Outcome of Direct Pulp Capping with Mineral Trioxide Aggregate: A Prospective Study

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Abstract

Introduction: The aim of this experimental study was to assess the outcome of direct pulp capping with mineral trioxide aggregate (MTA) after complete excavation of caries in permanent dentition with a 2-visit treatment protocol. **Methods:** Sixty-four teeth with deep carious lesions were consecutively selected. The mean age of the patients was 36.1 ± 15 years. An initial diagnosis of deep caries, with no irreversible pulp involvement, was made. Excavation of caries was performed under a rubber dam and operating microscope magnification. White MTA was applied, and a provisional restoration was placed. At the following appointment, positive sensibility testing and the MTA setting were confirmed. Bonded composite restorations were placed afterward. The patient was recalled at least 1 year after treatment for clinical and radiographic control. Outcome was described as success or failure. Success was defined as lack of complaints from the patient, positive reaction to cold testing, no sensitivity to percussion, and no widening of the periodontal ligament on the recall periapical radiograph. **Results:** Forty-six teeth (77.9%) were recalled after 3.6 years (standard deviation = 1.1 years). The overall success rate was 91.3%. The success rate in occlusal caries was 100% and 89.7% in proximal caries (difference = 10.3%; 95% confidence interval [CI], 8.5–89.1). The success rate in initial caries was 94.7% and 88.9% in secondary caries (difference = 5.8%; 95% CI, −48.1 to 59.7). The success rate in patients younger than 40 years was 100% and 80% in patients aged 40 years or older (difference = 20%; 95% CI, 4.2–35.8). **Conclusions:** Direct pulp capping with MTA after pulp exposure during excavation of deep caries could maintain pulp vitality in permanent teeth when a 2-visit treatment protocol is observed. *(J Endod 2015;41:1026–1031)*

Key Words

Complete excavation, direct pulp capping, mineral trioxide aggregate

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The first description of a pulp capping procedure was the application of a cap of lead foil to an exposed pulp by Pfaff (1756) (1, 2). Vital pulp therapy in the form of pulp capping and pulpotomy has long been recognized as a procedure aimed to maintain pulp vitality after caries exposure (3).

In deep carious lesions, inflammation in superficial layers of the pulp, especially subjacent to the region of the involved dentinal tubules, is more pronounced compared with deeper layers, whereas pulp tissue in the root canal usually remains normal, except for the presence of dilated blood vessels (3, 4). Pulpal healing and repair after direct pulp capping or partial pulpotomy was reported in *in vivo* studies after the removal of caries (6) or exposure after accidental trauma (7).

Optimal prognosis of vital pulp therapy is based on the elimination of etiologic factors with complete removal of diseased and contaminated tissues (6). When pulp exposure occurs, immediate direct pulp capping is preferred to reduce the risk of infection and further damage to the pulp.

The most studied material for direct pulp capping is calcium hydroxide (CH) in a variety of formulations (pure and fast setting). However, the success rate of direct pulp capping with fast-setting CH-based cements varied widely between 31.8% after 1 year (8) and 72.7% after 10 years (9).

Mineral trioxide aggregate (MTA) has been investigated as a material for direct pulp capping during recent years and showed superior results when compared with CH. MTA reduces inflammation, hyperemia, and necrosis levels. It also creates thicker dentin bridges and minimal tunnel defects, and the apposition of dentin is faster (10). MTA resists bacterial leakage and may provide protection for the pulp, allowing repair and continued pulp vitality (6). The disadvantages of MTA are discoloration (6), difficult manipulation, slow setting time (11), and cost of the material.

The purpose of this experimental study was to assess the treatment outcome of deep caries lesions treated with MTA direct pulp capping. The following parameters were addressed:

1. Pulp sensibility
2. Tooth discoloration
3. Caries recurrence

The tested null hypotheses were that the following parameters do not influence the outcome of direct pulp capping with MTA: bleeding or no bleeding during caries excavation, occlusal or proximal caries, initial or secondary caries, and age younger or older than 40 years.

Methods

All patients in this study were selected consecutively from the daily general private practice of 1 of the authors (M.S.M.) over a period of 3 years between 2008 and 2011. All patients had completed a detailed clinical history questionnaire, bite-wing radiographs, percussion, and cold thermal testing (EndoFrost; Roeko, Langenau, Germany).

Over this period, a total of 59 patients were treated after the diagnosis of extensive primary or secondary deep caries in 64 teeth in which pulp exposure was anticipated because of caries extension on radiographic or clinical evaluation. Eventually, 64 permanent teeth were treated: 5 incisors, 17 premolars, and 42 molars; 38 were maxillary,

and 26 were mandibular. The patient sample consisted of 32 females and 27 males with a mean age of 36.1 years (standard deviation [SD] = 15.1).

All participants or legal guardians were asked to sign an informed consent form in which the treatment was briefly explained. The inclusion criteria were permanent teeth with caries, a positive cold test, the absence of spontaneous and lingering pain, the absence of percussion pain, and the absence of sinus tract or swelling.

One operator (M.S.M.) completed all treatment procedures, with the exception of 2 definitive bonded restorations that were performed by another general practitioner at the same practice. All procedures were performed under a rubber dam and local anesthesia of 4% articaine with 1:100,000 epinephrine (ARTINIBSA; Laboratórios Inibsa SA, Barcelona, Spain). Caries excavation was performed under ×6 to ×16 magnification (DFV Vasconcellos MC-M1232; DFV, Rio de Janeiro, Brazil) using caries detector dye (Sable seek or Seek; Ultradent Products GmbH, Cologne, Germany) applied with a disposable brush tip (Black mini brush tip, Ultradent Products GmbH). High-speed round (801.314) diamond burs with medium grit 014, 016, or 018 (Komet Dental, Lemgo, Germany) on an air turbine with water and air spray coolant were used for enamel removal. Round steel (H1SE.204) slow-speed burs 014, 016, or 018 (Komet Dental) or LN burs 014, 016, or 018 (Dentsply Maillefer, Ballaigues, Switzerland) with water and air spray coolant and sharp hand excavators (EXCE2 and EXCE3; Hu-Friedy, Chicago, IL) were used for caries removal. Caries excavation continued even after pulpal exposures occurred and was complete when dentin offered resistance to hand excavation with a sharp excavator as per final inspection.

