Apexification of Anterior Teeth: A Comparative Evaluation of Mineral Trioxide Aggregate and Calcium Hydroxide Paste

Damle S G * / Bhattal H ** / Loomba A ***

Purpose: *This study was undertaken to compare the clinical and radiographic effectiveness of Mineral Trioxide Aggregate (MTA) and Calcium Hydroxide in apexification of traumatized young permanent incisors.* ***Methods:*** *Thirty permanent incisors with necrotic pulps and open apices were evenly divided into two groups – Group I (MTA group) & Group II (Calcium Hydroxide group) and treated by apexification. The time taken for apical barrier formation was analyzed. In MTA group, obturation using gutta-percha points was done after 24 hours, whereas in Calcium Hydroxide group obturation was carried out after radiographic confirmation of an apical barrier. Follow up evaluation (clinical and radiographic) was carried out at- 3, 6, 9 and 12 months.* ***Results:*** *The mean time taken for barrier in Group I was 4.50 ± 1.56 months whereas for Group II was 7.93 ± 2.53 months (p value- 0.0002). Radiographic evidence of mean time taken for completion of lamina dura in Group I was 4.07 ± 1.49 months whereas the time period for Group II was 6.43 ± 2.59 months (p value- 0.0067).* ***Conclusion:*** *MTA demonstrated good success and an effective option for apexification with the advantage of reduced treatment time, good sealing ability, biocompatible and provides barrier for immediate obturation.*

Keywords: *Apexification, Mineral Trioxide Aggregate, Calcium Hydroxide, Calcific barrier formation, Trauma.*

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INTRODUCTION

Dental injuries to anterior teeth in children, hamper mastication, speech, esthetics and create a psychological impact due to loss of tooth structure at an early age. Depending on the severity and intensity of trauma to teeth, pulpal necrosis ensues and consequently root development ceases. Endodontic treatment of immature teeth with necrotic pulp and wide open apices is aimed at obtaining an optimal seal of the root-canal system. Apexification (induction of a calcific barrier at open root apex of non-vital teeth) is a non surgical approach for obtaining apical barrier so as to prevent passage of toxins and bacteria into periradicular tissue. This barrier facilitates the placement of an appropriate root canal sealant and filling material, whilst reducing the possibility of their extrusion into periapical tissues.[1]

Calcium hydroxide has been considered as the gold standard for apexification because of predictable efficient results and no adverse periapical reaction. Its efficacy has been demonstrated by several researchers through several clinical and long term studies with success rate ranging between 74–100 percent.[2] However it has inherent limitations that include variability of treatment time ranging from 5.1–20.2 months, unpredictability of apical closure in relation to time, difficulty in patient returning for follow up, increased risk of tooth fracture and delayed treatment.[3]

Mineral Trioxide Aggregate (MTA®) introduced by Torabinejad (1993) has the ability to stimulate cytokine release from bone cells promoting hard tissue formation, prevents micro leakage, and promotes regeneration. It is biocompatible, antimicrobial and has no cytotoxicity, prevents bacterial leakage and effective even in moist environment.[4,5,6] It has advantage of providing artificial barrier that allows immediate obturation and has been proposed as a potential material to create an apical plug preventing the extrusion of filling materials.[7]

To ascertain efficacy between MTA and traditionally used Calcium Hydroxide in inducing root end formation of immature roots of young permanent anterior teeth, a comparative clinical and radiographic study was undertaken. This study also aimed at comparing the mean duration of formation of root end barrier.

* S G Damle PhD, MDS, Professor, Department of Paediatric Dentistry, M.M. College of Dental Sciences and Research, Mullana (Ambala).

