Original Article

Evaluation of Mineral Trioxide Aggregate for Root end Closure of Nonvital Permanent Teeth with Open Apices

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**ABSTRACT**

**Objective:** To evaluate the clinical and radiological outcome of MTA in nonvital teeth with open apices. **Methods:** Twenty-five non-vital teeth with open apices were treated with MTA apexification procedure. Standard endodontic procedures were followed and an apical plug of at least 5 mm was created by using MTA after a calcium hydroxide intra-canal dressing for at least 1 week. Final obturation was done after 24 hours by vertical compaction technique using gutta percha. Patients were recalled at 3, 6, 9 and 12 months interval. Clinical outcome was evaluated by assessing pain, tenderness, mobility and sinus tract. Blind to the treatment record, two examiners assessed the pre-treatment and post-treatment radiographs. Each radiograph was scored with the Periapical Index (PAI) and the size of the apical lesion was measured. The presence of an apical bridge over MTA was also noted. **Results:** Clinically 92% success rate was found whereas radiologically absolute success rate was 84%. Before treatment the mean PAI was 3.6 and mean size of the lesion was 3.24 mm. But, after 12 months follow up, the mean PAI was 1.36 and the mean lesion size was 0.68 mm. An apical barrier over MTA was distinguishable in 5 cases. **Conclusion:** Apexification using MTA can be considered as a predictable treatment option than calcium hydroxide apexification.

**Introduction**

The common causes for the interruption of root development are trauma and caries and the majority of injuries occur in young individuals when the root development is incomplete\(^1\). The completion of root development and closure of
the apex occurs up to 3 years following eruption of the tooth. When teeth with incomplete root formation suffer pulp necrosis, the root development ceases and apical closure cannot be achieved. Root canal treatment at this time is a significant challenge, because of the size of the canal, the thin and fragile dentine walls and the large open apex. Apexification is a well-established treatment for immature teeth with necrotic pulp. Materials used for apexification are calcium hydroxide [Ca(OH)$_2$], bone growth factor, collagen, tricalcium phosphate, osteogenic protein-1. Ca(OH)$_2$ pastes have been considered as the material of choice to induce the formation of a hard tissue apical barrier. But apexification with Ca(OH)$_2$ has several disadvantages such as long treatment period, difficulty of the patient’s recall management, number of radiograph, increase of the patient’s recall management, number of radiograph, increase of the risk of root fracture after dressing with Ca(OH)$_2$ for extended periods, formation of porous calcified bridge and the prognosis may be compromised by the placement of a temporary coronal seal. Recently, a new material mineral trioxide aggregate (MTA) has been introduced for apexification that appears to be a significant improvement over other materials.

The advantages of apical plug with MTA are less treatment time, possibility to restore the tooth with a minimal delay and thus to prevent the fracture of the root. MTA offers a barrier at the root end that permits vertical condensation of warm gutta-percha in the remainder of the canal. Clinical studies have reported that 77% to 85% of teeth with open apices healed completely within 1 to 3 years after the placement of MTA apical plug.

**Materials & Methods**

25 non-vital teeth with open apices had selected for the study after clinical and radio-graphical evaluation. At first visit, patient’s clinical signs or symptoms and radiographic evidences were recorded. The radiographs were examined by two examiners and recorded in the data collection sheet. After isolation of teeth with cotton roll and saliva ejector, a straight line access cavity was prepared and working length was determined with radiograph. Then the canal was debrided with Hedstrom file carefully and copious irrigation was done with sodium hypochlorite (2.5%) solution and normal saline, alternatively, followed by dried with sterile paper points. Ca(OH)$_2$ paste was mixed with glycerin and placed into the canal with lentulospiral followed by temporary restoration.

