

Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.elsevier.com/locate/jpfa



Mineral trioxide aggregate in management of immature teeth with open apices – A report of clinical cases

V.S. Raji, P. Karunakar, N. Madhavi*

Department of Conservative Dentistry & Endodontics, Panineeya Dental College, NTR Health University, Hyderabad, India

Keywords:
Apexification
Calcium hydroxide
Mineral trioxide aggregate (MTA)
Open apex
Regeneration

ABSTRACT

Injuries to immature permanent teeth due to trauma may eventually result in pulpal necrosis and the subsequent arrest of root development. These teeth are often difficult to treat as the associated open root apex hinders the placement of the root filling material. To overcome this drawback, various materials have been introduced to induce apex closure prior to endodontic treatment. One of the currently popular material for apexification is mineral trioxide aggregate due to its superior biocompatibility, good sealing ability & excellent marginal adaptability. The presented clinical cases justifies the successful nonsurgical management of traumatized upper anterior teeth with mineral trioxide aggregate (MTA).

Copyright © 2013, Pierre Fauchard Academy (India Section). Publishing Services by Reed Elsevier India Pvt. Ltd. All rights reserved.

1. Introduction

Traumatic dental injuries to the young permanent teeth may jeopardize pulp survival & root development which can cause incomplete closure of the apex of the root.[1] This often presents as an endodontic challenge to the clinician due to lack of formation of an adequate apical stop compromising the three dimensional sealing of the root canal system, which is essential for the successful outcome in endodontic therapy.

One of the traditional solutions to these challenges lies in the use of apexification procedures to create an artificial apical barrier or a stop at the root end against which a root canal filling material can be placed without over extrusion beyond the confines of the canal walls into the apical tissues.

To achieve this goal of a hard tissue barrier formation in the apical region various materials have been tried by the clinicians. These include, calcium hydroxide powder mixed with different vehicles, collagen calcium phosphate, tricalcium phosphate, apical dentin chip plugging, osteogenic protein, bone growth factor and oxidized cellulose.[1] Certain authors have also described over instrumentation technique to produce blood clot that will induce apical closure.[2]

Calcium hydroxide has been globally accepted and reported as the material of choice for apexification to induce radicular closure. One of the key characteristics of calcium hydroxide is its potential to facilitate mineral deposition at the site of application. A review of literature studies on apexification reported a success rate of 74–100% using calcium hydroxide.[3] However it is time consuming & requires upto 7–8 months where follow up appointments to radiographically assess the barrier formation are required.[1]

Also its inherent solubility suggests replacement at 3 monthly intervals which require patient compliance as demonstrated by Shabahang et al in his study report.[4] Studies have also reported in certain cases an increased risk of root fracture due to dressing the root canal with calcium hydroxide for extended period of time.

As an alternative to calcium hydroxide mineral trioxide aggregate (MTA) was developed at Loma Linda University in 1993 by Torabinejad and Chivian to induce hard tissue

* *Corresponding author*. Department of Endodontics, 24/88-22-1, Plot No 8, East Anand Bagh, Safilguda, Hyderabad 500047, Andra Pradesh, India. Tel.: +91 9963009230, +91 040 27223675.
E-mail address: dr.viola@gmail.com (V.S. Raji).

0970-2199/$ – see front matter Copyright © 2013, Pierre Fauchard Academy (India Section). Publishing Services by Reed Elsevier India Pvt. Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jpfa.2013.01.002

formation at the root apex.[5] Using MTA apexification can be carried out in a single visit which is advantageous over traditional calcium hydroxide apexification which requires a longer treatment time to induce the formation of the apical barrier.

Mineral trioxide aggregate (MTA) has a variety of potential uses in endodontic procedures. Numerous histological studies have demonstrated its osteoconductive & osteoinductive property in the regeneration of periradicular tissues, such as periodontal ligament, bone, and cementum.[1,3] There are also several reports of its superior biocompatibility with periodontal tissues, excellent sealing ability in the presence of moisture,[6,7] and appropriate mechanical properties as apical sealing material.

A systematic search of the scientific literature was done in order to identify, select and critically appraise the various materials and their efficacy in apexification. It was found that several authors in their research have demonstrated MTA as an effective material of choice in apexification.[8]

The authors of the present study decided to select MTA to carry out apexification based on evidence based literature reports of its efficiency. Also the shorter treatment time required with MTA was another major factor considered.

