

Direct Pulp Capping in Primary Molars using Mineral Trioxide Aggregate: An *in Vivo* Study

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Objective: To do a clinical and radiographic evaluation of the effectiveness of MTA when used as a direct pulp capping material in primary molars. **Study design:** Clinical and radiographic follow-up was performed on 30 primary molars with deep caries lesions in 30 patients from 3 to 9.75 years of age. Pulp exposed during cavity preparation were treated by direct pulp capping with MTA. The follow-up clinical and radiographic examinations were carried out at different time intervals: 6, 7-12, 13-18, 19-24, and >24 months after treatment. **Results:** Twenty-four teeth were evaluated during the entire observation period. Positive clinical and radiographic outcomes were achieved in 19 teeth (13 teeth were saved and 6 were exfoliated). In five teeth, complications were observed only in children under 7 years old. **Conclusion:** Based on these clinical and radiographic results, MTA was found to be successful when used as a direct pulp capping material in primary teeth.

Key Words: Direct pulp capping, mineral trioxide aggregate, primary molars.

INTRODUCTION

Cariosus pulp exposure presents a treatment dilemma for dentists. Direct pulp capping involves the application of a medicament, dressing, or dental material to the exposed pulp in an attempt to preserve its vitality. The aim of pulp treatment is to preserve pulp vitality as much as possible. Thus, direct pulp capping is less invasive than other endodontic treatment methods¹. However, in deciduous teeth there are more limitations compared with permanent ones. Calcium hydroxide, the most commonly used pulp capping material, has been found to be much less successful in primary teeth than in permanent teeth^{cit.2}. This has been explained by the pulp structure in primary teeth, showing a great number of non-differentiated mesenchymal cells which can be converted into odontoclasts, leading to internal resorption of dental tissues²⁻⁵.

Direct pulp capping of a carious pulp exposure in a primary tooth is not recommended, but can be used for exposed pulps in older children one or two years before normal exfoliation^{2,3,6}. In these children, a failure of treatment would not imply the need for a space maintainer after extraction, as it would in younger children. A number of new materials have been tested over the last decades as alternatives to calcium hydroxide. One of them has been Mineral Trioxide Aggregate (MTA).

According to the literature data, this material is biocompatible, non-mutagenic, with good sealing ability⁷⁻⁹. It is worthwhile to point out that recent reports described the use of MTA with good pulp response in primary teeth after direct pulp capping^{1,10-13}. Many authors have suggested the need for further studies involving long-term clinical evaluation of MTA as a direct pulp capping material on primary teeth^{1,6,10,11,14}.

Therefore, the aim of our study was to determine the clinical and radiographic outcomes of direct pulp capping with MTA in primary molars.

MATERIALS AND METHOD

Of 72 teeth with direct pulp capping, the authors were able to collect post-operative data on 30 teeth. This population consisted of 30 children (15 girls and 15 boys) with an age range of 3 to 9.75 years, mean age of 6.5, participated in the study according to the proposed inclusion criteria for direct pulp capping in primary molars with MTA. Prior to the beginning of treatment, parental informed consent was obtained. The distribution of teeth according to type is presented in Table 1.

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Table 1: Number and type of teeth treated

	1st molar	2nd molar	total
maxilla	14	8	22
mandible	2	6	8
total	16	14	30

The inclusion criteria for direct pulp capping were: children with no systemic pathology or allergies; symptom-free primary molars with deep carious lesions that resulted in accidental pulp exposure during cavity preparation; vital pulp; restorable crown; and readiness to appear for follow-up.

The exclusion criteria were: clinical symptoms of pulp degeneration (spontaneous pain, excessive bleeding from exposed pulp, tenderness to percussion, pathological mobility, abscesses, fistulous tracts).

The teeth were isolated with a rubber dam and the carious lesions were completely removed under local anesthesia. All cavities were Black's II class with exposure of mesial pulp horns (up to 1mm).

