Histologic Assessment of Human Pulp Response to Capping with Mineral Trioxide Aggregate and a Novel Endodontic Cement

Mohammad Hassan Zarrabi, DDS, Maryam Javidi, DDS,* Amir Hossein Jafarian, MD,† and Bahareh Joushan, DDS**

Abstract

Introduction: This study was conducted to compare human pulp response to mineral trioxide aggregate (MTA) and a novel endodontic cement (NEC) when used as pulp capping materials after a time period of 2 and 8 weeks. **Methods:** Thirty-two premolar teeth that were scheduled for extraction for orthodontic reasons were exposed and capped with either MTA or NEC. Half of the specimens underwent extraction and histologic analysis after 2 weeks, and the remaining half were assessed after 8 weeks. Each slide was graded histologically according to the morphology of the dentinal bridge, thickness of the dentinal bridge, presence of odontoblast cells, and inflammation of the pulp. **Results:** Both MTA and NEC showed significantly better pulp response after 8 weeks compared with 2 weeks, with a thicker and more tubular pattern of the dentinal bridge, less pulp inflammation, and a palisade pattern of odontoblast cells. Although MTA and NEC groups had no significant difference in each measure in both time intervals, NEC induced a thicker dentinal bridge with less pulp inflammation at both 2 weeks and 8 weeks, compared with MTA. **Conclusions:** MTA and NEC showed similar biocompatibility and favorable response in pulp capping treatment and inducing the formation of the dentinal bridge. *(J Endod 2010;36: 1778–1781)*

Key Words

Direct pulp cap, histology, MTA, NEC

From the *Department of Endodontics, Faculty of Dentistry and Dental Research Center, Mashhad University of Medical Sciences, Mashhad, Iran, and Iranian Endodontic Research Center, Tehran, Iran; and †Department of Pathology, Ghaem Hospital, Mashhad University of Medical Sciences, Mashhad, Iran.

Address requests for reprints to Dr Amir Hossein Jafarian, Department of Pathology, Ghaem Hospital, Mashhad University of Medical Sciences, Ahmad Abad St. Parastar Av., Mashhad, Khorasan, Iran. E-mail address: jafarianah@mums.ac.ir.

0099-2399/$ - see front matter

doi:10.1016/j.joen.2010.08.024

Conservative pulp therapy is indicated whenever the remaining pulp exhibits reversible pulpitis and can induce a reparative barrier that protects the tissue from microbial challenges. In particular, direct pulp capping can be performed for teeth with deep caries, mechanical exposures, and traumatic injuries to maximize pulp preservation. The goal of treating the exposed pulp with an appropriate pulp capping material is to promote the dentinogenic potential of pulp cells (1, 2).

Dentin bridge formation can occur under a variety of pulp capping materials. Direct pulp capping with mineral trioxide aggregate (MTA) has proved to be effective in stimulating tertiary dentin formation in canine models and primates (3). However, the mechanism by which this occurs has not been explained. MTA has been found to induce a significantly greater frequency of dentinal bridge formation, less pulp inflammation, and bridges with greater mean thickness compared with calcium hydroxide (3–5). However, MTA has a delayed setting time, poor handling characteristics, an off-white color, and is more expensive (6).

Recently, a novel endodontic cement (NEC) with different chemical composition from MTA (7, 8), but with identical applications, has been developed (9, 10). NEC consisting of different calcium compounds (ie, calcium oxide, calcium phosphate, calcium carbonate, calcium silicate, calcium sulfate, and calcium chloride) combines the biocompatibility of MTA with more efficient characteristics such as significantly shorter setting time, good handling characteristics, and no tooth staining (7, 10, 11). This cement has been evaluated in several research projects. Asgary et al (10) showed that NEC can result in better pulp response compared with MTA when used as a pulp capping agent and also can result in higher mean thickness of the dentinal bridge than MTA.

The purpose of the present study was to evaluate the histomorphologic response of human dental pulp to capping with MTA and NEC in 2-week and 8-week intervals after pulp capping.

Material and Methods

This prospective randomized controlled clinical trial was performed *in vivo* and was approved by the Ethics Committee of Mashhad University of Medical Sciences, Mashhad, Iran, in 2009, and the protocol was registered at clinical trials.gov (Clinicaltrials.gov ID: NCT01066533). First premolars that were scheduled for extraction for orthodontic reasons were selected. Inclusion criteria included the following: (1) patients who were 15–25 years old; (2) patients with no systemic disease; (3) teeth with clinically normal pulps, with closed apex, no caries either clinically or radiographically, and without any restoration; and (4) teeth with no periodontal involvement.

A total of 32 teeth were used, and according to the material used for pulp capping and the duration of follow-up, they were divided into 4 groups: NEC with 2-week follow-up (group 1), NEC with 8-week follow-up (group 2), MTA with 2-week follow-up (group 3), and MTA with 8-week follow-up (group 4). Teeth were randomly assigned to treatment groups by using a statistical randomized treatment table. Two intact teeth were selected as the control group. Signed consent was given by patients and their parents after they had received a thorough explanation related to the study. After local anesthesia, operative procedures were performed with rubber dam placement and

