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Clinical and Radiographic Evaluation of MTA, Biodentine, and A New Resin-Modified Calcium Silicate As Pulpotomy Agents in Primary Mandibular Second Molars- A Clinical Study

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Abstract

Background: Pulpotomy is the most commonly performed vital pulp therapy in pediatric dentistry to maintain primary tooth vitality. Among materials used for pulpotomy, Mineral trioxide aggregate (MTA) and Biodentine (BD) have shown strong regenerative potential. Recently, a dual-cured resin-modified calcium silicate material—TheraCal PT was introduced primarily for pulpotomies.

Aim: To compare the clinical and radiographic success of pulpotomy in primary mandibular second molars using TheraCal PT, MTA and Biodentine at 3, 6 and 9 months.

Materials & Methodology: Forty-Five patients of age 6-9 years having carious primary mandibular 2nd molar involving only coronal pulp were selected based on the inclusion and exclusion criteria. They were randomly allocated into 3 study groups based on pulpotomy medicament used: Group A- MTA (15), Group B- Biodentine (15) and Group C- TheraCal PT (15). Caries was excavated under local anaesthesia, hemostasias was achieved after removal of coronal pulp using spoon excavator and capped with MTA or Biodentine or TheraCal PT according to the groups. Clinical and radiographic success was evaluated by a blinded calibrated evaluator after 3,6 and 9 months.

Results: The difference in the clinical and radiographical success rate of three pulpotomy agents, were statistically significant (P<0.05). Biodentine has showed high success

rate both clinically as well as radiographically which is significant statistically (P<0.05).

Conclusion: Based on the clinical and radiographic observations, it is concluded that Biodentine has high success rates as a pulpotomy agent as compared to other two materials.

Keywords: Pulpolotomy, MTA, Biodentin, TheraCal PT

Introduction

Pulpotomy is a vital pulp therapy procedure commonly indicated in primary teeth with carious or traumatic pulp exposures where the radicular pulp is uninflamed and vital. According to the guidelines of the American Academy of Pediatric Dentistry (AAPD), "A pulpotomy is performed in a tooth with extensive caries without radicular pathology evidence when caries removal results in a carious or mechanical pulp exposure."[1]

Pulpotomy agents have evolved over the past century from causing devitalization (such as mummification and cauterization) to preserving the radicular pulp (minimal devitalization, non-inductive) and finally to tissue regeneration (reparative, inductive). These materials can be grouped based on their mechanisms of action: Devitalization (Formocresol (FC), Electrosurgery, and Laser), preservation (Ferric sulfate and Glutaraldehyde) and regeneration (Mineral Trioxide Aggregate (MTA), Calcium hydroxide, Biodentine, etc.).[2]

MTA, introduced in the 1990s, is a bioactive material made of calcium silicate, calcium oxide and other mineral oxides. It stimulates odontoblast-like cell activity to induce the formation of a dentinal bridge. It forms a tight seal between the material and the tooth, preventing bacterial infiltration. However, the material has a long setting time, which can complicate clinical procedures and it is prone to discoloration especially in anterior teeth, which can be an aesthetic concern.

Biodentine is another calcium silicate-based material that has gained popularity as a substitute for dentine and as a pulp-capping agent. It was introduced in 2009 as a "Dentin replacement" agent. It has improved handling properties and a shorter setting time and has shown comparable results to MTA in pulpotomy procedures.

TheraCal PT is a more recent addition to the family of pulp-capping materials. It is a resin-modified, calcium silicate-based material specifically designed for pulpotomy procedures. It combines the bioactivity of calcium silicates with the enhanced handling characteristics of resin-based materials. This hybrid composition allows it to set quickly and maintain a favourable environment for pulp healing.

This study aims to compare the clinical and radiographic success of pulpotomy in primary mandibular second molars using MTA, Biodentine and Theracal PT at 3, 6, and 9 months.

Materials and method

A sample of 45 children between 6-9 years who met the inclusion criteria[3] (i.e. asymptomatic primary molars with a deep carious lesion, minimal exposure of vital pulp due to dental caries, no clinical and radiographic evidence of inflamed pulp or pulp degeneration, teeth should be restorable after pulpotomy, absence of spontaneous pain, absence of swelling or alveolar abscess formation, absence of tooth mobility, cooperative child, teeth with sufficient coronal structure to receive rubber dam isolation and absence of coronal destruction that precludes restorability) were included in the study. The sample was randomly divided into three groups based on the pulpotomy medicament used Mineral trioxide aggregate (MTA), Biodentine or TheraCal PT allocating 15 teeth in each group (n=15).

