A COMPARATIVE STUDY OF THE SEALING ABILITY OF DIFFERENT ROOT END-FILLING MATERIALS: AN IN VITRO STUDY

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ABSTRACT

The purpose of the present study is to compare the sealing ability of three different root-end filling materials, namely: MTA, composite resin with Clearfil SE (Kuraray) two-step self-etching adhesive and composite resin with Excite (Ivoclar-Vivadent) two-step adhesive with phosphoric acid etching in root-end filling cavities prepared by burs or ultrasonic retrotips. The resected roots is resected in different angulations, 45° beveled and non-beveled resected roots.

120 single canal teeth were divided into two groups according to beveling of resected root (45° bevel and no bevel). The two groups were furtherly divided into 4 subgroups due to instrument used in root-end cavity preparation (burs - Ultrasonic tips). The subgroups were divided into subdivision according to material used for filling. Dye penetration method was used to evaluate the sealing ability of the fillings.

The results showed that MTA has significantly the highest sealing ability followed by Composite bonded with Clearfil-SE-Bond and the least sealing ability was reported by Composite resin bonded with Excite bonding agent.

The results of the study concluded that the best sealing ability gained with no beveling of resected root, using of ultrasonic tips in root-end cavity preparation and MTA as root-end filling material.

INTRODUCTION

Root end resection and the placement of root end fillings have been performed when nonsurgical endodontic therapy has failed or is considered unfeasible, apical surgery may be the only treatment available other than extraction. Endodontic surgery usually involves exposure of the apex, root resection, root-end preparation, and root-end filling. An ideal root-end cavity preparation can be described as a class I cavity at least 3 mm deep with parallel walls.

The main objective of a root-end filling material is to provide an apical seal that prevents the movement of bacteria and the diffusion of bacterial products from the root canal system into the periapical tissues.
The effect of beveling of resected root on the sealing ability had been examined for a long time and there were a lot of arguments on their effect. Also the use of burs or ultrasonic retrotips for retro-cavity preparations had a lot of controversy in results of many literatures.

The sealing ability of the root-end filling materials is primer importance in the success of apicoectomy, so many materials had been tested and there was no total agreement on a material for fulfilling the requirements of root-end filling materials.

In this study we used to compare the sealing ability of three different root-end filling materials, namely: MTA, composite resin with Clearfil SE (Kuraray) two-step self-etching adhesive and composite resin with Excite (Ivoclar-Vivadent) two-step adhesive with phosphoric acid etching in root-end filling cavities prepared by burs or ultrasonic retrotips. The resected roots is resected in different angulations, 45° beveled and non-beveled resected roots.

**MATERIALS AND METHODS**

One hundred and twenty recently extracted human, permanent single-canaled teeth were selected for this study.

The teeth were endodontically treated using conventional step-back technique for cleaning and shaping and lateral condensation technique for obturation. The coronal access was sealed with Cavit G.

The samples were divided into two equal groups. The two groups were divided according to the type of root-end resection done as follows:

- **Group-I:** 3 mm of the roots of this group were apically resected using high-speed carbide bur in horizontal plane (no bevel).

  This group was furtherly divided into two sub-groups according to instrument used for root-end cavity preparation as follow:

  - **Sub-group-1:** Class I root-end cavities were prepared using fissure bur. This sub-group was also divided into three sub-divisions according to the material used for retrograde filling as follow:
    - **Sub-division-(I-A):** the root-end cavity was filled with Pro-root MTA.
    - **Sub-division-(I-B):** the root-end cavity was filled with composite resin bonded by Excite bonding agent.
    - **Sub-division-(I-C):** the root-end cavity was filled with composite resin bonded by Clearfil SE-Bond bonding system.

- **Group-II:** roots of this group were resected with high-speed carbide bur in 45° beveled plane.

  This group was furtherly divided into two sub-groups according to instrument used for root-end cavity preparation as follow:

  - **Sub-group-3:** Class I root-end cavities were prepared using fissure bur. This sub-group was divided into three sub-divisions according to the material used for retrograde filling as follow:
    - **Sub-division-(II-A):** the root-end cavity was filled with MTA.
    - **Sub-division-(II-B):** the root-end cavity was filled with composite resin bonded by Excite bonding system.

Sub-division-(II-C): the root-end cavity was filled with composite resin bonded by Clearfil SE-Bond bonding system.

Sub-group-4: Class I root-end cavities were prepared using retrotips.

This sub-group was divided into three sub-divisions according to the material used for retrograde filling as follow:

Sub-division-(II-D): the root-end cavity was filled with MTA.

Sub-division-(II-E): the root-end cavity was filled with composite resin bonded by Excite bonding system.

Sub-division-(II-F): the root-end cavity was filled with composite resin bonded by Clearfil SE bond bonding system.

Each sub-division of the two groups contains 10 teeth.

