Microleakage of different types of temporary restorative materials used in endodontics

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Abstract: A temporary filling should seal the endodontic access cavity to avoid reinfection of the root canal system during endodontic treatment. The aim of this study was to evaluate the marginal seal of four temporary filling materials in endodontic access cavities in vitro, using the dye penetration method. Endodontic access cavity preparations were in 50 incisor and 50 molar noncarious nonrestored crowns of extracted human teeth. The coronal access of 10 teeth per group were filled with Coltosol, Algenol, IRM, Fermit or Fermit-N. After storing the teeth in demineralized water for 48 hours, they were immersed in 2% methylene blue dye for 24 hours. All the teeth were sectioned longitudinally and the linear depth of dye penetration was evaluated under a stereomicroscope. There was no significant difference in the microleakage observed in the high elasticity light-cured resin composite (Fermit) versus the low elasticity light-cured resin composite (Fermit-N) groups (p > 0.05). (J. Oral Sci. 42, 63-67, 2000)

Key words: microleakage, temporary restorative materials, endodontics.

Introduction

It is generally accepted that long-term endodontic success is dependent on proper cleansing and shaping to eliminate tissue debris and microorganisms and to seal the root canal systems. Sometimes it is not possible to clean, shape and obturate the endodontically-involved tooth in a single visit. Rather, multiple visits are necessary to perform this treatment (1). Therefore, when endodontic therapy requires multiple visits, it is important to provide a liquid-proof seal in the access cavity to prevent marginal leakage past the temporary restorative materials. Also, temporary restorative materials should be easy to manipulate, not soluble in saliva, nontoxic, and capable of withstanding masticatory stress.

A number of materials have been advocated for use as temporary endodontic materials and can be classified as zinc oxide-eugenol, zinc oxide-calcium sulphade without eugenol and a light-cured resin composite.

Numerous methods are described to determine the sealing properties of temporary restorative materials. Besides dye penetration tests, autoradiography, electrochemical methods, fluid filtration techniques, and bacterial penetration tests have been applied to determine microleakage (2-5). The dye penetration technique is the most popular method of studying microleakage because it is easy to conduct.

Recent studies have shown that coronal microleakage is a significant factor in the prognosis of root canal treatment. Moreover, the amount of coronal leakage that occurs within a relatively short time (2-3 days) should be considered as a potential etiological factor of root canal failure. This finding is of great importance to clinicians, who are often faced with the problem of scheduling multiple-appointment treatments over a lengthy period of time (6,7).

The aim of this in vitro study was to evaluate the marginal seal of five different types of temporary filling materials in endodontic access cavities, using the dye penetration technique.

Materials and Methods

Fifty anterior and fifty posterior molar non-carious, non-restored extracted human teeth were used. Immediately after extraction, the teeth were stored in distilled water to avoid dehydration. Standard endodontic access preparations
were made and the root canal contents were removed with a barbed broach. The patency of the apical foramen was determined using a #15 K-type file. Coronal flaring was accomplished by a step-back technique with Gates Glidden burs (Zimmerer), sizes 2 and 4. All teeth used in the study were instrumented in the same manner by one operator. The canals were dried by paper points then cotton pallets were packed to allow for 3.5 or 4.0 mm layer of temporary restorative material to be added.

The teeth were randomly divided into 5 groups of 20, with each group having 10 anterior and 10 posterior molars. Group 1 was restored with a 3.5-4.0 mm layer of Coltosol (Coltene, Switzerland), zinc oxide calcium sulfate without eugenol, and single paste. Group 2 had a 3.5-4.0 mm layer of Algenol (Kem-Dent, England), zinc oxide-eugenol cement, and powder-liquid. Group 3 had IRM (Caulk/Densply, USA) for the coronal seal, reinforced zinc oxide-eugenol, and cement powder-liquid. Group 4 had 3.5-4.0 mm thickness of Fermit (Vivadent, Liechtenstein) single component (high elasticity), and light-cured resin composite. Group 5 had restored Fermit-N (Vivadent, Liechtenstein) single component (low elasticity), and light-cured resin composite. The temporary restorative materials were placed incrementally (Fig. 1 a,b). The materials used for all groups is shown in table 1. After placement of the temporary restorative materials according to the manufacturer’s recommendation, all teeth were stored in distilled water at 37°C for 48 hours. Restored teeth were coated with two coats of nail polish with a 1 mm circumference around the restorations that was free of polish. The teeth were then immersed in 5% methylene blue dye for 24 hours. After 24 hours, the teeth were rinsed under tap water.