After these procedures, direct pulp capping was performed. Hemorrhage was controlled by placing sterile, saline-wetted cotton pellets under slight pressure, and waiting 2-3 minutes for hemostasis. Once hemostasis was obtained, the pulp was covered with white MTA (ProRoot; Dentsply/Tulsa Dental, Tulsa, OK, USA). MTA was mixed in accordance with the manufacturer's recommendation of 1g of powder per 0.33g of distilled water. A thick layer of the mixture was gently placed against the exposure using an MTA gun. The material was adapted with a sterile wet cotton pellet and excess MTA was scraped off. In nine cavities before final restoration, a wet cotton pellet was placed according to the manufacturer's instructions and was covered with reinforced zinc oxide-eugenol cement. Twenty-one teeth were restored in the same session. The material used for final restorations was Dyract eXtra compomer (DENTSPLY DeTrey GmbH, De-Trey-Straße 1, 78467 Konstanz, Germany).

The follow-up protocol was carried out in accordance with the Helsinki Declaration of Human Rights and was independently reviewed and approved by the 'Research Ethics Committee for scientific research on human subjects' at the university.

The follow-up examinations were carried out at different time intervals: 6, 7-12, 13-18, 19-24, and > 24 months after treatment. Treatment was considered a failure if one or more of these signs and symptoms were observed: spontaneous pain, swelling/abscess, sinus tract, pain to percussion and palpation, pathological mobility. Radiographic evaluations were performed to detect signs of furcation radiolucency, periapical bone destruction, internal root resorption, and pathological external root resorption.

Statistical analysis

Data was submitted to statistical analysis using the chi-square test. The level of significance was set at P<0.05. Statistical analysis was performed using the SPSS software, version 15.0 (SPSS Inc., Chicago, IL).

RESULTS

All data for the tested teeth are summarized in Table 2.

Table 2. Clinical and radiological outcomes following pulp capping with MTA

		pre-operative	recall time				
			6 months	7-12 months	13-18 months	19-24 months	>24 months
spontaneous pain	no	30	30	22	18	15	13
	yes	0	0	0	3	0	0
tenderness to percussion	no	30	30	22	21	13	13
	yes	0	0	0	0	2	0
tenderness to palpation	no	30	30	22	21	13	13
	yes	0	0	0	0	2	0
increased mobility	no	30	30	22	21	13	13
	yes	0	0	0	0	2	0
radiographic failure exfoliation	no	30	30	22	21	13	13
	yes	0	0	0	0	2	0
		0	0	2	1	3	0

Before the follow-up examinations, two examiners assessed 30 randomly attending patients, as a blind procedure. Inter-examiner agreement was tested using the Kappa index. There was no discrepancy in the results of the percussion tests and the evaluation of tooth mobility recorded by both examiners for the examined 30 patients (kappa value of 0.93). A high consensus was also achieved with regard to randomly selected radiographs from the computer database (kappa value of 0.85).

Six-month observation follow-up visit

All patients returned for check-ups during this time. This examination revealed no clinical or radiographic pathological findings on all treated teeth.

Seven-to-twelve-month observation follow-up visit

Six patients failed to return for evaluation during this period, and in two cases the treated teeth were lost due to natural exfoliation. The remaining 22 teeth did not show any signs of clinical or radiographic failures.

Thirteen-to-eighteen-month observation follow-up visit

One treated tooth was lost physiologically during this period. Three pulpotomy teeth failed. The remaining 18 teeth, signs of clinical and radiographic success were found .

Nineteen-to-twenty-four-month observation follow-up visit

Three patients lost the treated teeth due to normal exfoliation. Two teeth showed signs of apical periodontitis (presence of a sinus tract, radiologic signs of periapical bone destruction) and were extracted.

Twenty-four-month and over observation follow-up visit

Clinical and radiographic follow-ups were carried out on 13 patients. All teeth were rated successful both clinically and radiographically (Fig 1).

Figure 1: (a) Postoperative radiograph of the right upper first primary molar after direct pulp capping performed with MTA. (b) Sixty-month (5 years) follow-up radiograph of the same tooth. No pathological findings.



Summing up, 24 teeth were evaluated during the entire observation period. Positive clinical and radiographic outcomes were achieved in 19 teeth (13 teeth were saved and 6 were exfoliated). Complications were observed in five teeth.

In statistical analysis, the success rate of direct pulp capping with MTA was adjusted for two conspicuous factors: children’s age and placement time of a permanent restoration after the procedure.

Table 3 presents the distribution of pulp capping failure and success depending on the patients’ age at least 12 months after pulp capping. In total, five failures were observed. All of them were found in patients under 7 years old, and a statistically significant difference was detected between the two age groups ($P=0.044$).

