Histologic Assessment of Quick-Set and Mineral Trioxide Aggregate Pulpotomies in a Canine Model

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Abstract

Introduction: Quick-Set (Primus Consulting, Bradenton, FL) is a calcium aluminosilicate cement that is a potential alternative to mineral trioxide aggregate (MTA) with greater acid resistance and faster setting. The purpose of this study was to compare the effects of Quick-Set and MTA on pulpal tissues in response to pulpotomy procedures. **Methods:** The pulp chambers of 42 maxillary teeth in 7 beagle dogs were accessed, and the coronal pulpal tissue was removed. Pulpotomy procedures were performed, placing the experimental materials directly over the radicular pulp tissues. The dogs were sacrificed at 70 days, and the teeth and surrounding tissues were removed and prepared for histologic analysis. The sections of the pulpotomy areas were scored for inflammation, pulp tissue organization, reactionary dentin formation, and quality of dentinogenesis. **Results:** The Quick-Set group exhibited significantly more pulpal inflammation (P = .002) and significantly less pulp tissue organization (P = .004). No significant difference was noted for reactionary dentin formation (P = .526) and quality of dentinogenesis (P = .436). **Conclusions:** Compared with ProRoot White MTA (Dentsply Tulsa Dental Specialties, Tulsa, OK), Quick-Set exhibited more pulpal inflammation and decreased pulp tissue organization. No significant differences were noted for reactionary dentin formation and quality of dentinogenesis. *(J Endod 2015;41:1626–1630)*

Key Words

Calcium aluminosilicate cement, endodontics, mineral trioxide aggregate, pulpotomy, Quick-Set, tricalcium silicate cement

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Since its introduction to endodontics in 1993, mineral trioxide aggregate (MTA) has become a popular material for vital pulp therapy procedures, including pulpotomies. Numerous *in vitro* and animal studies have shown its biocompatibility (1, 2), high pH (3), osteogenic/odontogenic/cementogenic potential (4), and excellent sealing ability (5, 6). However, MTA has several characteristics that limit its usefulness. It has a relatively long setting time (3), can be washed out before setting, is considered difficult to handle, and can cause staining of tooth structure (7, 8). Despite these negative attributes, MTA has become the standard against which novel pulpotomy materials are compared.

Quick-Set (QS) (Primus Consulting, Bradenton, FL) is a new material designed to maintain the positive qualities of MTA while improving on some of its shortcomings. QS is a calcium aluminosilicate cement composed of a fine ceramic powder containing monocalcium aluminate among other proprietary components mixed with a water-based gel. A forerunner of QS was a similar experimental material named Capasio (Primus Consulting). Capasio had a cationic surfactant in the liquid component, whereas QS does not. QS has a working time of 9 minutes and a setting time as short as 12 minutes depending on the powder-to-liquid ratio. The use of the QS gel increases resistance to washout after placement. A similar gel formulation has been shown to reduce washout in MTA Plus (Avalon Biomed, Inc, Bradenton FL) (9).

Several studies evaluating Capasio or QS have been published. Porter et al (10) tested the physical properties of Capasio and ProRoot White MTA (WMTA) (Dentsply Tulsa Dental Specialties, Tulsa, OK). They found that Capasio had a greater washout resistance, a lower pH (10.3), a similar setting time, and improved acid resistance than WMTA. Capasio has shown greater dentinal tubule penetration compared with WMTA (11). When immersed in simulated tissue fluid, Capasio and WMTA formed similar apatite crystals on their exposed surfaces, which may facilitate bone and cementum deposition (11). More recently, the cytotoxicity and osteogenic properties of WMTA and QS were compared using murine odontoblastlike cells. These *in vitro* studies showed that QS and WMTA had similar cytotoxic and osteogenic/dentinogenic properties (12, 13).

Two published *in vivo* studies have evaluated QS. Kohout et al (14) found that QS and WMTA had a similar effect on healing of apical tissues after root end surgery in dogs. Kramer et al (15) showed no difference in pain responses between QS and WMTA in pulp caps of rat molars. Despite these promising results, QS has not yet been studied *in vivo* as a pulpotomy material. The purpose of this study was to compare the histologic response of pulpal tissues in dogs when exposed to QS or WMTA after pulpotomy. The null hypothesis was that there would be no difference in the histologic responses of QS or WMTA.

Methods

The study was approved by the Institutional Animal Care and Use Committee, Texas A&M University Baylor College of Dentistry, Dallas, TX. Forty-two maxillary premolar teeth were treated in 7 beagle dogs to test the healing of pulpal tissues after pulpotomy procedures with either QS or WMTA. Three teeth in each dog were treated using QS, and 3 other teeth were treated with WMTA. The teeth assigned to each material were randomized by a combination of coin flipping for the material and random drawing for the tooth.

Before every procedure, 11 mg/kg clindamycin was injected intramuscularly 1 hour preoperatively, and then 2.2 mg/kg ketamine and 0.22 mg/kg xylazine-100 were delivered intramuscularly to induce general anesthesia. The dogs were then intubated, and 1 L/min 1%–2% isoflurane in oxygen was used as an inhalational anesthetic throughout the procedure. Local anesthesia was performed with 3.6 mL 2% lidocaine with 1:100,000 epinephrine (Novocol Pharmaceutical, Cambridge, Ontario, Canada). Preoperatively, radiographs of the teeth were obtained, and the teeth were cleaned of debris using an ultrasonic scaler (NSK Dental, Chicago, IL) and disinfected with 0.12% chlorhexidine (Patterson Dental, Southlake, TX).

The teeth were isolated with a dental dam for the pulpotomy procedures. The pulpotomy procedures followed the protocol of Dominguez et al (16). All procedures were performed by a single operator. The access preparations and coronal pulp removal were achieved using 3.5× magnification and high-speed #4 diamond "Pulpshaper" burs (Dentsply Tulsa Dental, Tulsa, OK). The pulp chambers were irrigated with 6% sodium hypochlorite until hemostasis was achieved (Fig. 1); then, the experimental material was gently placed over the pulp tissues and the chamber floor to a depth of approximately 3 mm. Each material was mixed according to the manufacturer's directions. The access cavities were restored with Ketac Nano glass ionomer (3M ESPE, St Paul, MN). Post-treatment radiographs were obtained after the procedures (Fig. 2).

One milligram per kilogram nalbuphine was given subcutaneously immediately postoperatively and as needed every 12 hours for pain control. Postoperative care included intramuscular injection of 2.0 mg/kg ketoprofen once daily for a minimum of 2 days postoperatively. The dogs were placed on a soft diet for 2 days postoperatively.

The dogs were sacrificed 70 days postprocedure in accordance with the recommendations of the Panel on Euthanasia of the American Veterinary Medical Association using 2.2 mg/kg ketamine intramuscularly, 0.22 mg/kg xylazine-100 intramuscularly, and 2 mL Beuthanasia-D (Merck Animal Health, Whitehouse Station, NJ) (17). One liter of normal saline was used to flush the blood from the head followed by perfusion with 1 L 70% ethanol. Block sections were dissected out and placed in a container of 70% ethanol for further fixation. The resected blocks were demineralized in 0.5 mol/L EDTA and embedded in paraffin, and 5.0-μm serial sections were made in a sagittal orientation. The sections were stained with hematoxylin-eosin.

Histologic sections were evaluated using light microscopy by 2 calibrated examiners. The examiners were blinded to the type of material used in each sample. The sections were scored for inflammation, pulp tissue organization, reactionary dentin formation, and dentinogenesis using criteria adapted from Dominguez et al (16) who based her scoring on that of Stanley (18) (Table 1). If a discrepancy in scoring occurred, the examiners came to consensus on the score for that aspect of the sample. Each canal orifice was scored independently. When multiple sections were available, the scores were averaged. After scoring, the mean scores for each tooth were determined, and statistical analysis was performed using the Mann-Whitney *U* test with a significance level of $P = .05$. Note that with these scoring criteria, lower numeric scores represent desirable healing responses for the inflammation and pulp organization categories, but for the reactionary dentin formation and quality of dentinogenesis categories, higher numeric scores represent desirable healing.

Results

No periapical alterations were evidenced radiographically 70 days after pulpotomy with either QS or WMTA. Histologic samples were prepared from all teeth. Sections that were damaged during processing or did not include the necessary anatomy for scoring were excluded.

Figure 1. Example of pulpotomy preparations.

Thirty-three teeth were able to be scored with 1 to 12 sections available per tooth and a total of 199 sections. Sixteen of the scored teeth were treated with WMTA and 17 teeth with QS.

With $P = .05$, significant differences were noted between WMTA and QS for inflammation and pulp organization scores (Fig. 3). The pulpal tissues of teeth treated with QS exhibited significantly more inflammation and less organization compared with teeth treated with WMTA. However, no significant difference was noted between WMTA and QS for the reactionary dentin formation and quality of dentinogenesis scores.

Figure 2. Example of a post-treatment pulpotomy radiograph.