Clinical and Radiographic Evaluation of Mineral Trioxide Aggregate and Electrosurgical Pulpotomies in Primary Molars: An In-Vivo Study

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Introduction

Pulpotomy is a therapeutic procedure which is commonly employed in reversible inflammation of the coronal pulp of the primary teeth. This is required where radicular pulp tissue has to be maintained in a healthy condition for long-term, until exfoliation. The preservation of vitality of radicular portion of pulp tissue through pulpotomy procedure in the primary dentition is quite valuable from the point of view that, it not only helps in maintaining the arch integrity but also guides the erupting successor in correct path.¹

Formaldehyde derivatives have been used as an acceptable, highly successful, and most common agent for the fixation of pulp for many years.²,³ Despite its success, the empiricism supporting the use of formocresol as a pulpotomy agent has been questioned for many years.⁴ The search for the medicament to replace formocresol became vital after several negative reports questioned its local and systemic toxic effects. The greatest concerns seeking the alternatives for formaldehyde derivatives are:

1. Pulpal response with inflammation and necrosis⁵
2. Cytotoxicity⁶
3. Systemic disturbances⁷
4. Mutagenic and carcinogenic potential⁸
5. Immunologic responses.⁹

Electrosurgery has been proposed as an alternative treatment avoiding the toxic effects of chemical drugs applied over the pulp.⁴,¹⁰,¹¹ The exceedingly few investigations carried out with this method have reported a promising result. The electrosurgical pulpotomy appears to have its merit as it is self-limiting,¹²,¹³ pulp penetration when activated is few cells deep, excellent visualization and hemostasis is possible without chemical coagulation or systemic involvement. It is also less time consuming than the formocresol approach.¹⁴

Mineral trioxide aggregate (MTA) which was introduced by Dr. Mahmoud Torabinejad as root end/root canal repair material, has been advocated for other uses. In primary teeth, MTA is predominantly used for pulp capping and pulpotomy procedures. The major benefits of MTA are that it is biocompatible, bactericidal, and able to stimulate osteoecementum like structure. Its sealing, mineralizing, osteogenic and dentinogenic properties have made it a material of choice in various clinical scenario's.¹⁵

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Abstract:

Background: Pulpotomy is the most common treatment modality employed to preserve a cariously exposed symptom-free primary molars, which aims to preserve the vitality of radicular pulp till its exfoliation. Such pulpotomy agent should bactericidal, should not damage surrounding tissues, promote healing of remaining of pulp tissue, and should not affect physiological resorptive process of the tooth. The quest for one such ideal pulpotomy material/procedure is never conclusive. Hence, this study was conducted to assess and compare the clinical and radiographic outcomes of mineral trioxide aggregate (MTA) and electrosurgical pulpotomies in human primary molar teeth.

Materials and Methods: A total of 60 carious mandibular primary molars from 46 children whose pulpal status was indicated for pulpotomy procedures were considered. The selected teeth were randomly divided into two groups using simple randomization number table. MTA and electrosurgical pulpotomies were performed for the respective group followed by the placement of stainless steel crown. Pulpotomized patients were recalled for further follow-up at 1st, 3rd, 6th, 9th, and 12th month for clinical and radiological evaluation. McNemar’s test was used to determine the differences between groups.

Results: At the end of the 12 months follow-up, the overall success rate for MTA was at 96.7% and for electrosurgery was at 90%. However, there was no statistically significant difference between the groups compared.

Conclusion: Success of electrosurgical pulpotomies can be comparable with that of MTA.

Key Words: Electrosurgery, Mineral trioxide aggregate, Pulpotomy
For the above cited reasons, and considering the concerns regarding the formocresol and its adverse reaction, the predated studies formed the basis for current investigations. The aim of the study was to evaluate the effect of MTA and electrosurgical pulpotomies which are considered as safe for clinical and radiologic success on human primary molar for 12-month.