After anesthetizing the primary mandibular second molar and isolation with rubber dam, access cavity preparation

was done using a high speed airotor with a no. 6 round bur. The roof of the pulp chamber was exposed and then the coronal pulp was removed with spoon excavator. After amputation of coronal pulp, bleeding was controlled by moist cotton pellet.

For group A, MTA was used as pulpotomy agent. MTA powder was mixed with distilled water at a 3:1 powder/water ratio. Mixture was applied over amputated pulp stumps using an amalgam carrier. Wet cotton was used to condense the MTA. A thickness of 2-3 mm was applied covering the pulp stump. The access cavity was then filled with IRM. Patient was recalled after 24-hours for permanent restoration.

For group B, Biodentine was used. Before opening the capsule of Biodentine, it was tapped gently to diffuse the powder. Five drops of the liquid were added to the powder in the capsule and then the capsule was placed in the amalgamator for 30 seconds giving a paste that was gently applied to the pulp stump by means of agate spatula. A thickness of 2-3 mm was applied covering the pulp stump. Permanent restoration was done using Glass ionomer cement - Fuji IX in the same appointment. The patient was then recalled after 24-hours for placement of Stainless steel crown.

For group C, TheraCal PT was used. TheraCal PT is available in a dual-syringe with auto-mix tip that eliminates hand mixing. A thickness of 2-3mm was directly placed in the pulp chamber and light cured for 10 seconds. Permanent restoration was done using Glass ionomer cement - Fuji IX in the same appointment. The patient was then recalled after 24-hours for placement of Stainless steel crown.

A post-operative radiovisiograph (RVG) was taken immediately after the pulpotomy procedure and the children were recalled for clinical and radiographical evaluation at 3rd, 6th and 9th months. Clinically, presence of pain, swelling, draining sinus, pain on percussion and pathological mobility and radiographically, pathologic external or internal root resorption, periodontal ligament widening, furcation radiolucency and periapical abscess were evaluated.[3]

The data thus obtained were statistically analyzed using the Chi-square test with statistical significance set at $P < 0.05$.

Results

The majority of patients attended the scheduled follow-up visits, with the exception of two children who had a total of two teeth (one each from group A and group B) lost during the 3-month follow-up period. Consequently, 45 patients were clinically and radiographically evaluated by two independent investigators to reduce potential bias. An inter-examiner reliability coefficient of 0.93 (intraclass correlation coefficient = 0.93, kappa value) was obtained demonstrating excellent consistency in the observations. Patients exhibiting signs of treatment failure during 3 and 6 month follow-up periods were excluded from the study and provided with appropriate alternative treatment.

In this study, a comparison of clinical parameters between the three groups revealed no statistically significant difference in outcome. There was an absence of clinical findings at 3-month recall in all groups. At, 6 and 9 months recall, 1 case in Group A and 3 cases in Group C presented with the presence of clinical parameters (Table 1).

Radiographically, intra-group comparison showed statistical difference for radiolucency, PDL widening, pathological resorption and periapical abscess at the end of 9 months ($P<0.05$) (Table-2).

The overall clinical success rate for Group A, B and C was 93.3%, 100% and 86.7% respectively. The radiographic success rate was 80% for Group A, 93.3%

for Group B and 60% for Group C which was statistically significant (P<0.05) (Table-3).

Discussion

With the growing emphasis on biological preservation and tissue regeneration, the concept of regenerative pulpotomy has emerged as an advanced approach in vital pulp therapy. Unlike traditional methods that aim merely to preserve the remaining pulp or arrest inflammation, regenerative pulpotomy focuses on stimulating the natural healing potential of the pulp tissue to regenerate new dentin-pulp complex.[4]

The introduction of Mineral Trioxide Aggregate (MTA) marked a turning point in vital pulp therapy. MTA demonstrated excellent biocompatibility, sealing ability and the capacity to stimulate hard tissue formation, making it a widely accepted gold standard. Nonetheless, drawbacks such as long setting time, potential for discoloration and higher cost prompted the search for newer alternatives.[5]

To address some limitations of MTA, Biodentine was developed as a bioactive dentin substitute with faster setting time, enhanced mechanical properties and comparable pulpal response. Its ability to induce dentinal bridge formation and maintain pulp vitality made it a favorable option.[6]

More recently, TheraCal PT, a light-cured resin-modified calcium silicate, has gained attention due to its ease of application, immediate setting and ion release properties. It offers the advantages of bioactivity, durability and improved handling, positioning it as a promising material for single-visit procedures in pediatric dentistry.