** Hiteshwar Bhattal BDS, Resident, M.M. College of Dental Sciences and Research, Mullana (Ambala).

*** Ashish Loomba BDS, Resident, M.M. College of Dental Sciences and Research, Mullana (Ambala).

Send all correspondence to: S.G Damle, Professor, Dept of Paediatric Dentistry, M.M College of Dental Sciences and Research, Maharishi Markandeshwar University, Mullana (Ambala), Haryana- 133207- India

Tel: +91 9729062515
Fax no: +91 1731 274325;

E-mail: sgdamle@gmail.com

MATERIALS AND METHOD

Oral health survey of school children in the age groups of 8-12 years, was carried out in six schools located in semi-rural areas. A total of 1100 school children were surveyed for dental caries, periodontal status, dentofacial anomalies, traumatic injuries and findings were recorded on WHO oral health assessment performa (2004). The survey revealed that 58 children had one or two maxillary anterior tooth/teeth fracture, requiring treatment. Then a long term prospective clinical trial was designed in the Department of Pediatric Dentistry, M.M College of Dental Sciences and Research, Mullana (Ambala) Haryana, India. The clinical design was explained to parents in detail and written consent was taken. Approval of the Institutional Ethics Committee (IEC) was obtained before commencing the study.

Thirty nine children reported to the Pediatric Dentistry department. They were examined and radiographs taken. Twenty children meeting the studies inclusion criteria had comparable features like stage of root development, type of tooth/teeth, periapical radiolucency etc. The inclusion parameters were, children free from any systemic illness & having good general health, affected tooth/teeth showing delayed response(s) to pulp sensibility test i.e. cold test with dry ice snow (RCICE™, Prime Dental Products Pvt Ltd; India), root length formation approximately two thirds or more (Nolla's Stage 8, 9), adequate bone support, teeth with Ellis Class- III or IV fracture. In the 20 children, 10 children had single tooth fracture and other 10 children were with two teeth fracture (either two maxillary central incisors or one maxillary central incisor and one lateral incisor). The 20 children were divided by simple random sampling into two groups- Group I (MTA group) and Group II (Calcium Hydroxide group) as follows:

They were first divided into two groups- those with a single tooth fracture and those with two teeth fracture. The children with single tooth fracture were given sequential numbers and divided into group I (MTA group) and group II (Calcium Hydroxide group) of the study sample through random draw of lots (done by one child). In children with two incisors fractured in their respective dentitions similar methodology was used for dividing between the study groups. Further in these children; one traumatized tooth was treated with MTA and second one with Calcium Hydroxide in each child. The total sample size was of 30 non vital traumatized permanent maxillary anterior teeth with 15 teeth in each group.

The radiographic examination was done by intra oral periapical radiographs (IOPA) - pre operatively, intra operatively and post operatively using paralleling technique and the findings were recorded.

The apexification procedure performed using the same protocol and by a single operator, for both the groups is stated as under:

1. Preoperative radiograph was taken (Parallel technique) (Figure1).
2. After application of local anesthesia (Dentocaine, 2% lignocaine hydrochloride with 1:200000 adrenaline; Pharma health care product) the tooth was isolated using a rubber dam and accessed with the help of a high speed round, straight fissure diamond burs (diameter 014, Endo Z® bur; Dentsply)
3. Working length was established with diagnostic radiograph, canals were cleaned of necrotic pulp tissue with the help of Kerr files along with copious irrigation with normal saline. Minimal canal preparation was carried out to avoid damage to thin dentinal walls.
4. Canals were dried with sterile paper points. Thereafter, in Group I (MTA group) teeth, Pro-Root® (Dentsply, Mallifier, Switzerland) was mixed as per the manufacturer instructions and inserted at the apical one third of the root canal of teeth with the help of Micro Access Preparation (MAP) system (Dentsply, Tulsa Dental Oklahoma, USA) and condensed with hand pluggers until approximately 3-5 mm thickness of material was placed at the apical end of the root. In Group II injectable Calcium hydroxide (Metapaste™, Meta Biomed Co Ltd; Korea) was inserted and condensed with the help of hand pluggers.
5. Radiograph was taken to confirm the extension/condensation of calcium hydroxide paste/MTA apical plug in the root canals. Temporary filling was done with Cavit® (ESPE, Cergy Pontoise, France) (Figure 2).
6. For MTA, a moist cotton pellet was left in-situ for 24 hrs to allow the material to set. Obturation was done

Figure 1. Pre-operative radiograph of traumatized Maxillary (Rt) Central Incisor and Lateral Incisor.