In all cases in which pulp bleeding occurred, hemostasis was achieved with water from a 2-way syringe of the dental unit and occasionally pressure applied with dry cotton pellets. Subsequently, the surrounding dentin was gently air-dried with a 2-way syringe until all excess water had been removed. White MTA (ProRoot; Dentsply Tulsa Dental, Tulsa, OK) mixed according to the manufacturer's instructions, 3:1 powder-to-liquid ratio, was applied in a thin layer of 1.5 mm over the exposure site and surrounding dentin with the aid of a double-ended medium 1.2-mm/1.6-mm ball burnisher (Henry Schein Inc, Melville, NY), leaving some circumferentially dentin available for bonding. Ten minutes after the direct capping procedure, a provisional restoration with zinc oxide/zinc sulfate–based cement (Coltosol F; Coltène/Whaledent, Altstätten, Switzerland) was placed directly over the MTA.

At the following appointment, 4 to 12 weeks later, if spontaneous pain complaints were reported, cold testing was negative, and/or percussion resulted in a painful reaction, root canal treatment was performed. Otherwise, provisional restorations were removed with round steel (H1SE.204) slow-speed burs 014, 016, or 018 (Komet Dental) or LN burs 014, 016, or 018 (Dentsply Maillefer) with water and air spray coolant. MTA setting was confirmed and its color determined. A Palodent sectional matrix (Dentsply DeTrey GmbH, Konstanz, Germany) was adjusted, and a 35% phosphoric etchant solution (Ultra-Etch, Ultradent Products GmbH) for 30 seconds was applied on the enamel, dentin, and MTA surface and was rinsed and air-dried for 5 seconds. A light-curing adhesive agent (OptiBond Solo; KerrHawe Neos, Orange, CA) was applied with a microbrush in a brushing motion for 20 seconds, and excesses were blown out. The bonding agent was light cured (Bluephase G2 LED; Ivoclar Vivadent AG, Schaan, Liechtenstein) for 20 seconds, and all cavities were filled with composite (Tetric evo Ceram, Ivoclar Vivadent AG) in several layers and light cured for 40 seconds. Patients were recalled yearly for clinical tests and periapical radiographs. Success was defined as a positive cold test, no pain on percussion, and no widening of the periodontal ligament on the periapical radiograph. All radiographs were acquired using a dental radiograph unit (Philips Oralix 65; Philips, Eindhoven, The Netherlands) set at 65 kVp, 7.5 mA, and 0.2 seconds. A digital dental sensor (Visualix-1; Gendex Dental Systems, Milan, Italy) was used to capture all digital radiographs with a positioning holder using a perpendicular technique. The digital radiographs were visualized with imaging software (VixWin, Gendex Dental Systems) on a personal computer (ASUS Eee PC 1201 PN Netbook; ASUSTek Computer Inc, Taipei, Taiwan).

One operator (M.M.) diagnosed recurrent caries through clinical and radiographic evaluation. When in doubt, the case was classified as having recurrent caries. The same operator classified discoloration subjectively as either discolored or not discolored. When in doubt, the case was classified as discolored.

Data entry and analysis were performed with a statistical software package (SPSS 21.0; SPSS Inc, Chicago, IL). The Fisher exact test and the Kaplan-Meier method were used for analysis with a significance level of $P < .05$.

Results

This sample consisted of 12 teeth with occlusal caries and 52 with proximal caries, of which 26 were primary caries and 38 secondary caries. On the first appointment, pulp bleeding during caries excavation occurred in 29 of the 64 teeth; 92.2% of the patients (59 teeth) returned for the second appointment. In 3 of 5 teeth that were lost to recall, no bleeding was detected during the first appointment, and in the

TABLE 1. Outcome of Direct Pulp Capping with Mineral Trioxide Aggregate According to Study Variables: Bleeding, Caries Location, Caries Treatment, and Age

Studied variables	Bleeding		Caries treatment		Caries location		Age	
(*n* = analyzed teeth)	Present (*n* = 21)	Absent (*n* = 25)	Initial (*n* = 19)	Secondary (*n* = 27)	Occlusal (*n* = 7)	Proximal (*n* = 39)	<40 (*n* = 26)	≥40 (*n* = 20)
Success								
Pulp vitality without apical radiolucency, *n* (%)	19 (90.5)	23 (92)	18 (94.7)	24 (88.9)	7 (100)	35 (89.7)	26 (100)	16 (80)
Failure								
Spontaneous pain, *n* (%)	2 (9.5)	—	1 (5.3)	1 (3.7)	—	2 (5.7)	—	2 (10)
No pulp vitality with apical radiolucency, *n* (%)	—	2 (8)	—	2 (7.4)	—	2 (5.7)	—	2 (10)
Difference between groups, % (95% CI)	1.5 (−54.1 to 51.1)		5.8 (−48.1 to 59.7)		10.3 (8.5–89.1)		20 (4.2–35.8)	
P value	>.05		>.05		>.05		<.05	

CI, confidence interval.

Significance level, $\alpha < .05$. Only recalled patients were considered for these table calculations.