

One-year outcomes of MTA and modified Portland cement pulpotomy in primary teeth: a randomized clinical trial

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Abstract

Purpose: To compare the efficacy of Mineral Trioxide Aggregate (MTA) and Modified Portland Cement (MPC) as pulpotomy medicaments in primary molars. **Methods:** A sample of 54 children 4 to 6 years old of age, who had at least one primary mandibular second molar that needed pulpotomy were randomly placed in MTA ($n = 28$) or MPC ($n = 26$) groups. After completing the pulpotomy procedures, the teeth received a stainless-steel crown. Clinical and radiographic successes/failures were blindly evaluated at 6 and 12 months, and Fisher's exact test was used to analyze the differences. **Results:** At 6- and 12-month follow-ups, MTA and MPC had 100% clinical success rate. Radiographic success rates of MTA were 92.9% at 6 months and 89.3% at 12 months. While the rate for MPC group was 88.5% at both intervals. There was no statistically significant difference between the two groups. **Conclusion:** The results of this investigation showed that treatment success rate with MPC was comparable to MTA pulpotomy. However, additional clinical research that considers long-term follow-ups is required to test the usefulness of MPC in the pulpotomy treatment of primary teeth.

Keywords: portland cement, mineral trioxide aggregate, primary molars, pulpotomy.

Introduction

The American Academy of Pediatric Dentistry guidelines on pulp therapy for primary teeth declare that “the primary objective of pulp therapy is to maintain the integrity and health of the teeth and their supporting tissues.” (1) Nevertheless, clinicians have different opinions on the management of the primary teeth in cases where there is pulp exposure because of caries or mechanical procedures. (2) Pulpotomy is presently the standard one-stage treatment for caries-exposed pulps in symptom-free primary teeth. (3) A considerable number of medicaments have been suggested to be used for pulpotomy (1, 4).

For 60 years, devitalization by formocresol has been the optimum treatment for vital pulpotomy in primary teeth. (5) Although it has had success for six decades, its possible toxicity, mutagenicity, and carcinogenicity in humans is a concern. (6) Mineral Trioxide Aggregate (MTA) is composed of tricalcium oxide, tricalcium silicate, tricalcium aluminate, and silicate oxide. (7) MTA has already been established as a suitably biocompatible material with excellent potential for use in pulp capping, pulpotomy procedures, apexification procedures, as a restorative material for perforations, and apical sealing in the management of open-apex, non-vital teeth. Studies have also reported on its clinical and radiographic efficacy as a pulpotomy material in primary teeth. (8).

However, MTA has its limitations, such as long setting time, high cost compared to other medicaments, and its restricted use for solely low-stress bearing areas. (9) Another reported drawback is gingival and tooth discoloration by gray and white MTA. (10, 11)

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In the last 14 years, more than 100 publications have shown that Portland Cement (PC) (the material that makes up the majority of MTA) has similar properties to MTA through different in vivo and in vitro animal studies and, recently, through human trials (8).

The main difference between MTA and PC is that the latter does not have bismuth oxide. Therefore, in the most current studies, PC is modified with the addition of 20% bismuth oxide to render it radiopaque. The addition of bismuth oxide into PC does not change its pH level, cytotoxicity and biological reaction. (8, 12) PC is made up of various-sized particles; however, MTA has an even and smaller particle size (9).

Nonetheless, if we want to introduce PC as an alternate material to MTA, many more controlled clinical trials are needed to establish the clinical success compared to MTA (8).

The present study was aimed at comparing the clinical and radiographic success rates of MTA and modified Portland Cement (MPC) in pulpotomized human primary mandibular second molars.

Materials and methods

Homogeneity and size distribution of Portland cement Homogeneity and size distribution of Portland cement. The aggregate characteristics, texture, shape, and size distribution of PC contribute considerably towards its workability. Size distribution is vital for its performance in procedures. Therefore, a sieve analysis (a simple technique for particle sizing) was performed on weighed PC (Mashhad Cement Co., Iran).

The samples were then subjected to mechanical milling by a planetary ball-mill device for 15 hours at a constant speed of 200 rpm. The set of balls used in the milling device were 45 stainless-steel balls equally divided into 3 different sizes of 8, 10, and 12 mm in diameter. After that, 20% bismuth oxide was added to the homogenized PC, which was subsequently sterilized with ethylene oxide.

