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Clinical long-term evaluation of MTA as a direct pulp capping material in primary teeth

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Abstract

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Aim To evaluate the effectiveness of mineral trioxide aggregate (MTA) when used as a pulp capping material in primary teeth.

Methodology Clinical follow-up was performed on 25 symmetrical pairs of primary molars with deep occlusal caries, in 25 patients between the ages of 5 and 8 years. Pulps exposed during cavity preparation were treated by direct pulp capping with MTA or calcium hydroxide, based with resin-bonded zinc oxide eugenol cement and restored with amalgam. Clinical and radiographic examinations were carried out at 1, 3, 6, 9, 12, 18 and 24 months.

Results Twenty-four-month clinical and radiographic follow-ups were carried out on 22 patients. One patient failed to return for evaluation after 1 month, one after 9 months and another after 12 months. During follow-up, none of the MTA and calcium hydroxide groups exhibited clinical or radiographic failure.

Conclusions Mineral trioxide aggregate was found to be as successful as calcium hydroxide when used for direct pulp capping in primary teeth. Further histological investigations are needed to support these findings.

Keywords: direct pulp capping, mineral trioxide aggregate, primary teeth.

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Introduction

Despite modern advances in the prevention of dental caries and an increased understanding of the importance of maintaining the natural dentition, many teeth are still lost prematurely. This loss can lead to malocclusion or to aesthetic, phonetic, or functional problems that may be transient or permanent in nature. The primary objective of pulp therapy was to maintain the integrity and health of damaged teeth and their supporting tissues (Fuks 2000).

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 rationale behind this treatment is to encourage the pulp to initiate reparative tertiary dentine formation at the exposure site. The success rate of this treatment is not particularly high in primary teeth and it therefore has limited application in this field (Kopel 1992, Fuks 2000, Rodd *et al.* 2006).

Many materials and drugs have been used as pulp capping agents. Calcium hydroxide has been the standard by which all others were judged and has been generally accepted as the agent of choice (Camp & Fuks 2006, Olsson *et al.* 2006). Nevertheless, it has been shown that calcium hydroxide is soluble and degrades with time, and most dentine bridges contain multiple tunnel defects, which often leads to failure of a long-term bacteriometic seal (Cox *et al.* 1985, 1996).

A number of new materials have been tested during the last two decades as alternatives to calcium hydroxide. One of them is mineral trioxide aggregate (MTA), a biocompatible, nonmutagenic cement (Kettering & Torabinejad 1995, Torabinejad *et al.* 1995, 1998, Holland *et al.* 1999) with good sealing

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ability (Torabinejad *et al.* 1993, 1994, Bates *et al.* 1996, Fischer *et al.* 1998, Nakata *et al.* 1998). It was originally described in the dental literature by Lee *et al.* (1993) as a surgical root-end filling material. After its approval in 1998 by the US Food and Drug Administration, the use of MTA has expanded to other applications such as direct pulp capping (Aeinehchi *et al.* 2003, Bodem *et al.* 2004, Iwamoto *et al.* 2006), repair of root and furcation perforations (Torabinejad & Chivian 1999, Main *et al.* 2004), apexification (Shabahang & Torabinejad 2000, Steinig *et al.* 2003), pulpotomy (Eidelman *et al.* 2001, Agamy *et al.* 2004, Farsi *et al.* 2005, Holan *et al.* 2005) and obturation of retained primary teeth (O'Sullivan & Hartwell 2001).

Several animal studies on uninflamed, traumatically exposed pulps have shown that MTA exhibits better results than calcium hydroxide when used as direct pulp capping agent (Abedi *et al.* 1996, Pitt Ford *et al.* 1996, Faraco & Holland 2001). Although few in number, several studies specify MTA as an effective material for direct pulp capping in human permanent teeth with mechanical pulp exposures (Aeinehchi *et al.* 2003, Iwamoto *et al.* 2006). However, only a single case study with a long-term clinical and radiographic follow-up involving primary teeth has been reported (Bodem *et al.* 2004). Accordingly, the need for further studies involving the long-term clinical evaluation of MTA as direct pulp capping material on primary teeth is emphasized.

The aim of this *in vivo* study was to evaluate the long-term effectiveness of MTA when used as pulp capping material in primary teeth, compared with calcium hydroxide.

