Mineral trioxide aggregate vs. formocresol in pulpotomized primary molars: a preliminary report

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Abstract

Purpose: The aim of this study was to compare the effect of mineral trioxide aggregate (MTA) to that of formocresol (FC) as pulp dressing agents in pulpotomized primary molars with carious pulp exposure.

Methods: Forty-five primary molars of 26 children were treated by a conventional pulpotomy technique. The teeth were randomly assigned to the MTA (experimental) or FC (control) group by a toss of a coin. Following removal of the coronal pulp and hemostasis the pulp stumps were covered with an MTA paste in the experimental group. In the control group, FC was placed with a cotton pellet over the pulp stumps for 5 minutes and removed; the pulp stumps were then covered by zinc oxide-eugenol (ZOE) paste. The teeth of both groups were restored with stainless steel crowns. Eighteen children with 32 teeth arrived for clinical and radiographic follow-up evaluation ranging from 6 to 30 months.

Results: The follow-up evaluations revealed only one failure (internal resorption detected at a 17 months postoperative evaluation) in a molar treated with formocresol. None of the MTA-treated teeth showed any clinical or radiographic pathology. Pulp canal obliteration was observed in 9 of 32 (28%) evaluated molars. This finding was detected in 2 out of the 15 teeth treated with FC (13%) and in 7 out of the 17 treated with MTA (41%).

Conclusion: MTA showed clinical and radiographic success as a dressing material following pulpotomy in primary teeth and seems to be a suitable replacement for formocresol in primary teeth. (Pediatr Dent 23:15-18, 2001)

When the carious process exposes the pulp, it reacts via inflammation limited to the area close the caries lesion. If the pulp in the root canals seems to be unaffected, pulpotomy is the treatment of choice. Formocresol (FC) has been a popular pulpotomy medicament in the primary dentition for the past 60 years, and is considered the most universally taught and preferred pulp therapy for primary teeth.[1] Concerns have been raised about the toxicity and potential carcinogenicity of FC in humans,[1-8] and alternatives have been proposed to maintain partial pulp vitality. These include electrosurgery,[9,10] laser,[11] glutaraldehyde,[12-15] ferric sulfate,[16-18] freeze-dried bone,[19,20] bone morphogenetic protein,[21-22] and osteogenic protein.[23] Recently the physical and chemical properties of a new root-end filling material, mineral trioxide aggregate (MTA) were described by Torabinejad et al.[24] MTA is a biocompatible material and its sealing ability is better than that of amalgam or zinc oxide-eugenol. It is a powder that sets in the presence of moisture with a pH of 12.5. The setting time of the cement is 4 hours and its compressive strength is 70 MPA, which is comparable with that of IRM.[25] It has been demonstrated that MTA has the ability to stimulate cytokine release from bone cells, indicating that it actively promotes hard tissue formation.[26] The MTA has been proposed as a potential medicament for pulpotomy procedures as well as capping of pulps with reversible pulpitis, apexification, and repair of root perforation.[25] Lately, MTA was tested in monkey teeth as a pulp capping material and produced favorable pulp responses.[27] In this experiment, MTA was found to be superior to calcium hydroxide. After 5 months, no pulpal inflammation was observed in five of six samples capped with MTA, and all six pulps in this group had a complete dentine bridge. In contrast, all of the pulps capped with the calcium hydroxide preparation showed pulpal inflammation, and bridge formation occurred in only two samples.

The objective of this study was to clinically and radiographically evaluate the effects of MTA as a pulp dressing after coronal pulp amputation in primary molars and compare them to those of FC.

Methods

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, was obtained prior to the investigation.

Primary molars in children attending the undergraduate and graduate Pediatric Dentistry Clinics of the Hebrew University-Hadassah School of Dental Medicine were treated by a conventional pulpotomy technique. The suitability of the teeth for pulpotomy was assessed by the authors who also performed the procedures. The authors were previously involved in several pulpotomy studies and used a standardized technique. The criteria for selection of the teeth to be included in the study were: 1) symptomless exposure of vital pulp by caries; 2) no clinical or radiographic evidence of pulp degeneration, such as excessive bleeding from the root canal, internal root resorption, interradicular and/or periapical bone destruction, swelling or sinus tract; and 3) the possibility of proper restoration of the teeth.

