Histology of NeoMTA Plus and Quick-Set2 in Contact with Pulp and Periradicular Tissues in a Canine Model

Ryan M. Walsh, DDS, MS, Karl F. Woodmansey, DDS, MA,‡ Jianing He, PhD, DDS,† Kathy K. Svoboda, PhD,* Carolyn M. Primus, PhD,§ and Lynne A. Opperman, PhD**

Abstract

Introduction: NeoMTA Plus (Avalon Biomed Inc, Bradenton, FL) is a tricalcium silicate material similar to the first mineral trioxide aggregate product, ProRoot MTA (Dentsply Sirona, York, PA), but with improvements such as decreased setting time, increased ion release, increased water sorption, and nonstaining radiopacifiers. Quick-Set2 (Avalon Biomed Inc) is a newly formulated calcium aluminosilicate material that has a faster setting time and increased acid resistance and is nonstaining. The purpose of this study was to compare the healing of pulpal and periapical tissues in dogs after exposure to NeoMTA Plus and Quick-Set2 after pulpotomy and root-end surgery procedures. **Methods:** Seventy-two teeth (36 for each procedure) in 6 beagle dogs received pulpotomy or root-end surgery using either NeoMTA Plus or Quick-Set2. The dogs were sacrificed at 90 days, and the teeth and surrounding tissues were prepared for histologic evaluation. Sixty teeth were evaluated and scored histologically (29 with pulpotomies and 31 with root-end resections). Specimens were scored for inflammation, quality and thickness of dentin bridging, pulp tissue response, cementum and periodontal ligament formation, and apical bone healing. **Results:** Both materials displayed favorable healing at 90 days. The only significant difference was the quality of dentin bridge formation in pulpotomies using NeoMTA Plus compared with Quick-Set2. **Conclusions:** Quick-Set2 and NeoMTA Plus had similar effects on inflammation, pulp response, periodontal ligament and cementum formation, and apical tissue healing in dogs. NeoMTA Plus had superior dentin bridge quality compared with Quick-Set2. *(J Endod 2018;44:1389–1395)*

Key Words

Bioceramic, calcium aluminate, NeoMTA Plus, pulpotomy, Quick-Set2, root-end surgery, tricalcium silicate

Significance

Currently, no *in vivo* animal studies have been performed on the calcium aluminate material Quick-Set2. This study histologically evaluates the pulpal and periapical healing of Quick-Set2, a calcium aluminate, and NeoMTA Plus, a tricalcium silicate, in pulpotomies and root-end fillings in a canine model. If determined suitable for use in a canine model, these materials may be investigated further in a human clinical trial.

For the past 2 decades, the original hydraulic tricalcium silicate cement used in dentistry has been ProRoot MTA (Dentsply Sirona, York, PA). Despite clinical and commercial success for the past 2 decades, ProRoot MTA has suffered from clinician criticism because of its poor handling, long setting time, tooth discoloration, and high cost. To overcome the shortcomings of ProRoot MTA, several newer hydraulic tricalcium silicate cements have been developed with easier handling, faster setting, improved washout resistance, and lower material costs.

When considering bioceramic cements for dental uses, 2 primary categories have been tested: tricalcium silicates (mineral trioxide aggregate [MTA]-like materials) and calcium aluminosilicates (Quick-Set & Quick-Set2 [Avalon Biomed Inc, Bradenton, FL]), Capasio [Primus Consulting, Bradenton FL], and Endobinder [Binderware, Sao Carlos, Brazil]). MTA Plus and NeoMTA Plus (Avalon Biomed Inc) are tricalcium silicate–based materials (1, 2). Both MTA Plus and NeoMTA Plus kits contain a cement powder and an identical gel that when mixed have easier handling and washout resistance (3–5). The powder of MTA Plus has a finer particle size than ProRoot MTA, which may contribute to its decreased setting time, increased ion release, increased water sorption, and decreased porosity compared with ProRoot MTA (6, 7). MTA Plus has shown an equivalent favorable biological response to ProRoot MTA (3, 8). MTA Plus and NeoMTA Plus are indistinguishable materials with the exception of the radiopacifying agent (1, 2). NeoMTA Plus contains tantalum oxide as a radiopacifier, rather than bismuth oxide, to prevent postprocedural tooth discoloration (8). NeoMTA Plus has shown biological properties similar to MTA Plus and has been marketed for clinical use since 2013 (9).

Much less scientific literature is available regarding the calcium aluminate–based biomaterials. The Endobinder calcium aluminate material has been successfully tested for the repair of bony defects (10). Subcutaneous implantation showed its biocompatibility in rats (11). The physical properties and sealing ability of Endobinder are similar to other tricalcium silicate materials (12).

From the Departments of *Biomedical Sciences and †Endodontics, Center for Craniofacial Research and Diagnosis, Texas A&M University College of Dentistry, Texas; ‡Center for Advanced Dental Education, St. Louis University, St. Louis, Missouri; and §Lake Erie College of Osteopathic Medicine, School of Dental Medicine, Bradenton, Florida.

Address requests for reprints to Dr Ryan M. Walsh, Departments of Biomedical Sciences and Endodontics, Center for Craniofacial Research and Diagnosis, Texas A&M University College of Dentistry, 3302 Gaston Avenue, Dallas, TX 75246. E-mail address: ryan.walsh.dds@gmail.com

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Like its predecessors, Quick-Set and Capasio, Quick-Set2 is reported to have a similar short setting time, final pH, tubule penetration, acid resistance, and washout resistance (13–15). Both Quick-Set and Quick-Set2 have been shown to be as biocompatible as ProRoot MTA *in vitro*, and Quick-Set has demonstrated favorable healing and osteogenic/dentinogenic properties in *in vivo* animal models (16–19). Also, Quick-Set has similar osteogenic/dentinogenic properties to ProRoot MTA *in vitro* (19).

