Case Report

SingleVisit Apexification Technique for Inducing Root-End Barrier Formation in Apical Closures: Report of Two Cases

P. Jain, C. Rita, R.S. Agarwal

Department of Endodontics, Sri Aurobindo College of Dentistry, Devi Ahilya University, Indore

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Abstract:

Traumatized tooth rendered nonvital (pulpal necrosis) before the final stage of the root development results in a short root with a wide canal that can be either divergent or parallel. Although the root canal therapy is the choice of treatment for a nonvital tooth, the above mentioned abnormal root anatomy does not permit a predictable outcome. Mainly, it is not feasible to achieve a good apical seal due to lack of constriction in the open apex and a good lateral seal due to an abnormal width and shape of the root canal. Numerous procedures and materials have been utilized to induce root-end barrier formation. Mineral trioxide aggregate (MTA) reacts with tissue fluids to form a hard tissue apical barrier. As a result, MTA shows promise as a valuable material for use in single-visit apexification treatment, primarily for treating immature teeth with necrotic pulp. Here, we present two cases being successfully treated in a single visit apexification with MTA followed by endodontic treatment.

Key Words: apical closures, MTA, root end barrier formation, single-visit apexification, tooth trauma.

Introduction:

Dental caries and trauma are the most common challenges to the integrity of a tooth as it matures. Both insults can render the dental pulp nonvital. If this occurs prior to complete root formation and apical closure, normal root development is halted. Clinically, there are several conditions associated with treating teeth that have a widened or open apical foramen. For one, the apical diameter of the canal is often larger than the coronal diameter, so debridement is difficult. In addition, the lack of an apical stop makes obturation in all dimensions virtually impossible. Finally, the thin walls of the root canal are prone to fracture, so that surgical treatment is generally not a viable option[1].To avoid these complications, apexogenesis i.e. vital pulp therapy is indicated to encourage continued physiological development and formation of the root end .When the insult to the tooth has caused pulpal necrosis, alternative treatment modality that is apexification must be considered. The American Association Endodontist's Glossary of endodontic terms refers to apexification as "a method of inducing a calcified barrier in a root with an open apex or the continued apical development of an incompletely formed root in teeth with necrotic pulp."

Corresponding Author: Dr. Pradeep Jain, Professor and Head, Department of Conservative Dentisry, SAIMS College of Dentistry, Indore-Ujjain State Highway, MR-10, Bhorasala, Indore
Phone No.: +91 7312552074, +91 9977777725
E-mail : pradeep_endodon@rediffmail.com

Nonvital immature teeth require apexification prior to nonsurgical root canal treatment. Numerous procedures utilizing various materials have been recommended to induce root-end barrier formation. These include: no treatment,[2] infection control,[3] induction of a blood clot in the periradicular tissues,[4] antibiotic pastes,[5] and calcium hydroxide mixed with various materials.[6]

Since its first description in the dental literature by Lee et al[7] in 1993, and its first use as root end filling material,[8] the development of Mineral Trioxide Aggregate (MTA) material was truly a landmark event in dentistry and in endodontics in particular. This event dramatically increased the success rate of many cases that used to have high failure rates. Many advantages of MTA material enlarged its use markedly in different fields of dentistry, from which, endodontics was the largest field to take advantage of this material.

Mineral Trioxide Aggregate is a powder consisting of fine hydrophilic particles of tricalcium silicate, tricalcium aluminate, tricalcium oxide and silicate oxide. It also contains small amounts of other mineral oxides, which modify its chemical and physical properties. Hydration of the powder results in formation of colloidal gel that solidifies to form a strong impermeable hard solid barrier in approximately three to four hours. Electron probe microanalysis of MTA powder showed that calcium and phosphorus are the main ions present.[9] Bismuth oxide powder has been added to make the aggregate radio-opaque. Mineral trioxide aggregate has a pH of 12.5 after setting, similar to calcium hydroxide. This may impart some antimicrobial properties.[10] The material has a low solubility and a radio-opacity slightly greater than that of dentin. Because it has low compressive strength[9], it should not be placed in functional areas.

Case report 1:

An 18 year old female patient was referred to the Department of conservative dentistry with the chief complaint of spontaneous pain, the intensity of which increased on mastication. She had a history of trauma at the age of around 12 years but remained asymptomatic till recently.

Clinical examination revealed deep carious lesion involving the pulp of the concerned tooth 44. The tooth was tender on percussion and there was a mild pain on palpation. Labial mucosa adjacent to the concerned tooth was inflammed.

Intraoral periapical radiograph using radiovisiography (Kodak 5100, France) revealed short root. It also showed a blunderbuss open apex with thin dentinal walls of tooth 44. Small area of periradicular lesion associated with the root apex of the tooth 44 was also evident (Fig.I).