The coronal portions of the teeth were removed by sectioning at the cervical line with a high speed bur and sectioned buccal-lingually with a slow speed diamond saw (Isomet).

The degree of marginal dye penetration was evaluated under stereomicroscope at ×2 magnification. The measurement of dye penetration was scored in accordance with the following criteria (8,9):

0- No penetration
1- Dye penetration within the dentino-enamel junction (DEJ).
2- Dye penetration within half of the pulp chamber.
3- Dye penetration of half of the pulp chamber or greater.

The greatest depth of penetration along the wall of the access cavity of both split segments was determined and recorded for each specimen.

The data were analyzed using the Kruskal-Wallis test to determine whether any statistically significant differences existed between groups (p ≤ 0.05).

The leakage values indicated differences among the materials (Table 2). Coltosol presented the least microleakage (Fig. 2) whereas the other groups exhibited similar microleakage values. Furthermore dye penetration into the filling material was noted in the Fermit and Fermit-N anterior and posterior molar groups (Figs. 3,4).

The mean leakage values and standard deviations for each group are presented in Table 3. There were statistically significant differences between the Coltosol group and the other groups (p < 0.05), while there was no statistically

![Fig. 1 Incremental technique for a. posterior teeth, b. anterior teeth.](image)

<table>
<thead>
<tr>
<th>Materials</th>
<th>Anterior Leakage Grades</th>
<th>Posterior Leakage Grades</th>
<th>Number of Specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1: Coltosol</td>
<td>0 1 2 3</td>
<td>0 1 2 3</td>
<td>20</td>
</tr>
<tr>
<td>Group 2: Algenol</td>
<td>4 5 1</td>
<td>8 2</td>
<td>20</td>
</tr>
<tr>
<td>Group 3: IRM</td>
<td>2 8</td>
<td>3 7</td>
<td>20</td>
</tr>
<tr>
<td>Group 4: Fermit</td>
<td>1 4 5</td>
<td>1 1 4 4</td>
<td>20</td>
</tr>
<tr>
<td>Group 5: Fermit-N</td>
<td>2 8</td>
<td>1 3 1 5</td>
<td>20</td>
</tr>
<tr>
<td>Group 6: Coltosol and Algenol</td>
<td>1 2 7</td>
<td>1 1 8</td>
<td>20</td>
</tr>
</tbody>
</table>
significant difference in leakage between Algenol, IRM, Fermit and Fermit-N ($p > 0.05$). However, there was statistically significant difference in leakage between the Coltosol anterior and the Coltosol posterior groups ($p < 0.05$) and between the anterior and the posterior IRM groups ($p < 0.05$).

**Discussion**

In clinical endodontic practice, temporary restorative materials must possess physical properties that will allow for immediate sealing for access preparations. Also, due to various factors such as multiple appointments, difficulties in scheduling, or complexities of cases, these materials, even though they are considered temporary, should provide leak-proof seals for the duration of the root canal therapy (10).

All tested temporary restorative materials that were used were a total thickness of 3.5 to 4.0 mm in order to comply with the recommendation of Webber et al. (11), who found that a 3.5 mm thickness was needed to hamper leakage. Also, the technique of placing these temporary restorative materials into endodontic access cavities may have had some adverse effects on the marginal microleakage. In present study, all of the materials were incrementally added into the access cavities. Further, the marginal seal was applied by only one operator to decrease variability.

Clinically, the results could be impacted by the masticatory forces present in the oral cavity, and this may vary with such variables as sex, age, location of the tooth, and bruxism (12). Because of these differences, occlusal load was not applied in this in vitro study.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Anterior Mean</th>
<th>Anterior Std Dev</th>
<th>Posterior Mean</th>
<th>Posterior Std Dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1 Coltosol</td>
<td>1.5*</td>
<td>0.53</td>
<td>0.2*</td>
<td>0.48</td>
</tr>
<tr>
<td>Group 2 Algenol</td>
<td>2.8</td>
<td>0.42</td>
<td>2.7</td>
<td>0.48</td>
</tr>
<tr>
<td>Group 3 IRM</td>
<td>3.4*</td>
<td>1.71</td>
<td>2.1*</td>
<td>0.99</td>
</tr>
<tr>
<td>Group 4 Fermit</td>
<td>2.6</td>
<td>0.84</td>
<td>2</td>
<td>1.15</td>
</tr>
<tr>
<td>Group 5 Fermit-N</td>
<td>2.5</td>
<td>0.71</td>
<td>2.7</td>
<td>0.67</td>
</tr>
</tbody>
</table>