Figure 2. MTA apical plug inserted in Maxillary (Rt) Central Incisor (Group-I) and Calcium Hydroxide in Lateral Incisor (Group-II).

by lateral Compaction of Gutta Percha and Grossman's sealer (Densell Endo® Argentina). Coronal restoration was carried out with composite resin/ jacket crown according to the extent of fracture within 7–14 days (Figure 3).

7. In Group II, calcium hydroxide continued to serve the purpose of achieving root end induction. Obturation was carried out after radiographic evidence of apical calcific barrier (Figures 4 and 5).

Post operatively, clinical and radiographic follow up of both groups was done at one, three, six, nine and twelve months. The clinical evaluation (as per the parameters stated in Table 1) and pre-treatment, post-treatment and review radiographs (last review at 12 months–Figure 6) of both the groups of study patients were assessed at the recall periods and the findings recorded.

The data was evaluated with the Chi-squared test and unpaired t- test for comparison between both the groups.

RESULTS

A total of thirty anterior teeth were treated and the time period that lapsed between the patients sustaining injury and reporting for treatment ranged between 6 to 12 months. The post operative assessment of the treated teeth among the groups was analyzed as per the clinical criteria at 12 months and the results were statistically insignificant (Table 1).

The mean time required for barrier formation in Group I

Figure 3. Radiograph of Maxillary (Rt) Central Incisor (MTA) following obturation.

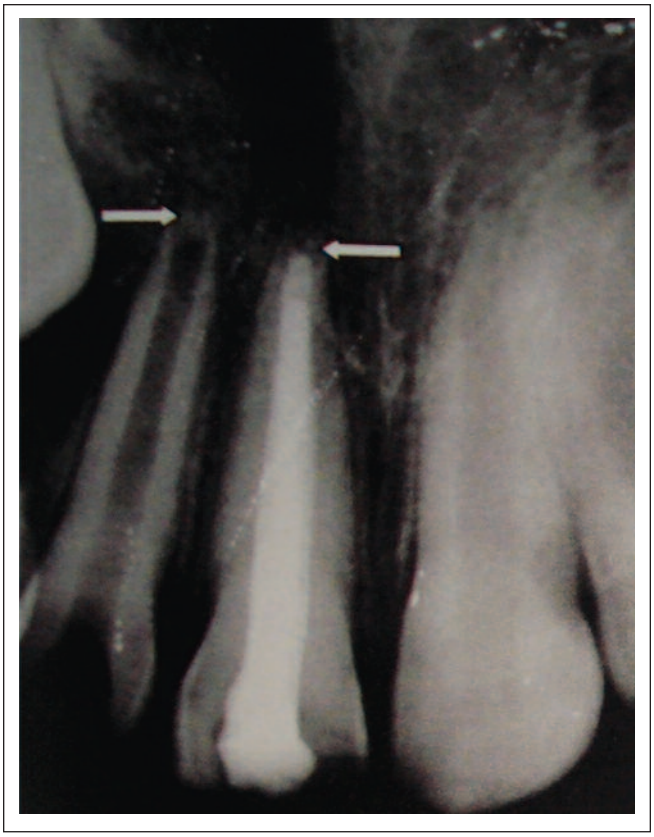

Figure 4. Six months follow up; arrows denoting calcific barrier in Maxillary (Rt) Central Incisor (MTA) and Lateral Incisor (Calcium Hydroxide).

Figure 5. Obturation of Maxillary (Rt) Lateral Incisor (Calcium Hydroxide) following radiographic evidence of calcific barrier.

Figure 6. Follow up radiograph of patient at 12 months.

was 4.5 + 1.56 months whereas for Group-II, it was 7.93 + 2.53 months which was statistically significant (p = 0.0002) (Table 2).

