Biological Evaluation of a New Pulp Capping Material Developed From Portland Cement in Dogs

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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.

An ideal pulp capping material must be capable of inducing the formation of reparative dentin as well as acceptable biocompatibility and strong antibacterial activity.
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.

Mineral trioxide aggregate had been recommended as a pulp capping material due to its higher biocompatibility, sealing ability and formation of thicker dentin bridges than calcium hydroxide.
However, MTA still has some limitations, including 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. Recently, the use of Portland cement as an alternative to MTA is gaining much popularity because of its lower cost and ample availability.
INTRODUCTION

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

Four mongrel dogs were selected for this study at Department of Surgery, Anesthesiology, and Radiology, Faculty of Veterinary Medicine, Cairo University-Egypt.
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).
Four dogs

Group A (2 dogs) (3 weeks)

Group B (2 dogs) (3 months)

MTA subgroup (n=8 teeth)

Port Cal subgroup (n=8 teeth)

Portland cement + bismuth oxide subgroup (n=8 teeth).
Formation of Port Cal:

- Bisthmus oxide was incorporated into Portland cement in the ratio of 20% by weight. The calcium hydroxide powder 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 ratio 3:1 (Negm et al., 2016).
MATERIALS AND METHODS

Procedure of pulp capping

Under general anesthesia, the teeth were disinfected by 0.5% povidone iodine solution. A class V buccal cavity was prepared approximately 3 mm coronal to the gingival margin with No. 2 Rose head carbide bur. Deepening of 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.
The used capping materials were placed on the exposure sites by a fine amalgam carrier according to subgroups.
MATERIALS AND METHODS

Final restorations were done by glass ionomer filling. For pain and infection control, all dogs were given intramuscular Cefotaxime sodium and Diclofenac sodium once/day for 5 days after surgery.
**MATERIALS AND METHODS**

- **Histologic examination**

  Histologic slides were prepared as usual and examined under light microscope for the following assessments:

  **Inflammatory cell count:**
  
  Total inflammatory cell number was counted as a factor of $10^3$ using image analysis software "Image J software."
MATERIALS AND METHODS

- **Dentin bridge formation**
  Dentin bridge formation was graded by the scoring system.
  Score 0: No dentin bridge.
  Score 1: partial dentin bridge formation.
  Score 2: complete dentin bridge formation.
  Dentin bridge thickness was assessed through the H&E stained sections using the image analysis software (Leica Queen 500).
MATERIALS AND METHODS

- Statistical analysis

Data were analyzed using SPSS (Statistical Packages for the Social Sciences 22, IBM, Armonk, NY, USA). Quantitative data of inflammatory cell count were tested for statistical significance using ANOVA and multiple comparisons ‘Duncan’s test’. The results of scored data were tested with the Mann–Whitney U and Kruskal–Wallis non-parametric tests. Significance was established at $P < 0.05$. 
### Results

Table 1: Mean inflammatory cell count for all experimental groups and subgroups.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Subgroup (1)</th>
<th>Subgroup (2)</th>
<th>Subgroup (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MTA</td>
<td>Port Cal</td>
<td>Portland cement + Bithmus oxide</td>
</tr>
<tr>
<td>Group A (3 weeks)</td>
<td>486.± 42.6*</td>
<td>1.009± 24.0</td>
<td>1.256± 68.4</td>
</tr>
<tr>
<td>Group B (3 months)</td>
<td>1.233± 92.3</td>
<td>1.333 ± 52.8</td>
<td>1.566± 50.4</td>
</tr>
</tbody>
</table>

*Significant at P≤0.05*
Table 2: Mean dentin bridge scores for all experimental groups and subgroups.

<table>
<thead>
<tr>
<th>Groups</th>
<th>Subgroup (1)</th>
<th>Subgroup (2)</th>
<th>Subgroup (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MTA</td>
<td>Port Cal</td>
<td>Portland cement + Bithmus oxide</td>
</tr>
<tr>
<td>Group A (3 weeks)</td>
<td>0.25±0.46</td>
<td>0±0</td>
<td>0.125±0.35</td>
</tr>
<tr>
<td>Group B (3 months)</td>
<td>1.875±0.35*</td>
<td>1.125±0.83</td>
<td>1.375±0.74</td>
</tr>
</tbody>
</table>

*Significant at P≤0.05
### Table 3: Distribution of dentin bridge scores for all experimental groups and subgroups

<table>
<thead>
<tr>
<th>Scores</th>
<th>Group A (3 weeks)</th>
<th>Group B (3 months)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subgroup (1)</td>
<td>Subgroup (2)</td>
</tr>
<tr>
<td>Score 0</td>
<td>75%</td>
<td>100%</td>
</tr>
<tr>
<td>Score 1</td>
<td>25%</td>
<td>0%</td>
</tr>
<tr>
<td>Score 2</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>

*Significant at P≤0.05
Fig. 1. (a) Photomicrograph of MTA subgroup (group A) showing hard tissue deposition, vasodilatation and a big area of necrosis with no dentin bridge formation (H&E 40x). (b) Photomicrograph MTA subgroup (group B) showing complete dentin bridge formation (arrows) with normal pulp and continuous odontoblastic layer (H&E 100x).
Fig. 2. (a) Photomicrographs of Port Cal subgroup (group A) showing the exposure site with normal pulp, no dentin bridge formation (a) and vasodilatation, areas of necrosis (N) and continuous odontoblastic layer (arrow, b). (H&E 100x).
Fig. 3. Photomicrographs of Port Cal subgroup (group B) showing the exposure site with partial dentin bridge formation (arrows, a), inflamed pulp (IF) under complete dentin bridge (arrows, b) and complete dentin bridge (arrows, c) over normal pulp (d). (H&E 100x).
Fig. 4. Photomicrographs of Portland cement with bismuth oxide subgroup (group A) showing vasodilatation and continuous odontoblastic layer (arrows, a), vasodilatation (arrows) and necrosis (N, b), severe inflammation (c) and no dentin bridge formation (d). (H&E 100x).
Fig. 5. Photomicrographs of Portland cement with bismuth oxide subgroup (group B) showing vasodilatation (a), complete dentin bridge formation (DB) over necrotic pulp (N, b), partial dentin bridge formation (arrows) and a failed attempt to form dentin bridge (arrows) over a necrotic pulp (N, d). (H&E 100x).
RESULTS

Fig. 6. Photographs of Portland cement with bismuth oxide subgroup (group B) showing pulp with pulp stone (PS, a), pulp with large detached pulp stone (PS, b), fatty degeneration (FD, c). Pulp inflammation (IF) and necrosis (N, d). (H&E 100x).
CONCLUSIONS

- Under the conditions of the present study, it could be concluded that although MTA shows the least inflammatory response with the greatest percentage of complete dentin bridge formation yet, the addition of calcium hydroxide to Portland cement improves the possibility of dentin bridge formation qualitatively and quantitatively.
Thank You