After one week, temporary coronal restoration was removed and repeated copious irrigation was done with 2.5% sodium hypochlorite solution followed by normal saline to remove all the Ca(OH)$_2$ paste. Canal was dried with sterile paper points and if any exudate was noticed, Ca(OH)$_2$ paste was re-applied for next one week. A plugger had made manually by heating and rolling with two Protaper gutta percha to condense the MTA at the apical area. A radiograph was taken to confirm that the plugger was at least 3-4 mm short of the apex. The ProRoot MTA (Dentsply) was mixed to a thick creamy consistency with distilled water (3:1) and delivered into the canal with lentulospiral. Then the plugger was inserted in the canal to condense the MTA at the apex with a thickness of at least 3 mm. Correct placement of MTA at apical 3-4 mm area was confirmed by taking another radiograph. A moist cotton pellet was placed into the chamber and the access was sealed with zinc oxide eugenol cement. After 24 hours, hardness of MTA was checked with a condenser and rest of the canal was sealed with gutta percha and zinc oxide eugenol sealer in vertical compaction technique. The access was sealed using composite resin restoration and a post-operative radiograph was taken.
Materials Heating & rolling

Custom made hand plugger Radiograph before apical plug

**Figure 1:** Custom made GP Plugger

**Evaluation**

For clinical evaluation, the preoperative and postoperative status was compared based on the presence or absence of pain, tenderness to palpation or percussion, mobility or presence/absence of any sinus tract. The comparative clinical outcome was graded according to clinical endodontic guideline as follows:

- **Success:** Absence of any pain or absence of tenderness to palpation or percussion, no sinus tract with normal physiological mobility.
- **Uncertain:** Low grade discomfort after percussion or palpation with sporadic vague pain and/or persistent mobility.
- **Failure:** Any signs or symptoms of persistent pain, predictable discomfort to percussion or palpation, recurrent sinus tract or excessive mobility.

For radiological evaluation, two examiners assessed the pre-treatment and post-treatment radiographs in a dark room using a magnifier. The apical area of involved tooth was scored with the Periapical Index (PAI) which was categorized as:

1. Normal periapical structure;
2. Small changes in bone structures;
3. Changes in bone structure with some mineral loss;
4. Periodontitis with well-defined radiolucent area; and
5. Severe periodontitis with exacerbating feature. The diameter of the lesion size was measured with a millimeter ruler and the presence or absence of an apical tissue barrier over the surface of MTA at apex was also noted. The pre-operative and the post-operative status were compared and the success or failure was graded as follows on the basis of the changes of size of the lesion and/or score of the PAI.

**Result**

Twenty-five nonvital teeth with open apices of 21 patients were treated with MTA apexification procedure. The mean age of the patients was 15 years (Figure 2). The preoperative and 12 months clinical follow up data were analyzed with ‘Z-test’ which have shown a significant success rate of 92% (Table 3). The variables for the clinical evaluation are shown at Table 1. The PAI scores of the preoperative and last review radiograph were analyzed with ‘paired t-test’ (P < 0.0001) and the mean PAI was reduced to 1.36 from 3.6. The mean size of the lesion was reduced after 12 months from 3.24mm to 0.68mm (Figure 4) and significant difference have shown between preoperative and 12 months follow up visit (t= 4.4945, P<0.0002). In consideration of the PAI and the size of the lesion (Table 2), 8% cases have shown relative failure and 92% have shown...
relative success. The absolute success rate was 84% (21 cases).

<table>
<thead>
<tr>
<th>Number of Patient</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of patient (year)</td>
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<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
</tr>
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<td>15</td>
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<td>24</td>
<td>25</td>
<td>26</td>
<td>27</td>
<td>28</td>
</tr>
</tbody>
</table>

Figure 2: Distribution of age of the patients.

Table 1: Clinical evaluation (n=25)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Preoperative (present)</th>
<th>12 months (present)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td>10(40%)</td>
<td>1(4%)</td>
<td>0.00107 (s)</td>
</tr>
<tr>
<td>ytiliboM</td>
<td>2(8%)</td>
<td>1(4%)</td>
<td>0.27425 (ns)</td>
</tr>
<tr>
<td>ssenredneT</td>
<td>18(72%)</td>
<td>1(4%)</td>
<td>0.00(s)</td>
</tr>
<tr>
<td>tcart suniS</td>
<td>5(20%)</td>
<td>0(0%)</td>
<td>0.00914 (s)</td>
</tr>
</tbody>
</table>

n : Number of tooth
ns : Non-significant
s : Significant

Table 2: Correlation between PAI and size of the lesion (n=25)