Received August 21, 2000 Revision Accepted December 11, 2000

Table 1. Distribution of Assessed Pulpotomized Primary Molars by Tooth Type

	1st primary molar	2nd primary molar	Total
Maxillary	4	5	9
Mandibular	12	11	23
Total	16	16	32

Table 2. Distribution of Assessed Teeth According to Type of Dressing Material

	1st primary molar	2nd primary molar	Total
MTA	8	9	17
Formocresol	8	7	15
Total	16	16	32

Technique

The teeth were randomly assigned to either group by a toss of a coin. In case a child had two molars needing pulpotomy, the second tooth was assigned to the alternative group In cases of three teeth, random assignment was used. All molars were treated with rubber dam isolation. After caries removal, coronal access was obtained with a #330 high-speed bur with water spray to expose the pulp chamber. Following removal of the coronal pulp with a round bur and hemostasis, the pulp stumps in the experimental group were covered with an MTA paste, obtained by mixing MTA powder with sterile saline at a 3:1 powder/saline ratio. In the control group, a cotton pellet moistened with FC was placed for 5 minutes on the amputated pulp, and the pulp stumps were covered by zinc oxide-eugenol (ZOE) paste; in both groups, a layer of IRM was placed prior to restoration with a stainless steel crown.

The children were recalled for clinical and radiographic examination every 6 months. When a patient did not respond or broke an appointment, further attempts were made to call the parents and a follow-up examination was rescheduled. The children were examined clinically at follow-up by one of the three authors who were not blind to which treatment group the subject belong. However, all three authors blindly evaluated the radiographs and a consensus was reached. The treatment was regarded as a failure when one or more of the following signs were present: internal root resorption, furcation radiolucency, periapical bone destruction, pain, swelling, or sinus tract. Pulp canal obliteration (PCO) was not regarded as a failure.

All data were entered into an Excel format and included the patient's name, gender, tooth number treated, age when treated, type of medicament placed over pulp, follow-up time in months, radiographic findings, and clinical findings for every recall visit.

The data were analyzed to assess the success rate of the treatment at the various follow-up periods.

A total of 45 primary molars were pulpotomized in 26 children. Of these 32 teeth in 18 children (11 boys and 7 girls) were available for follow-up evaluation after 6 or more months.

The children's age at time of treatment in the experimental group ranged between 5 and 12 years, with a mean age of 6 years, 5 months. In the control group the age ranged between 5-8 years with an average of 6 years and 2 months. The distribution of teeth according to type is presented in Table 1. MTA was the dressing material used in 15 molars and formocresol in the other 17 teeth (Table 2). Follow-up time ranged between 6 and 30 months, with a mean of 13 months with no difference between the experimental and control group (Table 3). One tooth was excluded from the analysis due to shedding prior to the first follow-up evaluation at 9 months.

The differences were statistically analyzed using the Chi-square test.

Results

Four children with 8 teeth had less than 6 months postoperative period at the time of data analysis. Three children with 5 teeth were not available for follow-up examination since they moved to another city.

The follow-up evaluations revealed only one failure in a mandibular first primary molar in which formocresol was used as a dressing material. The failure was expressed by internal resorption and was detected at a 17 months postoperative evaluation. None of the MTA-treated teeth showed any clinical or radiographic pathology.

Pulp canal obliteration was observed in 9 of 32 (28%) evaluated molars (Figs 1 – 3). This finding was detected in 2 out of the 15 teeth treated with FC (13%) and in 7 out of the 17

Fig 1. A bitewing radiograph showing deep carious lesions in the mandibular first and second primary molars.

Fig 2. The same teeth 9 months after pulpotomy with MTA. Notice dentine bridge formation in the distal root of the mandibular second primary molar (arrow).

Table 3. Maximum Follow- up Time of Pulpotomized Primary Molars

	Follow-up time (months)*				
	6 - 12	13 - 18	19 - 24	> 24	Total
MTA	9	3	4	1	17
Formocresol	9	3	3	-	15
Total	18	6	7	1	32

*Pulpotomized teeth with less than 6 months follow-up peiod were not included.

Table 4. Radiographic Appearance of the Pulp in Assessed Pulpotomized Primary Molars

	Normal appearance of the pulp (%)	Pulp canal obliteration (%)	Internal resorption (%)	Total (%)
MTA	10 (59)	7 (41)	-	17 (100)
Formocresol	12 (80)	2 (13)	1(7)	15 (100)
Total	22 (69)	9 (28)	1(3)	32 (100)

treated with MTA (41%) (Table 4). The difference, however, was not statistically significant ($p>0.1$). The average time of detection of obliteration was 12 months after treatment.