The relationship between the adequacy of placement of medicament and time taken for barrier formation in both Groups was statistically significantly associated. In Group I, thirteen teeth with adequately placed MTA at the apex had calcific barrier formation, whereas one tooth with MTA short of radiographic apex had barrier formation by 3 months. Another tooth, had MTA extruded (by 2mm) and it did not show calcific barrier formation even after 12 months. In children of Group II, fourteen teeth were adequately filled with calcium hydroxide, out of which one had internal resorption, and in remaining 13 teeth calcific barrier was evident. Barrier formation was observed in a single tooth with overfilled calcium hydroxide (1.5mm). The difference in both Groups was found to be statistically significant (Table 3)

Further, statistical significant difference was observed in the mean time taken for completion of lamina dura. In Group I it was 4.07 ± 1.49 months whereas the time period for Group II, it was 6.43 ± 2.59 months (p value- 0.0067) (Table 4).

The clinical success of the material was judged on the

Table 1. Post operative clinical assessment of Group I (MTA group) and Group II (Calcium Hydroxide group) for 12 months

	Clinical Follow up										Chi square test
	1 month		3 months		6 months		9 months		12 months		
Groups	I* (n=15)	II** (n=15)	I* (n=15)	II** (n=15)	I* (n=14)	II** (n=15)	I* (n=14)	II** (n=15)	I* (n=15)	II** (n=15)	p value
Clinical Signs											
Asymptomatic	11	8	12	11	12	10	14	14	15	15	0.98
Pain	2	4	1	2	1	4	0	1	0	0	0.88
Swelling/ sinus	0	1	0	0	0	0	0	0	0	0	1
Mobility	2	2	2	2	1	1	0	0	0	0	1
Tenderness to percussion	0	0	0	0	0	0	0	0	0	0	1

* Group I (MTA group); **Group II (Calcium Hydroxide group).
P > 0.5 in both groups (non significant)

Table 2. Radiographic/ Clinical assessment of time taken for barrier formation in Group I (MTA group) and Group II (Calcium Hydroxide group).

Group	Time for barrier formation	No of teeth	Mean time	SD	Unpaired t test
Group I (n =14)	3 months	7	4.5 months	1.56	P =0.0002 (Highly significant)
	6 months	7			
	9 months	0			
	12 months	0			
Group II (n =14)	3 months	1	7.93 months	2.53	
	6 months	5			
	9 months	6			
	12 months	2			

Table 3. Relationship between extent of placement of medicament and barrier formation in Group I (MTA group) and Group II (Calcium Hydroxide group).

Extent of placement of medicament	**Group I** (n=15)		**Group II** (n=15)	
	Calcific Barrier present	Calcific Barrier Absent	Calcific Barrier Present	Calcific Barrier Absent
Short of apex (n =1)	1	0	0	0
At Apex (n=27)	13	0	13	1
Beyond apex (n=2)	0	1	1	0
Chi square test	P = 0.0006 (HS)*		P= 1 (NS)**	
	P = 0.039 (Significant)			

*(HS) = Highly Significant; ** (NS) = Non Significant

Table 4. Radiographic assessment for the time taken for completion of lamina dura in Group I (MTA group) and Group II (Calcium Hydroxide group).

Group	Time for completion of	lamina dura	No of teeth	Mean time	SD
Unpaired t test Group I (n =14)	3 months	9	4.07 months	1.49	P = 0.0067 (Significant)
	6 months	5			
	9 months	0			
	12 months	0			
Group II (n =14)	3 months	4	6.43 months	2.59	
	6 months	4			
	9 months	6			
	12 months	0			

Table 5. Clinical and radiographic success rate in Group I (MTA group) and Group II (Calcium Hydroxide group).

	Clinical success		**Radiographic Success**	
	Group I	Group II	Group I	Group II
Success	15	14	15	14
Failure	0	1	0	1
Success Rate	100 %	93.33%	100 %	93.33 %
Chi square test	P = 0.38 (Non significant)		P= 0.38 (Non significant)	

basis of presence/ absence of clinical criteria's (Table 1). The teeth in Group I (MTA group) were asymptomatic at twelve month follow up (100%), while in Group II (Calcium Hydroxide group) fourteen teeth were asymptomatic with success rate of 93.33%. In MTA group all 15 teeth revealed calcific barrier formation, with no evidence of periapical pathology on radiographs. In Calcium Hydroxide group, a single tooth exhibited failure which was evident radiographically due to internal resorption which was seen at the end of twelve months and radiographic success was calculated at 93.33% (Table 5).