Therefore the present clinical case reports highlight the nonsurgical management of asymptomatic teeth with blunderbuss canal using MTA as the material of choice selected to carry out the apexification procedure.

2. Description of clinical case reports

2.1. *Case report 1*

An 18 year old female patient, reported to the Department of Conservative Dentistry and Endodontics, Panineeya Dental College, Hyderabad, with a chief complaint of discolored right maxillary central incisor with the history of trauma at the age of 9. She had a non contributory medical history. After detailed case history pulp testing modalities were performed. The concerned tooth did not respond to both electric and heat test. Detailed radiographic examination revealed a large blunderbuss canal with an associated periapical lesion in relation to maxillary right central incisor (Fig. 1).

The two treatment options contemplated were either surgical removal of the periapical lesion and retrograde filling or nonsurgical root canal treatment following MTA apexification procedures. To exclude the patient from surgical trauma & multiple visits for completion of the treatment, the nonsurgical treatment approach with MTA was opted over the traditional calcium hydroxide approach for apical closure.

Access opening was done & refined with a safe end tapered bur (Endo-Z) under rubber dam isolation (Hygenic Dental Dam Kit) and working length was determined radiographically (Fig. 2). Pus was extruded from the root canal immediately after the access preparation. Luke warm water was then used to irrigate the root canal which was left open till the exudate stopped draining out of the canal. Biomechanical preparation was done using no 80 K-file incorporating a circumferential filing motion. Root canal debridement was done using alternate irrigation with 2.5% NaOCl and saline (9% W/V). Calcium

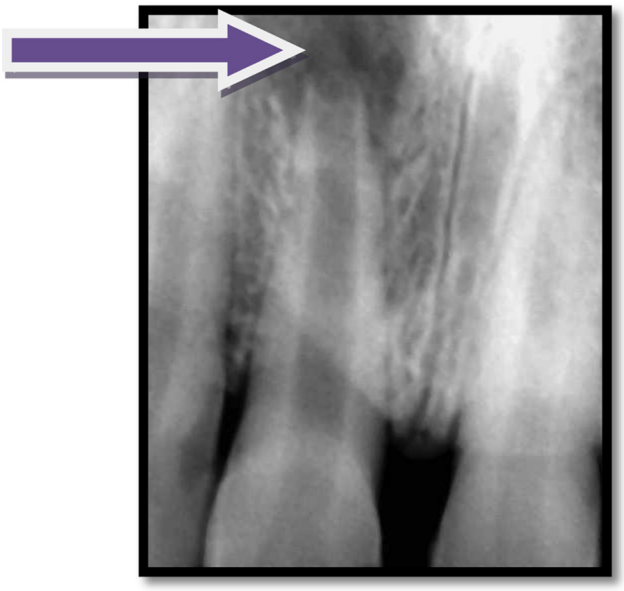


Fig. 1 – Digital radiographic image (RVG) with open apex& periapical defect of 11.

hydroxide and iodoform combination was placed in the root canal and the patient was recalled after one week.

At the subsequent appointment after removal of the temporary dressing the root canal was found completely dry. It was then debrided with 2.5% NaOCl followed by 17% EDTA (Prime Dental Product) and final rinse with 2% chlorohexidine.



Fig. 2 – Digital radiographic image (RVG) of 11 determining working length-21 mm.

The canal was dried with paper points and mineral trioxide aggregate was dispensed & mixed according to manufacturer's instructions. The canal was filled up to half its length using a MTA carrier & subsequent increments was condensed with hand pluggers & back-end of a paper point. The procedure was done with the aid of a surgical operating microscope to better observe the material during its placement in the canal. The thickness of the MTA plug was 3–5 mm and this was confirmed with a radiograph (Fig. 3).

A moist cotton pellet was inserted into the canal to aid in setting & was left undisturbed for 15 min according to manufacturer instructions. Access cavity was then sealed with temporary cement Cavit. In the subsequent appointment the root canal was back filled with Obtura II. Verification radiograph was taken (Fig. 4) and the access cavity sealed with composite.

A follow up radiograph after 4 months showed apex closure and that the periapical lesion had begun to resolve and the tooth was clinically asymptomatic (Fig. 5). The 2 year recall of the patient radiograph revealed complete dissolution of periapical lesion (Fig. 6). The tooth was clinically performing fine.

