Original Article

Comparison of Mineral Trioxide Aggregate and Calcium Hydroxide as pulpotomy agents in Primary Molars

* Md. Farid Uddin[a], Md. Shamsul Alam[b], Ali Asgor Moral[c], Md. Mujibur Rahman Howlader[d], Md. Ismail Hossain[e]

[a]Assistant Professor, Department of Conservative Dentistry & Endodontics, Pioneer Dental College & Hospital, Dhaka, Bangladesh.
[b]Professor, Dean, Faculty of Dentistry, Chairman, Department of Conservative Dentistry, BSM Medical University, Dhaka, Bangladesh.
[c]Professor, Department of Conservative Dentistry & Endodontics, BSM Medical University, Dhaka, Bangladesh.
[d]Associate Professor, Department of Conservative Dentistry & Endodontics, BSM Medical University, Dhaka, Bangladesh.
[e]Lecturer, Department of Conservative Dentistry & Endodontics, Dental Unit, Rajshahi Medical College & Hospital, Rajshahi, Bangladesh.

ARTICLE INFO

Article history:

Received : 21 October 2012
Accepted : 17 March 2013

Keywords:
MTA,
Calcium Hydroxide,
Pulpotomy in primary molar

ABSTRACT :

Background: The greatest threats to developing teeth are dental caries and traumatic injury. If pulpal exposure occurs, then a pulpotomy procedure aims to preserve pulp vitality to allow for normal root development. Historically, calcium hydroxide has been the material of choice for pulpotomy procedures. Recently, an alternative material called mineral trioxide aggregate (MTA) has demonstrated the ability to induce hard-tissue formation in pulpal tissue.

Objectives: This prospective study was conducted to observe the clinical and radiological findings of pulpotomies done with Mineral Trioxide Aggregate (MTA) &Calcium Hydroxide{$Ca(OH)_2$} and to evaluate success rate of MTA in maintaining pulpal health in teeth with carious lesion.

Materials and Methods: In this clinical trial study, 40 primary molars were treated by a conventional pulpotomy technique. They all fulfill the inclusion criteria and gave consent regarding this study. All selected teeth were evenly divided into 2 test groups. In group 1, the MTA pulpotomy (experimental) was performed, whereas in group 2, the conventional $Ca(OH)_2$ pulpotomy (control) was done. The teeth of both groups were finally restored by Glass Ionomer Cement (GIC). The children were recalled for clinical and radiographic evaluations after 3, 6, and 12 months.

Result: The follow-up evaluations revealed failure due to pain and swelling detected at 6 and 12 months postoperative evaluations in only 3 teeth treated with $Ca(OH)_2$ and one treated with MTA. The remaining 36 teeth appeared to be clinically and radiographically successful 12 months postoperatively. Calcific metamorphosis was a radiographic finding in 4 teeth treated with MTA and 2 teeth treated with $Ca(OH)_2$.

Conclusion: Based on this clinical and radiographical evaluation study of 3, 6, and 12 months follow-up, MTA could be used as a safe material for pulpotomy in cariously and mechanically exposed primary molars and seems to be a suitable alternative to calcium hydroxide. Further research, however, is required to clarify this conclusion.

*Address of Correspondence:
Dr. Md. Farid Uddin,
Assistant Professor, Department of Conservative Dentistry & Endodontics, Pioneer Dental College & Hospital, Dhaka.
Telephone: +8801716291504.
E-mail: faridrmc@yahoo.com

