Original Article

Evaluation of Mineral Trioxide Aggregate for Root end Closure of Nonvital Permanent Teeth with Open Apices

*Tasnim Wakia[a], Mohammad Aminul Islam[b], Mohammad Naser [c], Md. Shamsul Alam [d], Md. Ismail Hossain [e]

[a] Private Practitioner, Dhaka, Bangladesh
[b] FCPS trainee. BSMMU, Dhaka, Bangladesh
[c] Dental Surgeon and Endodontist, Dhaka CMH, Bangladesh
[d] Professor & Chairman, Dept. of Conservative Dentistry & Endodontics, BSMMU, Bangladesh
[e] Lecturer, Rajshahi Medical College Dental Unit, Bangladesh

ARTICLE INFO

Article History:
Received : 20 October 2012
Accepted : 17 March 2013

Key Words:
Mineral Trioxide Aggregate (MTA)
Nonvital Permanent Teeth
Open Apices

ABSTRACT

Objective: To evaluate the clinical and radiological outcome of MTA in nonvital teeth with open apices. **Methods:** Twenty-five non-vital teeth with open apices were treated with MTA apexification procedure. Standard endodontic procedures were followed and an apical plug of at least 5 mm was created by using MTA after a calcium hydroxide intra-canal dressing for at least 1 week. Final obturation was done after 24 hours by vertical compaction technique using gutta percha. Patients were recalled at 3, 6, 9 and 12 months interval. Clinical outcome was evaluated by assessing pain, tenderness, mobility and sinus tract. Blind to the treatment record, two examiners assessed the pre-treatment and post-treatment radiographs. Each radiograph was scored with the Periapical Index (PAI) and the size of the apical lesion was measured. The presence of an apical bridge over MTA was also noted. **Results**: Clinically 92% success rate was found whereas radiologically absolute success rate was 84%. Before treatment the mean PAI was 3.6 and mean size of the lesion was 3.24 mm. But, after 12 months follow up, the mean PAI was 1.36 and the mean lesion size was 0.68 mm. An apical barrier over MTA was distinguishable in 5 cases. **Conclusion:** Apexification using MTA can be considered as a predictable treatment option than calcium hydroxide apexification.

**Address of Correspondence:*
Dr. Tasnim Wakia. BDS, FCPS
Private Practitioner, Dhaka, Bangladesh
Telephone: 01718-939470
E-mail: dentalheaven@mail.com

Introduction

The common causes for the interruption of root development are trauma and caries and the majority of injuries occur in young individuals when the root development is incomplete[1]. The completion of root development and closure of

the apex occurs up to 3 years following eruption of the tooth[2]. When teeth with incomplete root formation suffer pulp necrosis, the root development ceases and apical closure cannot be achieved. Root canal treatment at this time is a significant challenge, because of the size of the canal, the thin and fragile dentine walls and the large open apex. Apexification is a well-established treatment for immature teeth with necrotic pulp[3]. Materials used for apexification are- calcium hydroxide [$Ca(OH)_2$], bone growth factor, collagen, tricalcium phosphate, osteogenic protein-1[4]. $Ca(OH)_2$ pastes have been considered as the material of choice to induce the formation of a hard tissue apical barrier. But apexification with $Ca(OH)_2$ has several disadvantages such as long treatment period[5], difficulty of the patient's recall management, number of radiograph, increase the risk of root fracture after dressing with $Ca(OH)_2$ for extended periods[6], formation of porous calcified bridge[7] and the prognosis may be compromised by the placement of a temporary coronal seal[8]. Recently, a new material mineral trioxide aggregate (MTA) has been introduced for apexification that appears to be a significant improvement over other materials[9].

The advantages of apical plug with MTA are less treatment time, possibility to restore the tooth with a minimal delay and thus to prevent the fracture of the root[10]. MTA offers a barrier at the root end that permits vertical condensation of warm gutta-percha in the remainder of the canal[9]. Clinical studies have reported that 77% to 85% of teeth with open apices healed completely within1 to 3 years after the placement of MTA apical plug[10-13].