<table>
<thead>
<tr>
<th>Size of the lesion</th>
<th>PAI ↓ (AS)</th>
<th>PAI stable=1 RS</th>
<th>PAI stable &gt;1 RS</th>
<th>PAI ↑ AF</th>
</tr>
</thead>
<tbody>
<tr>
<td>↓ (AS)</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>=0(RS)</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>&gt;0 (RF)</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>↑ (AF)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Discussion

The primary purpose for this clinical study was to evaluate the clinical and radiological outcomes of the MTA as root-end barrier. In a review study, 74–100% success rate was found by using Ca(OH)$_2$ for apical barrier formation. Though Ca(OH)$_2$ has been used as a material for apexification procedure from last century, many researchers have tried with other materials because of some problems associated with Ca(OH)$_2$ apexification process such as long-term treatment and the risk of root fracture. MTA has been proposed in experimental studies, clinical protocols, clinical cases and prospective studies as a potential material to form an apical barrier instead of multi-appointment Ca(OH)$_2$ apexification procedure. A comparative study showed that clinical and radiographic success rate for MTA was 100% where 87% with Ca(OH)$_2$. Also the time taken to complete the treatment and the biological barrier formation in MTA group was significantly less from Ca(OH)$_2$ group but the healing time for periapical radiolucency was almost identical.

In this study, the clinical and radiological outcome was assessed at 3, 6, 9 and 12 months. At least every 3 months radiographic review is recommended following completion of treatment to identify changes in the periapical area. The PAI score was used to evaluate the periapical health and the healing process because it was considered as the most appropriate of all the evaluation techniques validated in endodontics. When an apical lesion was present, its largest dimension was recorded. MTA was extruded beyond apex in 2 cases. In one case having PAI score 4 and 15 mm lesion reduced to 2 mm at 12 months. Placement of the root filling in a canal with an open apical foramen carries the risk of root filling material extrusion. For this reason, placement of an artificial matrix such as resorbable collagen, hydroxyapatite and calcium sulphate are recommended before placing MTA though no matrix was used in this study. MTA placement at the cemental limit of the canal showed better result than over filling.

A pilot study have shown 94.1% clinical success whereas 76.5% radiologically by using MTA as a apical barrier. Simon have shown healing occurred in 81% cases with MTA apexitification and an apical barrier over MTA was distinguishable in 26% cases where the results are about similar to the result of this study. On the other hand, induction of apical hard barrier tissue formation was found histologically in 100% success rate in a animal study treated with MTA. This difference may be due to limited thickness of the dentine bridge that was too thin to be clearly distinguishable radiologically. Ca(OH)$_2$ was used for approximately 1 week as
an intracanal medicament in this study similar with other several studies. The use of Ca(OH)₂ regarding MTA apical plug is still controversial. A study have shown favorable result without using Ca(OH)₂ where the teeth were treated directly with MTA apical plug in one visit whereas another study had shown Ca(OH)₂ for 7 days is highly effective in killing root canal flora. Hasselgren demonstrated that Ca(OH)₂ can be effective in dissolving necrotic pulp tissue but Hachmeister showed that Ca(OH)₂ had no significant effect on MTA leakage or displacement resistance. On the contrary, Porkaew suggested that remnants of Ca(OH)₂ on the canal walls may react to form calcium carbonate and interfere with the seal produced. However, recent data suggests that the combination of MTA and calcium hydroxide in apexification procedures may favorably influence the regeneration of the periodontium.

Using messeng gun with the aid of surgical operating microspoe and radiovisiography is recommended by manufacturer for carried out and condensation of MTA into apical area. Due to limitation of equipment, MTA was carried out in the canal with lentulospiral and condenced apically with a custom made gutta percha plugger in this study. Aminosharia reported that hand condensation resulted in better adaptation and fewer voids than ultrasonic method. In case of a traumatized immature teeth having thin wall, a different obturation technique would be more appropriate to increase the strength of the root canal walls and improve the long-term prognosis of these teeth to prevent cervical root fractures. The combination of apical MTA and an internal bonded composite (flowable dual cure composite) appears to have a more favorable prognosis than gutta-percha though all the cases of this study were obturated with gutta percha at coronal to MTA plug.

**Conclusion**

MTA has shown clinical and radiographic success as an apexification material in necrotic immature permanent teeth. It may be a suitable replacement for Ca(OH)₂ for the apexification procedure. However further clinical studies are recommended.

**References**