Materials and Methods
The patients were recruited from the out patients walking into the Department of Pedodontics and Preventive Dentistry of M S Ramaiah Dental College and Hospital, Bengaluru were included in the study. The parents and the children involved in the study were explained about the procedure, its possible discomforts, and benefits. Prior approval from the Institutional Ethical Committee was obtained. The intended sample of 60 carious mandibular primary molars from 46 children whose pulpal status indicated for pulpotomy was considered using the results of previous studies.

The sample size was arrived at, using the formula:

\[ n = \frac{2 (Z_a + Z_{\alpha/2})^2 (S_1^2 + S_2^2)}{(X_1 - X_2)^2} \]

Where, \( Z_a = 3.28 \), \( Z_{\alpha/2} = 1.28 \), power 90%, \( S_1 \) = Standard deviation of MTA group, \( S_2 \) = Standard deviation of electrosurgery group, \( X_1 \) = Mean of MTA group and \( X_2 \) = Mean of electrosurgery group.

The children were in the age group of 4-9 years. The indicated teeth were evaluated clinically and radiographically. All the children belonged to the American Society of Anesthesiologists I and II grading were included in the study. The inclusion criteria were: cooperative children, the presence of a deep carious lesion, no clinical sign of profuse bleeding from amputated radicular pulp, tenderness to percussion, no more than two third of root resorption, and a tooth which is restorable. Children with a history of systemic illness contraindicating for pulpotomy, spontaneous tooth pain or tenderness to percussion, pathologic mobility, the presence of any internal or external resorption, apical or furcal radiolucency, widened periodontal ligament space, and sinus tract were excluded from the study.

Allocation
Selected Mandibular primary molars were randomly divided into two groups using simple randomization number table. The allocation was done according to consort guidelines (Flow Chart 1). Mandibular primary molars were preferred in our study because the radiological changes during follow-up are better appreciated in mandibular molars when compared to maxillary tooth due to the favorable anatomy of mandibular molar for radiological examinations. Allocations were concealed from the clinician performing pulpotomies until baseline assessments were finished.

MTA group
A total of 30 primary molars to be pulpotomised with MTA (ProRoot MTA - DENTSPLY Tulsa Dental Specialties – White MTA) mixed as per the manufacturers instruction.

Electrosurgery group
A total of 30 primary molars in electrosurgery group were pulpotomised using U-shaped loop no S-6015A of perfect TCS™ (Coltene Whaledent).

Intervention
Before the start of pulpotomy technique, local anesthesia, placement of rubber dam, and treatment procedure was explained, to gain the confidence of the child. After inducing anesthesia, all the peripheral infected caries was excavated with an excavator. The roof of the pulp chamber was outlined and removed using No. 558 straight crosscut fissure bur; sharp spoon excavator was used for complete mechanical coronal pulp amputation. The pulp stumps were clearly excised with no tags of tissue extending across the floor of the pulp chamber and then irrigated with light flow of sterile water syringe and evacuated. A wet cotton pellet (soaked in sterile water) was placed over the amputated pulp stones for 3 min to achieve hemostasis. The status of the radicular pulp was assessed,
and the tooth was considered for pulpotomy once the bleeding was arrested naturally.

**MTA group**
The amputated pulp stumps were covered with thick paste of MTA (ProRoot MTA, DENTSPLY, Tulsa, USA) obtained by mixing MTA powder with sterile water at 3:1 powder to water ratio according to manufacturer’s instruction. Followed by the placement of zinc oxide eugenol cement.

**Electrosurgery group**
In the electrosurgical group, large sterile cotton pellets were placed into the chamber with pressure to obtain initial hemostasis. The cotton pellets were removed, and the U-shaped electrosurgery dental electrode was immediately placed at 1-2 mm above the tissue. The electrosurgery unit was set at 40% power. The electrode was allowed to bridge the gap on the first pulpal stump for one second followed by a cool down period of 5 s. Heat and electrical transfer were lessened by keeping the electrode secluded from the pulpal stumps and tooth structures as it would still allow electrical arcing to occur. This procedure was reiterated up to a maximum of 3 times on each pulpal orifice. On completion, the pulpal stumps appeared dry and fully blackened, which was later restored with zinc oxide eugenol cement. Following pulpotomy, stainless steel crowns were placed on all the pulpotomised teeth.