Pulp testing with an electric pulp tester (Parkell Inc. USA) and thermal test using hot gutta percha elicited non-responsiveness from the suspected tooth when compared to the control teeth. No signs of mobility or periodontal pockets were present. The diagnosis of pulpal necrosis with symptomatic periradicular Periodontitis was made.

The patient was discussed with various treatment plans and consent was obtained. Following isolation with a rubber dam, an endodontic access opening was made under magnification of an operating microscope (20X Seiler precision microscope, USA). The root canal was copiously irrigated with 5.2% sodium hypochlorite and 17% EDTA solution. Working length was determined by Root ZX^{R}. The root canal was cleaned and shaped by rotary nickel-titanium ProTaper instruments to the size F5. Calcium hydroxide paste (Ultracal, Ultradent, South Jordan, UT) was placed as an intra-canal medicament and the access cavity was temporized (Cavit G^{TM}). The patient was recalled 1 week later. On recall visit, the tooth was asymptomatic. The temporary restoration was removed and was irrigated with normal saline and dried. Once cleaning and shaping was completed, a plugger size 40 (generally used for warm vertical compaction) fitted loosely within 1.5 mm from the apex of the root canal system was

Fig. I: Preoperative radiograph of tooth 44 revealed short root with blunderbuss open apex and thin dentinal walls.

Fig.II. Mineral trioxide aggregate plug.

Fig.III. Post obturation radiograph.

selected. A thick mix of MTA and distilled water was prepared and then placed in the middle to apical third of the root canal system using an MTA gun (Fig. II). Mineral trioxide aggregate was compacted with the plugger previously fitted to the root canal system. Care was taken to prevent extrusion of the material into the periradicular area. The final adjustment was done with the light force using the butt end of sterilized greater taper paper points (Dentsply Maillefer) with the aid of the radiograph, leaving a minimal thickness of 6 mm. Once the MTA layer is adequately compacted to the working length and confirmed with a radiograph, the excess was removed from the coronal third of the canal system by irrigation with sterile water. The remaining fluid is removed with sterile paper points. A moist cotton pellet was placed against it, as the presence of moisture is essential for the material to set. The access cavity was temporized. The patient was recalled after 24 hours. At the next appointment, the MTA felt hard to an endodontic explorer DG-16 (Hu-Friedy International). The remaining part of the root canal was back-filled with injection molded thermoplastic gutta-percha (Obtura II, USA) and sealer (AH 26, Dentsply, Germany). Post obturation radiograph was taken which showed well obturated root canal (Fig. III). The patient was asked to report after a week for clinical evaluation and the post endodontic restoration.

During recall, the tooth was asymptomatic and post endodontic composite (Clearfil Majesty™, USA) restoration was placed and patient was recalled after six month for the follow-up.

Case report 2

A 14 year old boy was referred to the Department of conservative dentistry with the chief complaint of pus discharge from the openings near the root apices of tooth 11 and 21. He had a history of trauma due to fall two and half years back.

Clinical examination revealed fractured tooth 11 and 21 involving the pulp. Sinus opening was present near the root apices of both the central incisors. The teeth were not tender on percussion and there was no pain on palpation. Labial mucosa adjacent to the concerned teeth was inflammed.

Intraoral periapical radiograph using radiovisiography revealed blunderbuss open apices with thin dentinal walls of tooth 11 and 21. Small periradicular lesions was evident associated with the root apices of the tooth 11 and 21(Fig. IV).

The options for root-end management include classic apexification with long term Calcium hydroxide to induce formation of an osteodentin apical barrier, or single visit apexification with the placement of an artificial apical plug or barrier of MTA or periapical surgery with placement of a root-end filling, were discussed. The patient agreed and gave his consent for single visit apexification using MTA.

The inherent difficulties of inducing barrier formation over a period of months are avoided when treatment is completed in one appointment. Such treatment could be described as a single visit root-end barrier formation in apical closure with MTA. When MTA is used in this manner, it becomes the final obturating material in the apical to middle third of the canal system.

Following isolation with a rubber dam, an endodontic access opening was made for tooth 11 and 21 under magnification of an operating microscope. The root canals were copiously irrigated with 5.2% sodium hypochlorite and 17% EDTA solution. Working length was determined by Root ZX® (J. Morita Corporation, Kyoto, Japan).

Calcium hydroxide paste was placed as an intra-canal medicament and the access cavities were temporized (Cavit G™, 3M ESPE, Seefeld, Germany). The patient was recalled 1 week later. On recall visit, the tooth was asymptomatic. The temporary restoration was removed.

