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Original article

Biological evaluation of a new pulp capping material developed from Portland cement

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ABSTRACT

This study evaluates the biological properties of a new pulp capping material developed from Portland cement. This study was conducted on 48 teeth in 4 dogs (12 teeth/dog). The dogs were classified into two equal groups (n = 24 teeth) according to the evaluation period including: group A (3 weeks) and group B (3 months). Each group was further subdivided into three equal subgroups (n = 8 teeth) according to the capping material including: subgroup 1: mineral trioxide aggregate (MTA), subgroup2: Portland cement + 10% calcium hydroxide + 20% bismuth oxide (Port Cal) and subgroup 3: Portland cement + bismuth oxide. After general anesthesia, a class V buccal cavity was prepared coronal to the gingival margin. After pulp exposure and hemostasis,the capping materials and glass ionomer filling were placed on the exposure sites. All histopathological findings, inflammatory cell count and dentin bridge formation were recorded. Data were analyzed statistically. After 3 months, the histopathological picture of the pulp in subgroup 1 showed normal pulp, continuous odontoblastic layer and complete dentin bridge formation while subgroup 2 showed partial and complete dentin bridge over a normal and necrotic pulps. Subgroup 3 showed loss of normal architecture, areas of necrosis, complete, or incomplete dentin bridge formation, attached and detached pulp stones and fatty degeneration in group B. For group A, MTA subgroup showed the least number of inflammatory cell infiltrate followed by Port Cal subgroup. While subgroup 3 showed the highest number of inflammatory cell infiltrate. For group B, the mean inflammatory cell count increased with the three tested materials with no statistical difference. Regarding dentin bridge formation at group A, no significant differences was found between subgroups, while at group B, MTA subgroup exhibited significantly higher scores than other subgroups. In conclusion, addition of calcium hydroxide to Portland cement improves the dentin bridge formation qualitatively and quantitatively.

1. Introduction

Pulp capping is defined as the treatment of exposed vital pulp by the application of capping materials to induce the dentinogenic potential of pulp cells (Schröder, 1985). The choice of pulp capping material greatly affects the success of vital pulp therapy. An ideal pulp capping material must be capable of inducing the formation of reparative dentin as well as acceptable biocompatibility and strong antibacterial activity (Mjör et al., 1991)

Calcium hydroxide is considered the gold standard of pulp capping materials, However, the resultant incomplete dentin bridge with tunnel defects that may lead to the failure of pulp capping (Faraco and Holland, 2001; Al-Hezaimi et al., 2011a).

Mineral trioxide aggregate (MTA) was introduced by Torabinejad et al. (1993) and had been recommended as a pulp capping material. It has higher biocompatibility and sealing ability than calcium hydroxide (Parirokh and Torabinejad, 2010). Moreover, MTA can also induce the differentiation of dental pulp cells to odontoblast-like cells and form thicker dentin bridges (Masuda-Murakami et al., 2010; Al-Hezaimi et al., 2011a,b; Parirokh et al., 2011; Saleh et al., 2016).

The success rate of direct pulp capping using MTA was found to be more successful than calcium hydroxide (Aguilar and Linsuwanont, 2011). However, MTA still has some limitations, including

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difficult handling characteristics, long setting time and relatively high cost.

The base material of MTA is Portland cement in which bismuth oxide has been added to render the mixture radio-opaque (Torabinejad et al., 1995a,b). Recently, the use of Portland cement as an alternative to MTA is gaining much popularity because of its lower cost and ample availability.

Several studies have been investigated the biocompatibility of Portland cement (Abdullah et al., 2002; Camilleri et al., 2005; Ribeiro et al., 2005; De Deus et al., 2005). These studies concluded that Portland cement is a biocompatible material having the potential to be used as a proper pulp-capping agent.

Our previous study showed that addition of 10 wt% calcium hydroxide to Portland cement associated with 20% bismuth oxide produces a new pulp capping material (Port Cal) with acceptable physical and adhesive properties (Negm et al., 2016). Therefore, the aim of the present study was to evaluate the biological properties of this new pulp capping material developed from Portland cement in dog's teeth.

2. Materials and methods

2.1. Animals

This study was approved by the Ethics Committee at Faculty of Dentistry, Ain Shams University (2013/03END).

A total of four male mongrel dogs aged approximately 4–6 months were selected for this study at the department of Surgery, Anesthesiology, and Radiology, Faculty of Veterinary Medicine, Cairo University. The dogs were bathed in Diazinon (Neocidal® Ningbo Hi-Tech Biochemicals, China) in concentration of 1/1000 ml of water and then were injected subcutaneously with Ivermectin (Ivomec® Merial Limited, Canada) at a dose of 200 μg/kg body weight for control of external and internal parasites. They were fed three times a day on cooked or dry food. Pure water was available all the time. All the dogs were monitored daily for any pathological conditions under supervision of an expert veterinarian.