TABLE 1. Histologic Features and the Grading System to Evaluate the Samples

Feature	Grade I (worst)	Grade II	Grade III (best)
Morphology of dentinal bridge	No tubules present	Irregular pattern of tubules	Regular pattern of tubules
Thickness of dentinal bridge	<0.1 mm	0.1–0.25 mm	>0.25 mm
Intensity of pulp inflammation	Severe inflammation or abscess formation	Minimal to moderate inflammation	No inflammation
Odontoblast layer	Absent	Presence of odontoblast cells	Palisade pattern of cells

disinfected with 2% chlorhexidine gluconate. Class I occlusal cavities were prepared with ½ round carbide burs under air-distilled water cooling. At the exposure site hemorrhage was controlled by sterile cotton pellets, saline, and 5.25% NaOCl. NEC cement was mixed with its liquid to provide a dense creamy mixture, and it was applied as pulp capping material in groups 1 and 2. MTA (Angelus, Londrina, Brazil) was mixed according to the manufacturer's instructions until it had the consistency of wet sand. In experimental groups 3 and 4, each group had 8 teeth receive MTA as pulp capping material. All procedures were performed by the same operator, and the test materials were applied in a blinded fashion. The cavities were sealed immediately by sandwich technique, with a layer of Fuji II glass ionomer (GC International Corp, Tokyo, Japan) and composite resin (Helomolar HB; Ivoclar Vivadent, Schaan, Liechtenstein).

After 2 weeks teeth in groups 1 and 3 were extracted, and after 8 weeks teeth in groups 2 and 4 were extracted. After extraction, the apical third of the root was sectioned under water cooling, allowing better formalin fixation. The specimens were fixed in 10% formalin for 24 hours and then were decalcified in 14% ethylenediaminetetraacetic acid (4–6 months). They were then embedded in paraffin and cut at a microtome setting for 5 μm. The sections were stained with hematoxylin-eosin (H&E). Samples were evaluated microscopically in a blinded manner by a pathologist by using a light microscope equipped for histometry. The pathologist was not aware of the types of capping material. Each slide was graded from I to III (Table 1) according to criteria that were based on the standards defined by earlier studies (10, 12, 13). The data were analyzed with Mann-Whitney tests. Statistically significant differences were set at $P < .05$.

Results

The control intact teeth showed normal pulp tissue with no inflammatory cells, with columnar odontoblast cells. A summary of the results is presented in Table 2.

In the NEC group after 2 weeks (group 1), there was fibrous tissue with no calcification at the exposure site in 62.5% of specimens, and only 37.5% showed some evidence of calcified tissues in the fibrous matrix. In 50% of specimens the mean thickness of barrier was 0.1–0.25 mm, and the others were less. In this group, 50% of samples had no inflammation. Although 75% showed the presence of odontoblast cells beneath the barrier, 25% showed an absence of these cells (Fig.1 *A, B*).

In the NEC group after 8 weeks (group 2), 50% of samples showed a hard tissue barrier at the exposure site with regular tubules, and 75% showed sufficient thickness of the bridge (>0.25 mm). In this group 87.5% showed no inflammation, and 37.5% of specimens showed palisade pattern of odontoblast cells beneath the dentinal bridge (Fig. 1*C–E*).

In the MTA group after 2 weeks (group 3), 37.5% of samples showed fibrous tissue formed at the exposure site with no calcification. Also, in 62.5% the mean thickness of the formed tissue was <0.1 mm. Minimum to moderate inflammation was observed in 62.5% of samples, and the odontoblast cells were present in 75% of specimens (Fig. 1*F, G*).

In the MTA group after 8 weeks (group 4), 75% of samples showed a calcified dentinal bridge with irregular tubules, although regular tubules were present in 25%. In this group 37.5% of specimens showed adequate thickness of the dentinal bridge (>0.25 mm). Also 75% showed no inflammation, and in 50% of samples a palisade pattern of odontoblast cells was observed adjacent to the dentinal bridge (Fig. 1*H–J*). The Mann-Whitney test revealed that according to the morphology of the dentin bridge, there was a significant difference between groups 1 and 2 ($P = .003$) and between groups 3 and 4 ($P = .029$). The difference between other groups was not significant.

According to the thickness of the dentinal bridge, there was also a significant difference between groups 1 and 2 ($P = .002$) and between groups 3 and 4 ($P = .005$).

Evaluating the odontoblast-like cell layer showed that there was a significant difference between groups 1 and 2 ($P = .029$) and between groups 3 and 4 ($P = .015$). However, the difference was not significant between other groups. These findings showed that the morphology and thickness of the dentinal bridge and odontoblast-like cell alignment were improved in NEC and MTA groups after 8 weeks, compared with 2 weeks.

This test showed that there was no significant difference between groups according to intensity of inflammation, except between groups 3 and 4 ($P = .011$), which showed less inflammation in group 4 compared with group 3.

Discussion

Preserving the vitality of exposed pulp, particularly in immature teeth, is the ultimate goal in vital pulp therapy. Stanley (12) advocated that pulp capping procedures could be performed successfully on

TABLE 2. Number (%) of Different Categories of Histologic Features for Each Group According to the Scores (Table 1)

	Group 1			Group 2			Group 3			Group 4		
Feature	I	II	III	I	II	III	I	II	III	I	II	III
Morphology of dentinal bridge	5 (62.5)	3 (37.5)	0	0	4 (50)	4 (50)	3 (37.5)	5 (62.5)	0	0	6 (75)	2 (25)
Thickness of dentinal bridge	4 (50)	4 (50)	0	0	2 (25)	6 (75)	5 (62.5)	3 (37.5)	0	0	5 (62.5)	3 (37.5)
Intensity of pulp inflammation	1 (12.5)	3 (37.5)	4 (50)	0	1 (12.5)	7 (87.5)	2 (25)	5 (62.5)	1 (12.5)	0	2 (25)	6 (75)
Odontoblast layer	2 (25)	6 (75)	0	0	5 (62.5)	3 (37.5)	2 (25)	6 (75)	0	0	4 (50)	4 (50)