Materials & Methods

25 non-vital teeth with open apices had selected for the study after clinical and radio-graphical evaluation. At first visit, patient's clinical signs or symptoms and radiographic evidences were recorded. The radiographs were examined by two examiners and recorded in the data collection sheet. After isolation of teeth with cotton roll and saliva ejector, a straight line access cavity was prepared and working length was determined with radiograph. Then the canal was debrided with Hedstrom file carefully and copious irrigation was done with sodium hypochlorite (2.5%) solution and normal saline alternatively, followed by dried with sterile paper points. $Ca(OH)_2$ paste was mixed with glycerin[14] and placed into the canal with lentulospiral followed by temporary restoration.

After one week, temporary coronal restoration was removed and repeated copious irrigation was done with 2.5% sodium hypochlorite solution followed by normal saline to remove all the $Ca(OH)_2$ paste. Canal was dried with sterile paper points and if any exudate was noticed, $Ca(OH)_2$ paste was re-applied for next one week. A plugger had made manually by heating and rolling with two Protaper gutta percha to condense the MTA at the apical area. A radiograph was taken to confirm that the plugger was at least 3-4 mm short of the apex. The ProRoot MTA (Dentsply) was mixed to a thick creamy consistency with distilled water (3:1) and delivered into the canal with lentulospiral[15]. Then the plugger was inserted in the canal to condense the MTA at the apex with a thickness of at least 3 mm. Correct placement of MTA at apical 3-4 mm area was confirmed by taking an another radiograph. A moist cotton pellet was placed into the chamber and the access was sealed with zinc oxide eugenol cement. After 24 hours, hardness of MTA was checked with a condenser and rest of the canal was sealed with gutta percha and zinc oxide eugenol sealer in vertical compaction technique. The access was sealed using composite resin restoration and a post-operative radiograph was taken.

Materials

Heating & rolling

Custom made hand plugger

Radiograph before apical plug

Figure 1:Custom made GP Plugger

Evaluation

For clinical evaluation, the preoperative and post operative status was compared based on the presence or absence of pain, tenderness to palpation or percussion , mobility or presence/absence of any sinus tract. The comparative clinical outcome s w ere graded according to clinical endodontic guideline[16] as follows-

Success :Absence of any pain or abscence of tenderness to palpation or percussion, no sinus tract with normal physiological mobility.

Uncertain : Low grade discomfort after percussion or palpation with sporadic vague pain and/or persistant mobility.

Failure :Any signs or symptoms of persistant pain, predictable discomfort to percussion or palpation, recurrent sinus tract or excessive mobility.

For radiological evaluation, two examiners assessed the pre-treatment and post-treatment radiographs in a dark room using a magnifier. The apical area of involved tooth was scored with the Periapical Index (PAI) [17] which was catagorized as: (1) Normal periapical structure; (2) Small changes in bone structures; (3) Changes in bone structure with some mineral loss; (4) Periodontitis with well-defined radiolucent area; and (5) Severe periodontitis with exacerbating feature. The diameter of the lesion size was measured with a millimeter ruler and the presence or absence of an apical tissue barrier over the surface of MTA at apex was also noted. The pre-operative and the post-operative status were compared and the success or failure was graded as follows on the basis of the changes of size of the lesion and/or score of the PAI[10].

Absolute success :Both PAI score and size of the lesion was decreased significantly.

Relative success : Size of the lesion decrease in size but PAI was static with previous score or where there was no change in size of the lesion but PAI score was decreased.

Relative failure : No change in size of the lesion but the size was greater than zero (0) mm with a stable PAI score.

Absolute failure : Either size of the lesion incresing or PAI score was greater than previous.

Result

Twenty-five nonvital teeth with open apices of 21 patients were treated with MTA apexification procedure. The mean age of the patients was 15 years (Figure 2). The preoperative and 12 months clinical follow up data were analyzed with 'Z-test' which have shown a significant success rate of 92% (Table 3). The variables for the clinical evaluation are shown at Table 1. The PAI scores of the preoperative and last review radiograph were analyzed with 'paired t-test' ($P < 0.0001$) and the mean PAI was reduced to 1.36 from 3.6. The mean size of the lesion was reduced after 12 months from 3.24mm to 0.68mm (Figure 4) and significant difference have shown between preoperative and 12 months follow up visit ($t= 4.4945$, $P<0.0002$). In consideration of the PAI and the size of the lesion (Table 2), 8% cases have shown relative failure and 92% have shown

relative success. The absolute success rate was 84% (21 cases).