DISCUSSION

Trauma to young permanent anterior teeth may result in necrotic changes to the pulp as it may not withstand the impact of injury, leaving the tooth with thin fragile root walls, blunder buss canals and infection which promotes root resorption and periradicular disease. Apexification procedure is a non surgical approach widely accepted and involves induction of osteodentin or similar hard structure at the root apex with or without concomitant root growth.[8]

Efficacy of Calcium Hydroxide for apexification has been attributed to its alkaline pH (pH = 10.5) and antibacterial properties which provides a conducive environment for healing as well as for regeneration of apical and periapical tissues, by activating alkaline phosphatase enzyme and increasing the activity of calcium dependent pyrophosphatase enzyme.[9] But it has inherent limitations such as lack of corono-radicular restoration whilst the canal systems are not filled and prolonged contact with calcium hydroxide inducing significant decrease in intrinsic properties of exposed dentin leading to increased incidence of root fracture before treatment completion.[10,11,12]

Mineral trioxide aggregate (MTA) owing to presence of several mineral oxides in its composition, has good reparative and regenerative potential and inherent advantage of setting to a hard consistency by nearly 4 hours of mixing due to which it provides an artificial barrier for immediate obturation.[10,11]

In the present study, the criteria for selection of teeth was on the basis of presence of either one or combination of following clinical features i.e. pain, discoloration, pus discharge, swelling or sinus present in traumatized fractured

incisors, indicative of necrotic pulp tissue. Teeth with good restorability were selected to avoid unfavorable outcome due to poor coronal seal. Some studies suggest that the combination of MTA and calcium hydroxide in apexification procedures may favorably influence the regeneration of the periodontium.[13] However in the present study we have used either Calcium hydroxide or MTA for apexification procedure was used.

The results of present study consisting of the total sample of 30 treated cases followed at one, three, six, nine and 12 months intervals revealed evidence of calcified bridge formation at 4.50 + 1.56 months for Group-I whereas for Group-II it was 7.93+ 2.53 months which was statistically significant (p = 0.0002) and progressive completion of lamina dura in Group I was 4.07 ± 1.49 months whereas the time period for Group II, it was 6.43 ± 2.59 months (p-value 0.0067).

The clinical examination of teeth treated with MTA revealed that pain was reported in single tooth with extruded MTA by approximately 1mm due to irritation to the periapical areas which subsided after 6 months. Studies by Shabahang *et al*[10] and Pradhan *et al*[14] observed tenderness in teeth with extruded MTA upto 3 months time period. In present study, barrier formation was not evident in one of the teeth even after 12 months, which could be due to extrusion of MTA apically. The extrusion of MTA from the apical area was claimed not to prove a hindrance in the healing process and a slight overfill of MTA would not prevent the healing mechanism.[15]

In calcium hydroxide group, one of the lateral incisor had intra oral abscess at one month follow up, considered to be acute exacerbation of chronic pulpitis, which subsided with change of intra canal dressing after one week. Similar findings are also reported by Pradhan *et al*,[14] Walia et *al*.[16]

Some of the authors have postulated that possible leakage of MTA could be influenced by the thickness of the apical plug. In the present study, the thickness of the MTA apical plug varied from 3 mm to 5 mm. In teeth with a short root canal the thickness of the apical plug was reduced to 3 mm to allow for the subsequent filling. Hachmeister *et al* underlined that the thickness of the apical plug may have a significant impact only on displacement resistance.[17]

CONCLUSION

The present study confirms that MTA provides excellent mechanism of forming the apical plug. The time taken for barrier formation was significantly lesser in teeth treated with MTA as compared to the teeth treated with Calcium hydroxide. Also completion of lamina dura was significantly faster with Mineral Trioxide Aggregate.

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