2.2. *Case report 2*

A 20-year-old female patient reported to the Department of Conservative Dentistry and Endodontics, Panineeya Dental College, Hyderabad, with a chief complaint of pain & discolored tooth in the upper anterior region of the mouth. Patient had a dental trauma 12 years back i.e., during the developmental stage of the tooth root. Clinical examination revealed the discoloration of 11. Pulp vitality testing indicated a non-vital tooth. Radiographic examination showed an immature tooth with a wide-open apex with periapical destruction (Fig. 7).



Fig. 3 – Digital radiographic image (RVG) of 11 with MTA apical plug-5 mm.



Fig. 4 – Digital radiographic image (RVG): backfilling with thermoplastisized guttapercha –(obtura II).

Nonsurgical endodontic treatment was performed using mineral trioxide aggregate to induce mineral deposition at the root apex followed by root canal therapy. The similar procedure carried out in the first case report was initiated digital radiographic images (RVG) were taken for verification of working length, (Fig. 8) MTA placement (Fig. 9) and canal backfilling with thermoplasticized gutta-percha (Fig. 10). Immediate post treatment the patient was completely asymptomatic.

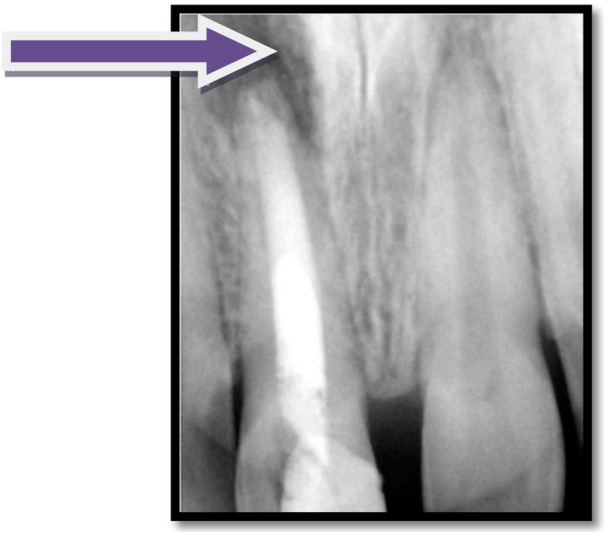


Fig. 5 – Digital radiographic image (RVG) of 11 at 4 months recall showing apical closure.

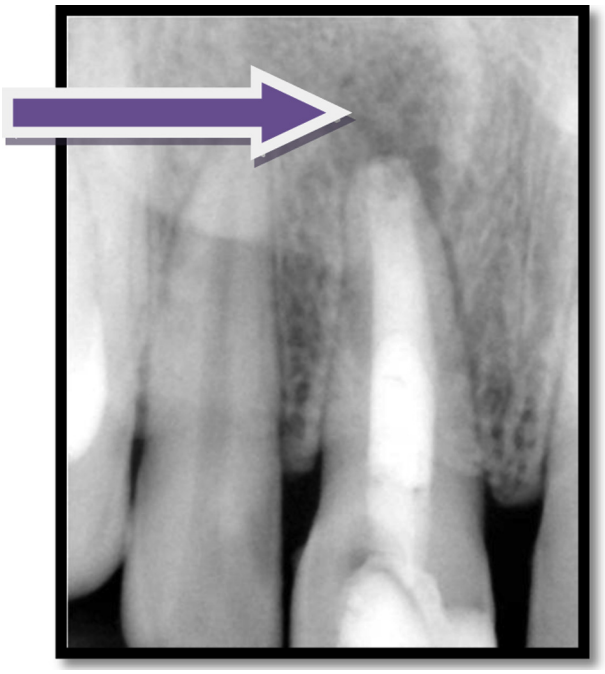


Fig. 6 – Digital radiographic image (RVG) of 11 at 2 years follow up showing total resolution of the periapical rarefaction.



Fig. 8 – Digital radiographic image (RVG) of 11 determining working length 20 mm.

The follow-up of the clinical findings revealed an asymptomatic tooth with the radiographic examination at 4 month and 8 month intervals showing calcification of the root apex (Fig. 11) and dissolution of the periapical destruction suggestive of bone healing and regeneration (Fig. 12).

