Comparison of the Microleakage of Octacalcium Phosphate and Mineral Trioxide Aggregate for Furcal Perforation Repair: An In Vitro Study

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Abstract

Objective: Furcal perforation is an undesirable complication that may occur during root canal therapy and seriously compromises the prognosis of endodontic treatment. The prognosis of furcal perforation repair depends on the prevention of bacterial infection of the perforation site. Thus, use of a biocompatible material for complete sealing of the perforation site is critically important. This study aimed to compare the microleakage of mineral trioxide aggregate (MTA) and octacalcium phosphate (OCP) for furcal perforation repair.

Methods: This experimental study was conducted on 70 human mandibular molars with divergent roots, intact furcation site and completely formed apices. The teeth were randomly divided into 4 groups of two experimental (n=30), one positive control and one negative control group (n=5). The furcation floor was then perforated. In the first and second experimental groups, furcation perforations were repaired with OCP and MTA, respectively. In the positive control group, the perforation was left untreated and in the negative control group no furcal perforation was created. The access cavity in all groups was filled with Cavit. The teeth were stored in 100% humidity for 48h. Root apices were sealed with sticky wax and the entire external surface of teeth except for 0.5 mm around the perforation site was covered with two coats of nail polish. The specimens were immersed in India ink for 4 days and then sectioned in half buccolingually. The sections were separated and dye penetration was evaluated using a stereomicroscope at 25X magnification. Obtained data were analyzed using independent t-test.

Results: No microleakage was observed in the negative control group. In the positive control group, the dye had completely penetrated into the walls. The amount of dye penetration was 1.64 and 1.22 mm in the OCP and MTA groups, respectively. Statistical analysis of data revealed that the sealability of MTA was significantly greater than that of OCP (p<0.0001).

Conclusion: OCP cannot be an acceptable alternative to MTA in terms of sealability.

Key words: Comparison, Furcation, Microleakage, Mineral trioxide aggregate (MTA), Octacalcium phosphate (OCP), Perforation.

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Introduction:

Furcal perforation is an undesirable complication that may occur during root canal treatment and creates a path between the root canal system and periodontium. Bacterial microleakage through this path leads to periodontal destruction and eventual tooth loss (1). The main goal of furcal perforation repair is to quickly seal the perforation site and provide
optimal conditions for periodontal reattachment at the area. This goal can only be achieved if a complete seal is obtained (2). Selection of the restorative material for this purpose is an important factor in determining the prognosis of the perforated tooth because the biocompatibility and sealability of the restorative material affect the prognosis. El Deeb, et al. in 1982 and Balla et al. in 1991 emphasized that the sealability of the restorative material is an important parameter for favorable prognosis of root perforation repair (3, 4).

MTA is one of the various materials that have been used for this purpose and has shown high sealability and biocompatibility (5). MTA was first introduced in early 1990 by Torabinejad as a suitable root end filling material (6). Lee, et al. in 1993 showed that MTA had superior sealability compared to amalgam and IRM (7). Also, Torabinejad, et al. in 1994 demonstrated that the MTA adaptation to the cavity wall was superior to that of amalgam, Super EBA and IRM and MTA provided a better seal at the root end (8). Also, MTA had less microleakage (9). Nakata, et al. in 1998 reported that MTA performed better than amalgam in prevention of Fusobacterium nucleatum microleakage (10). On the other hand, Ferk Luketić, et al. in 2008 compared the microbial microleakage of MTA and zinc-free amalgam as root end filling materials and concluded that MTA had significantly better sealability than amalgam (11). Samiee, et al. in 2010 reported favorable histological responses following the application of MTA and calcium enriched mixture (CEM) cement for furcal perforation repair especially in terms of formation of cementum-like hard tissue (12). Several studies have confirmed clinical and radiographic success of MTA for repair of furcal perforations through long-term follow-ups (13-16). Despite the favorable characteristics of MTA, its clinical application is not easy and its long setting time compromises single-visit treatments. On the other hand, MTA is expensive and increases the total cost of treatment.

Octacalcium phosphate is a calcium phosphate derivative and a possible precursor to the formation of apatite in osteogenesis. It is more potent than other calcium phosphate derivatives for osteoinduction and osteoconduction (17). Octacalcium phosphate is a bioprecursor with osteoinductive and osteoconductive properties and high biocompatibility. It is easily applied and appears to be effective for repair of perforations close to bone. When in contact with bone, this material can induce new bone formation.