The distribution of pulp capping failure and success depending on placement time of the final restoration is showed in Table 4. There was a significantly higher success rate in teeth with immediate than in those with postponed placement of a final restoration ($P=0.008$).

Table 3. Distribution of pulp capping failure and success depending on the patients’ age for patients that followed-up at least 12 months after pulp capping.

age	n	failure	success
< 7 years	13	5 ^a	8
≥ 7 years	11	0 ^a	11
total	24	5	19

^aStatistically significant difference ($P=0.044$).

Table 4: Distribution of pulp capping failure and success depending on the placement time of final restoration.

placement time of final restoration	n	failure	success
directly after pulp capping	18	1	17 ^a
in a second session	6	4	2 ^a
total	24	5	19

^aStatistically significant difference ($P=0.008$).

DISCUSSION

Use of the direct pulp capping method in the treatment of primary teeth has been discussed in the literature. Some authors believe that the method should not be applied to primary teeth due to the high risk of pulp infection in the carious process^{2,3}. Others suggest that it can be used for primary teeth only in the case of traumatic damage to the crown with pinpoint pulp exposure or in the case of carious pinpoint pulp exposure, but only when the pulp has been exposed during final removal of carious dentin³.

The authors emphasize that capping healthy pulp gives very high success rates, whereas capping inflamed pulp results in lower and less predictable success^{2,14}. In our studies, asymptomatic pulp was a prerequisite for inclusion in the direct pulp capping method.

Until the 1990s, mixtures containing calcium hydroxide were regarded as the materials of choice in the treatment of exposed pulp^{3,14}. The spectrum of success rates ranged from 13% to 96%^{15,16}. There are several disadvantages of calcium hydroxide: disintegration over time, inability to provide a permanent seal, the porous nature of the reparative dentin bridge, and creation of risk of internal root resorption^{15,16}.

In the 1990s, Torabinejad and his coworkers at Loma Linda University (California) developed mineral trioxide aggregate (MTA) for multiple use in restorative dentistry and surgical procedures¹⁷. MTA is a biocompatible material with good sealing ability. It has been demonstrated that MTA has the ability to stimulate cytokine release from bone cells indicating that it actively promotes hard tissue formation. Several studies document that MTA is an effective material in pulp capping and pulpotomy in primary teeth. Excellent tissue healing has been observed over the useful life of primary teeth and no adverse effects have been noted on exfoliation or the eruption of permanent teeth^{6,11,15}.

In the current study, six patients missed long-term follow-up and 24 returned. Positive outcomes were achieved in 19 teeth of the 24 patients that followed-up. In the available literature, there are few

publications presenting the results of direct pulp capping in primary dentition. Bodem *et al*¹ were the first authors to publish a case report evaluation of MTA as a direct capping material in a primary first molar in a 7-year-old boy. They found no pathological clinical or radiographic findings 18 months after the procedure. Caicedo *et al*¹⁰ obtained 80% and Kotsanos *et al*¹⁸ 88.3% success rates in direct pulp capping. On the other hand, Aminabadi *et al*¹³ and Ghajari *et al*¹² demonstrated an overall success rate above 90% and Tuna *et al*¹¹ showed positive outcomes even in all 22 primary molars after a 24-month observation.

In our study, complications were observed in five cases. All complications appeared after at least 12 months following the procedure, and only in children under 7 years old. There were no treatment failures in older children, over 7. The complications could be associated with difficulties and uncertainties of diagnosing pulp disease, especially in younger children¹⁰.

We found that the time of restoration placement greatly impacts the success rate of exposed pulp healing. We observed significantly more failures in teeth with delayed restorations compared with immediate definitive restorations, which was also confirmed by other authors^{13,19}. In a pulp capping procedure, bacterial leakage through the temporary filling is considered to be detrimental to treatment outcome. Microleakage of coronal restoration allows bacteria to migrate pulpally and initiate degenerative pathosis^{10,16}. For this reason, immediate application of the final restoration should be recommended.

CONCLUSION

Based on the clinical and radiographic results, MTA was found to be successful when used as a direct pulp capping material in primary teeth. Further long-term investigations are needed to support these outcomes.

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