Materials and methods

Clinical follow-up was performed on symmetrical pairs of primary molars with deep occlusal caries, on healthy participants between the ages of 5 and 8 years. All subjects and their parents were informed of possible complications and parents' informed consent for treatment was obtained. Procedures were approved by the Human Ethics Committee at the Ankara University Faculty of Dentistry. Amongst possible candidates, the teeth that had any of the clinical and radiographic criteria mentioned in Table 1 were excluded from the study. Under local anaesthesia and after rubber dam isolation, carious enamel lesions were removed using high-speed handpieces with diamond burs. The dentine caries lesions were excavated with low-speed handpieces and tungsten carbide burs. During these procedures, if the pulps were exposed and if the exposure was <1 mm, direct pulp capping was performed according to the nature of the bleeding from the exposure (red colour, haemostasis evident in 2–3 min). The cavities were washed with sterile saline and dried with sterile cotton pellets. Light pressure was applied with moist cotton pellets to control haemorrhage. Once haemostasis was obtained, the pulp in one of the symmetric primary molars was covered with white MTA (ProRoot; Dentsply/Tulsa Dental, Tulsa, OK, USA) or calcium hydroxide (Dycal; Dentsply, L.D. Caulk, Milford, DE, USA) and the second tooth was treated with the alternate agent. The material employed for the first tooth was randomized. MTA powder was mixed with sterile water in a 3 : 1 ratio, placed on the exposure sites with plastic amalgam carriers and light pressure was applied with moist cotton pellets. Hard setting calcium hydroxide paste (Dycal) was mixed according to the manufacturer's instructions and applied to the exposure sites with ball-ended instruments. Resin-bonded zinc oxide eugenol (ZOE) (Kalzinol; Dentsply) cement at a thickness of 2 mm was used over both materials. Finally, the teeth were restored with amalgam (Cavex non-gama 2; Cavex Holland B.V., Haarlem, the Netherlands).

If the pulp of one of the symmetrical molars was not exposed during cavity preparation, the tooth was restored and the patient was excluded from the study.

Table 1 Clinical and radiographic exclusion criteria[a]

Clinical exclusion criteria	Radiological exclusion criteria
Spontaneous pain	Periodontal ligament space widening
Sensitivity to percussion/palpation	Loss of lamina dura
Swelling of the vestibulum or associated sinus tracts	Furcation radiolucency
Pathological mobility	Internal or external root resorption

[a]The cases exhibiting the factors were not accepted into the study.

Table 2 Distribution of direct pulp capped primary molars

	First primary molars	Second primary molars	Total
Maxillary	0	4	4
Mandibular	10	36	46
Total	10	40	50

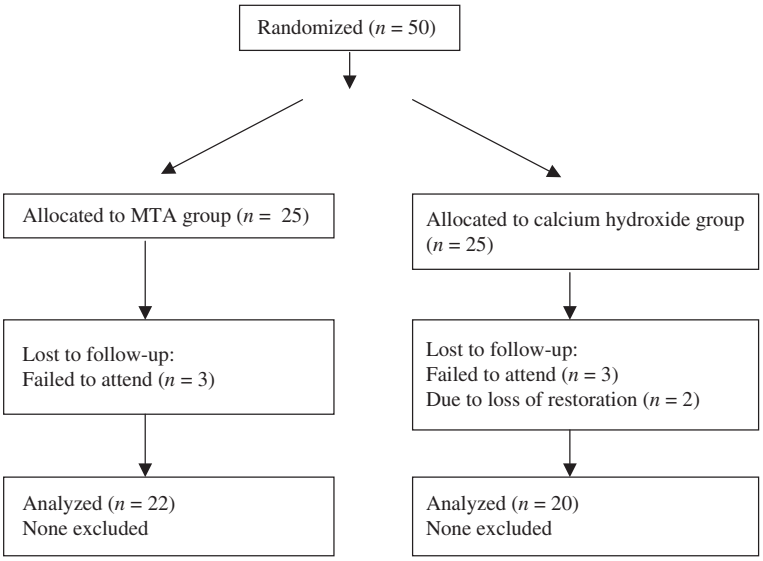

Figure 1 Flow diagram of trial.

