Published in final edited form as:

J Endod. 2018 September ; 44(9): 1389–1395. doi:10.1016/j.joen.2018.05.001.

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

Ryan M Walsh, D.D.S., M.S.^{*}, Karl F Woodmansey, D.D.S., M.A.[‡], Jianing He, Ph.D., D.D.S.[†], Kathy K Svoboda, Ph.D.^{*}, Carolyn M Primus, Ph.D.[§], and Lynne A Opperman, Ph.D.^{*}

^{*}Departments of Biomedical Sciences, Texas A&M University College of Dentistry, Texas

[†]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

[§]Lake Erie College of Osteopathic Medicine, School of Dental Medicine, Bradenton, Florida.

Abstract

Introduction: NeoMTA Plus is a tricalcium silicate material similar to the first MTA product, ProRoot MTA, but with improvements such as decreased setting time, increased ion release, increased water sorption and non-staining radiopacifiers. Quick-Set2 is a newly formulated calcium aluminosilicate material that has a faster setting time, increased acid resistance and is non-staining. The purpose of this study was to compare healing of pulpal and periapical tissues in dogs after exposure to NeoMTA Plus and Quick-Set2 following 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 histological 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 PDL formation and apical bone healing.

Results: Both materials displayed favorable healing at 90 days. The only significant difference was quality of dentin bridge formation in pulpotomies using NeoMTA Plus compared to Quick-Set2.

Conclusions: Quick-Set2 and NeoMTA Plus had similar effects on inflammation, pulp response, PDL and cementum formation and apical tissue healing in dogs. NeoMTA Plus had superior dentin bridge quality compared to Quick-Set2.

Corresponding author: Ryan M. Walsh, DDS, MS, Department of Endodontics and Department of Biomedical Sciences, Texas A&M University College of Dentistry, 3302 Gaston Avenue, Dallas, TX 75246, ryan.walsh.dds@gmail.com, Phone: 712-490-0714.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Keywords

bioceramic; calcium aluminate; NeoMTA Plus; pulpotomy; Quick-Set2; root-end surgery; tricalcium silicate

Introduction

The original hydraulic tricalcium silicate cement used in dentistry is ProRoot® MTA (Dentsply Sirona, York, PA.), for the past two decades. Despite clinical and commercial success for the past two decades, ProRoot MTA has suffered from clinician criticism about 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, two primary categories have been tested: tricalcium silicates (MTA-like materials) and calcium aluminosilicates (Quick-Set & Quick-Set2 (Avalon Biomed Inc., Bradenton, FL, USA)/Capasio (Primus Consulting, Bradenton FL, USA) & Endobinder (Binderware, Sao Carlos, Brazil)). MTA Plus and NeoMTA Plus (Avalon Biomed Inc., Bradenton, FL, USA) 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 has 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 to ProRoot MTA (6, 7). MTA Plus has demonstrated 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 post-procedural tooth discoloration (8). NeoMTA Plus has demonstrated 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 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).

Like its predecessors, Quick-Set, and Capasio, Quick-Set2 is reported to have 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 histological evidence of inflammation in the periapical region following 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 to 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. Seventy-two teeth were treated in six beagle dogs to evaluate healing of pulpal tissues following 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 manufacturers recommendations. Thirty-six maxillary premolar teeth received pulpotomy procedures with a putty-like 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 putty-like consistency. Clinical procedures were similar to those reported previously (21, 22). Prior to every procedure, 11 mg/kg of clindamycin was injected intramuscularly 1 hour pre-operatively, 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 of 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, additional 1.8–3.6 mL 2% Lidocaine with 1:50,000 epinephrine was epinephrine (Novocol Pharmaceutical, Cambridge, Ontario, Canada) was injected for hemostasis adjacent to the apices of teeth planned for resection. Pre-operative 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 3.5x magnification and high-speed #4 carbide round burs. The pulp chambers were irrigated with 10ml of 6% sodium hypochlorite until hemostasis was achieved. Each material was mixed according to manufacturer's directions,

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. Post-treatment radiographs were obtained following all the other procedures.

Root-end Surgery

The surgical phase was performed immediately following the non-surgical root canal treatment of mandibular premolars. An additional 1.8 – 3.6 mL 2% Lidocaine with 1:50,000 epinephrine (Novocol Pharmaceutical, Cambridge, ON, Canada) 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, USA) 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 rootend resection. Flaps were reapproximated and closed with 4–0 Vicryl sutures (Ethicon, Somerville, NJ, USA).

The dogs were restricted to a soft diet for 90 days post-operative. Post-operative care included intramuscular injection of 2.0 mg/kg ketoprofen immediately following 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, USA) (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 bones containing the treated teeth were dissected at sacrifice, and stored in a container of 70% ethanol waiting fixation.

Histology

The resected blocks were gradually demineralized in 0.5 mol/L ethylenediamine tetraacetic acid. When demineralized, the blocks were embedded in paraffin and 5 µm serial sections were cut and stained with hematoxylin and eosin. Histologic samples were prepared from all teeth treated, with 2 to 8 sections per tooth. Sections that were damaged, distorted or did not contain the necessary anatomy for scoring were excluded.

The histologic sections were evaluated using transmission light microscopy by two calibrated examiners (RW and LO). The examiners were blinded to the type of material used in each sample. The scoring criteria were adapted from Stanley, Dominguez et al. and Kohout et al. (22, 23, 25). The criteria are described in Table 2 for pulpotomy histology and Table 3 for apical histology. The pulpotomy sections were scored for inflammation, pulp tissue organization, reactionary dentin formation and dentinogenesis. The root-end surgery sections were scored for inflammation, cementum deposition on the root canal aperture, apical periodontal ligament formation, and bone quality. Lower scores represent desirable healing responses for all categories. If a discrepancy in scoring a section occurred, the

examiners conferred to reach consensus for the scores. Each tooth and each procedure within the same tooth were scored independently. When multiple sections were available for each tooth, the scores were averaged. Statistical analysis was performed using the Mann-Whitney U test with a significance level of $P = 0.05$.

Results

Pulpotomy

Pre-sacrifice radiographs show the material was confined to the pulp chamber region with minimal extension into the root canal space. At sacrifice, the glass ionomer restoration had remained intact providing sufficient coronal seal. No evidence of periapical pathosis was noted (Figure 1) for any specimens.

Twenty-nine of the 36 teeth could be scored. Seven teeth were unable to be accurately scored due to damage during histological processing. Dentin with well-defined tubules was visible in the dentin bridge adjacent to the experimental and control materials (Figure 2). Thick layers of dentin were routinely visible separating the materials from the underlying pulp tissue. The dentin was more organized in the presence of NeoMTA Plus, with some dystrophic dentin present in sections with Quick-Set2. Odontoblasts were adjacent to the secondary dentin along the canal walls. The pulp tissue was normal with organized cells. Occasionally, pulp tissue tags were contained completely within the dentin bridge.

No significant differences were noted for inflammation, pulp tissue organization or dentin bridge formation between the experimental and control materials (Figure 3). Significant differences between materials were only noted for the quality of dentin formation ($p=0.002$), with NeoMTA Plus showing better results.

Moderate inflammation was noted in two teeth, and mild inflammation was observed in two other teeth; the latter both in the Quick-Set2 group. Two of the sections with inflammation were from the same animal (dog F). No inflammation was observed in the NeoMTA Plus group in this animal. The differences in pulp tissue organization and dentin bridge formation trended toward better outcome associated with NeoMTA Plus, however, the difference was not statistically significant ($p>0.05$).

Root-End Resection

Post-operative and pre-sacrifice radiographs show the distal root obturations were of adequate length, density and taper (Figure 4). The osteotomies at the root apices of the distal roots are visible radiographically in the post-operative radiograph. At 90-days post-operative, the glass ionomer restorations remained intact providing sufficient coronal seal. Pre-sacrifice radiographs (90-day) showed the osteotomy sites with bone healing and PDL formation (Figure 4). For all specimens, no evidence of periapical pathosis is noted.

Thirty-one of the 36 teeth could be evaluated histologically and scored. Five teeth were unable to be accurately scored due to damage during histological processing. The majority of specimens had some calcified cementum immediately adjacent to the materials (Figure 5). The calcified cementum extended from the lateral resected surface toward the center of the

canal space. In some specimens the cementum spanned the resected root surface. Functionally oriented periodontal ligament fibers were noted at the periphery of the root-end resection and continued across the resected surface. The fibers nearest the center of the resected surface were often not completely functionally oriented but were clearly ligamentous fibers. Dense and highly mineralized bone was present throughout the apical crypt. Some specimens displayed experimental material particles contained within the newly formed bone (see asterisks in Figure 5 C/D). However, the majority of the material was clearly contained within the root canal space.

Inflammation was noted in one of the NeoMTA Plus specimens and in three of the Quick-Set2-treated roots (Figure 6). Both groups had a low score (desirable healing) for inflammation and reparative bone formation, and generally displayed cementum and PDL reformation. No significant differences were found in inflammation, cementum deposition, bone formation or PDL formation between the two materials ($p>0.09$)

Discussion

The current study evaluated the pulpal and periapical tissue healing response after exposure to Quick-Set2 and NeoMTA Plus. This is the first in vivo report on Quick-Set2 or NeoMTA Plus for procedures related to pulpotomy, root-end resection and sealing in vivo. Both materials induced healing in the pulp and periapical tissues in this canine model after 90 days.

Previous studies have demonstrated MTA Plus and ProRoot MTA to have similar bioactivity (7). Additionally, similar biologically favorable findings have been observed between MTA Plus and NeoMTA Plus (9). Given the very similar composition of MTA Plus and NeoMTA Plus, differing only in the radiopacifier used, and the previously reported similar biological responses, these materials were considered biologically equivalent for the purposes of this study (1, 2). In order to minimize the number of canine samples necessary for investigation, NeoMTA Plus was used as an established equivalent and the control group to compare to Quick-Set2.

Numerous researchers have demonstrated success of MTA for various endodontic applications (26). Tricalcium silicate cements have primarily been used for pulpotomy, perforation repair or root-end fillings. Tricalcium silicate cements like NeoMTA Plus and calcium aluminosilicates like Quick-Set2 use their unique water-based gels to allow for variations in viscosity. By varying the powder to liquid gel ratio, the clinician can achieve a putty-like consistency or a more sealer-like texture. As previously demonstrated with MTA and Quick-Set, the biocompatibility of these materials remained unchanged when mixed in thin or thick consistencies (21, 22, 27). Additionally, Quick-Set has been demonstrated to have comparable pulpal and periapical tissue healing as White ProRoot MTA (21, 22). The histological results of this study showed equivalent healing with Quick-Set2 or NeoMTA Plus to the earlier studies using experimental MTA or ProRoot MTA (26, 28, 29).

The only significant difference between the two materials in the current study was the quality of the dentin bridge after pulpotomy. The dentin bridge formed in response to

NeoMTA Plus was more organized with less cell or matrix inclusion compared to Quick-Set2. An ideal dentin bridge has organized tubules produced by underlying odontoblasts (21, 30). These organized dentinal tubules may provide a superior barrier compared to amorphous calcified “dentin-like” tissue seen in pulp tissue underlying rapidly progressing caries lesions (21, 30). However, the clinical implications of the quality of dentin bridging are currently unknown because it can only be assessed histologically.

The difference in the quality of bridge formation may be attributed to the chemical differences between the materials. The free alumina particles present in Quick-Set, not present in Quick-Set2, may have increased inflammation. While inflammation was still present in some sections in the present study, the degree of inflammation and number of teeth with inflammation was much reduced with the modified formulation of Quick-Set2 (21, 22). The maximum pH of NeoMTA Plus and Quick-Set2 is approximately 12 and 10, respectively. For calcium aluminates, fewer calcium and hydroxyl ions will be present compared to the tricalcium silicates at the material-tissue interface, which may lead to poorer bridge quality during the healing process (21).

Both Quick-Set2 and NeoMTA Plus are mixed with a gel to form a putty-like consistency for pulpotomies. Since both materials were mixed to a similar consistency, the handling properties, placement and material adaptation against dentin and pulp surfaces were nearly identical. Therefore, any differences in the regeneration of pulpal tissues may be attributed to differences in the material’s individual chemistries.

Of the total inflammation observed across all procedures, the level of inflammation was disproportionately high in one animal having one third of all incidences. This single outlier had increased inflammation for unknown reasons.

When evaluating only the clinically relevant factors, inflammation, pulp tissue organization and presence of dentin bridge formation, both materials performed similarly. However, this study may be underpowered to discern a statistical difference. Within the limits of this study both materials appeared adequate for use in pulpotomy and root-end filling procedures in canines and suitable for further clinical investigations.

References

1. AvalonBiomedInc. Safety Data Sheet - Gray MTA Plus Powder. Bradenton, FL, USA: Avalon Biomed Inc.
2. AvalonBiomedInc. Safety Data Sheet - NeoMTA Plus Powder. Bradenton, FL, USA: Avalon Biomed Inc.
3. Gandolfi MG, Siboni F, Botero T, et al. Calcium silicate and calcium hydroxide materials for pulp capping: biointeractivity, porosity, solubility and bioactivity of current formulations. *J Appl Biomater Func* 2015;13:43–60.
4. Formosa LM, Mallia B, Camilleri J. A quantitative method for determining the antiwashout characteristics of cement-based dental materials including mineral trioxide aggregate. *Int Endod J* 2013;46:179–186. [PubMed: 22845340]
5. AvalonBiomedInc. Safety Data Sheet - MTA Plus Gel. Bradenton, FL, USA: Avalon Biomed Inc.
6. Camilleri J, Formosa L, Damidot D. The setting characteristics of MTA Plus in different environmental conditions. *Int Endod J* 2013;46:831–840. [PubMed: 23441890]

7. Gandolfi MG, Siboni F, Primus CM, et al. Ion release, porosity, solubility, and bioactivity of MTA Plus tricalcium silicate. *J Endod* 2014;40:1632–1637. [PubMed: 25260736]
8. Camilleri J Staining Potential of Neo MTA Plus, MTA Plus, and Biodentine Used for Pulpotomy Procedures. *J Endod* 2015;41:1139–1145. [PubMed: 25887807]
9. Siboni F, Taddei P, Prati C, et al. Properties of NeoMTA Plus and MTA Plus cements for endodontics. *Int Endod J* 2017;50 Suppl 2:e83–e94. [PubMed: 28452115]
10. Garcia Lda F, Huck C, Scardueli CR, et al. Repair of Bone Defects Filled with New Calcium Aluminate Cement (EndoBinder). *J Endod* 2015;41:864–870. [PubMed: 25720982]
11. Aguilar FG, Roberti Garcia LF, Panzeri Pires-de-Souza FC. Biocompatibility of new calcium aluminate cement (EndoBinder). *J Endod* 2012;38:367–371. [PubMed: 22341076]
12. Garcia Lda F, Chinelatti MA, Rossetto HL, et al. Solubility and disintegration of new calcium aluminate cement (EndoBinder) containing different radiopacifying agents. *J Endod* 2014;40:261–265. [PubMed: 24461415]
13. Porter ML, Berto A, Primus CM, et al. Physical and chemical properties of new generation endodontic materials. *J Endod* 2010;36:524–528. [PubMed: 20171376]
14. Bird DC, Komabayashi T, Guo L, et al. In vitro evaluation of dentinal tubule penetration and biomineralization ability of a new root-end filling material. *J Endod* 2012;38:1093–1096. [PubMed: 22794212]
15. Niu LN, Watson D, Thames K, et al. Effects of a discoloration-resistant calcium aluminosilicate cement on the viability and proliferation of undifferentiated human dental pulp stem cells. *Sci Rep* 2015;5:171–177.
16. Cornelio AL, Rodrigues EM, Salles LP, et al. Bioactivity of MTA Plus, Biodentine and experimental calcium silicate-based cements in human osteoblast-like cells. *Int Endod J* 2017;50:39–47. [PubMed: 26610093]
17. Kramer PR, Woodmansey KF, White R, et al. Capping a pulpotomy with calcium aluminosilicate cement: comparison to mineral trioxide aggregates. *J Endod* 2014;40:1429–1434. [PubMed: 25146026]
18. Niu L PD, Morris M, Jiao K, et al. Mineralogenic characteristics of osteogenic lineage committed human dental pulp stem cells following their exposure to a discoloration-free calcium aluminosilicate cement. *Dent Mater* 2016;32: 1235–47. [PubMed: 27497745]
19. Eid AA, Niu LN, Primus CM, et al. In vitro osteogenic/dentinogenic potential of an experimental calcium aluminosilicate cement. *J Endod* 2013;39:1161–1166. [PubMed: 23953291]
20. Marciano MA, Costa RM, Camilleri J, et al. Assessment of color stability of white mineral trioxide aggregate angelus and bismuth oxide in contact with tooth structure. *J Endod* 2014;40:1235–1240. [PubMed: 25069940]
21. Woodmansey KF, Kohout GD, Primus CM, et al. Histologic Assessment of Quick-Set and Mineral Trioxide Aggregate Pulpotomies in a Canine Model. *J Endod* 2015;41:1626–1630. [PubMed: 26307509]
22. Kohout GD, He J, Primus CM, et al. Comparison of Quick-Set and mineral trioxide aggregate root-end fillings for the regeneration of apical tissues in dogs. *J Endod* 2015;41:248–252. [PubMed: 25459572]
23. Dominguez MS, Witherspoon DE, Gutmann JL, et al. Histological and scanning electron microscopy assessment of various vital pulp-therapy materials. *J Endod* 2003;29:324–333. [PubMed: 12775004]
24. Leary S, Underwood W, Anthony R, et al. AVMA Guidelines for the Euthanasia of Animals: 2013 Edition. Schaumburg, IL; 2013.
25. Stanley HR. Criteria for standardizing and increasing credibility of direct pulp capping studies. *Am J Dent* 1998;11 Spec No:S17–34.
26. Torabinejad M, Chivian N. Clinical applications of mineral trioxide aggregate. *J Endod* 1999;25:197–205. [PubMed: 10321187]
27. Holland R, Mazuqueli L, de Souza V, et al. Influence of the type of vehicle and limit of obturation on apical and periapical tissue response in dogs' teeth after root canal filling with mineral trioxide aggregate. *J Endod* 2007;33:693–697. [PubMed: 17509408]

28. Torabinejad M, Pitt Ford TR. Root end filling materials: a review. *Endod Dent Traumatol* 1996;12:161–178. [PubMed: 9028180]
29. Holland R, Bisco Ferreira L, de Souza V, et al. Reaction of the lateral periodontium of dogs' teeth to contaminated and noncontaminated perforations filled with mineral trioxide aggregate. *J Endod* 2007;33:1192–1197. [PubMed: 17889688]
30. Ricucci D, Loghin S, Lin LM, et al. Is hard tissue formation in the dental pulp after the death of the primary odontoblasts a regenerative or a reparative process? *J Dent* 2014;42:1156–1170. [PubMed: 25008021]

Highlights

- Comparison of NeoMTA (tricalcium silicate) and Quick-Set2 (calcium aluminate).
- Histological evaluation for pulpal and apical healing in a canine model.
- Favorable healing in canine models for both NeoMTA Plus and QuickSet2.

Figure 1:
Pre-operative and pre-sacrifice radiographs depicting 90-day healing after pulpotomy procedures.

Figure 2: Micrographs showing hematoxylin-eosin-stained histologic sections of pulp tissue exposed to NeoMTA Plus (a&b) and Quick-Set2 (c&d). Asterisk (*) indicates pulp tissues inclusion and solid arrows indicate dentin bridging. Scale bar in panels a & c = 62.5 μ m, panels b & d = 31.25 μ m (db, dentin bridge; dn, dentin; p, pulp; QS2, Quick-Set2; NMTA+, NeoMTA Plus).

Figure 3:
Mean histological scores with standard deviation. Significant difference in quality of dentin formation between NeoMTA Plus and Quick-Set2 (* indicates significance). (NMTA N=10; QS2 N=19)

Figure 4:
Pre-operative, post-operative and pre-sacrifice radiographs showing complete bone healing (*) with PDL reformation (solid arrows) at 90 days.

Figure 5: Micrographs showing hematoxylin-eosin-stained histologic sections of root-end resections exposed to NeoMTA Plus (a&b) and Quick-Set2 (c&d). Dense newly formed bone present in all samples. Open arrows indicate new cementum formation. Asterisk indicates experimental material particles contained within the newly formed bone in the Quick-Set2 sample. Scale bar in panels a & c = 250 μ m, panels b & d = 125 μ m (ab, alveolar bone; dn, dentin; p, PDL; NMTA+, NeoMTA Plus; QS2, Quick-Set2)

Figure 6:
Mean histologic scores with standard deviation. No significant difference between groups.
(NMTA N=10; QS2 N=21)

Table 1:

Procedures and teeth for testing

Teeth	Procedure	# Teeth/Roots Treated			# Teeth/Roots Scored/Analyzed		
		Expt'l (QS2)	Control (NMTA)	Total Treated	Expt'l (QS2)	Control (NMTA)	Total Teeth Analyzed
Maxillary Premolars	Pulpotomy	6×4=24	6×2=12	36	19	10	29
Mandibular Premolars	Obturation & root-end resection	6×4=24	6×2=12	36	21	10	31
				72	40	20	60

Table 2:**Grading Scale for Pulpotomy Histological Samples**

Inflammation	Pulp tissue Organization
0= None or a few scattered inflammatory cells	0= Normal tissue
1= Slight inflammatory cell infiltrate with polymorphonuclear or mononuclear leukocytes.	1= Odontoblastic layer disorganization, but central pulp normal
2= Moderate inflammatory cell infiltrate involving the coronal pulp.	2= Total disorganization of the pulp tissue morphology.
3=Severe inflammatory cell infiltrate involving the coronal pulp or abscess present	3= Pulp necrosis.
Reactional Dentin Formation	Quality of Dentinogenesis
0= Intense hard tissue deposition beneath the exposed area appearing as 75 – 100% complete	0= Highly organized dentinogenesis – greater than 75% up to 100% normal tubular dentin formation
1= Moderate hard tissue deposition beneath the exposed area; bridge up to 50% complete	1= Mixture of organized (tubular) and irregular, dystrophic dentinogenesis 25% - 50%
2= Modest hard tissue deposition beneath the exposed area; bridge up to 25% complete	2= Minimal cells and matrix; up to 25% organized
3= No bridge	3= None

Table 3:

Grading Scale for Apical Histological Samples (*% functionally oriented collagen fibers insertion in the new cementum & bone)

Inflammation	Bone Quality, apical resorption
0 = None	0 = Normal bone formation; no resorption
1 = mild	1 = Lack of bone formation; no resorption
2 = moderate	2 = Normal bone formation; concomitant resorption
3 = severe	3 = Lack of bone formation; resorption
Cementum deposition on root canal aperture	Apical periodontal ligament (PDL) formation*
0 = Cementum observed on >75%	0 = FOCF >75%
1 = Cementum covering >50<75%	1 = FOCF >50<75%
2 = Cementum covering >25<50%	2 = FOCF >25<50%
3 = Cementum covering <25%	3 = FOCF <25%