No statistical analysis was performed regarding success of treatment since all teeth in the MTA group and all but one tooth of the controls were clinically and radiographically successful.

Discussion

This preliminary report examined the clinical and radiographic success rates of pulpotomies with mineral trioxide aggregate (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 promotes regeneration of the original tissues when it is placed in contact with the dental pulp or periradicular tissues.[25]

Formocresol was selected as the control group, since it is still considered the gold standard in primary tooth pulp therapy, in spite of the reported toxic, mutagenic, and carcinogenic properties.[3,4,5]

Fig 3. The same teeth 22 months post operative. Notice the almost complete obliteration of the root canals in the mandibular second primary molar (arrow).

The success rates of MTA in this study are promising, with all 15 molars in the experimental group being radiographically successful, compared to 16 of 17 in the control group. Since almost half of the cases had less than 1 year follow up, a longer follow-up period is necessary to reach sound conclusions; however, some teeth were followed for up to 25 months, with no radiographic pathology evident. The formocresol group showed 1 case of internal resorption that was regarded as failure in the present study. However, a recent study has categorized internal resorption as radiographic success.[28] In this study, teeth with internal resorption were not treated but left for follow-up observation. The authors claimed that since this dental radiographic finding does not involve osseous changes it would not affect the permanent successor. For this reason, the authors propose that internal resorption, as long as it is confined to the tooth, should not be defined as failure. Pulpotomy cannot be regarded as successful if it presents internal resorption or any other pathologic consequence of the treatment, even if the permanent successor erupts into its proper location and presents no enamel defect. Not every pathological finding in a primary tooth requires intervention since primary tooth survival or the permanent successor may not necessarily be affected. However, one cannot include such pathological reaction in the definition of successful treatment.

Pulp canal obliteration (some times termed "calcific metamorphosis"[28]) was the most common radiographic finding in both groups. PCO is the result of odontoblastic activity and suggests that the tooth is retaining some degree of vitality[29] and therefore was not regarded as failure. PCO is a common radiographic finding in pulpotomized teeth and a wide range of frequencies has been reported in teeth treated with formocresol;[29] diluted formocresol,[17,28,30] and ferric sulfate.[31] PCO was observed in 13% of the teeth treated with FC that is similar to the frequency of PCO reported in a previous study in which diluted FC was used. This is unlike the findings of Fei et al[17] who reported 44% PCO after application of diluted FC in 27 human molars.

The presence of a dentine bridge in cases treated with MTA was not surprising, since this material has been shown to induce a dentine bridge in studies on monkeys' teeth.[27]

Another clinical advantage of MTA over formocresol is the fact that less time is needed for the procedure. While formocresol requires 3-5 minutes application before the cotton pellet is removed, with MTA the pulp chamber is filled with IRM immediately after application of the dressing material. In addition, in the FC procedure the cotton pellet sometimes adheres to the clot and bleeding reoccurs when the pellet is removed. This does not occur with MTA that is applied directly without a cotton pellet.

Previous investigations of ZOE as a pulpotomy agent or as a base for pulpotomies suggest that ZOE can cause pulp inflammation[32] with a risk of subsequent internal resorption. This reaction is also evident when ferric sulfate is used, since ZOE is placed directly over the pulp tissue. This could be the reason for the observed instances of internal resorption in ferric

sulfate pulpotomies.[28,31] In contrast to this observation, in the present study a layer of MTA separated the pulp from the irritating ZOE. This might be a possible explanation for the lack of internal resorption in teeth treated with MTA. One cannot preclude, however, the development of internal resorption with longer follow-up periods as a response to the MTA.

The authors recognize that it is still premature to draw definitive conclusions on this dressing material for the pulpotomy procedure despite the high success rate observed, as the sample size is small and the follow-up period is short.

Conclusion

MTA showed clinical and radiographic success as a dressing material following pulpotomy in primary teeth after a short-term evaluation period and has a promising potential to become a replacement for formocresol in primary teeth.

The authors wish to thank Dr. Mahmoud Torabinejad from Loma Linda University for providing the MTA material and for his suggestions to the research protocol.

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