Studies have shown that Theracal PT has a promising potential for clinical application due to its biocompatibility and induction of reparative dentin formation. Not many in-vivo studies are done to see the efficacy of TheraCal PT as a pulpotomy agent.

Hence, this clinical study was planned to observe the efficacy of TheraCal PT as pulpotomy agent and compare the clinical and radiographic success for TheraCal PT with MTA and Biodentine as pulpotomy agents in primary molars.

Mineral Trioxide Aggregate (MTA) showed clinical success rate of 93.3% and 80% radiographic success rate. Biodentine showed 100% clinical success rate and 93.3% radiographic success rate while TheraCal PT showed 86.7% clinical success rate and 60% radiographic success rate.

Clinical parameters are checked in all three groups for a period of 9 months follow up. There was no history of pain, swelling, draining sinus, pain on percussion and pathological mobility in any of the teeth after 3 months. In MTA group, history of pain, swelling, pain on percussion and pathological mobility was seen in one case after 6 months. In TheraCal PT group, after 6 months two cases presented with history of pain, swelling and pain on percussion and one with sinus opening and pathological mobility.

After 9 months, one case presented with history of pain, swelling, pain on percussion and pathological mobility in MTA group. Two cases presented with history of pain, swelling, pain on percussion and pathological mobility and one case had sinus opening in TheraCal PT group after 9 months. No clinical failures were found in Biodentine group at the end of 6 months and 9 months.

Radiographical parameters were assessed in all three groups for a period of 9 months follow up. After 3 months, one case showed radiolucency and two cases showed pathological resorption in MTA group. In TheraCal PT group, one case showed PDL widening and three cases showed radiolucency.

After 6 months, one case showed PDL widening and radiolucency and 3 cases showed pathological resorption

in MTA group while in Biodentine group, one case showed periapical abscess and radiolucency. In TheraCal PT group, one case showed periapical abscess, 3 cases showed PDL widening and six cases showed radiolucency.

At the end of 9 months, pathological resorption was observed in three cases treated with MTA, while it was not detected in the other two groups. Periodontal ligament (PDL) widening was noted in one case in the MTA group and in four cases in the TheraCal PT group, with no such findings in the Biodentine group.

Radiolucency was seen in two cases of MTA group, one case of Biodentine group and six cases of TheraCal PT group. Periapical abscess was seen in one case of Biodentine group and four cases of Theracal PT group.

The difference in the clinical and radiographical success rate of three pulpotomy agents, in the present study were statistically significant ($P<0.05$). Biodentine has showed good results both clinically as well as radiographically which is significant statistically ($P<0.05$).

Comparable findings were reported by Nasseh et al. (2018), Nowak et al. (2013) and Ahuja et al. (2020), who evaluated the clinical and radiographic outcomes of Biodentine and MTA. They concluded that Biodentine demonstrated favorable biological, physical and mechanical properties, along with ease of manipulation, making it a suitable pulpotomy medicament for pediatric patients.

Bakhtiar H et al. (2017) evaluated the clinical efficacy of TheraCal in comparison with Biodentine and ProRoot MTA for partial pulpotomy and concluded that Biodentine and MTA demonstrated superior performance compared to TheraCal. In contrast, a study by Rajasekharan S et al. (2017) found no significant difference between Biodentine and MTA when used as pulpotomy agents in primary molars.

Future research involving larger sample sizes and extended follow-up periods is necessary to validate these findings and offer more robust evidence on the most suitable pulpotomy material for primary teeth. Furthermore, the influence of variables such as patient age, severity of carious lesions and operator technique on treatment outcomes should be investigated to enhance clinical decision-making.

Conclusion

This study demonstrated that all three materials—MTA, Biodentine and TheraCal PT—are clinically effective for pulpotomy in primary molars of pediatric patients each yielding acceptable outcomes. However, differences were observed in radiographic healing and long-term success rates with Biodentine showing superior performance in both clinical and radiographic parameters compared to the other two materials.