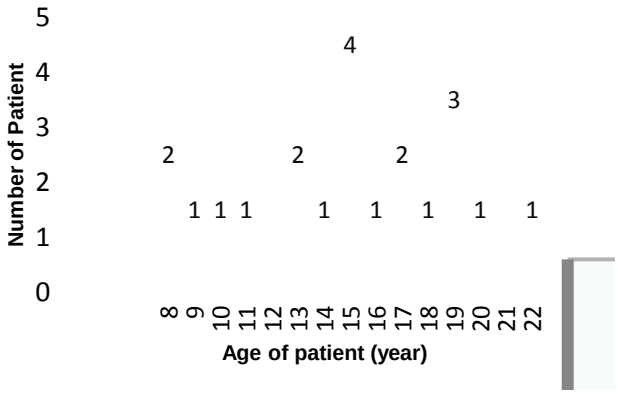

Figure 2: Distribution of age of the patients.

Table 1: Clinical evaluation (n=25)

Variable	Preoperative (present)	12 months (Present)	P value
Pain	10(40%)	1(4%)	0.00107 (s)
ytiliboM	2(8%)	1(4%)	0.27425 (ns)
ssenredneT	18(72%)	1(4%)	0.00(s)
tcart suniS	5(20%)	0(0%)	0.00914 (s)