Sasano, et al. in 1995 demonstrated that the biological properties of OCP for increasing bone tissue activity are comparable to those of prostaglandin E1 (18). Kamakura, et al. in 1996 reported that OCP played a more active role than hydroxyapatite in biological activities and in contrast to hydroxyapatite, OCP stimulates osteogenesis (19). Sargolzaei, et al. in 2001 evaluated the role of OCP in repair of bone defects and concluded that the osteogenesis was first initiated in the OCP intergranular spaces; and then newly formed bone tissue increased in the center of defect and in between the implanted materials. At day 21 post-implantation, despite osteogenesis at intergranular spaces, new bone formation was also observed at the defect margins and areas adjacent to host bone (20). Murakami, et al. in 2010 demonstrated that the intergranular spaces in OCP should be large enough to allow osteoconduction. Such large spaces may be achieved by using bigger granules (21). As mentioned above, the sealability of restorative material plays a critical role in prognosis of perforation repair and considering the fact that to the best of our knowledge, no study has directly reported the amount of microleakage of MTA and OCP for furcal perforation repair, the present study sought to compare the microleakage of MTA and OCP for
Methods:

This experimental study was conducted on 70 human mandibular molar teeth with divergent roots, intact furcation sites and mature apices. After extraction, the organic residues and soft tissues attached to the teeth were removed, the teeth were immersed in 0.5% sodium hypochlorite for 48 hours for disinfection and were then stored in physiologic saline solution. Access cavity was prepared using tapered diamond bur along with water and air spray. The furcation site was perforated using a #2 round bur and a perforation with approximately 2 mm in diameter was created (14). The teeth were then randomly divided into 4 groups: two experimental groups of 30 each and positive and negative control groups of 5 each. In order to simulate clinical setting, a damp cotton pellet was placed below the furcation perforation area. The specimens were then placed in putty impression material and after setting of putty, the teeth were prepared for the next step. The teeth in our study were selected using convenience sampling and sample size was calculated using the following equation:

\[
n = \frac{(Z_1 - \frac{a}{2})^2 + Z_2 - \beta)^2}{(X-1 - X-1)} \times (S_1^2 + S_2^2) = 13.7 \approx 14
\]

\[
Z_1-a/2=2.58 \rightarrow \alpha=0.01 \text{ & } Z_2-\beta=1.64 \rightarrow \beta=0.05
\]

\[
S_1=0.22, S_2=0.407, X-1=0.225, X-1=0.757
\]

The calculated sample size using the above mentioned equation was 14 and in order to increase the accuracy of results, 30 teeth were evaluated in each experimental group.

In the first experimental group, octacalcium phosphate powder was mixed with distilled water to obtain a homogenousthick paste. The paste was applied to the perforation site with an amalgam carrier and packed with a condenser. In the 2nd experimental group, MTA powder (Angelus Indústria de ProdutosOdontológicos Ltd., Londrina, PR, Brazil) was mixed with distilled water according to the manufacturer’s instructions, applied to the perforation site similar to OCP and covered with a damp cotton pellet. The teeth were then stored in a closed lid container at 37°C and 100% moisture for 48h. After the complete setting of OCP and MTA, the access cavity was filled with Cavit and the teeth were placed in a closed lid container with damp gauzes for 12h in order for the Cavit to set.

In the positive control group, the perforation was left untreated and the access cavity was filled with Cavit. In the negative control group, the perforation was not created and the access cavity was restored with Cavit. Apices of teeth in all groups were sealed with sticky wax. The teeth surfaces were coated with two layers of nail polish except for the perforation site and 0.5 mm margin around it. The nail polish was allowed to dry and the teeth were immersed in India ink for 4 days. Next, the teeth were removed from the dye, rinsed under running water, dried and buccolingually sectioned by a laboratory hand piece and a diamond disc. Sections were made in dry conditions to prevent possible elimination of dye. Buccal and lingual surfaces were sectioned to 1 mm distance from the perforation site. Then, in order to bisect the tooth, a spatula was inserted into the created cleft and used as a wedge to split the tooth in half (spatula was used to exert wedging forces to separate the sectioned pieces and prevent the spread of dye at the perforation site. The restorative material was removed from the perforation site using the tip of an explorer and the teeth sections were observed and evaluated by 3 observers under a stereomicroscope (Zeiss STEMI SV6 NY) equipped with a scaled ruler with 0.01 mm readability. The mean microleakage was recorded for each tooth. Data were statistically analyzed using t-test.

Results:

Dye penetration was zero in the negative control
group. In the positive control group, the dye penetrated into the entire cavity wall; which indicated the ability of the dye to penetrate into the perforation site and its observation under a microscope. In order to increase the accuracy, three observers made the measurements. To determine the difference between the obtained values by the three observers, repeated measures ANOVA was applied and showed that the obtained values by the three observers for MTA and OCP were not significantly different ($p>0.05$). Thus, the mean of three values was used as the final value for each specimen (the minimum value obtained for MTA and OCP was 0.62 and 0.9 and the maximum value was 1.85 and 2.6, respectively).