Quick-Set2 is composed of a calcium aluminosilicate powder, a radiopacifier, and other proprietary components mixed with a unique water-based gel. Like NeoMTA Plus, Quick-Set2 also contains tantalum oxide as the radiopacifier to avoid tooth discoloration associated with the presence of bismuth oxide, which is present in ProRoot MTA and some other MTA-type materials (20). Additionally, Quick-Set2 contains fewer free alumina particles than the predecessor materials Quick-Set and Capasio. The free alumina particles in Quick-Set were hypothesized to cause histologic evidence of inflammation in the periapical region after endodontic procedures in canines (20–22). However, no *in vivo* animal studies have been performed on Quick-Set2. The purpose of this study was to histologically evaluate the pulpal and periapical healing of Quick-Set2 compared with NeoMTA Plus in pulpotomies and root-end fillings in a canine model.

Materials and Methods

The study was approved by the Institutional Animal Care and Use Committee, Texas A&M University College of Dentistry, Dallas, TX. Seventy-two teeth were treated in 6 beagle dogs to evaluate healing of pulpal tissues after endodontic procedures with either Quick-Set2 or NeoMTA Plus (Table 1). The material assigned to each tooth was randomized by a computerized random sequence generator. Both materials were mixed with their corresponding gel according to the manufacturer's recommendations. Thirty-six maxillary premolar teeth received pulpotomy procedures with a puttylike mixture of either material. The distal roots of mandibular premolars were instrumented and obturated with either material mixed to a putty consistency. Immediately after the orthograde treatment, an apicoectomy was performed on the distal root. This procedure simulated root canal treatment followed by root-end resection, which may be performed after root canal treatment failure, further minimizing the treatment time and the animal's trauma. For the pulpotomy and root-end filling procedures, the powder was mixed at approximately a 3:1 powder-to-gel ratio to achieve a puttylike consistency. Clinical procedures were similar to those reported previously (21, 22). 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 intubated and 1 L/min 1%–2% isoflurane in oxygen was used as an inhalational anesthetic throughout the procedure. Local anesthesia with 3.6 mL 2% lidocaine with 1:100,000 epinephrine (Novocol Pharmaceutical, Cambridge, Ontario, Canada) was achieved. For the surgical procedures, an additional 1.8–3.6 mL 2% lidocaine with 1:50,000 epinephrine (Novocol Pharmaceutical) was injected for hemostasis adjacent to the apices of teeth planned for resection. Preoperative digital radiographs of the teeth were obtained. Then, the teeth were cleaned of debris using an ultrasonic scaler (NSK Dental, Chicago, IL) and disinfected with 0.12% chlorhexidine (Patterson Dental, Southlake, TX).

Pulpotomy

The teeth were isolated with a dental dam for the pulpotomy procedures. The pulpotomy procedures followed the protocol of Dominguez et al (23). The access preparations and coronal pulp removal were made using 3 to 3.5× magnification and high-speed #4 carbide round burs. The pulp chambers were irrigated with 10 mL 6% sodium hypochlorite until hemostasis was achieved. Each material was mixed according to the manufacturer's directions, and then the material was gently placed over the pulp tissues and the chamber floor to a depth of approximately 3 mm. The access cavities were restored with Ketac Nano Light-Curing Glass Ionomer (3M ESPE, St Paul, MN), and the occlusion was adjusted to ensure no occlusal trauma. Posttreatment radiographs were obtained after all the other procedures.

Root-end Surgery

The surgical phase was performed immediately after the nonsurgical root canal treatment of mandibular premolars. An additional 1.8–3.6 mL 2% lidocaine with 1:50,000 epinephrine (Novocol Pharmaceutical) was injected for hemostasis adjacent to the apices of teeth planned for resection. A buccal, full-thickness, mucoperiosteal flap was reflected. Osteotomies approximately 5 mm in diameter were made using a Lindemann bone bur (Hu-Friedy, Chicago, IL) at the apex of each distal root. Approximately 3 mm was resected from the distal roots to expose the root filling materials to the periapical tissues. Saline irrigation was used continuously during the osteotomy and root-end resection. Flaps were reapproximated and closed with 4-0 Vicryl sutures (Ethicon, Somerville, NJ).

The dogs were restricted to a soft diet for 90 days postoperatively. Postoperative care included an intramuscular injection of 2.0 mg/kg ketoprofen immediately after the procedures to control inflammation. After surgery, 2 mg/kg nalbuphine was administered subcutaneously immediately and every 12 hours for 1 week postoperatively for pain control. The dogs were sacrificed 90 days after surgery with methods 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, Millsboro, MI) (24). One liter of normal saline was used to flush the blood from the head followed by perfusion with 1 L 70% ethanol. Block sections of

TABLE 1. Procedures and Teeth for Testing

Teeth	Procedure	No. of teeth/roots treated			No. of teeth/roots scored/analyzed		
		Experimental (QS2)	Control (NMTA)	Total treated	Experimental (QS2)	Control (NMTA)	Total teeth analyzed
Maxillary premolars	Pulpotomy	6 × 4 = 24	6 × 2 = 12	36	19	10	29
Mandibular premolars	Obturation and root-end resection	6 × 4 = 24	6 × 2 = 12	36	21	10	31
				72	40	20	60

NMTA, NeoMTA Plus; QS2, Quick-Set2.