Clinical follow-ups were performed on 50 primary molar teeth in 25 patients, of whom 13 were females and 12 were males. The distribution of the evaluated teeth is presented in Table 2.

Clinical and radiographic follow-up was carried out at 1, 3, 6, 9, 12, 18 and 24 months. Two investigators, who attended a calibration session before the follow-up examinations, blindly evaluated the teeth clinically and radiographically, and consensus was reached. The treatment was considered to be clinically and radiographically successful when none of the following signs or symptoms was present: spontaneous pain, tenderness of percussion, swelling, fistulation, pathological mobility, furcation radiolucency, periodontal ligament space widening, internal or external root resorption.

A CONSORT diagram showing the flow of participants through each stage of the trial is shown in Fig. 1. The differences were planned to be statistically analysed by the chi-squared method.

Results

Twenty-four-month clinical and radiographic follow-ups were carried out on 22 patients. One patient failed to return for evaluation after 1 month, one after 9 months and another after 12 months. Although no pathological signs were observed, because of the loss of restoration that had been placed on the pulp capping material, one tooth was excluded from the clinical study after 9 months and one tooth after 18 months, both from the calcium hydroxide group.

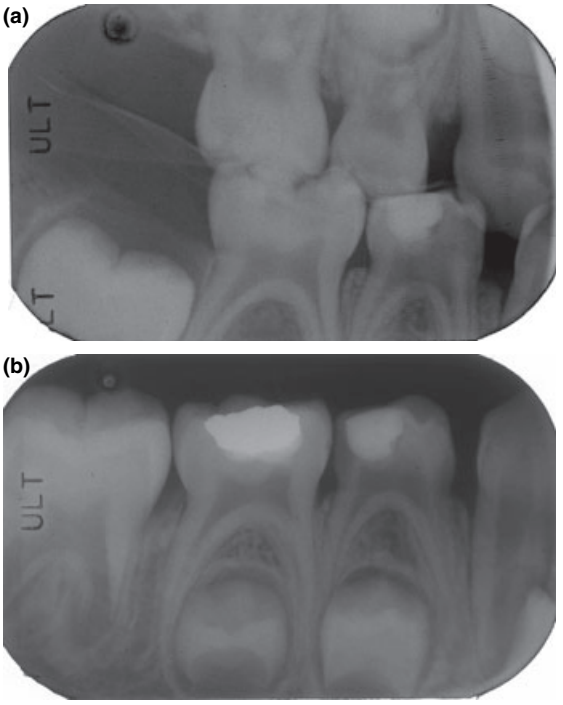

Figure 2 (a) Preoperative radiograph of the right mandibular second primary molar before direct pulp capping performed with MTA. (b) Twenty-four-month follow-up radiograph of the same tooth after direct pulp capping with MTA. No pathological findings. The first primary molar with caries was treated later on.

Radiographs obtained from the patients during their follow-up examinations were assessed according to the evaluation criteria and their clinical and

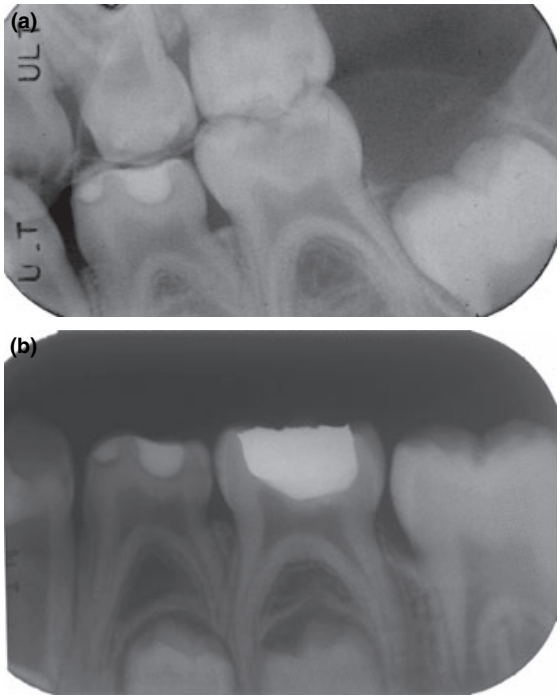

Figure 3 (a) Preoperative radiograph of the left mandibular second primary molar of the same patient before direct pulp capping performed with calcium hydroxide. (b) Twenty-four-month follow-up radiograph of the same tooth after direct pulp capping with calcium hydroxide. No pathological findings.

radiographic success status was determined (Figs 2 and 3).