Four teeth in three quadrants of each dog were included in the study summing up the total number of teeth to 48 (12 teeth/dog). The dogs were classified into two equal groups (n = 24teeth) according to the evaluation period including: group A (3 weeks) and group B (3 months).

Each group was further subdivided into three equal subgroups (n = 8) according to the used capping material including: subgroup 1: MTA, subgroup 2: Portland cement + 10% calcium hydroxide + 20% bismuth oxide (Port Cal) and subgroup 3: Portland cement + bismuth oxide.

2.2. Formation of Port Cal

Bisthmus oxide (LobaChemie, India) was incorporated into Portland cement (ASEC Helwan cement, Egypt) in the ratio of 20% by weight. The calcium hydroxide powder (ANALAR, Oxford laboratory, Mumbai, India) was then mixed with Portland cement in the ratio of 10% by weight.

The ingredients of the powder were blended together in a vibratory mixer for one hour. The resultant mixture was mixed with distilled water with a powder/water ratio 3:1 and the newly formed cement was designated Port Cal according to (Negm et al., 2016).

2.3. Procedure of pulp capping

The anesthetic regimen for each dog included subcutaneous injection of atropine sulphate (Atropine®, ADWIA, Egypt) at adose of 0.05 mg/kg body weight and intravenous injection of xylazine HCl (Xylaject®, ADWIA, Egypt) 1 mg/kg body weight as a premedication. The anesthesia was induced by ketamine HCl (Ketamine®, EPICO, Egypt) 5 mg/kg body weight given i.v. via a 20 gauge cannula. The anesthesia was maintained during operation by 25 mg/kg incremental doses of 2.5% solution of thiopental sodium (Thiopental Sodium®, EPICO,Egypt) given i.v.

After general anesthesia, the teeth were disinfected by 0.5% povidone iodine solution (Betadine®, Nile company, Egypt). A class V buccal cavity was prepared approximately 1 mm coronal to the gingival margin with No. 2 Rose head carbide bur under copious normal saline irrigation in each tooth. Deepening of the pulpal floor for each cavity was done until the color of pulp tissue was reflected through the remaining dentin layer. Sterile sharp probe was used mechanically to expose the pulp. Bleeding was controlled by rinsing with sterile saline until the physiologic hemostasis occurred.

The capping materials were obtained by mixing the powder designated by each subgroup with distilled water on sterile glass slab using metal spatula to obtain a putty-like consistency; subgroup 1 “MTA” (Endocem Maruchi, Korea), subgroup 2 “Port Cal” and subgroup 3 “Portland cement + Bithmus oxide”. This mix was placed on the exposure sites by a fine amalgam carrier and condensed lightly with a moistened cotton pellet. Final restorations were done by insertion of glass ionomer filling (Riva, SDI, Australia). For pain and infection control, all dogs were given intramuscular cefotaxime sodium at adose of 10 mg kg and diclofenac sodium at a dose of 1.1 mg kg once/day for 5 days after surgery (Abu-Seida, 2012)

2.4. Histologic examination

Dogs were sacrificed after each observation period by using 20 ml of 5% thiopental sodium solution rapidly injected through the cephalic vein. The maxilla and the mandible were removed surgically and sectioned into two halves at the midline. Blocks containing a single tooth with its surrounding bone were obtained by sectioning the jaws with a sharp saw. Burning of the other parts of the dead dogs was done in the medical waste incinerator at Faculty of Veterinary Medicine, Cairo University.

The teeth were fixed in 10% neutral buffered formalin for 72 h. Specimens were then decalcified in 17% EDTA solution for 120 days. A fine needle was used to perforate the specimens to allow EDTA penetration and the specimens were examined continuously for decalcification. After decalcification, specimens were dehydrated in ascending concentrations of ethanol then embedded in paraffin blocks. The embedded specimens were serially sectioned in buccolingual plane to the tooth main vertical axis, through the capping site and the pulp; into sections of 5 μm thickness. Serial sections that showed the deepest part of the cavity and the underlying pulp were selected for histological evaluation. These sections were stained with H&E for evaluation.

Histologic slides were examined under light microscope for the following assessments:

2.4.1. Inflammatory cell count: as described by (Tawfik et al., 2013)

For each slide, three representative fields were analyzed at ×200 magnification. Fields were selected conforming to the following criteria; i) well preserved tissue with good architecture and no artifacts, ii) intense inflammatory cells infiltration. Total inflammatory cell number was counted using image analysis software “Image J software. The color coding threshold was adjusted to select the perimeter of the whole range of inflammatory cells in order to exclude other non-desired structures. Then binary thresholds of the selected color coded inflammatory cells were completed prior to calculation. The total number of cells was then counted as a factor of 10^3.