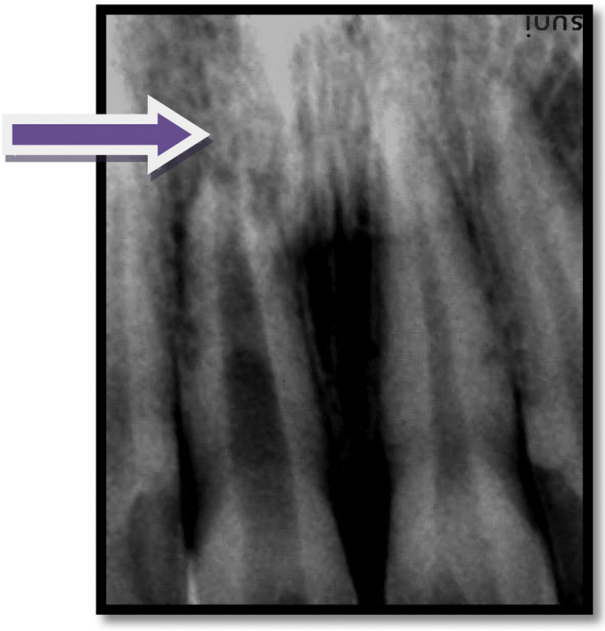


Fig. 7 – Digital radiographic image (RVG) of 11 with periapical defect.



Fig. 9 – Digital radiographic image (RVG) taken after placement of MTA apical plug-11.



Fig. 10 – Digital radiographic image (RVG) of 11 after obturation.

3. Discussion

The most common sequelae of traumatized immature teeth is pulp necrosis with periapical involvement. The management of such large periapical pathologies with open apices ranges from non-surgical root canal treatment and/or surgical intervention to tooth extraction.[9]

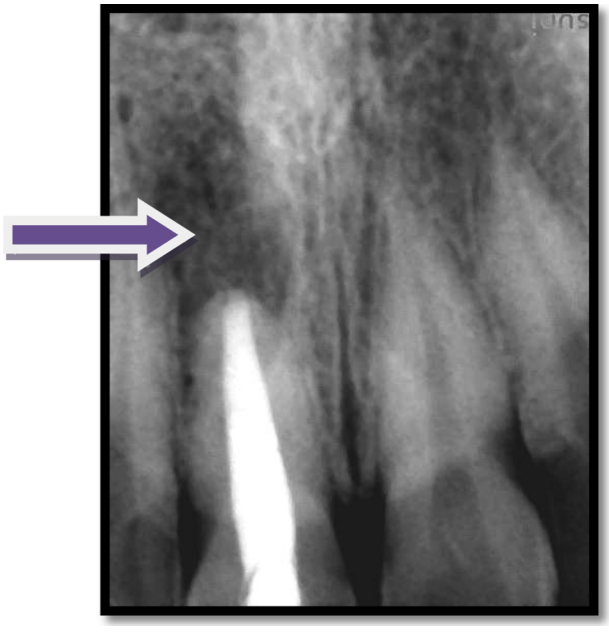


Fig. 11 – Digital radiographic image (RVG) of 11 at 4 months recall showing apical closure.

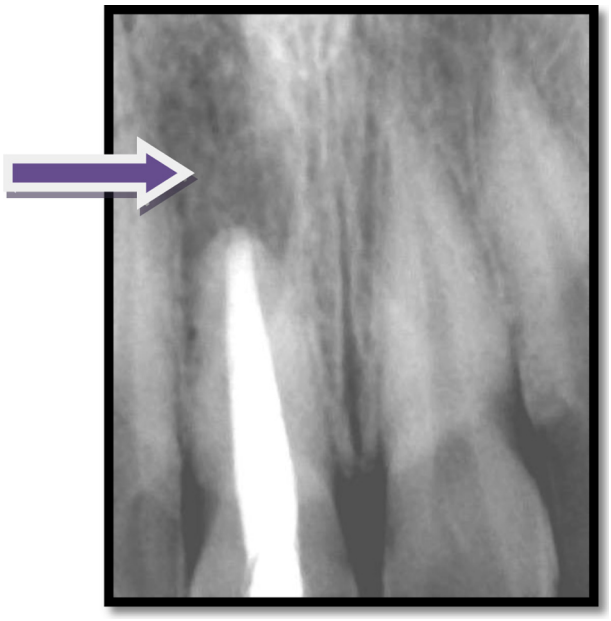


Fig. 12 – Digital radiographic image (RVG) of 11 at 8 months recall suggestive of healing of periapical rarefaction.