The external surfaces of the roots were covered by two layers of nail polish except at the resected root surface. Sealing ability of the different materials was assessed by immersing the examined group’s roots in 2% methylene blue dye in upright position at room temperature for the period of twenty four hours.

After the period of examination passed, the teeth were removed from the dye then washed and left to dry.

Roots were then sectioned longitudinally by means of a diamond disc mounted to a slow speed straight handpiece and the depth of dye penetration was measured in each of the tested specimens.

The degree of dye penetration was measured twice by the same person at different times by using digital caliber and the mean between the two readings was calculated and statistically analyzed.

# RESULTS

I. Comparison between the different interactions

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Mean</th>
<th>SD</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No beveling x Bur x Kuraray</td>
<td>1.15 c</td>
<td>0.56</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>No beveling x Bur x Excite</td>
<td>1.65 b</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>No beveling x Bur x MTA</td>
<td>0.62 d</td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td>45º beveling x Bur x Kuraray</td>
<td>1.16 c</td>
<td>0.57</td>
<td></td>
</tr>
<tr>
<td>45º beveling x Bur x Excite</td>
<td>1.78 b</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>45º beveling x Bur x MTA</td>
<td>0.56 d</td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td>No beveling x US x Kuraray</td>
<td>1.06 c</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>No beveling x US x Excite</td>
<td>1.97 a</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>No beveling x US x MTA</td>
<td>0.30 e</td>
<td>0.52</td>
<td></td>
</tr>
<tr>
<td>45º beveling x US x Kuraray</td>
<td>1.14 c</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>45º beveling x US x Excite</td>
<td>1.67 b</td>
<td>0.42</td>
<td></td>
</tr>
<tr>
<td>45º beveling x US x MTA</td>
<td>0.59 d</td>
<td>0.57</td>
<td></td>
</tr>
</tbody>
</table>

*: Significant at P ≤ 0.05, Different letters indicate statistically significant differences according to Tukey’s test

The statistically significantly highest mean value (least sealing ability) was found with (No beveling x US x Excite).
There was no statistically significant difference between (No beveling x Bur x Excite), (45° beveling x Bur x Excite), (No beveling x US x Excite) and (45° beveling x US x Excite) which showed lower mean values (higher sealing ability).

There was no statistically significant difference between (No beveling x Bur x Kuraray), (45° beveling x Bur x Kuraray), (No beveling x US x Kuraray) and (45° beveling x US x Kuraray) which showed lower mean values (higher sealing ability).

Much higher sealing ability was found with (No beveling x Bur x MTA), (45° beveling x Bur x MTA), (No beveling x US x MTA) and (45° beveling x US x MTA) with no statistically significant difference between the three groups.

The statistically significantly lowest mean value (highest sealing ability) was found with (No beveling x US x MTA).

In this study, the sealing ability of the examined materials with different angulations of root resections was compared. The angulations of beveling used were 45° and no bevel (perpendicular to the long axis of the tooth). This was done to simulate the different treatment modalities that could be done clinically and examined the materials in these different situations.

Engel et al. showed that there was no significant difference at the time of preparation between the use of the ultrasonic instrument and the microhandpiece under the conditions of their study, but it was possible that the ultrasonic instrument may be more time saving during actual surgical procedures due to the improved access possible with this instrument. The gouging caused by microhandpiece may increase the risk of perforation. The ultrasonic instrument may aid in access and provided superior control, reducing the risk of perforation. (2)

On comparing ultrasonic and bur root-end preparations Wuchenich et al. found that ultrasonic preparations were deeper than the bur preparations. They also found that ultrasonic tips produced root-end preparations that followed the direction of the canal space better and had cleaner cavity surfaces than those prepared by burs. (3)

So in this study, we compared the sealing ability of retrograde filling materials examined in root-end cavities prepared with bur and ultrasonic retrotips. This would make a comparison between traditional surgical endodontic technique, modern technique, and combination of the two techniques and their effect on sealing ability of root-end filling materials examined in our study.

An ideal root-end filling material should produce a complete apical seal, have antibacterial activity, and be...
nontoxic, biocompatible, nonabsorbent, dimensionally stable, easy to manipulate, unaffected by moisture, and radiopaque.\(^{(4)}\)

Composite resins were used as a root-end filling material but they seemed to be subjected to microleakage. To prevent microleakage the use of dentin bonding agents had been proposed.\(^{(5)}\)

The self-etch adhesives were made to solve difficulties commonly associated with the clinical application procedures of etch-and-rinse adhesives. Their application procedure was considered less time consuming and less technique sensitive, in particular with regard to keeping the dentin surface in an adequate state of hydration. Self-etch adhesives were associated with less nanoleakage.\(^{(6)}\)

The bond strengths of Clearfil SE-bond were proved to be high by Bouillaguet et al.\(^{(7)}\) Also they showed that using of this bonding agent could compensate for the polymerization stresses increasing the sealing ability of the composite to the radicular dentin.

In this study, we compared the sealing ability of composite resin combined with two different types of two-step bonding agents. The first type was etch-and-rinse bonding agent with primer and bond in single bottle (Excite- Ivoclar- Vivadent). The second type was self-etch bonding agent with two-step priming and bonding (Clearfil SE-Bond-Kuraray). These two bonding agents were tested by dye penetration for their sealing ability when bonded to composite resin as a root-end filling material with different angulations of beveling of the resected root (no bevel & 45° bevel) and different instruments used for root-end cavity preparation (bur & ultrasonic).

MTA sealing ability was evaluated in comparison with commonly used root-end filling materials, MTA showed less dye penetration and bacterial leakage than amalgam, Super-EBA or Intermediate Restorative Material (IRM). In addition, when marginal adaptation of MTA root-end fillings was compared with those of amalgam, Super-EBA, and IRM under scanning electron microscope, they reported no noticeable gap between MTA and its surrounding dentinal wall.\(^{(8)}\)

Although MTA had superior biocompatibility and sealing ability when compared to the traditional materials used in root-end filling and root repair, it was a costly material and had poor handling characteristics. Despite the numerous carrier devices available in the market to help in its clinical placement, clinicians are still finding MTA difficult to use in certain surgical situations because of the location of the surgical site and the small size of the root-end preparation.\(^{(9)}\)

In this study, as MTA had all of these advantages, we used MTA to be compared with the other materials because it had the best sealing ability as root-end filling material. The MTA was proved in many references to be the best material used as root-end filling instead of amalgam. In the past, any material used as root-end filling must be compared with amalgam sealing ability. But now MTA is the best root-end material, and any material would be examined must be compared with MTA because of its high sealing ability, and biocompatibility.

Although there were numerous methods of studying apical leakage, the dye penetration method was chosen for this experiment as it was the conventional and most popular method. Dye leakage investigations had proved to be simple, inexpensive, and did not require the use of complex laboratory equipment.\(^{(10)}\)

The results by the current study showed no significant difference between the two groups (no bevel – 45° bevel) among the three tested materials.

These results disagreed with Gilheany et al\(^{(1)}\) who found that the sealing ability was better with the non beveled roots than 45° beveled roots because of the exposure of less dentinal tubules with the non beveled roots.
The non significance in this study might be due to the use of bonding agents which cover the root-end cavity and the dentin of the resected root.

Under the conditions of this study there was no significant difference between the use of ultrasonic tips or burs in root end cavity preparation with 45° beveling or without beveling.

These results disagreed with Rainwater et al.\textsuperscript{(10)} and De Lange et al.\textsuperscript{(12)} who found that the ultrasonic retrotips used for root end cavity preparation were stated to give higher sealing ability than burs. The non significance in the current study might be due to the use of different materials in this experiment.

The higher sealing ability gained from the use of ultrasonic tips was due to the advantage gained from its preparation. The refinement of cavity margins that were obtained with ultrasonic tips positively affects the delivery of materials into the cavities and enhanced their seal.\textsuperscript{(13)}

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The mean of results of dye penetration was highest using composite resin bonded with Excite bonding agents as root-end filling material in root-end cavities either prepared with ultrasonic tips or burs. The root-end cavities prepared with ultrasonic tips or burs and filled with composite resin bonded with Clearfil-SE-Bond (Kuraray) had lower mean of dye penetration than composite filling with Excite bonding agent. The mean of dye penetration of MTA filled in root-end cavities prepared with either ultrasonic tips or burs was the lowest of all the root-end filling materials.

These results disagreed with Frankenberger et al.\textsuperscript{(14)} and Perdigão et al.\textsuperscript{(15)} who found that the sealing ability of composite resin bonded with 2-step total etch bonding agents was higher than the sealing ability of composite resin bonded with 2-step self-etching bonding agents.

The results disagreed with Adamo et al.\textsuperscript{(16)} who found that there was no significant difference of sealing ability between MTA and the other materials tested in their study.

The results of the present study also disagreed with Fogel and Peikoff\textsuperscript{(17)} who found that there was no significant difference of the sealing ability between MTA and composite resin as root-end filling materials, while our results showed significance.

The difference between the results of the current study and others studies was due to the use of different materials and the use of different techniques for testing the sealing ability.

**CONCLUSION**

These results showed that composite resin with Clearfil-SE-Bond (Kuraray) had acceptable sealing ability that was not very high like MTA but in comparison to Excite there was significant difference between them. Kuraray had higher sealing ability than Excite that means the use of two step self-etching bonding agents has higher sealing ability in root-end filling than two steps etch and bond bonding agents.

**REFERENCES**