n : Number of tooth
ns : Non-significant
s : Significant

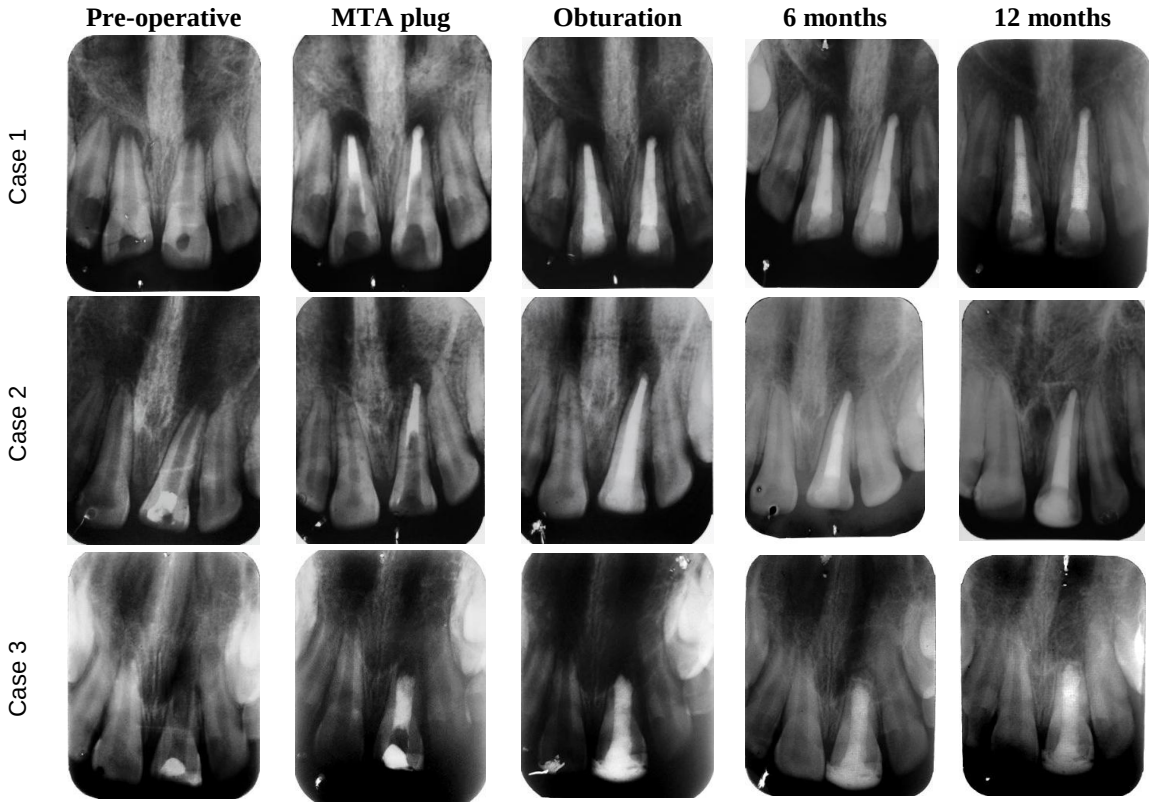

Figure 3: Radiological picture of MTA apexification

Table 2: Correlation between PAI and size of the lesion (n=25)

	PAI ↓ AS	PAI stable=1 RS	PAI stable >1 RS	PAI ↑ AF
Size of the lesion ↓(AS)	21	0	0	0
Size of the lesion =0(RS)	0	2	0	0
Size of the lesion stable >0 (RF)	1	0	1	0
Size of the lesion ↑ (AF)	0	0	0	0

AS: Absolute Success, RS: Relative Success RF: Relative Failure, AF: Absolute Failure

Figure 4: Changes of Mean PAI and mean lesion size

Table 3: Clinical outcome After 12 months follow up (n=25)

Acceptable	Uncertain	Unacceptable
23	2	0
(92%)	(8%)	(0%)

n: Number of tooth

Discussion

The primary purpose for this clinical study was to evaluate the clinical and radiological outcomes of the MTA as root-end barrier. In a review study[18], 74–100% success rate was found by using $Ca(OH)_2$ for apical barrier formation. Though $Ca(OH)_2$ has been used as a material for apexification procedure from last century, many researchers have tried with other materials because of some problems associated with $Ca(OH)_2$ apexification process such as long-term treatment and the risk of root fracture[6]**.** MTA has been proposed in experimental studies[19-20]**,** clinical protocols[21], clinical cases[9,22] and prospective studies[10] as a potential material to form an apical barrier instead of multi-appointment $Ca(OH)_2$ apexification procedure. A comparative study [23] showed that clinical and radiographic success rate for MTA was 100% where 87% with $Ca(OH)_2$. Also the time taken to complete the treatment and the biological barrier formation in MTA group was significantly less from $Ca(OH)_2$ group but the healing time for periapical radiolucency was almost identical[24].

In this study, the clinical and radiological outcome was assessed at 3, 6, 9 and 12 months. At least every 3 months radiographic review is recommended following completion of treatment to identify changes in the periapical area[12]. The PAI score was used to evaluate the periapical health and the healing process because it was considered as the most appropriate of all the evaluation techniques validated in endodontics[17]**.** When an apical lesion was present, its largest dimension was recorded. MTA was extruded beyond apex in 2 cases. In one case having PAI score 4 and 15 mm lesion reduced to 2 mm at 12 months. Placement of the root filling in a canal with an open apical foramen carries the risk of root filling material extrusion. For this reason, placement of an artificial matrix such as resorbable collagen, hydroxyapatite and calcium sulphate are recommended before placing MTA though no matrix was used in this study[25]. MTA place at the cemental limit of the canal showed better result than over filling[19].

A pilot study[12] have shown 94.1% clinical success whereas 76.5% radiologically by using MTA as a apical barrier . Simon[10] have shown healing occuered in 81% cases with MTA apexification and an apical barrier over MTA was distinguishable in 26% cases where the results are about similar to the result of this study. On the other hand, induction of apical hard barrier tissue formation was found histologically in 100% sucess rate in a n animal study treated with MTA[20]**.** This difference may be due to limited thickness of the dentine bridge that was too thin to be clearly distinguishable radiologically . $Ca(OH)_2$ was used for approximately 1 week as

