canal system and the periodontium (5). For this reason, it is currently being used in several clinical situations such as root-end filling, repair of root and furcation perforations, apical plugs, and root canal filling (3,5). MTA also use at direct pup capping and pulpotomy. MTA was developed and recommended for endodontic procedures cause of it is nontoxic, noncarcinogenic, nongenotoxic, biocompatible, insoluble in tissue fluids and dimensionally stable nature (6-8). Materials used in endodontics are frequently placed in intimate contact with the periodontium and thus must be nontoxic and biocompatible with host tissues (9). There are a lots of study try to evaluate MTA's biocompatibility. In these studies, authors using several tests for evaluate different specialties with animal and laboratory test for description toxicity of MTA. Many studies evaluating its cytotoxicity against cell lines and biocompatibility in animal models in which, in general, it has performed better than other comparable materials (9-11). Mineral trioxide aggregate (MTA) appears to have more reliable effects than materials previously used (12). MTA has been shown to induce hard-tissue repair of exposed pulps in experimental animals (13). MTA generate a greater frequency of dentin bridge formation than earlier materials (14). Min et al, reported that the dentinogenic process in human pulp capping is induced more effectively by MTA than by calcium hydroxide (15). However, MTA and calcium hydroxide have same mechanism of hard-tissue formation known to cause inflammatory and necrotic changes on pulp tissue (16). Effects like these imply that the development of nontoxic and biologically active pulp-capping agents is warranted (12). MTA also creates a biocompatible environment in periodontal tissues and can stimulate cementogenesis when used in the perforation area (8). Oviir et al examined the effects of MTA in vitro on the proliferation of oral keratinocytes and cementoblasts and compared WMTA with gray MTA (GMTA), and they found that cementoblast proliferation significantly increased when grown on the surface of WMTA, compared with cementoblasts grown on GMTA (17).

The aim of this review is to present a comprehensive list of articles from 2000 and 2010

regarding to composition, biological action and cellular effects of MTA.

Composition of Mineral Trioxide Aggregate

MTA is derived from ordinary Portland cement with slight difference in composition (18). MTA powder is composed from 20% bismuth oxide, 5% gypsum and trace amounts of SiO_2 , CaO , MgO , K_2SO_4 , Na_2SO_4 (19). MTA powder contains fine hydrophilic particles that set in the presence of moisture (3). MTA contains Calcium oxide (CaO) and silicon (SiO), this two components major components of MTA (20,21). Two forms of MTA; Gray-MTA and White MTA are available in dental markets. Until 2002 only one form of MTA (GMTA) was in dental usage, but because of its color problem and esthetic concern a new type of MTA (WMTA) was introduced at 2002 (22). The main differences between GMTA, WMTA and Portland cement are absence of bismuth oxide and potassium (23). GMTA basically consists of dicalcium and tricalcium silicate and bismuth oxide, whereas WMTA is primarily composed of tricalcium silicate and bismuth oxide (21). When MTA mixed with water at first calcium hydroxide and calcium silicate hydrate are formed this provide alkalinity of MTA after hydration (25). MTA has potential to interact with fluids which present in tissues (26). So for increases cement setting time and protect the cement from future hydration sulphur amount on the surface of MTA is important (27). Although portland cement is major ingredient of MTA, two material has big differences (18). Portland cement was significantly more soluble, less radioopacity, and lower microhardness value than MTA (28). The amount of Al_2O_3 , MgO and Fe_2O_3 in WMTA is lower than GMTA (29). The lower amount of Fe_2O_3 in white MTA is responsible for its tooth-colored appearance (18,29).

Biologic Action of Mineral Trioxide Aggregate

Mineral trioxide aggregate is bioactive material because of its contains. (30). Many investigation shows that MTA can induct hard tissue formation (31), and previous studies showed the effect of MTA on cementoblasts and odontoblasts (32,33). According to Boezman after placing MTA, there is a white structure which has similar containings with hydroxiapatite and showed that GMTA produce more hydroxyapatite than WMTA (35). Some studies shows that a layer of hydroxyapatite covers MTA and doing a chemical bonding between cavity wall and MTA surface (36,37). Cementoblasts can attach surface of MTA and it can be grow. Cementoblasts also produce mineralized matrix gene on MTA (32,37). Some studies show its anti-inflammatory effects on the pulp (38). In different type of cell culture MTA has least cytotoxicity (39). A study of the mutagenicity of MTA showed that it

is not mutagenic to strains of *Salmonella typhimurium* LT-2 (40). Studies on hamster ovary cell system and human peripheral lymphocytes were MTA, showed no cytotoxicity or genotoxicity in concentrations of 1–1000 mg/mL on 1 hour of exposure at 37°C⁰ (41,42).

Studies have shown that placement of MTA on pulp tissue causes proliferation, migration, and differentiation of odontoblast-like cells that produce a collagen matrix (6,43,44). The formed matrix is then mineralized and produces osteodentin initially and is followed by a tertiary dentinal bridge formation a few months after pulp capping. The mechanism of action of MTA is very similar to the effect of CH on pulp tissue after pulp capping (6). Tomson et al showed that GMTA and WMTA release different signaling molecules from dentin, powder that might influence the quality and the rate of calcified bridge formation (45). During dentin formation, odontoblasts synthesize and secrete several noncollagenous proteins into the dentin extracellular matrix (46). Dentin sialoprotein (DSP) and alkaline phosphatase (ALP) are play a regulatory role in the mineralization of reparative dentin (32,46). It has been shown that the DPSCs

secrete large amounts of angiogenic factors like vascular endothelial growth factor (VEGF) and Fibroblastic Growth Factor-2 (FGF-2) (47). These angiogenic factors are important because they play a critical role in tissue development, cell migration, and inflammation and wound repair (48). VEGF also provides important information related to the functionality of the cells (49). According to Parirokh and Torabinejat (6); when MTA is placed in direct contact with human tissues, material does the following:

1. Forms CH that releases calcium ions for cell attachment and proliferation
2. Creates an antibacterial environment by its alkaline pH
3. Modulates cytokine production
4. Encourages differentiation and migration of hard tissue- producing cells
5. Forms Hydroxyapatit on the MTA surface and provides a biologic seal (4,6)

CONCLUSION

MTA is bioactive material and has clear success at dental procedures. But MTA has need more study about its bioactivity mechanism

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