**Follow-up assessment**
During the follow-up recall, post-operative intraoral periapical digital radiographs – Radovisiograph were taken by using paralleling cone technique with cone positioners. The children were recalled for clinical and radiological evaluation for 1 year (1st, 3rd, 6th, 9th, and 12th months, respectively) (Figures 1 and 2).

The tooth was considered as clinically success if they had: (1) No symptoms of pain (2) no swelling, fistula or pathologic mobility and (3) tenderness to percussion. The tooth was considered as radiographically success if they had: (1) Absence of pathologic internal or external resorption, (2) absence of inter-radicular or periapical radiolucency, (3) absence of pulp canal calcification, and (4) crypt of surrounding tooth was intact.

Clinical and radiographic assessments were done by an investigator who was blind to the pulpotomy technique employed.

**Statistical analysis**
The data thus obtained was analyzed using SPSS Version 20. McNemar’s test was used to determine difference between the groups at 95% confidence level ($P = 0.05$).

**Results**
The final sample consisted of 60 primary molars from 46 children (27 male and 19 females) with a mean age of 5 years 6 months at the time of intervention. All patients were recalled at assigned times post-operatively for clinical and radiographic evaluation. Once the pulpotomised tooth was considered as a failure, it was no longer included for forthcoming evaluation. None of the pulpotomised teeth presented with adverse effects for the medicament or the technique employed for pulpotomy.

One tooth in MTA group showed radiological sign of failure, pulp canal obliteration (PCO) during the 6th month of follow-up (Table 1), which was subsequently extracted and dropped from further follow-up.

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**Figure 1:** (a) Pre-operative radiograph of primary molar selected for electrosurgical pulpotomy, (b) immediate post-operative radiograph of electrosurgically pulpotomized primary molar, (c) 1st month post-operative radiograph of electrosurgically pulpotomized primary molar, (d) 3rd month post-operative radiograph of electrosurgically pulpotomized primary molar.

**Figure 2:** (a) 6th month post-operative radiograph of electrosurgically pulpotomized primary molar, (b) 9th month post-operative radiograph of electrosurgically pulpotomized primary molar, (c) 12th month post-operative radiograph of electrosurgically pulpotomized primary molar.
In the electrosurgery group, one tooth showed internal resorption at 1st month, another with mobility, swelling, and furcal radiolucency and external resorption at 6th month and one more with internal resorption at 9th month of follow-up. All the teeth which failed in electrosurgery were extracted, and necessary space management steps were taken during subsequent appointments. Internal resorption was the ubiquitous radiographic failure at 12th month follow-up. It was noted in 6.6% of sample with two in electrosurgery group. By the end of 12th month follow-up when the data was analyzed for success rates, the overall clinical success was 96.7% for MTA and 90% (Table 1) for electrosurgery. However, there was no statistically significant difference between the two groups (P = 0.353), but there was a decrease in success rate as the follow-up period was increased in both groups.

**Discussion**

Over the years, lot of concern has been raised regarding the use of formocresol in dentistry. Even though it was the gold standard medicament for pulpotomy procedures in primary molars, lot of other materials were introduced to overcome adverse effects of formocresol.19-22 With this in mind, this study was an attempt find a non-chemical alternative to formocresol, which proved to be success with 96.7% success for MTA and 90% for electrosurgery. The success rates of this study were comparable to most of the studies in the past irrespective of the pulpotomy procedure employed.15

The procedure of pulpotomy for primary teeth has been developed along three lines: Devitalization, preservation, and regeneration. Devitalization where the intent is to destroy vital tissue, typified by formocresol, preservation, where the retention of maximum vital tissue with no induction of reparative dentine, is epitomized by glutaraldehyde and ferric sulfate. Regeneration, where the stimulation of dentine bridge has been associated with calcium hydroxide, MTA and recently bioactive materials like biodentine and enamel matrix derivative and has been tried as a pulpotomy agent.