an intracanal medicament in this study similar with other several studies[10,11,23]. The use of $Ca(OH)_2$ regarding MTA apical plug is still controversial. A study[26] have shown favorable result without using $Ca(OH)_2$ where the teeth were treated directly with MTA apical plug in one visit whereas another study[27] had shown $Ca(OH)_2$ for 7 days is highly effective in killing root canal flora. Hasselgren[28] demonstrated that $Ca(OH)_2$ can be effective in dissolving necrotic pulp tissue but Hachmeister[29] showed that $Ca(OH)_2$ had no significant effect on MTA leakage or displacement resistance. On the contrary, Porkaew[30] suggested that remnants of $Ca(OH)_2$ on the canal walls may react to form calcium carbonate and interfere with the seal produced. However, recent data suggests that the combination of MTA and calcium hydroxide in apexification procedures may favorably influence the regeneration of the periodontium[31].

Using messing gun with the aid of surgical operating microspoe and radiovisiograpgy is recommended by manufacturer for carried out and condensation of MTA into apical area. Due to limitation of equipment, MTA was carried out in the canal with lentulospiral and condenced apically with a custom made gutta percha plugger in this study. Aminosharia[32] reported that hand condensation resulted in better adaptation and fewer voids than ultrasonic method. In case of a traumatized immature teeth having thin wall, a different obturation technique would be more appropriate to increase the strength of the root canal walls and improve the long-term prognosis of these teeth to prevent cervical root fractures[33]. The combination of apical MTA and an internal bonded composite (flowable dual cure composite) appears to have a more favorable prognosis than gutta-percha[34] though all the cases of this study were obturated with gutta percha at coronal to MTA plug.

Conclusion

MTA ha s shown clinical and radiographic success as an apexification material in necrotic immature permanent teeth. It may be a suitable replacement for $Ca(OH)_2$ for the apexification procedure. However further clinical studies are recommended.

References

1.Andreasen JO, Andreasen FM. Textbook and color atlas of traumatic injuries to the teeth. **3rd** edn. Copenhagen: Munksgaard Publishers. 1993; 315-378.

2.Nolla C. The development of the permanent teeth. *J Dent Child* 1960; **27**: 245–66.

3. Morse DR, Larmic JO, Yesilosy C. Apexification review of the literature. *Quint Int* 1990 ; **21**: 589-98.

4.Ratfar M. Apexification: A review. *Dent Traumatol* 2005; **2:**1-8.

5.Dominguez RA, Munoz ML, Aznar MT. Study of calcium hydroxide apexification in 26 young permanent incisors. *Dent Traumatol* 2005; **21**: 141–5.

6.Andreasen JO, Farik B, Munksgaard EC. Long-term calcium hydroxide as a root canal dressing may increase risk of root fracture. *Dent Traumatol* 2002*;* **18**: 134–7.

7.Binnie WH, Rowe AHR. A histological study of periapical tissues of incompletely formed pulpless teeth filled with calcium hydroxide. *J Dent Res* 1973; **52**: 1110-1116.

8.Tronstad L, Asbjørnsen K, Døving L, Pedersen I, Eriksen HM. Influence of coronal restorations on the periapical health of endodontically treated teeth. *Endod Dent Traumatol* 2000; **16**: 218–21.

9.Torabinejad M, Chiavian N. Clinical application of mineral trioxide aggregate. *J Endod* 1993; **25**: 197–205.

10.Simon S, Rilliard F, Berdal A, et al. The use of mineral trioxide aggregate in one-visit apexification treatment: a prospective study. *Int Endod J* 2007; **40**: 186–97.

11.Holden DT, Schwartz SA, Kirkpatrick TC, et al. Clinical outcomes of artificial root-end barriers with mineral trioxide aggregate in teeth with immature apices. *J Endod* 2008; **34**: 812–7.

12.Sarris S, Tahmassebi JF, Duggal MS, et al. A clinical evaluation of mineral trioxide aggregate for root-end closure of non-vital immature permanent incisors in children- a pilot study. *Dent Traumatol* 2008; **24**: 79–85.

13.Witherspoon DE, Small JC, Regan JD, et al. Retrospective analysis of open apex teeth obturated with mineral trioxide aggregate. *J Endod* 2008; **34**: 1171–6.

