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# Histologic evaluation of pulpotomies in dog using two types of mineral trioxide aggregate and regular and white Portland cements as wound dressings

Renato Menezes, DDS, MS,<sup>a</sup> Clóvis Monteiro Bramante, DDS, MS, PhD,<sup>b</sup> Ariadne Letra, DDS, MS,<sup>c</sup> Vanessa Graciela Gomes Carvalho,<sup>d</sup> and Roberto Brandão Garcia, DDS, MS, PhD,<sup>e</sup> Bauru and Niterói, Brazil

UNIVERSITY OF SÃO PAULO AND FLUMINENSE FEDERAL UNIVERSITY

**Objective.** The purpose of this study was to investigate the pulpal response of dogs' teeth after pulpotomy and direct pulp protection with MTA Angelus, ProRoot, Portland cement and white Portland cement.

**Study design.** Seventy-six teeth were treated with these materials. One hundred twenty days after treatment, the animals were sacrificed and the specimens removed and prepared for histological analysis.

**Results.** All the materials demonstrated similar results when used as pulp-capping materials. Pulp vitality was maintained in all specimens and the pulp had healed with a hard tissue bridge.

**Conclusion.** The materials used in this study were equally effective as pulp protection materials following pulpotomy. (Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004;98:376-9.)

The procedure of pulp capping or pulpotomy relies primarily on the ability of pulpal tissue to heal. Various factors affect this process including age, periodontal condition, and stage of root formation. Procedural factors such as the size of exposure, its nature (traumatic, mechanical or carious) and microbial contamination of the site have also been described as determinants of the success of pulp protection.<sup>1</sup>

A mineral trioxide aggregate (MTA) was studied in a series of investigations, in vivo and in vitro. They reported good sealing ability<sup>2,3</sup> and tissue healing.<sup>4,5,6</sup> Formation of new cementum over the material was reported in repair of experimentally perforated furcations,<sup>7</sup> after root end filling,<sup>2,8,9</sup> and in root canal filling of dogs' teeth.<sup>10</sup> Bridge-like dentin was observed in cases of pulp capping<sup>6,11,12</sup> and pulpotomy<sup>4,13</sup> in monkey and dog teeth.

Wucherpfenning and Green<sup>14</sup> reported that MTA and Portland cement seem almost identical macroscopically,

microscopically, and by x-ray diffraction analysis. They reported that both substances support matrix formation in a similar fashion in cultures of osteoblast-like cells, and also in apposition of reparative dentin when used as direct pulp capping material in rat teeth. Other studies<sup>15,16</sup> affirm that Portland cements contain the same chemical elements as MTA. Some of these ingredients are calcium phosphate, calcium oxide, and silica. MTA also contains bismuth oxide, which increases its radiopacity. This is absent in Portland cement.

Portland cement has great similarity to MTA and offers significant economical incentives if applicable in biological systems. Therefore, the purpose of this study was to evaluate the pulp response of dog's teeth to 2 forms of MTA, regular Portland cement, and white Portland cement when used as wound dressings after pulpotomy.

## MATERIAL AND METHODS

Seventy-six teeth from 4 mongrel dogs 12-18 months of age were used in this experiment. Under general anesthesia with Telazol (Fort Dodge, Overland Park, Kan) and with a rubber dam in place the pulp was mechanically exposed via class V cavities in canines and incisors and through occlusal cavities in premolars (Figs 1 and 2). The coronal portion of the pulp was removed with a bur and a surgical spoon. Light pressure with sterile cotton pellets and copious irrigation with sterile saline solution was applied to control hemorrhage. The pulp wounds were covered with the experimental materials. The materials used were MTA Angelus (Angelus Soluções Odontológicas, Londrina, Brazil), ProRoot (Dentsply, Tulsa Dental, Ballaigues, Switzerland), Portland cement (Votorantim-Cimentos,

<sup>a</sup>PhD student, Department of Endodontics, Bauru Dental School, University of São Paulo.

<sup>b</sup>Head Professor, Department of Endodontics, Bauru Dental School, University of São Paulo.

<sup>c</sup>PhD student, Bauru Dental School, University of São Paulo, SP, Brazil.

<sup>d</sup>MS student, College of Veterinary Medicine, University of São Paulo.

<sup>e</sup>Professor, Department of Endodontics, Bauru Dental School, University of São Paulo.

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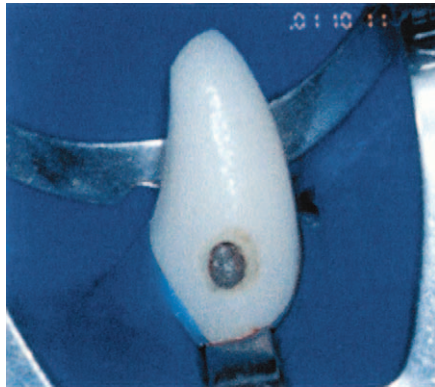


Fig 1. Class V access cavities in canine. Pulp tissue covered with Portland cement.

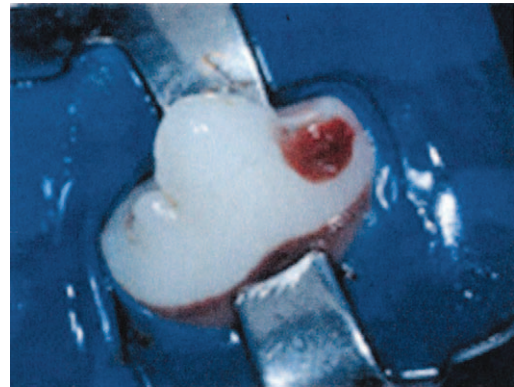


Fig 2. Class I access cavity in a premolar.

São Paulo, Brazil) and white Portland cement (Irajazinho; Votorantim-Cimentos). A total of 19 teeth were used per material. All the animals received the 4 materials assigned randomly among incisors, canines and premolars. Portland cement and white Portland cement were previously sterilized by gamma rays. All materials were mixed in a 3:1 powder–distilled water ratio and placed on the pulp wound. Light pressure was applied with a wet cotton pellet to secure the material. The cavities were sealed with Coltosol (Colthene-Whaledent, Cuyahoga Falls, Ohio) and restored with amalgam (SS White, Rio de Janeiro, Brazil). Teeth fractured after procedures were removed from the samples.

One hundred twenty days after treatment, the animals were killed and perfused with 10% buffered formalin. Sections of the mandibles were removed and placed in 10% buffered formalin before demineralization in sodium citrate buffered formic acid. Tissue blocks were dehydrated and embedded in paraffin. Serial sections were cut at a setting of 6  $\mu$ m in a buccolingual direction and stained with hematoxylin and eosin. The sections were examined by 2 observers who were not aware of the source of the specimens. Every sample was evaluated for severity of tissue reactions. The type and location of inflammation, presence of necrosis, hyperemia, calcification other than in the area of the bridge, and regrowth of odontoblasts. The presence and quality of the hard tissue bridge (continuity, morphological aspects, thickness), inflammatory reaction (chronic or acute, number of cells, and extension of the reaction), presence of giant cells, particles of capping material, and dentin.

## RESULTS

After 120 days, the results observed for the 4 materials were very similar. The pulp wounds healed with hard tissue formation of considerable thickness, completely

closing the access cavities. The pulp tissue appeared normal. No pulp necrosis was observed.

The tissue reactions were highly favorable and no difference was observed between any of the 4 materials.

In all specimens, the pulp access openings were closed. The coronary third of the root canals were completely closed by a newly formed homogeneous mineralized tissue. A basophilic-like mass constituting the remnants of the pulp capping materials could be seen covering the newly formed dentin. The pulp tissue was normal and free of inflammatory cells. No tissue necrosis was noticed. A discrete presence of macrophages was also observed in some cases. See Figs 3-5 for details.

## DISCUSSION AND CONCLUSION

The hard tissue formation associated with MTA shows some similarity to healing after pulp capping with calcium hydroxide.<sup>5</sup> It has been suggested that Portland cement contains the same chemical elements as MTA.<sup>14,15</sup> Furthermore, it has been demonstrated that MTA and Portland cement showed comparable biocompatibility when evaluated in vitro and in vivo.<sup>17</sup> This suggests that Portland cement has the potential to be used as a less expensive endodontic wound dressing material.

Various studies<sup>4,6,11-14</sup> have presented excellent results when using MTA on pulp tissue. Only 2 studies reported considerable success when using Portland cement for conservative pulpal therapy in rats<sup>14</sup> and dogs.<sup>4</sup> Our results are in agreement with these studies. This is the first report on white Portland cement.

The tissue reaction patterns and cell reactions were identical for ProRoot, MTA Angelus, Portland cement, and white Portland cement. This is not unexpected, because the high surface pH, especially when these materials are freshly mixed, will cause denaturation of adjacent cells and tissue proteins.<sup>17</sup> This denaturation includes a few bacteria present in the wound area. As the

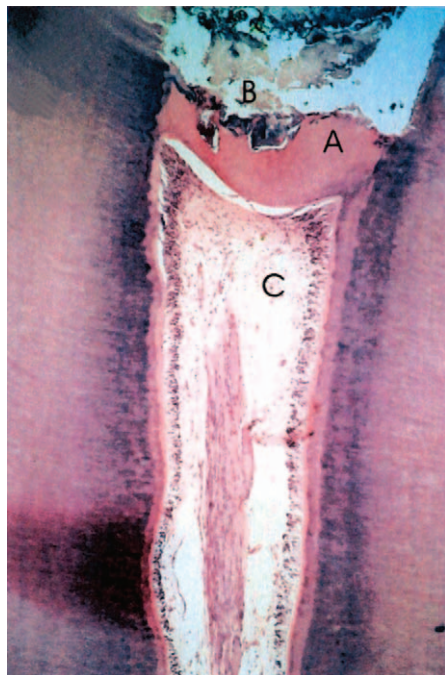


Fig 3. Pulpotomy with MTA Angelus. A, Dentin barrier; B, MTA Angelus material used for the pulpotomy; C, pulp tissue appears normal without inflammatory infiltrate. Htx-eosin (10 $\times$ ).

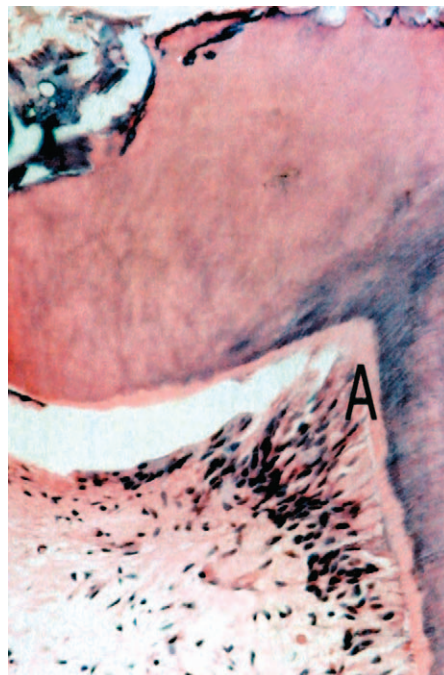


Fig 4. Pulpotomy with MTA Angelus. Higher magnification of Fig 3. Solid dentin bridge with no tissue inclusions. A, Odontoblasts. Htx-eosin (40 $\times$ ).

materials set, the pH changes and the cell injuries subside.

Our study suggests that MTA, Portland cement, and white Portland cement represent biocompatible substrates to which formative cells can attach and produce new soft or hard tissue, preserving pulp vitality. This is in agreement with previous data<sup>4</sup> showing them to be effective materials for pulp protection.

It is known that the presence of bacteria is a significant inhibiting factor for healing of pulp exposures.<sup>18</sup> In this study, no sections were stained for bacterial presence. The Portland cements were sterilized by gamma radiation to avoid bacterial contamination and yet preserve characteristics of the materials. This might not have been necessary owing to the high pH of the materials, in which microorganisms are less likely to survive.

The ability of MTA and Portland cement to support the formation of a dentin bridge may be attributed to excellent sealing ability and fast setting. This prevents the diffusion of the material into the tissues, and reduces microleakage during the healing period.

It should be emphasized that these pulpotomies were done under ideal conditions; ie, all teeth were free of caries and pulp inflammation, which may impair the healing. Therefore, studies under such compromised conditions would be of great value.

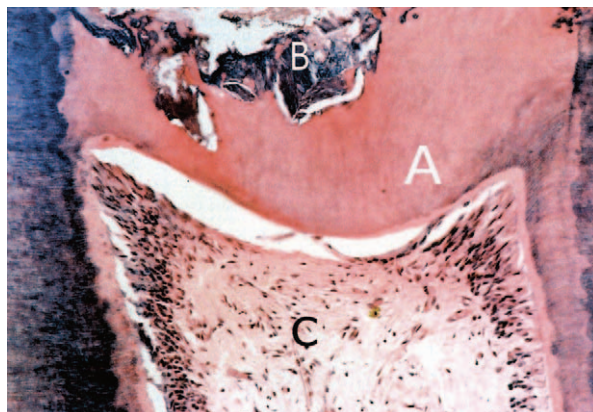


Fig 5. Pulpotomy with MTA Angelus. Higher magnification of Fig 3. A, Pulp tissue healed with a continuous dentin barrier without tissue inclusions; B, MTA Angelus; C, normal pulp tissue free of inflammation. Htx-eosin (25 $\times$ ).

In a recent study, Abdullah et al<sup>19</sup> observed that one type of accelerated Portland cement (APC) is nontoxic and may have the potential to promote bone healing. They also state that further development of APC is needed to produce a viable dental restorative material and possibly a material for orthopedic purposes.

MTA is commonly used for a variety of endodontic indications but the material is expensive and its clinical

use is therefore restricted to more affluent patients. According to many recent clinical and animal studies Portland cement appears to be an alternative to MTA as the biologic effects are identical. Such an inexpensive and easily available material could allow very successful pulp treatments in many indigent patient populations. Nevertheless, further clinical studies and considerations of limitations and the potential unknown risks involved in the use of building materials as medical devices are necessary to define their safe use.

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## Reprint requests:

Dr. Renato Menezes  
Rua Amadeu Gomes  
126 quadra 5 casa 10  
Pendotiba – Niterói, RJ  
Brasil 24320-010  
menezesr@uol.com.br