Considering the less amount of trauma involved and predictability of treatment outcomes, the current philosophy revolves around the use of non-surgical root canal treatment procedures to manage these periapical defects.

In the event of pulp necrosis and canal infection, it is necessary to disinfect the root canal and stimulate the formation of a hard tissue apical barrier that would allow for the placement of a root filling material and healing of the periapical lesion. This is achieved by the process of apexification using appropriate materials and medicaments that can regenerate odontogenic tissue successfully, both from an endodontic and periodontal aspect.[10,11]

The goal of an apexification procedure is to create an environment to permit deposition of cementum, bone and periodontal ligament to aid its function of root development. This mineral deposition facilitates the formation of an apical barrier at the root end to prevent the passage of toxins and bacteria into the periapical tissues from the root canal.[11] Technically this hard tissue apical stop is necessary to allow compaction of the root filling material during the root canal procedure for an immature tooth.

Numerous research studies have been conducted over the past decades and in the recent years to introduce regenerative materials capable of being applied permanently at the ends of tooth roots to induce radicular closure.[12–14]

Calcium hydroxide is currently the most widely accepted and researched material for the procedure of apexification.[11,15] It has been used with great success to induce an apical hard tissue barrier in immature open apices. Despite its popularity for the apexification therapy calcium hydroxide has some inherent limitations such as failure to control infection, susceptibility to re-infection because of a temporary seal and cervical fracture. The time interval for calcium

hydroxide therapy has been reported to be variable, ranging from 3–24 months but this was not attempted because of the difficulty in patient follow up, delay of treatment completion time and unpredictability of the apical closure.[16]

Another drawback of this technique is the nature of the barrier that is formed, which although apparently calcified, is actually porous and is sometimes even found to contain small amounts of soft tissue by some investigators. This porous barrier formed by calcium hydroxide apexification has been reported by certain authors in their studies to be incomplete having a Swiss cheese appearance which permits apical percolation. Thus a permanent root canal filling at the apical end is still mandatory for a favorable apical seal.

In 1999, Torabinejad and Chivian introduced the use of mineral trioxide aggregate (MTA) and ever since its introduction it has been suggested as a viable option for apexification as it has high sealing ability, excellent marginal adaptation and a high degree of biocompatibility. In 1998, the US Food and Drug Administration approved MTA for endodontic applications.[17,18]

MTA allows for an immediate apical barrier to be formed at the site of application and thus immediate obturation of the root canal system can be carried out. MTA may therefore overcome a few of the shortcomings currently experienced in calcium hydroxide apexification procedures.

MTA material is available as a fine hydrophilic powder composed predominantly of calcium and phosphorus ions, with added bismuth oxide to provide better radio opacity greater than dentin 9. The powder is mixed with supplied sterile water in a 3:1 powder/liquid ratio and it is recommended that a moist cotton pellet be temporarily placed in direct contact with the material and left until a follow-up appointment.[19]

Upon hydration, MTA forms a colloidal gel that solidifies to a hard structure in approximately 3–4 h. The setting process is described as a hydration reaction of tricalcium silicate ($3CaO•SiO_2$) and dicalcium silicate ($2CaO•SiO_2$), which contributes to the development of the material's strength.[20]

Although one-step apexification procedures with MTA have been advocated by Giuliani et al and other authors, it has been demonstrated by Matt et al and Sarkar et al, that additional moisture from a cotton pellet helps the material to attain its optimum properties. These findings concur with the manufacturer's recommendations of placing a moist cotton pellet in the canal, temporizing it and then allowing the material to set for a minimum of 4 h.[21]

The process of setting of MTA in the presence of moisture holds clinical significance. The presence of exudates, blood or tissue fluid enhances its setting reaction and closely simulates an environment akin to periradicular infection.

Also the setting expansion of MTA aids in achieving an effective seal against the root canal walls and ensures a proper apical barrier, which is required for the resolution of the periapical lesion.