* Statistically different, $p<0.01$.
Temperature fluctuations can harmfully affect the marginal seal ability of temporary restorative materials as well as other dental materials (13). In contrast, Rossmomando and Wendt Jr. (14) and Kidd (15) stated that in vitro thermal cycling procedures did not adversely affect the microleakage. In this in vitro study, thermal cycling was not performed.

Zinc oxide-calcium sulfate without eugenol-based material is the most extensively used temporary endodontic filling material because of its ease of manipulation, it requires no spatulation, its ease of removal from access cavities, and it has been tested and compared with a variety of material in a number of dye marginal leakage experiments (10,13,16). The result of this in vitro study indicated that zinc oxide-calcium sulfate without the eugenol-based material, Coltosol, provided a better coronal marginal seal in standardized endodontic access preparations than Algenol, IRM, Fermit, or Fermit-N, which is consistent with the findings of other investigators (5,9). There are hygroscopic materials that possess a high linear expansion resulting from water absorption during setting. This expansion enhances the sealing of the access cavity.

Reinforced zinc oxide-eugenol cement (IRM) exhibited leakage to a lesser extent than the zinc oxide-eugenol cement (Algenol) or the resin-based materials (Fermit and Fermit-N). The sections of crowns restored with IRM revealed, in most teeth, a very dense mass with good adaptation to the cavity walls of the teeth, but there was no significant difference between IRM and Algenol because of their similar formulation.

There was a significant difference in leakage between the Coltosol anterior and posterior groups. This result may depend on the mass of the material, where in posterior teeth the mass of the material is larger than in the anterior teeth. There was also statistically significant differences between the IRM anterior and posterior groups, however, we can not explain this phenomenon at this time.

IRM and Algenol are packaged as a liquid and powder that must be mixed before placement. This is a disadvantage in that the material takes a considerably longer time to place and adjust than zinc oxide-calcium sulfate without the eugenol-base materials and light-cured composite resin based materials.

Zinc oxide-eugenol cement and zinc oxide-calcium sulfate without eugenol-based materials have relatively low compressive strengths and do not adhere to the structure of the teeth. This makes both materials unsuitable for use where insufficient coronal tooth structure remains to provide mechanical retention, or when aesthetics is a crucial consideration because of their unattractive color. However, light-cured resin composite temporary restorative materials overcome, in part, this problem.

The light-cured composite resin-based Fermit and Fermit-N showed similar microleakage values with zinc oxideeugenol-based IRM and Algenol, but showed more microleakage than Coltosol. Teplitsky and Meimaris (17) compared the sealing ability of zinc oxide-calcium sulfate without eugenol Cavit and light-cured composite resin TERM using methylene blue dye and found that Cavit had a more effective seal than TERM and this findings is in accordance with our results. Anderson et al. (18) stated that Cavit and TERM provided leakproof seals while IRM demonstrated significant more microleakage. This finding is not in accordance with the current findings, but it may be due to the difference of the microleakage technique and/or because of thermal stress.

Using the dye penetration technique, all samples showed some leaking to the tooth access preparation wall-restoration interface. Additionally, Fermit and Fermit-N absorbed the methylene blue. The reason for this phenomenon was probably a lack of the microparticules in the light-cure resin composite temporary restorative materials. However they do not attain an adequate environment to start its setting as Coltosol. Comparing Fermit and Fermit-N with the other tested temporary restorative materials, the light-cured resin composite materials have excellent color matches with the anterior teeth. During the restoration of temporary materials, it was observed that Fermit was slightly more difficult to manipulate than Fermit-N. This is likely the result of differences between the elasticity of these two materials. According to the manufacturer information, Fermit-N had a lower elasticity than Fermit.

Certainly this in vitro method of microleakage measurement cannot duplicate the environment that exists in vivo, but the finding of this in vitro measurement provides information that may aid clinicians in the selection of materials.

References
Comparison of four thermocycling techniques. J. Prosthet. Dent. 53, 50-53