14.Faval LGR, Saunders WP. Calcium hydroxide pastes: classification and clinical indications. *Int Endod J* 1999; **32**: 257-282.

15.Rita S, Anil D, Rohit N . Delayed MTA apical plug in immature open apex-A case report. *Endodontology* 2008; 49-52.

16.American association of endodontics : *Guide to clinical endodontics*, edi **4**, Chicago, 2004, AAE.

17.Ørstavik D, Kerekes K, Eriksen HM. The periapical index: a scoring system for radiographic assessment of apical periodontitis. *Endod Dent Traumatol* 1986; **2:** 20–34.

18.Sheehy EC, Roberts GJ. Use of calcium hydroxide for apical barrier formation and healing in non-vital immature permanent teeth: a review. *Br Dent J* 1997; **183 (7)**: 241-246.

19.Shabahang S, Torabinejad M, Boyne PP, et al. A comparative study of root-end induction using osteogenic protein-1, calcium hydroxide, and mineral trioxide aggregate in dogs. *J Endod* 1999; **25**: 1–5.

20.Felippe WT, Felippe MC, Rocha MJ. The effect of mineral trioxide aggregate on the apexification and periapical healing of teeth with incomplete root formation. *Int Endodc J* 2006; **39**: 2–9.

21.Shabahang S, Torabinejad M. Treatment of teeth with open apices using mineral trioxide aggregate. *Pract Perio Aest Dent* 2000; **12:** 315-20.

22.Hayashi M, Shimizu A, Ebisu S. MTA for obturation of mandibular central incisors with open apices: case report. *J Endod* 2004; **30**:120-2.

23.El-Meligy OA, Avery DR. Comparison of apexification with mineral trioxide aggregate and calcium hydroxide. *Pediat Dent* 2006; **28(3):** 248-53

24.Pradhan DP, Chawla HS, Gauba K, Goyal A. Comparative evaluation of endodontic management of teeth with unformed apices with mineral trioxide aggregate and calcium hydroxide. *J Dent Child* 2006; **73(2)**: 79-85.

25.Roheet A K, Vivek S H. Use of matrix for apexification procedure with MTA. *J Cons Dent* 2010; **3(1)**: 54-57.

26.Steinig TH, Regan JD, Gutmann JL. The use and predictable placement of mineral trioxide aggregate in one-visit apexification cases. *Aust Endod J* 2003;**29**: 34–42.

27. Sjogren U, Figdor D, Spangberg L, Sundqvist G. The antimicrobial effect of calcium hydroxide as a short-term intracanal dressing. *Int Endod J* 1991; **24**: 119–125

28.Hasselgren G, Olsson B, Cvek M. Effects of calcium hydroxide and sodium hypochlorite on the dissolution of necrotic porcine muscle tissue. *J Endod* 1988; **14**: 125–127.

29.Hachmeister DR, Schindler WG, Walker WA, Thomas DD. The sealing ability and retention characteristics of mineral trioxide aggregate in a model of apexification. J Endod 2002; 28: 386–90.

30.Porkaew P, Rettief H, Barfield RD, Lacefield WR, Soon S. Effects of calcium hydroxide paste asan intracanal medicament on apical seal. *J Endod* 1998; **24**: 176–9.

31.Ham KA, Witherspoon DE, Gutmann JL, Ravindranath S, Gait TC, Opperman LA. Preliminary evacuation of BMP-2 expression and histological characteristics during apexification with calcium hydroxide and mineral trioxide aggregate. *J Endod* 2005; **31:** 275–9.

32.Aminoshariae A, Hartwell GR, Moon PC. Placement of mineral trioxide aggregate using two different techniques. *J Endod* 2003; **29**: 679–82.

33.Cvek M. Prognosis of luxated non-vital maxillary incisors treated with calcium hydroxide and filled with Gutta–Percha. A retrospective clinical study. *Endod Dent Traumatol* 1992; **8:** 45–55.

34.Lawley GR, Shindler WG, Walker WA, Kolodrubetz D. Evaluation of ultrasonically placed MTA and fracture resistance with intracanal composite resin in a model of apexification. *J Endod* 2004; **30**: 167–72.