Thermal sensitivity was observed in one tooth from the calcium hydroxide group in the first month and in one tooth from the MTA group in the third month. Complaints decreased in the following months.

During the follow-up periods, no teeth exhibited clinical and radiographic failure. Hence, no statistical analyses were performed regarding the success of the treatment.

Discussion

This study was designed to evaluate the effectiveness of MTA used as a direct pulp capping material in primary molar teeth, compared with calcium hydroxide. Patient-to-patient variability was minimized by utilizing a split-mouth model. However, a limitation of this *in vivo* study was to collect a satisfactory number of eligible patients with occlusal caries of similar depth in symmetric primary molars within a reasonable time frame.

Direct pulp capping treatment is generally not recommended for primary teeth because the prognosis is reported to be generally poor (Fuks 2000, Rodd *et al.* 2006). Kennedy & Kapala (1985) stated that the high cellular content of primary pulp tissue may be responsible for failures of direct pulp capping in primary teeth. These authors believe that undifferentiated mesenchymal cells may differentiate into odontoclastic cells in response to either the caries process or the pulp capping material, which could lead to internal resorption. In the present study, however, no failure was observed in the long-term clinical follow-up of the primary teeth treated with MTA or calcium hydroxide as pulp capping materials.

Following a pulp capping procedure, bacterial leakage through the final restoration is considered by some to be more detrimental to outcome than bacterial contamination at the time of the treatment (Cox *et al.* 1982, 1985). This finding underlines the need for a good seal in the final restoration after the completion of the pulp capping procedure (Mjor 2002). For this reason, resin-bonded ZOE was placed above the pulp cap and before permanent restoration. Amalgam restoration was preferred over stainless steel crowns as the teeth had occlusal caries and the cavity margins were not involved in the approximal surfaces.

Mineral trioxide aggregate has been shown to give better results than calcium hydroxide in direct pulp capping of uninflamed animal pulps (Abedi *et al.* 1996, Pitt Ford *et al.* 1996, Faraco & Holland 2001). Aeinehchi *et al.* (2003) reported less inflammation and thicker dentine bridge with MTA than calcium hydroxide when used as a pulp capping material in human teeth with mechanical pulp exposures. MTA does not contain calcium hydroxide, but after its hardening, it contains calcium oxide that could react with tissue fluids to form calcium hydroxide. Therefore, it is believed that MTA has an action similar to that of calcium hydroxide (Faraco & Holland 2001). According to Pitt Ford *et al.* (1996), MTA's superiority could be due to its good sealing ability and biocompatibility. On the other hand, Cox *et al.* (1985) demonstrated long-term evidence that calcium hydroxide softens and allows leakage, resulting in recurrent pulpal inflammation and necrosis after 1–2 years. In the present study, both MTA and calcium hydroxide were successful when used as direct pulp capping material in primary molars. The reason for this similarity might be the application of ZOE, which provides a long-term bacterial-tight seal and compensates for the dissolution of calcium hydroxide.

Iwamoto *et al.* (2006) reported that there were no significant clinical and radiographic differences between MTA and calcium hydroxide as direct pulp capping materials following 30 and 136 days of evaluation in mechanically exposed human third molars. Their histological findings did not show statistically significant differences in pulpal response and presence of a dentine bridge between the two materials. Although the clinical follow-up periods in the present study are longer, there is an agreement between the two studies.

With the exception of the case report of Bodem *et al.* (2004), no data have been published concerning the clinical evaluation of MTA as direct capping material in primary teeth. They stated that there was no pathological finding either on the radiograph taken after 1 year or on the clinical examination after 18 months, and the pulps remained vital after direct capping of cariously exposed primary molar pulp with MTA.

Conclusion

Based on the results of this long-term clinical and radiographic study, MTA was found to be as successful as the control calcium hydroxide when used as direct pulp capping material in primary teeth. Further histological investigations are needed to support these findings.

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