ISSN Print: 2394-7489
ISSN Online: 2394-7497
IJADS 2016; 3(1): 71-75

www.oraljournal.com
Received: 13-11-2016
Accepted: 14-12-2016

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Mineral trioxide aggregate in endodontics

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Abstract
Root canal treatment in teeth with open apices along with periapical infection is difficult to treat. More challenging is to obtain good apical seal. Apical barrier formation by conventional treatment with calcium hydroxide requires many appointments and not accepted by many patients. Use of MTA for pulp capping, pulpotomy, apical barrier formation in teeth with open apices, repair of root perforations and root canal filling as been known. Various studies have been published regarding various aspects of MTA as root end material. MTA has been successfully used for one visit apexification.

Keywords: Mineral trioxide aggregate, open apex, portland cement, apical plug, apexification

Introduction
Need for newer materials in the field of dental science is never ending. Many materials have been tested and standardised to obtain maximum benefit for good clinical performance [5]. The main aim of endodontics is to prevent or treat apical periodontitis, leaksge of irritants through improperly sealed root end filling material into periradicular tissues is the most common cause for endodontic failure [4]. One such new material is mineral trioxide aggregate. Mineral trioxide aggregate (MTA) was developed at Loma Linda University in the 1990s as a root-end filling material. Acceptance by the US Federal Drug Administration was obtained and was commercially ProRoot MTA (Tulsa Dental Products, Tulsa, OK, USA) [1]. MTA promises to be one of the most versatile materials in the century in the field of dentistry [5]. The use of MTA as a root –end filling material was identified because the material is a hydraulic cement which sets in the presence of water [1]. studies have shown that MTA not only exhibits good sealing ability, excellent long term prognosis, relative ease of manipulation and good biocompatibility but also favours tissue regeneration[5]. In this article we shall review the availability, composition, manipulation, setting reaction, properties and clinical applications of MTA.

Availability of MTA
MTA is a fine hydrophilic powder available in single sachets of 1 gram. Premeasured water sachets for ease of use is also available[5]Some commercially available MTA are ProRoot MTA (Dentsply), white ProRoot MTA, MTA Angelus.

Composition
MTA consist of fine hydrophilic particles of tri calicium silicate, tricalcium aluminate, tricalcium oxide, silicate oxide and bismuth oxide [4]. It is similar to Portland cement except for the absence of bismuth oxide in Portland cement. Bismuth oxide (17-18%) is added to improve the properties and the radiopacity. The particles are smaller and uniform in size in MTA when compared to Portland cement [5]. MTA is available as white and grey. The two differ mainly in the amount of iron, aluminium and magnesium oxides. various studies have been conducted on the biocompatibility of both the MTA [5]. Perez *et al* used a different type of cell and concluded that grey MTA is more biocompatible than the white and reported that the difference id due to surface morphology of these materials [4]. Asgray *et al* claim that the oxides are present less in white MTA while others claim the total absence of these oxides in white MTA [5]. X-ray diffraction analysis has demonstrated that 18.8% of the material is insoluble in water [5] and crystallinity close to 80%.

Manipulation and Setting Reaction

Slukyk *et al*, Torbinejad *et al* and Schmitt *et al* dvocated that the powder water ratio for MTA should be 3:1 [4] to obtain putty like consistency. Mixing can be done on paper or on a glass slab using a plastic or metal spatula. Mix is placed in the desired location and covered with moistened cotton pellet to prevent dehydration of the mix[2] and also improves the flexural strength of the set cement[5].MTA has a pH of 10.2 immediately after mixing and increases to 12.5% after 3 hours almost similar to calcium hydroxide. The mixing time of MTA is crucial. if the mixing time is prolonged it results in dehydration of the mix. Sluyk *et al* (1998) suggested that mixing time should be less than 4 minutes. MTA takes long time to set compared to other material. According to torabinejad *et al* is 2 hours and 45mins for grey MTA. Islam *et al* claimed it to be 2 hours and 55mins for grey MTA and 2 hours and 20 minutes for white MTA. Incorporation of accelerators such as sodium phosphate dibasic and calcium chloride may reduce the setting time [5].