Further studies have proven that MTA in apexification procedures represents a primary monoblock. During the maturation of MTA appetite like interfacial mineral deposits form resulting in filling the gap and increasing the frictional resistance of MTA to the radicular walls. This reduces the chances of root fracture in immature teeth with thin roots as the material immediately bonds with the roots and strengthens it.[22]

Hydrated MTA products have an initial pH of 10.2, which rises to 12.5 three hours after mixing 4, 9. By virtue of its alkaline pH (12.5), which remains the same after setting, it is thought to impart an antibacterial effect.[23]

It has a compressive strength equal to zinc oxide eugenol with polymer reinforcement and all-purpose lining and cement (SuperEBA, Harry J. Bosworth, Skokie, Ill.) but less than that of silver amalgam. It is available commercially and has first been advocated for use in vital pulp therapy.[24]

MTA has superior biocompatibility and in the presence of calcium and phosphate ions its formulation results in a capacity to attract blastic cells and promotes a favorable environment for cementum-like hard tissue directly apposed to the material. This osteoconductive nature of the material may help the periapical tissues to adapt and heal.[25]

According to manufacturer's instructions a 3–5 mm thickness is a more effective apical plug as it is significantly stronger and shows less leakage than 2 mm barrier. Also it could be placed and condensed more at 5 mm thickness due to increased resistance to dislodgment through the open apex as observed in certain studies.[2,26]

In the performed case reports a two-step technique with a 5 mm apical barrier of MTA was carried out. Prior to MTA treatment the root canals were medicated with calcium hydroxide for one week to enhance the disinfection of the canal as suggested by various authors. As the orthograde delivery of the MTA material is very technique sensitive its placement was verified with radiographs and passive condensation with hand instruments was done because of minimal or no resistance at the apex. However as studies have confirmed that the placement of MTA under microscopic observation helps to ensure that it is properly placed with minimal or no extrusion into the periapical tissues this method was also carried out in our case reports.[13,27]

The present cases were reviewed at intervals of one month, three months, six months and twelve months post treatment with MTA apexification. Radiographs obtained at the one-year interval revealed resolution of the apical infection and rarefaction of the periapical area suggestive of bone healing and regeneration of the root apex around the MTA material.

In our investigation it was found that due to the fast setting time of MTA, patient compliance is much less of a concern as fewer follow-up appointments were required. However the sandy consistency of MTA makes it more difficult to work with compared to calcium hydroxide. Also it is much more expensive for the initial treatment but the treatment can be carried out within the first visit with successful outcomes.

Nevertheless, additional research, especially randomized controlled clinical trials with more subjects, comparing MTA and calcium hydroxide for apexification is suggested. MTA has several obvious advantages and has promising potential for successful management of necrotic immature permanent teeth. The review of the case reports presented here showed positive outcomes as evidenced by the clinical and radiographic follow-up periods.

There are also other exciting and upcoming treatment options which are currently being investigated for the apical closure of a permanent necrotic immature tooth. Revascularization, which is the regeneration of the apex via blood clot formation and stem cell regeneration modalities, provides scope for future areas of research.[8,28,29]

Until further investigations, it is of utmost importance to research what treatment options are the best in an evidence-based manner in order to strive to give the patients the best possible standard of care.

4. Conclusion

We concluded through our case investigations that MTA addresses most of the challenges encountered in traumatized immature teeth with open apices. Also using MTA lessens the patient's treatment time between the first appointment and final restoration.

It has been observed that through careful follow-up of the case details that MTA as an apical plug in apexification is a boon to endodontic procedures with positive predictable outcomes and it can be a viable alternative to use of long term calcium hydroxide apexification.

Conflicts of interest

All authors have none to declare.