Participants. This clinical trial was performed on 54 primary mandibular second molar teeth in 54 children aged 4–6 years. The Ethics Committee of the Mashhad University of Medical Science of Iran approved the study (NO: 87463). The procedure was explained in its entirety to the patients' guardians, and informed consents were obtained before their participation in the study. Carious primary mandibular second molars were taken from otherwise healthy children who were referred to the pediatric department of the of Mashhad Dental School. For these patients, the vital pulp was likely to be exposed during removal of caries.

The candidates could participate in this study if they met all of the following inclusion criteria: (1) they were aged between 4 and 6 years; (2) they had deep caries in at least one primary lower second molar that

necessitated pulpotomy; (3) their teeth were free from clinical and/or radiographic symptoms, such as spontaneous pain, tenderness to pressure/percussion, mobility, swelling or sinus tract, internal and external and furcal radiolucency; (4) they were systematically healthy children; and (5) they were cooperative. Evaluation of the inclusion criteria and pulpotomy of the teeth was accomplished by a postgraduate student of pediatric dentistry, who was assisted by an academic staff member. After taking the patients' history, their teeth were assessed clinically and radiographically. Periapical radiographs were taken by a 70 kvp and 7 mA periapical X-ray unit (Siemens, Dentotime, Germany) with an extension-cone paralleling aiming device (XCP, Kerr; Sybron Dental Specialties, Bioggio, Switzerland) using the parallel technique. All patients were protected using a lead apron and collar. Randomization. For randomized allocation, one of the investigators, who was blind to the procedure, selected the randomized numbers between 1 and 54 by means of a random number generation website (<http://www.randomizer.org>).

Interventions. The pulpotomy was done based on the standard single-visit treatment protocol. Once the pulpotomy was done, each patient was randomly placed in 1 of 2 groups (group 1: MTA and group 2: MPC) based on their random numbers. The sequence of the steps taken for both groups was as follows: (1) Local analgesia with 2% lidocaine and 1:80000 epinephrine was applied (Daru Pakhsh, Tehran, Iran). (2) The tooth was isolated with a rubber dam. (3) Caries were removed with high-speed carbide burs. The bur was changed after preparation of each 5 samples. (4) The pulp chamber roof was completely removed. (5) The coronal pulpal tissue was removed using a large round steel bur in a slow handpiece. (6) Initial hemostasis was attained by the gentle application of a small, sterile cotton pledget moistened with saline. After hemostasis, 2 mm of MTA (ProRoot; Dentsply Tulsa Dental, OK, USA) (group 1) or MPC (group 2) was applied directly over the radicular pulp. The medicaments were prepared using a 3:1 powder to liquid ratio.

A moist cotton pellet was put in the pulp chamber and the tooth was temporary restored with Zonalin (Kemdent, Wiltshire, UK). After one week, the temporary material and cotton pellet were discarded, and the tooth was restored by a metal crown cemented using glass ionomer cement.

Follow-up. The patients were summoned back for clinical and radiographic evaluations at 6 and 12 months. Two experienced and experimentally blinded dentists clinically and radiographically evaluated the teeth. Inter-examiner reproducibility was found to be good ($k = 0.83$). To assess intra-examiner reproducibility for radiographic assessment, 10% of the

radiographs were reevaluated after two weeks, and the result was optimal ($k = 1.0$).

Hypothesis and outcomes. The study's null hypothesis was that the two treatments (MTA or MPC) would show no differences in clinical and radiographic effectiveness. The clinical success criteria were as follows: lack of pain, mobility, swelling, sinus tract and tenderness to percussion,. Radiographic success was assessed according to the following criteria: normal width and trabeculation in the periodontal ligament and periapical regions, absence of furcal radiolucency, and absence of pathologic root resorption. Pulp canal obliteration was accepted and considered as a normal condition. Presence of clinical/radiographic failure, even in a single canal, rendered the treatment as a failure. In this event, the tooth was excluded from the trial and received suitable treatment.

Sample size. According to prior studies (10), a sample size of 20 in each group with 99% confidence and a power of 90% could detect the differences between the 2 groups (MTA and MPC) at the 6-month follow-up. Considering a probability of a 30% dropout, the groups had a sample size of 26. **Statistical methods.** Fisher's exact test was used to analyze the differences in treatment outcomes. We used the SPSS 24 software (SPSS Inc, Chicago, IL., USA) to perform the analyses, and the significance level was set at 5%.

Result

A sample of 54 children between 4–6 years old were randomly placed in either the MPC (26 teeth) or MTA (28 teeth) group. Treatment results for the 2 groups at the 6- and 12-month follow-ups are presented in Table 1. At both the 6- and 12-month postoperative evaluations, all of the teeth were clinically successful. Radiographic evaluation at 6 months after treatment showed that the MTA group had radiolucency at the furcation area in 2 cases, whereas the MPC group had 3 such cases.

The remaining treated teeth did not show any radiographic changes. The remaining 49 children were recalled for further follow-up at 12 months. At 12 months after treatment, only 1 new case treated with MTA showed furcation radiolucency; however, none of the radiographic failures of the MPC group were new. Even so, no statistically significant difference regarding this parameter existed between the two groups during the course of the follow-up. There were no unfavorable occurrences or side effects in the course of this study.

Table 1. 6- and 12-month radiographic success and failure rates

Group	Evaluations	
	6 months <i>n</i> (%)	12 months <i>n</i> (%)
MTA		
Success:	26 (92.9)	25 (89.3)
Failure:	2 (7.1)	3 (10.7)
MPC		
Success:	23 (88.5)	23 (88.5)
Failure:	3 (11.5)	3 (11.5)
<i>p</i>-value	.663	1.00

Discussion

Treatment options for vital pulp in primary teeth have been a debated topic for years in pedodontics.(11) A precise and accurate diagnosis followed by appropriate treatment is crucial for primary teeth caries.(13) In this regard, treatment choices include the use of many different methods and various dental materials.(14) Studies have shown that MTA has an excellent clinical and radiographic success in primary teeth pulpotomies.(5,15–17)

However, MTA has its limitations, such as its extended setting time, high cost, and difficulty in storage.(17) The literature has shown that MTA and PC have similar favorable effects. This has resulted in a significant body of research showing that PC appears to be a useful alternative for MTA.(19,20)

The first research on PC as a potential alternative material for MTA was done in 2000.(21) Thereafter, a large number of studies have been done to show that MTA can be successfully replaced by PC.(8,9,19,22) However, PC studies have generally been performed on animal models, and clinical research studies on PC are new and limited in number. In the current study, we compared the radiographic and clinical success rates of MTA and modified PC. The radiographic and clinical success and failure rates at 6 and 12 months after pulpotomy treatments were evaluated by Fisher's exact test. The two groups did not have any statistically significant differences in clinical or radiographic results.

Similar to our study's, Oliveria et al. (23) and Sakai et al. (10) reported clinical success rates of 100% (follow-up duration: 24 months). However, unlike those studies, the clinical success rate of Yildirim et al. (24) was 93.3% in the PC group (24 months). In our study, the radiographic success rate was 89.3% in the MTA group and 88.5% in the MPC group. Our results were close to Yildirim's et al. (24) who reported 93.9% radiographic success in the MTA group and 86.7% in the PC group. Also, Ansary et al. (25) described a 95% (24 months) radiographic success rate in the MTA group. In contrast to these findings, Oliveria et al. (23)

and Sakai et al. (10) found radiographic success rates of 100% for both groups (24 months). Agamy et al. (5) (12 months) and Mortazavi (26) (24 months) both reported radiographic success rates of 100% in the MTA group. In this study, all of the radiographic failures showed radiolucency of the furcation.

Most of these studies pointed out the similarities of these two materials in regards to basic composition, physical and chemical characteristics, and biocompatibility, though a few studies on MTA showed its differences with PC.(8) PC particles have a large range of sizes, whereas MTA particles are uniform and smaller in size.(9) Another disadvantage of PC is its lower radiopacity. In this study, PC was modified to obtain uniform particle size and higher radiopacity. Therefore, it could be expected that the two groups would have almost identical results. Finally, this study shows that MPC is a potential option (at least in a short period) for primary molar pulpotomy because it is effective and less expensive, although a few parameters regarding the use of PC as a MTA alternative have to be further investigated and established.

Conclusion

MTA and MPC can be used effectively for primary teeth pulpotomy. Based on the present evidence, MPC can be considered to be an effective and more economical alternative medicament to MTA for use in primary molar pulpotomy. Although the results are promising, more research with longer follow-ups is necessary to determine the suitability of PC before its universal use can be recommended in clinical practice.

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