A thick mix of MTA and distilled water was prepared and then placed in the middle to apical third of the root canal system using an MTA gun (Fig. V). Mineral trioxide aggregate was compacted with the plugger previously fitted to the root canal system .Care was taken to prevent extrusion of the material into the peri-radicular area. The final adjustment was done with the light force using the butt end of sterilized greater taper paper points (Dentsply Maillefer) with the aid of the radiograph, leaving a minimal thickness of 6 mm. Once the MTA layer was adequately compacted to the working length and confirmed with a radiograph, the excess was removed from the coronal third of the canal system by irrigation with sterile water. The remaining fluid was removed with sterile paper points. A moist cotton pellet or paper point was placed against it, as the presence of moisture is essential for the material to set. The access cavity was temporized (Cavit-G). The patient was recalled after 24 hours. At the next appointment, the MTA felt hard to an endodontic explorer DG-16. The remaining part of both the root canal was back-filled with injection molded thermoplastic gutta-percha (Obtura II,Obtura Corporation, Fenton, USA) and sealer (AH 26, Dentsply, Germany). Post obturation radiograph was taken which showed well obturated root canal (Fig. VI). The patient was asked to report after a week for clinical evaluation and the post endodontic restoration.

During recall, the tooth was asymptomatic and post endodontic composite (Clearfil Majesty™ posterior Kuraray America, NY, USA) restoration was placed and patient was recalled after six month for the follow-up.

Fig.IV Preoperative radiograph of teeth 11 and 21 revealed blunderbuss open apex and thin dentinal walls and small periradicular rarefaction.

Fig.V Mineral trioxide aggregrate Apical plug with 11 and 21.

Fig.VI: Post obturation radiograph.

Discussion:

Any extended treatment plan runs the risk of losing the patient due to geographical reasons. If a child moves during the course of treatment, it is difficult to ensure that dressing changes will be made as necessary until a barrier is formed. Repeated clinical visits can be disruptive and difficult to maintain. These appointments are also easy to forget, since the patient has little discomfort and the tooth looks normal clinically. Children may be more traumatized by apexification treatments that require repeated visits, and it is these younger children with very wide apices that often need extended treatments. Thus, the need for a reliable one-visit apexification treatment is evident. Most commonly, the apexification procedure has been performed utilizing calcium hydroxide. In 1959, Granath was the first to describe the use of calcium hydroxide for apical closure.[11] Prior to this, nonvital immature teeth were often extracted.[12] Frank popularized the technique in which the canals are debrided, Calcium hydroxide is mixed with camphorated *p*-chlorophenol to make a paste that is then placed into the canals, and the access opening is subsequently filled.[6] In this procedure, the calcium hydroxide dressing is replaced every three months until a barrier is formed, which may require up to 24 months. When this procedure is performed today, the calcium hydroxide is most commonly mixed with sterile water or an anesthetic, but the time for barrier formation remains the same.[13]

Unfortunately, the Frank's technique sometimes provides inconsistent results due to: 1) The periapex closes with a definite (though minimal) recession of the root canal. The apical aspect continues to develop with a seemingly obliterated apex. 2) The obliterated apex develops without any change in the root canal space. 3) A thin, calcific bridge that is not radiographically discernable develops. 4) A calcific bridge forms just coronal to the apex and can be determined radiographically. Other inconsistencies relating to the use of calcium hydroxide for apexification include the time for root apices to close, the number of dressings necessary to complete closure, and the role of infection. Depending on the study, the speed of barrier formation varies from 3 to 24 months.[6,14] There are also variations in the recommended number of reapplications of calcium hydroxide.[14-18] Reapplication at 1 month then 3 months, or 1 month then 6 to 8 months has been suggested until apical barrier formation occurs.[16] Finally, some studies have reported an increase in the time for apexification when infection is present,[19,20] while others have demonstrated no statistically significant differences.[17,18,21]

These conflicting reports aside, the procedure for treating teeth with open apices is a difficult one. The root walls are thin and fragile, which render the tooth more susceptible to fracture during compaction of the obturation material.[1] Since patients are generally young, surgery is not a desirable course of treatment because immature teeth have large, patent dentinal tubules and a root-end filling may not provide an optimal seal. Compaction of a root-end filling may also cause fracture of the thin dentinal walls. Another factor that may compromise long- term apexification is the difficulty in maintaining a temporary filling that adequately seals the access opening. A temporary filling 4 mm in thickness is required to create a suitable seal. If there is dilution and/or contamination of the paste during the apexification treatment, with exposure of the healing tissues to bacteria, then acute exacerbation and a delayed healing response may occur.[6]

Hence in the present cases a non surgical,single visit apexifecation using Mineral trioxide aggregate was performed. An artificial apical plug or barrier of MTA was placed followed by the endodontic treatment.

Torabinejad et al performed a series of biocompatibility studies with MTA.[23] Kettering & Torabinejad found it to be non mutagenic,[22] and Torabinejad et al found it to be less cytotoxic than SuperEBA and IRM.[23] In animal studies, MTA was the only material studied that allowed cementum overgrowth. [24,25] It was found to be biocompatible when implanted into guinea pigs,[26,27,28] dogs[24] and monkeys,[25] and was more biocompatible than amalgam, Super EBA or IRM. In vitro studies of human osteoblasts showed that MTA stimulated cytokine release[29] and interleukin production.[30] These studies suggest that MTA is not just an inert material but may actively promote hard tissue formation.

Torabinejad et al tested MTA, amalgam, ZOE and SuperEBA against nine facultative bacteria and seven strict anaerobes.[10] Mineral trioxide aggregate was found to have an antibacterial effect on five of nine facultative bacteria but no effect on any of the strict anaerobes. The other materials had similar effects. The researchers concluded that none of the test materials had all of the antibacterial effects desired for a root-end filling material. Since the present case had an acute infection hence MTA was used owing to its antibacterial properties.

Shabahang et al compared MTA, osteogenic protein- 1 and Calcium hydroxide for apexification in dogs.[31] They found that MTA induced hard-tissue formation more often than did the other test materials and concluded that MTA was suitable for use as an apical barrier for apexification in immature roots..

In preparing the site to receive the MTA, the clinician should follow several guidelines. All irrigation should be performed before the MTA is placed. Any irrigation after placement will cause significant washout of the material. The preparation or resorptive defect does not have to be perfectly dry, but most of the fluid should be removed. If MTA is placed from inside the tooth, a moist cotton pellet or paper point should be placed against it, because the presence of moisture is essential for the material to set. The access cavity is then closed. MTA requires several hours to set into a hard mass. Most internal repairs with MTA require a second visit to complete the root canal therapy or restoration.

In the present case report all the guidelines for the placement of MTA were followed.

Blood contamination of the root-end site during barrier formation is also a relevant concern. In a similar comparative study, investigators noted that the presence of blood did not affect MTA's ability to maintain a seal.[32] Holland et al theorized that the tricalcium oxide in MTA reacts with tissue fluids to form calcium hydroxide, resulting in an apical barrier.[33] In addition, apexification implies the presence of a necrotic pulp, so a material with antibacterial properties is also desired. Several studies have evaluated the ability of MTA to kill bacteria. In a comparison study of root-end filling materials and their effects on nine facultative bacteria and seven strict anaerobic species, MTA had an antibacterial effect on some of the former, but no effect on the latter.[23]

Irregular dentinal walls and divergent apices make the adaptation of MTA more difficult. In this case, the access cavity was widened to enhance the visibility of the root and provide straight access to the apices of the tooth. The procedure should be done with caution. The orthograde placement of the apical plug is more sensitive than the retrograde method. Hachmeister et al also found that the sealing ability of MTA is superior when used as an orthograde plug[34].

In the present case the plugger size 40 fitted loosely within 1.5 mm from the working length. With this plugger the MTA was applied to the walls of the root canal system and the final adjustment was done with light force using the back end of sterilized paper points with the aid of the radiograph. Care was taken to prevent extrusion of the material in to the periradicular area.

The procedure of apexification often requires special instrumentation and the improved visualization. Hence, in the present case reports illumination and magnification was achieved by using an operating microscope (20X Seiler precision microscopes, St.Louis, MO, USA).

Hachmeister et al emphasized that the apical plug thickness may only have a significant impact on displacement resistance[34] while in the present case the thickness of apical plug of MTA was 6 mm and the remaining part of the root canal was back-filled with injection molded thermoplastic gutta-percha (Obtura II, USA) and sealer (AH 26, Dentsply, Germany).

Conclusion:

The development of Mineral Trioxide Aggregate (MTA) material by Torabinejad was truly a landmark event in dentistry and in endodontics in particular. The use of MTA changed dramatically the treatment plan and increased the success rate of many previously thought of as hopeless cases. MTA is an efficient and promising dental material. The many advantages of MTA enlarged its use markedly in different fields of dentistry, from which, endodontics was the largest field to take advantage of this material. MTA's approval in 1998 by the U.S. Food and Drug Administration should lead to more widespread use. The material appears to be an improvement over other materials for some endodontic procedures that involve root repair and bone healing. Although these potential concerns must be addressed and considered, the potential advantages of single-visit apical closure with MTA outweigh any negatives. As previously discussed, one-visit treatment is always advantageous over multiple treatments that may occur over many months. Another positive aspect is that MTA provides scaffolding for the formation of hard tissue and the potential of a better biological seal. When obturation finally occurs following hard tissue deposition with Calcium hydroxide, the clinician can never be sure of the integrity of the barrier. Single-visit apical closure with MTA avoids many of the pitfalls of traditional treatment methods. It is a viable option for treating immature teeth with necrotic pulps and should be considered as an effective alternative.

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