REFERENCES

1. Nuvvula Shivakumar, Tejas H. Management of immature teeth with apical infections using mineral trioxide aggregate. *Contemp Clin Dent*. Jan–March 2010;1(1):51–53.
2. Kubasad Girish C, Ghivari Sheetal B. Apexification with apical plug of MTA-report of cases. *Arch Oral Sci Res*. 2011;1(2):104–107.
3. Gaitonde P, Bishop K. Apexification with mineral trioxide aggregate: an overview of the material and technique. *Eur J Prosthodont Rest Dent*. 2007;15(1):41–45.
4. Shahabang S, Torabinejad M. Treatment of teeth with open apices using mineral trioxide aggregate. *Pract Periodontics Aesthetic Dentistry*. 2000;12:315–320.
5. Torabinejad M, Hong CU, Mcdonald F, et al. Physical and chemical properties of a new root-end filling material. *J Endod*. 1995;21:349.
6. Teja Tanvir S, Verme Meha, Meshram Suresh. Evaluation of sealing ability of white MTA when used in an orthograde manner in simulated immature apices – an invitro study. *JIDA*. December 2011;5(12).
7. Villa P, Fernandez R. Apexification of replanted tooth using mineral trioxide aggregate. *Dent Traumatol*. 2005;21:306–308.
8. Clark Allison, Pino Anthony, Attoe Danielle. *Comparison of MTA and Ca(OH)2 for the Apexification of Necrotic Immature Permanent Teeth. An Evidence Based Report" – Doctoral Diss*. University of Toronto, DDS; 2007.
9. Smita Govila, Vivek Govila. Mineral trioxide aggregate. As an apical plug for apical closure & periapical healing-A case report – Endodontolgy.
10. Tom David. *Apexification procedure using MTA*. Canadian Academy of Endodontics – Contr; July 2000.
11. Ghaziani Pari, Aghasizadeh Navid, Sheikh-Nezami Mahshid. Endodontic treatment with MTA apical plugs: a case report. *J Oral Sci*. 2007;49(4):325–329.
12. Torabinejad M, Watson TF, Pitt Ford TR. Sealing ability of mineral trioxide aggregate when used as a root-end filling material. *J Endod*. 1993;19:591.
13. Torabinejad M, Chivian N. Clinical applications of mineral trioxide aggregate. *J Endod*. 1999;25:197.
14. Roberts Jr SC, Brilliant JD. Tricalcium phosphate as an adjunct to apical closure in pulpless permanent teeth. *J Endod*. 1975;1:263.
15. Friend LA. The treatment of immature teeth with nonvital pulps. *J Br Endodont Soc*. 1967;1:28.
16. Weisenseel JA, Hicks ML, Pelleu GB. Calcium hydroxide as an apical barrier. *J Endod*. 1987;13:1.
17. Schumacher JW, Rutledge RE. An alternative to apexification. *J Endod*. 1993;19:529.
18. Germain LP. Mineral trioxide aggregate: a new material for the new millennium. *Dent Today*. 1999;1:66–71.
19. Mineral tri oxide aggregate used as apical plug in open apex cases - a review and case report. *Ind J Dent Sci*. October 2011;Vol.:3(4).
20. Germain Schwartz RS, Mauger M, Clement DJ, et al. Mineral trioxide aggregate: a new material for endodontics. *J Am Dent Assoc*. 1999;30:967.
21. Witherspoon DE, Ham K. One-visit apexification: technique for inducing root-end barrier formation in apical closures. *Pract Proced Aesthet Dent*. 2001;13:455.
22. Park Jun-Beom, Lee Jeong-Heon. Use of mineral trioxide aggregate in the open apex of a maxillary first premolar. *Journal of Oral Science*. 2008;50(3):355–358.
23. Camilleri J, Montein FE, Papaioannous S, McDonald F, Pitford TR. Biocompatibility of two commercially available forms of mineral trioxide aggregate. *Int Endod J*. 2004;37:699–704.
24. Fischer EJ, Arens DE, Miller CH. Bacterial leakage of mineral trioxide aggregate as compared with zinc-free amalgam, intermediate restorative material and super EBA as root-end filling material. *J Endod*. 1998;24(3):176–179.
25. Lee SJ, Monsef M, Torabinejad M. Sealing ability of a mineral trioxide aggregate for repair of lateral root perforations. *J Endod*. 1993;19:541.
26. Valois CRA, Costa Jr ED. Influence of the thickness of mineral trioxide aggregate on sealing ability of root-end filling in vitro. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2004;97:108–111.
27. Aminoshariae A, Hartwell GR, Moon PC. Placement of mineral trioxide aggregate using two different placement techniques. *J Endod*. 2005;31:101–113.
28. Thibodeau B, Trope M. Pulp revascularization of a necrotic infected immature permanent tooth: case report and review of the literature. *Pediatr Dent*. 2007;29(1):47–50.
29. Friedlander LT, Cullinan MP, Love RM. Dental stem cells and their potential role in apexogenesis and apexification. *Int Endod J*. 2009;42(11):955–962.

Our mission as Fellows in the Pierre Fauchard Academy is to consistently focus on professionalism, integrity, and ethics worldwide, by our own conduct as worthy role models, by the advancement of dentistry to the highest level, by supporting and honoring colleagues for their distinguished work, research, contributions, and public service, and by providing excellence in programmes, education and example.