MTA may be placed into the desired location using a hand instrument or ultrasonic condensation. Pluggers, paper point or messing gun can be used for hand condensation. ultrasonic condensation is done by first placing a hand instrument such as condenser in direct contact with MTA then an ultrasonic instrument is placed touching the shaft of the hand instrument and activated for several seconds[5].

Mechanism of Action

Once MTA is placed in direct contact with human tissues, it appears that the material

- Release of calcium ions for cell proliferation
- Antibacterial environment due to alkaline Ph
- Cytokine production is modulated
- Migration and differentiation of hard tissue producing cells
- Biological seal by formation of HA (or cardonated apatite) on the MTA surface.

Properties

Compressive Strength

According to Torabinejad *et al* (1995) compressive strength of MTA at 24 hours 40.0 Mpa at 21 days 67.3 Mpa. The compressive strength of gray MTA> white MTA.

Radio-Opacity

Ding SJ (2008) and Shah PMN (1996) found that MTA has comparable radiodensity compared zinc oxide eugenol and it is less radio opaque than super EBA, gutta-percha or amalgam. Torabinejad M (1995) concluded that mean radio-opacity of MTA is 7.17mm of equivalent thickness of aluminium, which is adequate to make it easy to visualize radiographically.

Solubility

BUDING (2008) found that the set MTA when exposed to water it releases calcium hydroxide. Calcium hydroxide might be responsible for its cementogenesis – inducing property.

Marginal Adaptation and Sealing Ability

According to Shipper *et al.* (2004) [17] and Torabinejad *et al.* (1995) [18] MTA has excellent sealing ability. MTA expands during setting reaction. Sealing ability of MTA in presence of moist environment is enhanced due to the setting expansion hence a moistened cotton pellet should be placed in contact with MTA before placement of the permanent restoration. Valois *et al.* (2004) [19] claimed that about 4-mm thickness of MTA ensure a good sealing.

Antibacterial and Antifungal Property

Al-Hazaimi *et al.* (2006) [20] stated that MTA has antibacterial effect especially against *Enterococcus faecalis* and *Streptococcus sanguis*. But, in contrary to Torabinejad *et al.* (1995) [21] stated that MTA showed no antimicrobial action against any of the anerobes. But showed certain effect on facultative bacteria.

Reaction with Other Dental Materials

Nandini S *et al*. (2006) [22] found MTA did not react or interfere with any other restorative material. Setting reaction of MTA is not effected by either GIC or composite placed over it. Srinivasan V *et al* (2009) [3] claimed that residual calcium hydroxide may interfere with the adaptation of MTA to dentinal wall leading to reduced sealing ability which occurs either by a mechanical obstacle of $CaOH_2$ particle by chemically reaction with MTA.

Biocompatibility

Kettering and Torabinejad (1995) [23] in a study compared MTA with Super EBA and IRM and concluded that MTA is not mutagenic and less cytotoxic. MTA is well tolerated by the tissues and biocompatible was claimed by Sumer *et al.* (2006) [24]. MTA was used to treat furcation perforations and osseous repair by Arens and Torabinejad (1996) [25] Pelliccioni *et al.* (2004) [26] evaluated osteoblast-like cell response to MTA and hence concluded that MTA has good interaction with periapical and periradicular tissues. MTA has potential effect on cell viabilities collagen release mechanism. MTA as a property to produce interleukin and also offers a biologically active substrate for bone cells.

Case Report

A 29 year old male reported with a chief complaint of discoloured upper front tooth since 5 years along with intermittent pus discharge from the gums in relation to the tooth. History revealed trauma to the upper front tooth 20 years back, medical history was non- contributory. Intra-oral clinical examination revealed discoloured 11 which was slightly tender on percussion. A patent sinus tract opening was seen in the alveolar mucosa adjacent to 11. Per-apical radiographs revealed blunderbuss canal in 11 and a well defined radiolucency around the root apex. upon examination, the treatment plan of choice was orthrograde endodontic therapy of the tooth along with periapical surgery and placement of retrograde MTA apical plug. Rubber dam was applied and teeth were isolated. access opening was done followed by cleaning and shaping of the canal till ISO # 80 K file. The canal was irrigated with 2.5% sodium hypochrite and 17% EDTA and 2% chloeohexidine followed by placement of calcium hydroxide as intra-canal medicament and tooth was sealed using IRM. calcium hydroxide dressing was placed for 4 weeks which was changed after every week. On the week recall, the canal was dried and obturated using roll cone technique using gutta –percha and zinc oxide eugenol sealer.

Periapical surgery was done under local anaesthesia, horizontal and vertical incisions were given and full thickness mucoperiosteal rectangular flap was reflected. Presence of a bony window was identified in relation to the apex of 11, the granulation tissue mass was curetted out of the bony cavity and placed in 10% formaline solution and sent for histopathological examination. The margins of the bony window were smoothened with carbide burs and bone files

under copious irrigation. 3mm of gutta-percha was removed from the apex and MTA plug placed by manipulating it according to manufacturer's directions. The flap was later repositioned and suturing done. Suture removal was done after 96 hours and satisfactory healing was observed

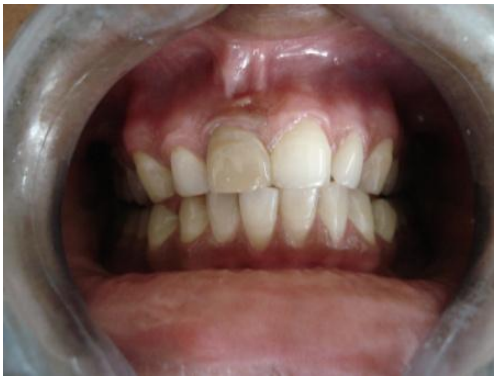

Fig 1: Pre-Operative

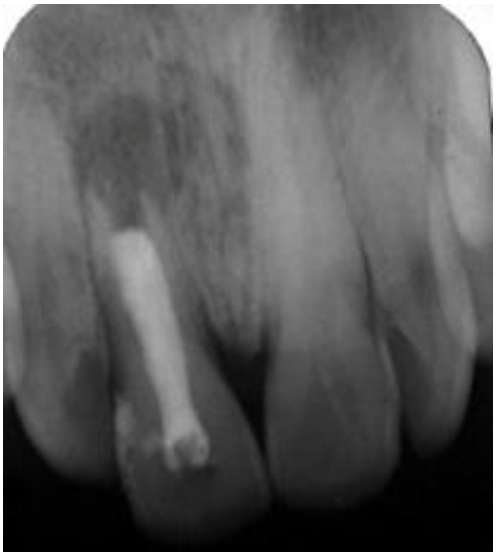

Fig 2: Retrograde Cavity Preparation

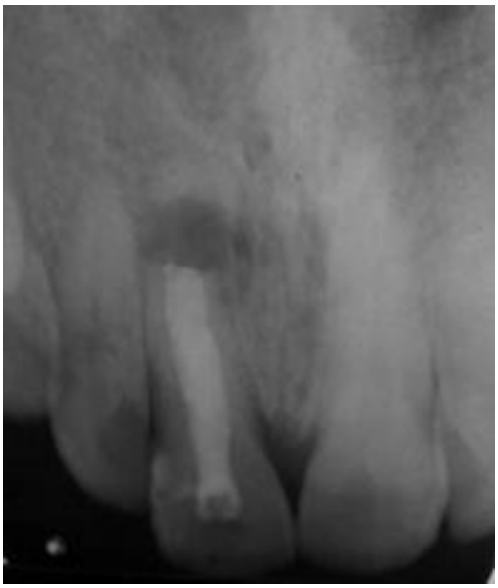

Fig 3: Mta Plug After Root Resection

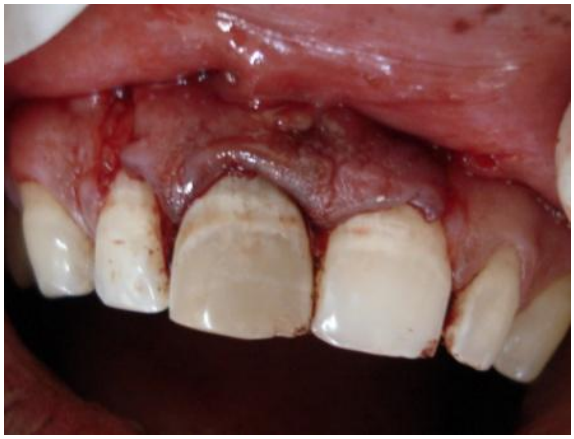

Fig 4: Incisions

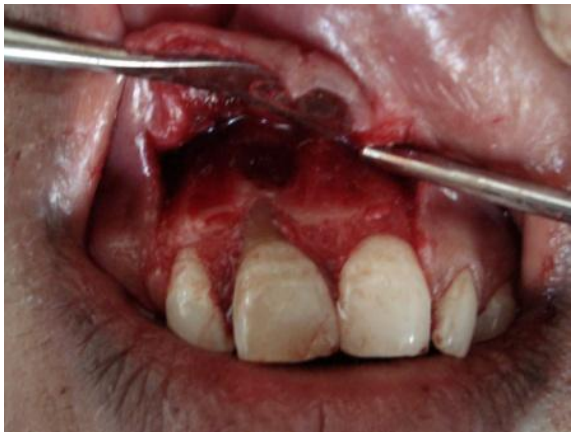

Fig 5: Flap Reflection

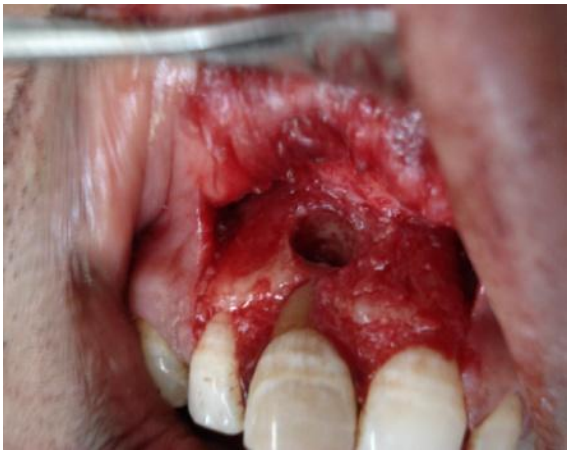

Fig 6: Bony Cavity

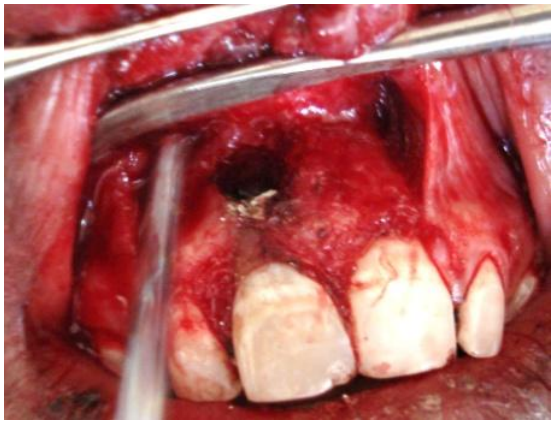

Fig 7: Mta Placement

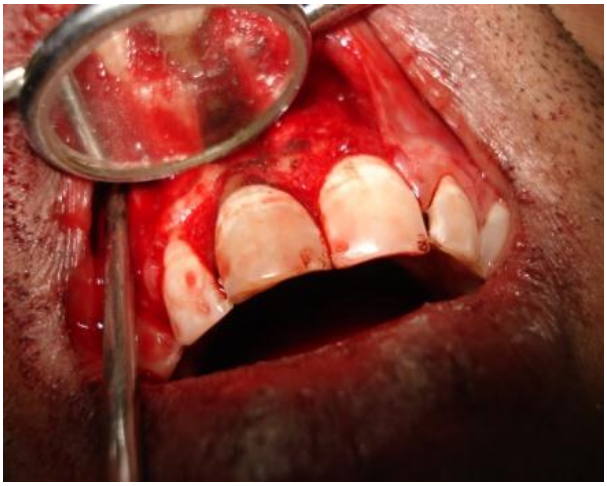

Fig 8: Post –Operative

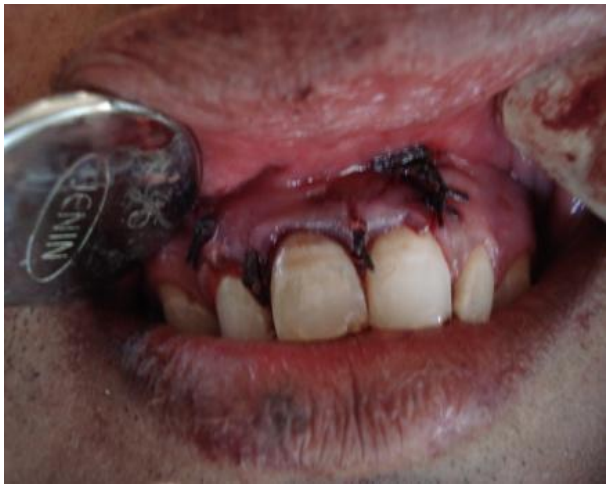

Fig 9: After Suturing

Case 2

A 21year old male patient A 29 year old male reported with a chief complaint of discoloured upper front tooth since 3 years. History revealed trauma to upper front tooth 20 years back, medical history was non-contributory. Intra-oral clinical examination revealed discoloured 11 which was slightly tender on percussion.

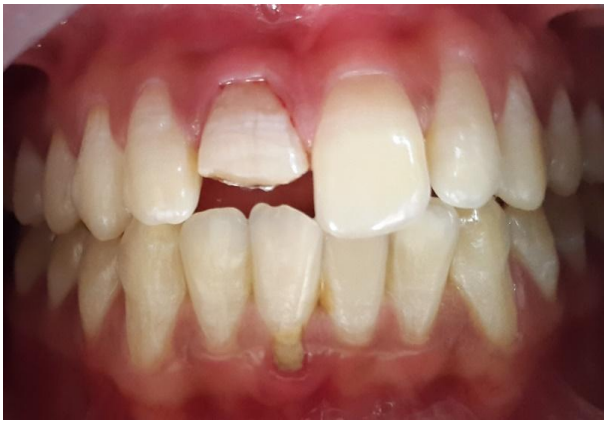

Fig 1: Pre-Operative

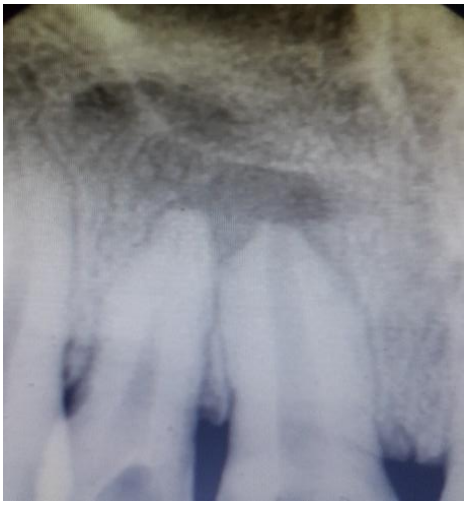

Fig 2: Pre-Operative Radiograph

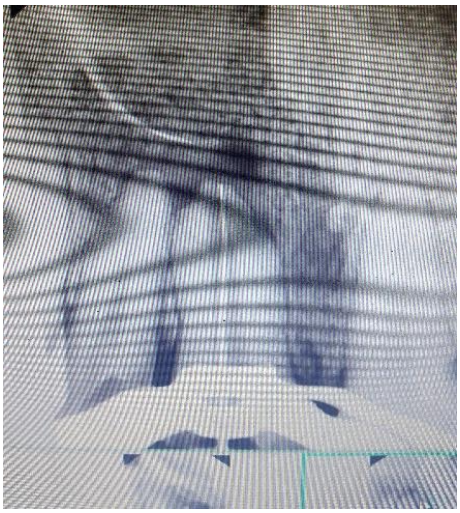

Fig 3: Workig Length

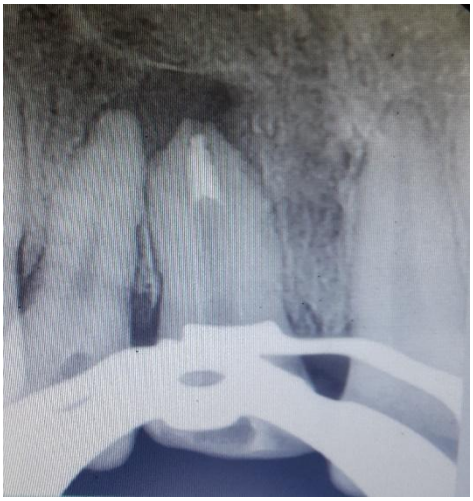

Fig 4: Mta Plug Orthograde Approach

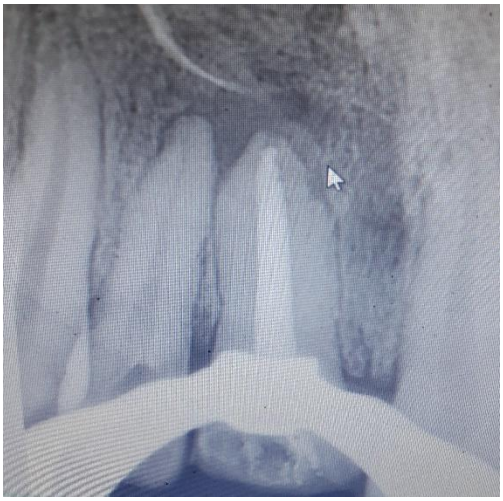

Fig 5: Obturation

Discussion

A conventional approach to treat teeth with open apices is by use of calcium hydroxide and inducing apical barrier formation, during such treatment follow up period the immature tooth is prone to fracture or re-infection. Calcium hydroxide induced apexification requires 3 months to 24 months period. Long term calcium hydroxide has also been reported to weaken the root structure. MTA is gaining popularity for use as an apexification material with good physical and biological properties. the presented cases showed that MTA can be used for the root end restoration in cases with open apex and periapical infection. Follow up of cases showed periapical healing and formation of hard tissue in apical end of root of affected tooth. Al-Kahtani *et al* has recommended in his study placement of a 5 mm apical barrier MTA in cases of apexification, as this allows excellent seal, and provides sufficient material thickness to prevent it from being displaced. Thermaplasticized gutta-percha is usually recommended in these cases with thin walls but custom made gutta percha can also be used depending on the thickness of walls. In the present case obturation with custom made gutta percha points was done as there was enough thickness of dentine. Placement MTA has been considered in these cases as it is effective as an apical barrier and its application results in predictable apical closing, reduced treatment time and a reduced number of exposures to radiographs. Follow up after treatment of the case is of utmost importance to study the success of the treatment. In the present case 6 months of follow-up, the clinical and radiographic appearance of the teeth showed resolution of the periapical lesions and hard tissue formation at apex.

Conclusion

MTA is a biocompatible material with various exciting applications in dentistry. An ideal root end material should have the most important quality of being nontoxic and other qualities like resistance to micro leakage, non –resorbable and should also have ease of clinical manipulation. MTA has high pH similar to calcium hydroxide and thus induces the hard tissue formation often after the use of this substance. Hence MTA can be of a great choice I various treatment aspect of dentistry.

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