Devitalization was the first approach in pulpotomy of primary teeth. The multiple visit formocresol technique as introduced by Sweet was designed to mummify the tissues completely.18 The only rationale for using formocresol is “it succeeds than fails.” Even with its stupendous success over the years as a pulpotomy agent, it has received a lot of criticism, which have shown formaldehyde to be toxic, mutagenic, and carcinogenic.26-32 In an attempt altogether to avoid chemicals, MTA and electrosurgical pulpotomies were given importance. For electrosurgical pulpotomy, an undamped, fully rectified, high-frequency current with an electrode is placed in direct contact with tissues. It has the merit of having – “limited pulpal penetration, complete hemostasis, and clear visualization without using any chemical preparation,” which has been acknowledged by many such studies.33,34

Several studies exist comparing the radiographic and clinical results of electrosurgery to other medicaments.5,10-14 Although many pulpotomy techniques have been suggested, a review article5 and available literature suggest that evidence is lacking as to state which pulpotomy procedure is the appropriate one.55

It has been reported that clinical evaluation is the most optimistic criteria for the success of any pulpotomy procedure,56 but the first sign of failure was usually detected radiographically.

In the MTA group, one case presented with the radiological finding of PCO in the 6th month follow-up. Even it is debatable whether PCO is due to inflammatory response or due to inductive properties of MTA. However, considering our post-operative evaluation criteria the case was considered as failure and excluded from further follow-up. A systemic review has presented with a higher incidence of PCO when MTA was used as a pulpotomy medicament.37

Internal resorption is usually the first radiological sign of failure.38 In this study, two from electrosurgery group were considered as a failure due to internal resorption. It has been suggested previously that similar failures were the result of - improper coronal seal,11 inflammatory response to zinc oxide eugenol,7 inconsistency in techniques using multiple operators, or improper selection of cases.39 However, in cases of electrosurgery, lateral heat, which was dissipated from the electrode, could be the cause of chronic inflammatory changes such as internal resorption.40 Both the clinical and radiological success rates of electrosurgical pulpotomy were in par with the studies published in the recent past.30,41

Other radiological signs of failure like furcal and periapical radiolucency, external resorption was noted in a case in electrosurgery group. Clinical signs of failure like, mobility and swelling were also observed in one of the cases in electrosurgery group. The first sign of failure among pulpotomised teeth will be normally detected radiographically as the tooth may remain asymptomatic. Such signs of failure which emphasizes the importance of a periodic radiological follow-up even in the absence of clinical signs and symptoms. Similar to ample of studies which have reported having a decrease in success rate with increased follow-up period,2,15,18,33,42 There was also a decrease in both clinical and radiographic success rates, in this study.

**Table 1: Success rate of MTA and electrosurgical pulpotomies at recall visits.**

<table>
<thead>
<tr>
<th>Materials</th>
<th>Result</th>
<th>Follow-up times in months, N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1st</td>
</tr>
<tr>
<td>MTA</td>
<td>Success</td>
<td>30 (100)</td>
</tr>
<tr>
<td>Electrosurgery</td>
<td>Success</td>
<td>29 (96.7)</td>
</tr>
</tbody>
</table>

McNemar’s test P=0.353. MTA: Mineral trioxide aggregate.
Conclusion
Considering the limitation of this *in-vivo* study: That is a larger sample size and longer follow-up period, it can be concluded that since there was no statistically significant difference between the two groups (P = 0.353), the success of electro-surgical pulpotomy in primary teeth is comparable to that of MTA. If these concerns regarding, the use of formocresol were to be true, MTA, and electrosurgery can be the method of choice for pulpotomy procedures in primary molar teeth.

References