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Legend Tables and Figures

Table 1: Post-operative clinical assessment after 3rd, 6th and 9th month in all the groups

Clinical Parameters	3rd Month			P Value	6th Month			P Value	9th Month			P Value
	MTA	BD	TH		MTA	BD	TH		MTA	BD	TH	
History of pain	15	15	15	-	14	15	13	0.34	14	15	13	0.18
Swelling	15	15	15	-	14	15	13	0.34	14	15	13	0.18
Sinus opening	15	15	15	-	15	15	14	0.36	15	15	14	0.4
Pathological mobility	15	15	15	-	14	15	14	0.59	14	15	13	0.18
Pain on percussion	15	15	15	-	14	15	13	0.34	14	15	13	0.18

P: Probability. *: Significant.

Table 2: Post-operative radiological assessment after 3rd, 6th and 9th month in all the groups

Clinical Parameters	3rd Month			P Value	6th Month			P Value	9th Month			P Value
	MTA	BD	TH		MTA	BD	TH		MTA	BD	TH	
Pathological resorption	13	15	15	0.12	12	15	15	0.04*	12	15	15	0.04*
Pdl widening	15	15	14	0.36	14	15	12	0.14	14	15	11	0.031*
Radiolucency	14	15	12	0.044*	14	14	09	0.022*	13	14	09	0.051
Periapical abscess	15	15	15	-	15	14	14	0.59	15	14	11	0.031*

Table 3: Clinical and radiographic success rate of teeth in all the groups

Success Rate							P Value
Group	MTA		Biodentine		Theracal PT		
	n	%	n	%	n	%	
Clinical success	14	93.3	15	100	13	86.7	0.045*
Radiographic success	12	80	14	93.3	09	60	0.020*

Figure 1: MTA (ProRoot MTA, Dentsply Sirona)

Figure 2: Biodentine (Septodont, Saint-Maur-des-Fosses Cedex, France)

Figure 3: TheraCal PT (Bisco, Schaumburg, IL, USA)

Post-operative Radiographs after 3, 6 and 9 months

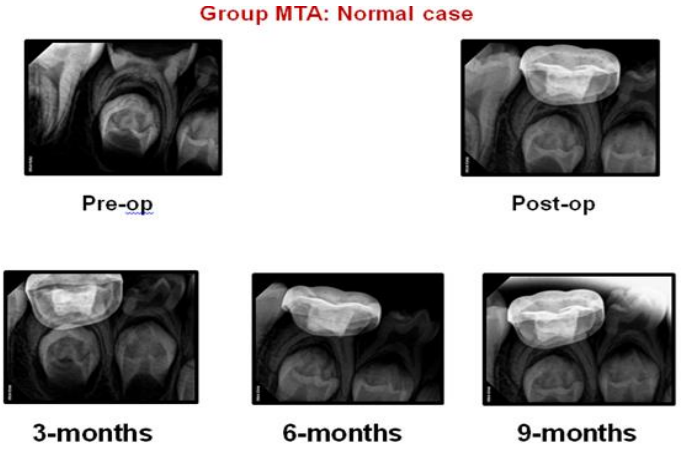


Figure 4:

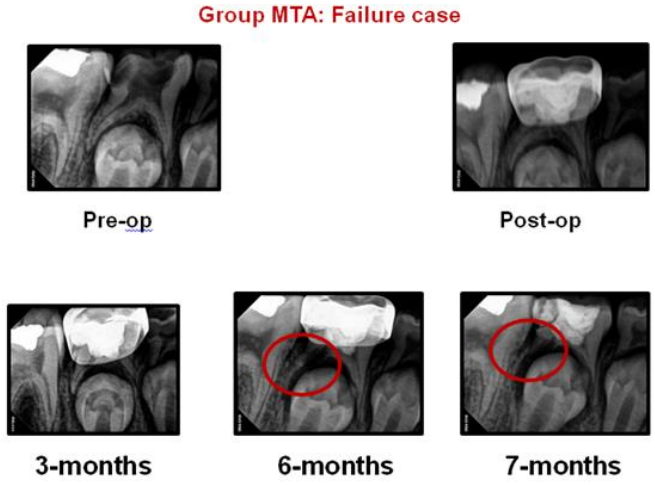


Figure 5:

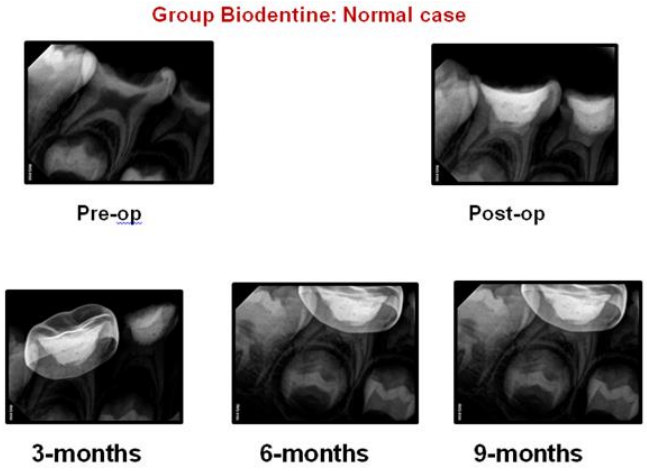
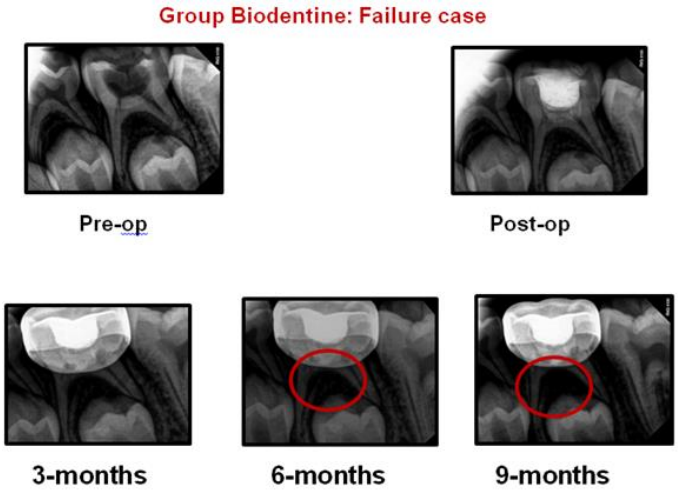


Figure 6:



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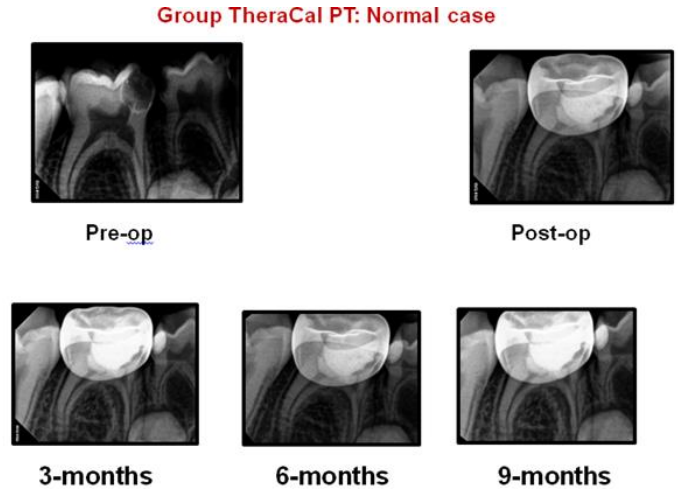

Figure 8:

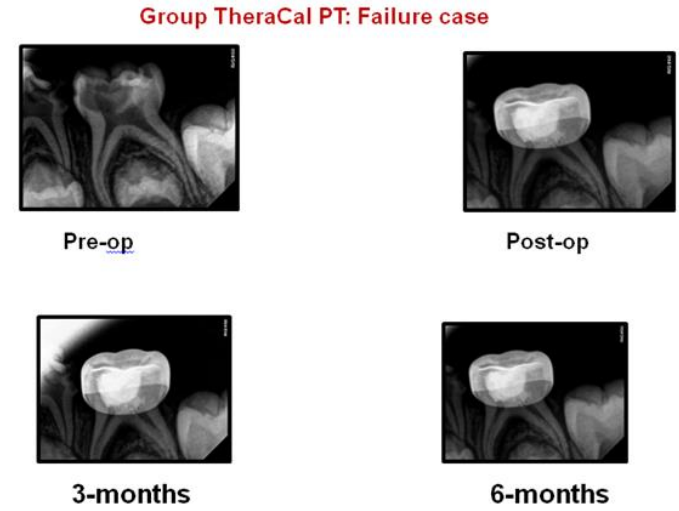

Figure 9: