MTA AND CALCIUM HYDROXIDE FOR PULP CAPPING

MTA E HIDRÓXIDO DE CÁLCIO PARA PROTEÇÃO PULPAR DIRETA

**Alexandra Mussolino de QUEIROZ[1], Sada ASSED[1], Mario Roberto LEONARDO[2],
Paulo NELSON-FILHO[1], Léa Assed Bezerra da SILVA[1]**

1- Professor at Department of Pediatric Dentistry, Ribeirão Preto Dental School, University of São Paulo, Brazil.
2- Professor at Department of Restorative Dentistry, Araraquara Dental School, State University of São Paulo; Visitant Professor of the Ribeirão Preto Dental School, University of São Paulo, Brazil.

Corresponding address: Alexandra Mussolino de Queiroz - Rua Humaitá, 381, Apto 44 - Ribeirão Preto – SP - Cep.: 14020-680 - Brazil
e-mail: amqueiroz@forp.usp.br_-_Fax:(16)633-0999

ABSTRACT

*T*his study evaluated the biocompatibility of mineral trioxide aggregate (MTA) after direct capping of exposed pulp tissue in dog's teeth. Class I cavities were prepared in 26 teeth from 3 adult dogs. MTA was applied over the exposed pulp in 13 teeth and paste of calcium hydroxide plus distilled water (control) was applied in the remaining 13 teeth. After 90 days, the animals were killed; the maxilla and mandible were dissected and sectioned to obtain individual roots. The samples were processed histologically. The pulp and periapical response observed with the use of MTA was similar to that of calcium hydroxide paste. In all specimens, there was a dentin bridge obliterating the exposure, an intact odontoblastic layer, no inflammatory cells, normal connective pulp tissue, normal apical and periapical regions and no bone tissue changes. Similar to calcium hydroxide, MTA presented excellent response when used for direct pulp capping.
Uniterms: Dental pulp capping; Calcium hydroxide; Mineral trioxide aggregate.

RESUMO

O objetivo deste trabalho foi avaliar a biocompatibilidade do agregado de trióxido mineral (MTA), após proteção pulpar direta em dentes de cães. Foram preparadas cavidades de Classe I, em 26 dentes de 3 cães adultos. O MTA foi aplicado sobre 13 dentes e a pasta de hidróxido de cálcio (grupo controle) foi aplicada sobre os 13 dentes remanescentes. Após 90 dias, os animais foram mortos, a maxila e a mandíbula foram dissecadas e os dentes foram seccionados para obtenção de raízes individualizadas. Os espécimes foram processados histologicamente. A resposta do tecido pulpar e periapical foi semelhante para o MTA e o hidróxido de cálcio. Em todos os espécimes havia ponte de dentina obliterando o local da exposição pulpar, camada odontoblástica íntegra, ausência de células inflamatórias, tecido pulpar normal, e ausência de alterações na região periapical e óssea. Da mesma maneira que o hidróxido de cálcio, o MTA apresentou excelente biocompatibilidade quando usado para proteção pulpar direta.
Unitermos: Capeamento da polpa dentária; Hidróxido de cálcio; Agregado de trióxido mineral.

INTRODUCTION

Direct pulp capping is a dental procedure in which the exposed pulp is covered with a protection material, minimizing additional injury and allowing exposed tissue to heal[7,28]. This treatment is indicated when the pulp is accidentally exposed during cavity preparation[23] or by trauma and should be done immediately, or at least 24h after its occurrence[2].

Calcium hydroxide continues to be the most accepted material for pulp capping. When calcium hydroxide is placed in contact with the pulp tissue, it preserves vitality, with no inflammatory response, stimulating the formation of a mineralized tissue barrier[7]. Although treatment with calcium hydroxide has been successful, in the last decade other materials have been tested as pulp protectors *in vivo* and *in vitro*, such as adhesive systems[4] and mineral trioxide aggregate[1,21].

Mineral trioxide aggregate (MTA) was developed at the University of Loma Linda (USA) to seal communications between the root canal system and the external tooth surface at all levels[27], and recently indicated in pulp treatment as

direct pulp capping[1,21].

The following properties of MTA have been reported: biocompatibility[13,16,24], great sealing capacity[26,27], antibacterial effects[25], no mutagenic potential[14], low cytotoxicity[13], no change in cytomorphology of osteoblastic cells[15], stimulation of formation of mineralized tissue[1,12], coverage by cementum[12], aid in periodontal ligament regeneration[22] and lead to biological response in osteoblastic cells[16,18].

The aim of this study was to evaluate histopathologically the response of the pulp tissue and the periapical region when applying MTA directly over the exposed pulp in dog´s teeth, using calcium hydroxide plus distilled water as a negative control.

MATERIAL AND METHODS

The second and third maxillary premolars and second, third and fourth mandibular premolars of three mongrel dogs (age: 12-18 months old; weight: 8-10 kg), totaling 26 teeth were selected for treatment.

The animals were anesthetized intravenously with 3% sodium thiopental (30 mg/kg body weight; Thionembutal, Abbot Laboratories, São Paulo, SP, Brazil). Standardized periapical radiographs were taken with a Heliodent RX machine (Siemens, Erlanger, Germany) with 60 kVp, 10 mA and 0.4 s exposure. Ultraspeed periapical film (Eastman Kodak Corp., Rochester, NY, USA) was used and the radiographs were processed by the time/temperature method.

After prophylaxis, the dental area was isolated with a rubber dam and the operative field was disinfected with 2.0% chlorhexidine gluconate. Two distinct class I cavities were prepared on the occlusal portion, one mesial and one distal, with a high-speed #1015 round diamond bur (KG Sorensen, Ind. Com., São Paulo, SP, Brazil) under copious water spray, creating standardized pulp exposures (1-mm diameter). Intermittent movements were performed during cavity preparation to avoid the generation of excessive heat. After pulp exposure, the cavities were then irrigated with saline (0.9% sodium chlorite, Glicolabor Ind. Farm. Ltda, São Paulo, SP, Brazil) to control hemorrhage and remove debris.

Because all variables should be tested in the same animal and in the different quadrants, each hemiarch was submitted in an alternate manner to the experimental protocols.

The pulp exposure was dried with sterile cotton pellets. Group I (13 teeth): the exposed pulp tissue was covered with MTA powder mixed with distilled water at a 3:1 powder:water ratio (MTA, Dentsply, Tulsa Dental, Tulsa, OK, RJ, USA), according to the manufacturer's instructions. After initial setting and removal of excess from the cavity walls, an adhesive system (Prompt L-Pop, Espe Dental AG, Germany) was applied with microbrushs for 15 s. Gentle air jets were applied until a thin, shiny, and homogeneous layer was obtained. The adhesive was cured for 10s (Ultralux Eletronic, Dabi Atlante, Ribeirão Preto, SP, Brazil).

Group II (13 teeth): the exposed pulp tissue was covered with a calcium hydroxide paste (0.5 g of calcium hydroxide p.a. Merck, Germany plus 0.5 mL of distilled water) mixed at the time of the procedure. A calcium hydroxide cement (Dycal, Dentsply Ind. Com. Ltda., Petrópolis, RJ, Brazil) was then applied, followed by application of Prompt L-Pop adhesive system.

The cavities of both groups were restored with a microhybrid light-activated resin composite (Z-100; B2 color; 3M do Brasil Ltda., Sumaré, SP, Brazil), inserted using the incremental placement technique. Each increment was approximately 1mm thick and was light cured for 40 seconds. The light curing unit was 450mW/cm^2. For adequate cure, the light-curing unit was monitored throughout the study with a radiometer.

Ninety days after the surgical procedure, all teeth were radiographed in a standard manner, and the animals were killed by anesthetic overdose. The maxilla and mandible were dissected and sectioned to obtain individual roots, and the dentin bridging was evaluated separately for each cavity preparation. Serial 6-µm wide longitudinal sections were stained with hematoxylin and eosin, Mallory's Trichrome and Brown and Brenn.

Histopathological analysis was subjectively performed using a light microscope. The following parameters were analyzed: presence or absence of dentin bridge, presence or absence of pulp tissue changes, intensity of the inflammatory infiltrate (absent, mild, moderate or severe), type of inflammatory infiltrate (acute, chronic or mixed), periodontal ligament thickness (normal, slightly, moderately or intensely increased), presence or absence of resorption of mineralized tissues (dentin, cementum or alveolar bone) and changes at the periapical region.

The results were submitted to statistical analysis using the Mann-Whitney nonparametric test with a equal to 0.05. The computer package used was GMC 8.1 (http://www.forp.usp.br/restauradora/gmc/gmc.html).

RESULTS

After ninety days, the results were similar (p>0.01) in the 13 pulps treated with MTA (Figures 1, 2 and 3) and in the 13 pulps treated with calcium hydroxide (Figures 4, 5 and 6). There was a compact, thick dentin bridge totally obliterating the pulp exposure, and a layer of normal odontoblasts under the dentin bridge. The connective pulp tissue was intact in all specimens with fibroblasts and a moderate quantity of collagen. There was no inflammation and the connective tissue was normal. The periapical and apical regions were normal with cementoblasts in the cementum surface. The alveolar bone had osteoblasts in the surface and no signs of resorption. The periodontal ligament, composed of dense vascularized connective tissue, was of normal thickness with no inflammation. Bacteria were not observed.

DISCUSSION

In the present study, 100% of the specimens capped with MTA and calcium hydroxide paste presented a compact thick dentine bridge, normal odontoblastic layer, connective pulp tissue and apical and periapical regions with no inflammatory response, with no bone, cementum or dentin resorption.

According to Zander[29] and Hess[8], the main indicator of success in direct pulp capping or pulpotomies is the formation of dentin bridges. Specific literature has shown that MTA stimulates the formation of mineralized tissue[1,9]
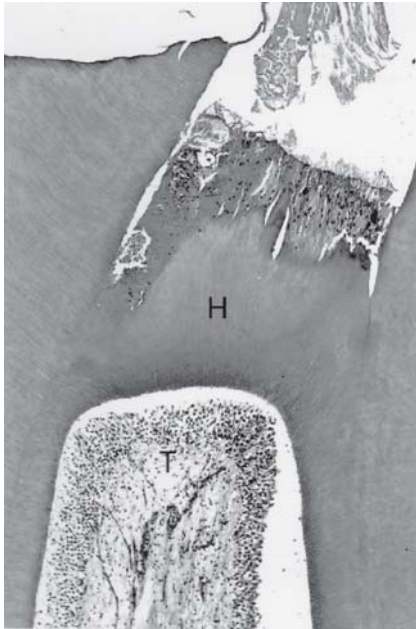

FIGURE 1- Group I (MTA): thick dentine bridge totally obliterating the pulp exposure (H). Normal connective pulp tissue (T). (hematoxylin and eosin - X 24)
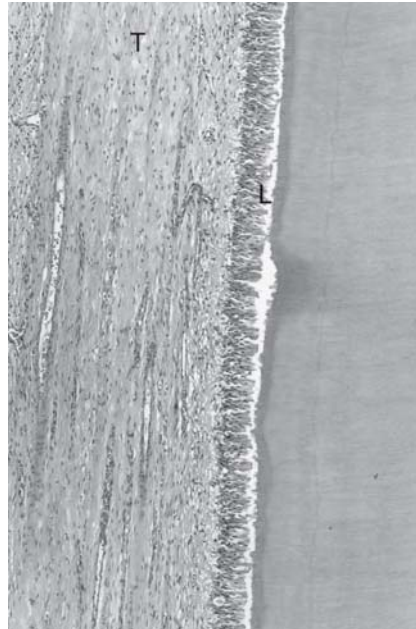

FIGURE 2- Group I (MTA): normal odontoblastic layer (L). Normal connective pulp tissue (T). (hematoxylin and eosin - X 40)
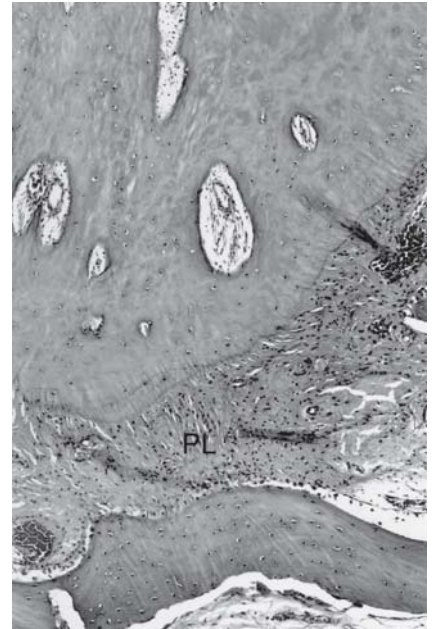

FIGURE 3- Group I (MTA): periodontal ligament in the apical region with normal thickness (PL) and no inflammation. (hematoxylin and eosin - X 40)
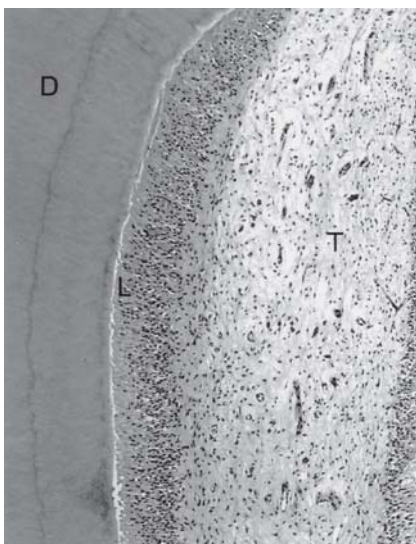
FIGURE 4- Group II (Calcium hydroxide): normal dentine (D), odontoblastic layer (L) and connective pulp tissue (T). (hematoxylin and eosin - X 40)
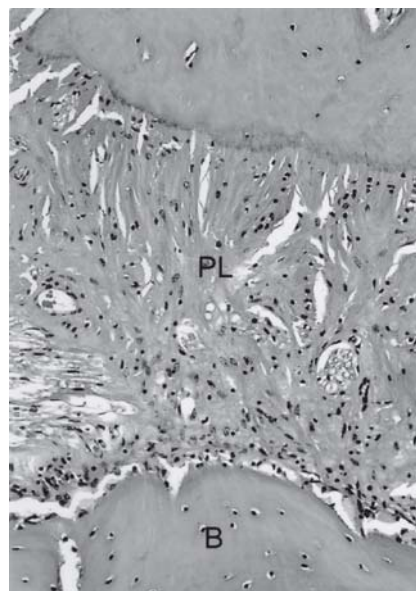
FIGURE 5 - Group II (Calcium hydroxide): normal periodontal ligament (PL) with densely vascularized connective tissue and presence of collagen fibers and cells. Absent inflammatory infiltrate and normal alveolar bone (B). (hematoxylin and eosin - X 80)
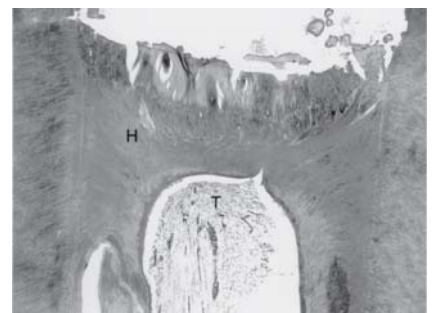
FIGURE 6- Group II (Calcium hydroxide): dentin bridge obliterating the pulp exposure (H). Normal connective pulp tissue (T). (hematoxylin and eosin - X 10)

and recent studies[1,5,9,21] have applied MTA directly to the exposed pulp tissue in direct capping or pulpotomies, forming dentin bridges and showing no inflammatory response. This was confirmed in the present study, with formation of a thick compact dentin bridge obliterating the exposed site in 100% of the cases after 90 days of MTA pulp capping.

Faraco Júnior and Holland (2001), comparing the response of the pulp of dogs to capping with MTA or a calcium hydroxide cement, observed that MTA exhibited better results than the calcium hydroxide cement[5].

MTA can induce biological responses in osteoblastic cells due to adhesion[30], increasing cytokines[16,18] and osteocalcine production[16]. Osteocalcine is the most found non-collagenic protein characteristic of osteoblast synthesis, and can be used as an indicator of matrix production. Thus, MTA presents a biologically active substrate for bone cells and stimulates the production of interleukines[15]. However, according to Moretton, et al.[19], MTA is not osteoinductive (does not induce the differentiation of cells that produce bone tissue in tissues where bone is not present, such as connective tissue) but is only osteoconductive (stimulates the production of mineralized tissue in areas where this tissue is normally present).

The formation of dentin adjacent to the MTA occurs due to its sealing ability, which prevents microleakage, to its biocompatibility, alkalinity, or due to other properties such as the capacity to stimulate cytokine release by the bone cells[21].

When analyzing the action of MTA after implantation of dentin tubes filled with MTA or calcium hydroxide and distilled water paste in the subcutaneous connective tissue of rats to observe the action of MTA and calcium hydroxide on the dentin walls, Holland, et al.[11] found large and birefringent granulation deposits near the tube opening and inside the dentinal tubules. These granulations are calcite crystals originated from the reaction of calcium hydroxide with tissue carbon dioxide, which allied to fibronectin, are the precursors of mineralized tissue barrier. The similar results found for calcium hydroxide and MTA, which does not have calcium hydroxide in its composition, occur because MTA contains calcium oxide, which reacts with tissue fluids to form calcium hydroxide. Holland, et al.[10] observed that when MTA is in contact with water, calcium oxide forms calcium hydroxide, which reacts with tissue carbon dioxide producing calcite crystals. The tissue in contact with these crystals forms an extracellular fibronectin mesh. Thus, they conclude that the MTA mechanism of action is similar to that of calcium hydroxide.

The present study did not show bacteria in any specimen of either group, which is probably due to the fact that there was no marginal leakage and that the materials used had antibacterial activity. The pH of MTA immediately after manipulation with distilled and deionized water is 10.2, increasing to 12.5 after 3h and then remaining constant. Similar to calcium hydroxide, the high pH of MTA is responsible for its antibacterial activity[25].

It should be emphasized that the favorable results found when applying calcium hydroxide paste over the exposed pulp tissue are due to its biocompatibility[20], antibacterial activity[6,17] and stimulation of mineralized tissue deposition[3], which stimulate the healing process.

We believe that the excellent results found with MTA and calcium hydroxide allow its recommendation for direct pulp capping. However, MTA is expensive and research results are related to short-time periods. On the other hand, calcium hydroxide has a low cost, is easily found and has been presenting excellent clinical, radiographic and histopathologic results over the last 80 years.

CONCLUSION

Mineral trioxide aggregate presented similar response to calcium hydroxide in the pulp tissue and periapical region when used for direct pulp capping.

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