Preservation of primary teeth before the eruption of permanent teeth is desirable since they help to determine the shape of dental arches, maintain the space between teeth, prevent detrimental tongue and speech habits, preserve aesthetics, and maintain chewing function. Hence, teeth with caries should ideally be restored rather than be extracted.[1]In primary teeth, especially, there is a high chance of pulp exposure because the thickness of dentine is thin in these teeth in comparison to permanent teeth. When pulp is exposed, several vital pulp treatments such as direct pulp capping and pulpotomy have been suggested by many of the previous studies.[2,3]Although, in young permanent teeth, indirect and direct pulp capping techniques are an accepted procedure, but in primary teeth it is contraindicated because of possibility of undetected avascular microscopic pulp exposure.[2,4]
Calcium hydroxide has been a popular pulpotomy agent for vital pulp therapy and is widely used clinically. It was introduced by Herman as a biologic dressing.[5]Despite its apparent success in vital pulp therapy, considerable confusion and condemnation of this material have long persisted because $Ca(OH)_2$ —in its pure state and in the original formulations—actually kills a certain amount of tissue when placed in direct contact with the pulp rather than merely functioning as a biologic dressing. Because of its alkalinity (pH of 12), it is so caustic that when placed in contact with vital pulp tissue, the reaction produces a superficial necrosis of the pulp.[7]Studies have also shown that $Ca(OH)_2$ is extremely toxic to cells in tissue culture, also it has some tissue altering and dissolving effects.[7, 8]
Mineral Trioxide Aggregate (MTA) was developed and introduced in 1993 at the Loma Linda university, California, USA, as a root-end filling material and was approved by The US Food and Drug Administration for human teeth treatment in 1998.[9, 10]The principal components of the grey- coloured formula are Tricalcium oxide, Tricalcium aluminate, Tricalcium silicate, Tetracalcium aluminoferrite and Calcium sulfate dehydrate. The more aesthetic white-coloured preparation lacks the tetracalcium aluminoferrite. Lately,MTA has been used as a pulpotomy material in primary molars and it was found to be a successful material.[9, 11]
MTA was developed with the purpose of serving as an apical root end filling material, but it has also proven to be successful in vital pulp therapy procedures both in animals [12, 13] and humans.[4]Many clinical studies have recommended that, MTA is a biocompatible material and its sealing ability is better than that of amalgam or zinc oxide eugenol.[4, 15] Furthermore, its ability to stimulate cytokine release from bone cells has been demonstrated which means that it can actively promotes hard tissues formation.[4]Although the use of MTA has been extended to pulp capping and pulpotomy of primary teeth but, there are only few studies have been published regarding its clinical success.
Therefore, in the present study, the clinical outcome of MTA in pulpotomy of primary teeth was compared with that of Calcium hydroxide at 3, 6, and 12 months follow-up periods.

MATERIALS AND METHODS

Patients with 40 deep carious primary molar teeth were selected requiring pulpotomy treatment in the department of Conservative Dentistry and Endodontics, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, along with a preoperative intra oral periapical radiograph. The procedure and its possible discomfort, or risks, and benefits were explained fully to the parents of the children involved, and their informed consent, as approved by the institutional review board of human subjects experiments, were obtained prior to the investigation.
Sample size was selected into two test groups (n=40). Group- 1: contains patients having 20 carious primary molar teeth for MTA Pulpotomy. (Experimental group) Group- 2: contains patients having 20 carious primary molar teeth for $Ca(OH)_2$ pulpotomy. (Control group)Patients those were attending in outdoor hospital at Bangabandhu Sheikh Mujib Medical University (BSMMU) based on inclusion and exclusion criteria. Inclusion Criteria: (1) Symptomless Carious or Mechanical exposures of pulp in vital primary molar teeth; (2) Class-I deep dentinal caries in primary molar teeth having 3-4 mm depth; (4) Age: 5 – 7 years. Exclusion Criteria: (1) Haemostasis takes more than 3 minutes or Uncontrollable haemorrhage from the amputed pulp stamps; (2) Clinical

symptoms or evidence of pulp degeneration, such as excessive bleeding from the root canal, history of swelling, clinical mobility (3º), spontaneous pain, or sinus tracts; (3) Radiographic signs of internal or external root resorption, inter-radicular and/or periapical bone destruction, furcal radiolucency, or periodontal ligament space widening; (4) More than one-third physiologic root resorption has occurred; (5) Patients having Cardiac disease or other systemic diseases; (6) Pulp calcification.

An experimental study was designed to compare the clinical effects of MTA and $Ca(OH)_2$ pulpotomies in primary molars in these children.40 selected teeth were randomly assigned to either experimental (ProRoot®MTA, Densply, Maillefer, USA) or control (Calcium Hydroxide, DEEPLL DENTAL PRODUCTS, INDIA) group of 20 teeth each. The selected teeth were treated by a conventional pulpotomy technique under local anaesthesia. Isolation of teeth was obtained with cotton roll and with the used of saliva ejector. After caries removal and pulp chamber exposure, the coronal pulp was amputated with a round bur & a spoon excavator. Haemorrhage was controlled by placing sterile, saline-wetted cotton pellets on the radicular pulp stumps under slight pressure.

Patients in Experimental Group 1 - Pro-Root MTA (Dentsply, Maillefer, USA) was mixed according to the manufacture's recommendations using plastic spatula, in ratio 3: 1. Then, smooth mix of MTA was obtained and then applied over the pulp and into the base of the cavity. Then, by using a sterile cotton pellet moistened with distilled water MTA was condensed properly over the chamber. After the setting of MTA, the rest of the cavity was filled with Fuji-IX Glassionomer cement. Bite was checked for any high spots and 2 coats of Varnish were applied over the Glassionomer Filling. Patients in Control Group 2 - $Ca(OH)_2$ (DEEPLL DENTAL PRODUCTS OF INDIA)powder was mixed with saline to a thick consistency. The paste was carefully placed on the pulp stump surface 1 to 2-mm thick layer of zinc oxide-eugenol paste and Glassionomer (Fuji-IX) Cement and a coat of Varnish was applied over the Glassionomer Filling.

After initial Clinical and Radiographic examinations teeth were evaluated after 3, 6, and 12 months forclinical signs or radiographical signs of failure. If calcific metamorphosis occurred, it was noted but not regarded as a treatment failure. The treatment was judged as successful if the teeth met with the following criteria: (1) Clinical assessment: (a) the teeth showed no symptoms of pain, (b) No pain on palpation or percussion, (c) No evidence of swelling or sinus tract& (d) No pathological mobility, and (2) Radiographic assessment: (a) the teeth showed no periapical or interradicular radiolucency, (b) no widening of periodontal ligament or no internal or external root resorption.

Results:

The study involve patients with 40 deep carious primary Molar teeth were selected requiring pulpotomy treatment. All cases treated with MTA and Ca $(OH)_2$ as pulpotomy agents. The follow-up period was 12 months. The results are showed in the following Table. I – V.

At 3-months following treatment all, MTA pulpotomy and $Ca(OH)_2$ pulpotomy showed 100% success rate both in clinical and radiographic assessments. Pain, postoperative swelling, tenderness or mobility has not detected in any cases. In radiographic examinations, there was also no sign of radiolucent area.

At 6-months interval, however one patient in Ca $(OH)_2$ pulpotomy group reported pain in molar tooth and 1 patient in MTA pulpotomy and 3 patients in Ca $(OH)_2$ pulpotomy group reported pain during 12th months follow-up. The overall assessment of MTA pulpotomy and Ca $(OH)_2$ pulpotomy treatments were successful; there was only postoperative swelling 15.0% in Ca $(OH)_2$ pulpotomy group, there was no mobility or sinus formation in both groups and tenderness on percussion 5.0% and 15.0% in MTA pulpotomy and Ca $(OH)_2$ pulpotomy group respectively. Radiographic examination also showed Periapical/inter-radicular radiolucency 5.0% and 15.0% in MTA pulpotomy and Ca $(OH)_2$ pulpotomy group respectively.

Table I: Age distribution of the study patients (n=40)

Age in years	Group I (n=20)		Group II (n=20)		P Value
	n	%	n	%	
0 – 7	5	25.0	4	40.0	0.704
> 7	0	0.0	0	0.0	

Group I: MTA pulpotomy

Group II: Ca $(OH)_2$ pulpotomy
NS=Not Significant
P value reached form Chi square test

Most of the cases was found in the age group 5 to 6 years in both groups which was 15(75.0%) in group I and 16(80.0%) in group II. The difference was not significant (p>0.05) in Chi square test. Other results are depicted in the above table.

Table II: Sex distribution of the study patients (n=40)

Sex	Group I (n=20)		Group II (n=20)		P Value
	n	%	n	%	
Male	8	40.0	6	30.0	0.507^{ns}
Female	12	60.0	14	70.0	

Group I: MTA pulpotomy
Group II: Ca $(OH)_2$ pulpotomy
NS=Not Significant
P value reached form Chi square test

This study was conducted among 40 patients and they were divided into Male and female. Female was predominant in both groups which was 12(60.0%) in group I and 14(70.0%) in group II. Male female ratio was 1:1.9 in the whole study. No significant (p>0.05) difference was observed in Chi square test regarding sex of the study patients.

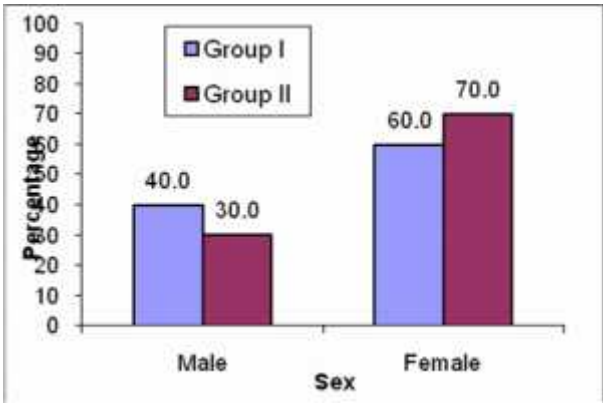

Fig 1: Bar diagram showing the sex distribution of the study patients.

Table III: Pain status of the study teeth during 12 months follow up (n=40)

Pain status	Group I (n=20)		Group II (n=20)		P Value
	n	%	n	%	
Baseline					
Pain					
Present	0	0.0	0	0.0	-
Absent	20	100.0	20	100.0	
VAS Score					
No pain	20	100.0	20	100.0	
Mild pain	0				
Moderate pain	0	0.0	0	0.0	-
Sharp/Spontaneous pain	0	0.0	0	0.0	
After 3 months					
Pain					
Present	0	0.0	0	0.0	
Absent	20	100.0	20	100.0	-
VAS Score					
No pain	20	100.0	20	100.0	
Mild pain	0	0.0	0	0.0	
Moderate pain	0	0.0	0	0.0	-
Sharp/Spontaneous pain	0	0.0	0	0.0	
After 6 months					
Pain					
Present	0	0.0	1	5.0	0.311^{ns}
Absent	20	100.0	19	95.0	
VAS Score					
No pain	20	100.0	19	95.0	
Mild pain	0	0.0	0	0.0	
Moderate pain	0	0.0	1	5.0	0.311^{ns}
Sharp/Spontaneous pain	0	0.0	0	0.0	
After 12 months					
Pain					
Present	1	5.0	3	15.0	0.291^{ns}
Absent	19	95.0	17	85.0	
VAS Score					
No pain	19	95.0	17	85.0	
Mild pain	0	0.0	0	0.0	
Moderate pain	0	0.0	1	5.0	0.485^{s}
Sharp/Spontaneous pain	1	5.0	2	10.0	

Group I: MTA pulpotomy
Group II: Ca $(OH)_2$ pulpotomy
NS=Not Significant
P value reached form Chi square test

According to 100 mm horizontal Visual Analogue Scale (VAS):
No pain: 0
Mild pain: 1 to 3
Moderate pain: 3 to 7
Severe pain: 7 to 10

Table III shows the pain status of the study teeth during 12 months follow up and observed that, pain was not found in both group at baseline and 3rd months follow-up. After 6 months follow up one patient in group II had pain, which was moderate. After 12 months follow up 1(5.0%) of the study patients had Spontaneous pain in group I. In group II, 3(15.0%) had pain among them 2(10.0%) had Sharp/Spontaneous pain and 1(5.0%) moderate pain. No significant (p>0.05) difference was observed in Chi square test. Other results are depicted in the above table.

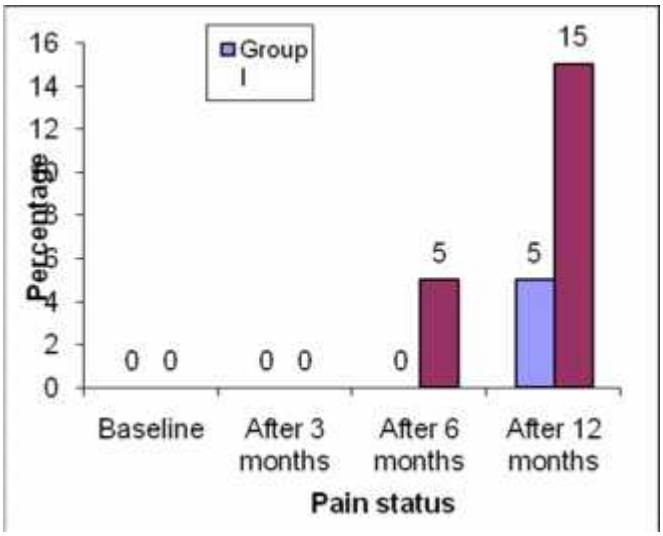

Fig 2: Bar diagram showing the pain status of the study teeth during 12 months follow up.

Table IV: Clinical assessment of the groups at evaluation period (n=40)

Clinical assessment	Group I (n=20)		Group II (n=20)		P value
	n	%	n	%	
Baseline					
Swelling	0	0.0	0	0.0	-
Mobility	0	0.0	0	0.0	-
Sinus tract	0	0.0	0	0.0	-
Tenderness on percussion	0	0.0	0	0.0	-
After 3 months					
Swelling	0	0.0	0	0.0	-
Mobility	0	0.0	0	0.0	-
Sinus tract	0	0.0	0	0.0	-
Tenderness on percussion	0	0.0	0	0.0	-
After 6 months					
Swelling	0	0.0	0	0.0	-
Mobility	0	0.0	0	0.0	-
Sinus tract	0	0.0	0	0.0	-
Tenderness on percussion	0	0.0	0	0.0	-
After 12 months					
Swelling	0	0.0	3	15.0	0.071 ns
Mobility	0	0.0	0	0.0	-
Sinus tract	0	0.0	0	0.0	-
Tenderness on percussion	1	5.0	3	15.0	0.291 ns

Group I: MTA pulpotomy
Group II: Ca $(OH)_2$ pulpotomy
NS=Not Significant
P value reached form Chi square test

Table IV shows the clinical assessment of the groups at evaluation period and observed that, swelling and tenderness on percussion was not found during baseline, 3rd months and after 6 months follow-up. After 12 months follow up swelling was observed only in group II which was 3(15.0%). Tenderness on percussion was observed 1(5.0%) in group I and 3(20.0%) in group II. No statistical significant (p>0.05) difference was found between two group during 12 months follow-up.

Table V: Radiographic assessment of the groups at evaluation period (n=40)

Radiographic assessment	Group I (n=20)		Group II (n=20)		P Value
	n	%	n	%	
Baseline					
Periapical/inter-radicular radiolucency	0	0.0	0	0.0	-
External root resorption	0	0.0	0	0.0	-
Internal root resorption	0	0.0	0	0.0	-
After 3 months					
Periapical/inter-radicular radiolucency	0	0.0	0	0.0	-
External root resorption	0	0.0	0	0.0	-
Internal root resorption	0	0.0	0	0.0	-
After 6 months					
Periapical/inter-radicular radiolucency	0	0.0	0	0.0	-
External root resorption	0	0.0	0	0.0	-
Internal root resorption	0	0.0	0	0.0	-
After 12 months					
Periapical/inter-radicular radiolucency	1	5.0	3	15.0	0.291 ns
External root resorption	0	0.0	0	0.0	-
Internal root resorption	0	0.0	0	0.0	-

Group I: MTA pulpotomy
Group II: Ca $(OH)_2$ pulpotomy
NS=Not Significant
P value reached form Chi square test

Table V shows the radiographic assessment of the groups at evaluation period. Periapical/inter-radicular radiolucency was observed only during 12 months follow up which was 1(5.0%) in group I and 3(15.0%) in group II. No statistical significant ($p>0.05$) difference was found between two group during 12 months follow-up.

Discussion:

Pulpotomy is effective for the treatment of carious or mechanical pulp exposure in primary teeth.[2, 15] Due to its high success rate, it is an acceptable clinical technique for treating inflammation of coronal pulp. Treatment usually consists of removal of coronal pulp followed by application of medicament such as MTA, Formocersol, Calcium hydroxide, Ferric sulphate, Gultaraldehyde, and then final restoration.[15]

In the present study, 40 primary teeth were treated either by MTA or $Ca(OH)_2$ and the clinical outcomes at 3, 6, and 12-months intervals were examined. The assessment was performed according to clinical and radiographical evaluations. In clinical evaluation, pain, swelling, tenderness, mobility, sinus was examined. On the other hand, radiographic examination was performed according to presence or absence of radiolucent area.

The result of the present study showed that regarding pulpotomy with MTA, all cases showed successful at 3, 6, and 12-months following treatment but one patient reported spontaneous pain at 12-months. However, in $Ca(OH)_2$ group, three patients reported spontaneous pain at 12-months. In these cases treatment was done by pulpectomy. The exact reason of pain is not clearly understood. However, It is possible that the pulp of these teeth were inflamed prior to treatment but without clinical signs of such inflammation. The subsidence of symptoms may be partly due to the effect of the medication but it may also be a result of the pulps undergoing necrosis at which stage the symptoms generally disappear until further apical periodontitis develops later.

This study examined the clinical and radiographic success rates of primary molar tooth pulpotomies with MTA, a material with evidence-based success in many endodontic procedures. Several in vitro and in vivo studies have shown that MTA prevents microleakage, is biocompatible and nonresorbable, has low solubility and high comprehensive strength, and promotes tissue regeneration when it is placed in contact with dental pulp or periradicular tissues.[15, 17, 18, 19, 20]

Ca $(OH)_2$ was selected as the control pulpotomy agent because it is currently considered the standard therapeutic agent for pulpotomy procedures in primary molar teeth. $Ca(OH)_2$ has a

long and proven record as an effective pulp therapy agent, including pulpotomies, and it is not expensive. On the other hand, $Ca(OH)_2$ has high solubility and low strength. $Ca(OH)_2$ has been reported to produce more inflammation and lower quality bridge formation when compared with MTA in monkeys and dogs.[12, 19] Similar results were found when human third molars were used to compare the effect of pulp capping with MTA and $Ca(OH)_2$.[21]

The $Ca(OH)_2$ group in this study showed 3 teeth with pathologic signs and symptoms and they were regarded as failures at the 12-month evaluation. Walton and Torabinejad believe that failure usually results from bacterial contamination through microleakage around the restoration and through the porous bridge at the pulpotomy site.[22] $Ca(OH)_2$ offers no protection against microleakage while MTA remains stable and resists microleakage after it sets.[17]

MTA has been shown to prevent bacterial penetration and to be biocompatible when used for direct pulp capping and pulpotomy in mechanically exposed pulps.[15]Such characteristics were also evident in this study of both mechanically and cariously exposed pulps.

Periapical/inter-radicular radiolucency occurred in the four teeth with clinical symptoms – one of these (MTA pulpotomy case) had a periapical radiolucency and the other three ($Ca(OH)_2$ pulpotomy cases) had periapical & inter-radicular radiolucencies. The presence of these findings is consistent with the clinical findings (pain, tenderness to percussion, presence of gingival swelling). It is to be expected that necrosis and infection of the remaining pulp would manifest radiographically in this manner and therefore the results of this study are consistent with contemporary dental treatment. In the cases of $Ca(OH)_2$ pulpotomy, inter-radicular /furcation radiolucency is unlikely since the pulp chamber will be filled with the pulpotomy and restorative dental materials and hence, this part of the tooth is unlikely to be infected. However, if the radicular pulp becomes necrotic and infected then periapical radiolucency will develop because of the release of bacteria and their toxins via the apical foramina.

Regarding discolourations of treated teeth in MTA pulpotomy it was found that there was brown to black color which was more prominent on the clinical crown of first primary molars than on the second primary molars. It may be due to thickness of enamel and dentine of first primary molar is less than the second primary molars. Therefore, Mortazavi M. et al (2009) suggested that the use of more recent product of white MTA could solve this problem. Based on the present study together with the previous studies, it can be said that, MTA has better biocompatibility and high success rate and the problem of these discolorations are not the major issue.

Calcific metamorphosis was the most common noteworthy radiographic finding in both groups in this study, although it is not considered as a criterion for success or failure in the treated teeth. It results from vigorous odontoblastic activity and indicates pulpal vitality. Calcific metamorphosis is a common radiographic finding in pulpotomized teeth and in the present study, it was observed in 2 teeth treated with $Ca(OH)_2$ and in 4 teeth treated with MTA.

Conclusion:

MTA is a recently developed biocompatible material advances to propose of potential pulpotomy material for various pulpal procedures. Based on this Clinical and radiographic evaluation study of 3, 6, and 12-months follow-up, MTA pulpotomy have high success rate than $Ca(OH)_2$ Pulpotomy.

So, MTA could be used as a safe material for pulpotomy in cariously or mechanically exposed primary teeth and could be a substitute for $Ca(OH)_2$.

REFERENCE

1. arr, ES, Flaitz CM, Hicks, MJ, 1991. A retrospective radiographic evaluation of primary molar pulpectomies. Pediatric Dentistry, vol.13 pp.4-9.
2. Fuks, A.B., 2002. Current concepts in vital primary pulp therapy. *Paediatric Dentistry*, vol.3, pp.115-120.
3. Noorollahian, H., 2008. Comparison of mineral trioxide aggregate and formocresol as pulp medicaments for pulpotomies in primary molars. *British Dental Journal*, E20 pp.204-207.
4. Eidelman, E., Holan, G., Fuks, A.B., 2001. Mineral Trioxide Aggregate VS Formocresol in pulpotomized primary molars a preliminary report. *Pediatric Dentistry*, vol.23, pp.15-18.

Herman, B., Biologische Wurzelbehandlung, Frankfurt,Germany: W.Kramer,1936.

6. cDonald, RE, Avery DR, Dean JA, 2004. Treatment of deep caries, vital pulp exposure and pulpless teeth. In: Dentistry for the Child and Adolescent. 8th ed. St. Louis, Mo: Mosby Co, pp.389-412.
7. ndersen, M, Lund A, Andreasen, JO, Andreasen, FM, 1992. In vitro solubility of human pulp tissue in calcium hydroxide and sodium hypochlorite' Endo Dent Traumatol. Vol.8 pp.104-8.
8. arnes, IE, Kidd EA 1979. Disappearing dycal. Br Dent J, vol.147 pp.111
9. Farsi, N., et al., 2005. Success of mineral trioxide aggregate in pulpotomized primary molars. J *Clin Pediatr Dent*, vol.29(4), pp.307-311.
10. Schwartz, R.S., et al., 1999. Mineral trioxide aggregate: A new material for endodontics. *J Am Dent Assoc*. p. 130.
11. Holan, G., Eidelman, E., Fuks, A.B., 2005. Long-term evaluation of pulpotomy in primary molars using mineral trioxide aggregate or formocresol. *Paediatric Dentistry*, vol.27, pp.129-136.
12. araco, IM Jr, Holland, R, 2001. Response of the pulp of dogs to capping with mineral trioxide aggregate or a calcium hydroxide cement' Dental Traumatology. Vol.17 pp.163-6.
13. Menezes, R., et al., 2004. Microscopic analysis of Dog dental pulp after pulpotomy and pulp protection with Mineral Trioxide Aggregate and White Portland cement. *J Appl oral Sci*, vol.12 (2), pp.104- 107.

of

mineral trioxide aggregate for root-end filling in dogs. *J Endod*, vol.21, pp.603-608.

15. Torabinejad M, Chivian N, 1999. Clinical M applications of mineral trioxide aggregate. *J Endod*, vol.25, pp.197-205.
16. Alacam, A., 1984. Pulpal tissue changes following pulpotomies with formocresol, glutaraldehyde-zinc oxide eugenol pastes in primary teeth. *Journal of* A *Pedodontics*, vol. 13, pp.123-132.
17. akland, LK, 2000. Management of traumatically injured pulps in immature teeth using MTA. J Calif Dent Assoc, vol.28 pp.855-8. B
18. anchs, F, Trope M 2004. 'Revascularization of immature permanent teeth with apical periodontitis: New treatment protocol' J Endod , vol.30 pp.196-200.
19. Pitt Fort, T.R., et al., 1996. Using mineral trioxide aggregate as pulp-capping material. *J Am Dent Assoc*., vol.127, pp.1491-1494.
20. luyk, SR, Moon, PC, Hartwell, GR, 1998. Evaluation of setting properties and retention characteristics of mineral trioxide aggregate when used as a furcation perforation repair material. J F Endod, vol.24 pp.768-71.
21. Aeinehchi, M., Eslami, B, Ghanbariha, M., Saffar, AS., 2003. Mineral trioxide aggregate (MTA) and calcium hydroxide as pulp-capping agents in human teeth: a preliminary report. *Int. Endo. J.*, vol.36,pp.225-231.
22. Walton, RE, Torabinejad M., 2002. Management of incompletely formed roots. In: Principles and Practice of Endodontics. 3rd ed. Philadelphia, Pa: WB Saunders; pp.388-404.