The mean amount of dye penetration in the OCP and MTA groups was 1.64 and 1.22 mm, respectively (Table 1). Independent t-test was used to assess the difference between groups and revealed that the difference between the two experimental groups was statistically significant ($p<0.001$). OCP and MTA were significantly different in terms of sealability. MTA showed more favorable results in this respect.

<table>
<thead>
<tr>
<th>Type of material</th>
<th>mean</th>
<th>Standard deviation</th>
<th>Standard error</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCP</td>
<td>1.6441</td>
<td>0.29035</td>
<td>0.05301</td>
<td>30</td>
</tr>
<tr>
<td>MTA</td>
<td>1.2200</td>
<td>0.33239</td>
<td>0.06060</td>
<td>30</td>
</tr>
</tbody>
</table>

**Discussion:**

Furcal perforations occur due to iatrogenic and non-iatrogenic causes. When encountered, the perforation site should be sealed with a restorative material. Several materials have been suggested for this purpose; among which, MTA has shown favorable results due to its optimal properties. Studies have demonstrated that OCP stimulates osteogenesis and induces new bone formation at the perforation site (17-22). Thus, this material may be suitable for repair of perforations close to bone since it induces osteogenesis. Our study aimed to evaluate the sealability of OCP and compare it with MTA-Angelus.

Our study showed that MTA and OCP had a significant difference in degree of microleakage for repair of furcal perforations and MTA was more favorable for this purpose.

Hashem and Hassanien in 2008 reported that MTA-Angelus with internal matrix and Pro-root MTA with or without internal matrix had the lowest rate of microleakage (23). Also, Duarte, et al. in their study in 2003 showed that MTA-Angelus and Pro-root MTA were similar in terms of composition (24) but Sassone, et al. in 2008 reported that the sealability of Pro-root MTA was better than that of MTA-Angelus and the two materials had a statistically significant difference in this regard (25).

The sealability of restorative materials can be measured by different techniques. The most common method for microleakage assessment is the linear measurement of dye penetration (26, 27). In our pilot study, we tried two commonly used dyes namely India ink and 2% methylene blue. Since the penetration and dissemination of methylene blue into the cavity wall and dentinal tubules were greater than India ink, dye-penetrated margins were more easily detectable when using India ink. India Ink has tiny particles and if not penetrated through the gap between the perforation wall and the restorative material, it indicates that larger particles such as bacteria and their end toxins cannot penetrate either (28). Thus, we used India ink in our main experiment. In order to assess the degree of dye penetration, longitudinal sections, transverse sections, decalcification or clearing techniques are usually
used (29). We used longitudinal sectioning of teeth for this purpose because in this technique, measurement of dye penetration is easier and more accurate. In order to simulate the clinical setting, damp cotton pellet was placed below the restorative material sealing the furcation perforation defect; which is similar to what was done in El Deeb, et al. study in 1982 (3). In Torabinejad, et al. study in 1995 (9) linear dye penetration was measured in 4 root end filling materials of Super EBA, IRM, MTA and amalgam by longitudinal sectioning of teeth. The mean dye penetration was 0.81 mm in the MTA group; whereas, this rate was 1.22 mm in our study. This difference may be explained by the different site of perforation (retrograde cavity versus furcal perforation), type of dye used (methylene blue versus India Ink) and type of restorative material (Pro-root MTA versus MTA- Angelus). Atbaei et al. in 2010 compared the sealability of Pro-root MTA and Portland cement for repair of furcal perforations and found no significant difference between the two materials (30). In their study, the mean dye penetration was 1.38 mm in the Pro-root MTA; which is different from our obtained rate (1.22 mm). Due to the use of India ink and almost similar methodologies of both studies, this difference may be attributed to the different type of MTA used. In our study, the macroscopic size of OCP particles was larger than MTA particles. As the result, the homogeneity of MTA mixture was greater than that of OCP mixture. Thus, use of smaller OCP particles may increase its marginal adaptation and affect the results. Consequently, a significant difference may not be found between the two materials. Stabholz, et al. in 1985 showed that marginal adaptation of restorative materials had a direct correlation with their sealability (31). On the other hand, pure OCP was prepared and used in our study; whereas, MTA is a synthetic product and several materials have been incorporated to improve its properties. This issue may explain the low sealability of OCP compared to MTA. Thus, by using smaller OCP particles we may be able to obtain a better seal. Otherwise, considering the current composition of OCP, this material cannot be a good alternative to MTA for repair of perforations.

Conclusion:

Large-particle pure OCP cannot be a suitable alternative to MTA in terms of sealability for repair of furcal perforations.

Conflict of Interest: “None Declared”

References:


