APICAL MICROLEAKAGE OF DIFFERENT LUTING AGENTS IN ENDODONTICALLY TREATED TEETH RESTORED WITH PARA-POST SYSTEM

Z. Polat, S. Başkan, İ. Tacır
University of Dicle, Faculty of Dentistry, Prosthodontics Department, Diyarbakır, Turkey

ABSTRACT
Endodontically treated teeth are known to present a higher risk of biomechanical failure than vital teeth. Complete obturation of the root canal system to the cementodentinal junction is assumed to be an important goal in endodontic treatment. The microleakage is determined today by many in vivo and in vitro techniques such as; staining, measurement by scanning electron microscope, bacterial activity, decay, air pressure, chemical agents, markers, neutron activation analysis, radioisotope, ionisation, autoradiography, and reversible radioactive adsorption and thermal cycle application. The purpose of this study was to compare the apical leakage with using the biomolecular characteristics of the methylene blue technique in root canals obturated with a stainless-steel post system (ParaPost System) cemented with zinc-policarboxilate cement, glass-ionomer cement and resin cement. Fifty mandibular first premolar teeth with straight root canals, anatomically similar root segments (root lengths 17 mm.), and fully developed apices, extracted for periodontal reasons, were selected and divided into 5 groups of 10 each. Analysis of variance (ANOVA) was used to determine whether significant differences existed between the means of the different groups. Multiple comparisons and rankings were done using Duncan’s multiple range test. The negative controls and positive controls all leaked significantly more than all of the experimental groups. Glass ionomer cement had significantly less microleakage than zinc-policarboxilate cement. Composite resin (self-cured) cement had significant more microleakage than all of the cements at (p<0.001).

Introduction
Endodontically treated teeth are known to present a higher risk of biomechanical failure than vital teeth. Dowels are generally needed to allow clinicians to replace missing tooth structure and restore pulpless teeth. Complete obturation of the root canal system to the cementodentinal junction is assumed to be an important goal in endodontic treatment. To achieve this, it is believed that the root canals fillings must seal the pulpal space both apically and laterally to prevent possible further apical irritation from incomplete elimination of bacterial products or continuous communication between apical tissues and the oral cavity (1-8). The microleakage is determined today by many in vivo and in vitro techniques such as; staining, measurement by scanning electron microscope, bacterial activity, decay, air pressure, chemical agents, markers, neutron activation analysis, radioisotope, ionisation, autoradiography, and reversible radioactive adsorption and thermal cycle application (9-17). The staining method is, however, by far the most preferred one. The types of dye staining and their concentrations are acridine orange (0.1%), toluidine blue (0.25%), erythrosine (2%), methylene blue (0.2%), fluorescent (20%), phosphoric acid (37%), basic fuchsin (0.5 to 2%), silver nitrate (50%), crystal violet.
TABLE 1

<table>
<thead>
<tr>
<th>Materials</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Para Post</td>
<td>Whaledent (New York, NY)</td>
</tr>
<tr>
<td>Poly-F Plus (polycarboxylate cement)</td>
<td>De Trey Dentsply (Weybridge, Surrey, UK)</td>
</tr>
<tr>
<td>Aqua Cem (glass ionomer cement)</td>
<td>De Trey Dentsply (Weybridge, Surrey, UK)</td>
</tr>
<tr>
<td>Unite ™ Bonding Adhesive (composite (self-cured) resin cement)</td>
<td>3 M Unitek, Inter-Unitek GmbH (Germany)</td>
</tr>
</tbody>
</table>

Fig. 1. The molecular structure of the methylene blue.

Fig. 2. The view of the luting agents used in the study.

(0.05%) and aniline blue (2%) (9-19).

The methylene blue molecule consists of an organic alkali tied to an acid. Its molecular weight is 319.868/mol and the surface area of a single adsorbed particle is 120Å (Fig. 1) (9).

The significant differences between these methods are suggestive of the fact that a valid method for the determination of the microleakage has not been yet established (9).

The success of endodontic therapy is commonly through of in terms of an adequate apical seal because of this, cementation of the post into the prepared canal is critical. Zinc-policarboxilate cement has been the most commonly used cementing agents and remains the comparison standard. Zinc-policarboxilate cement consist of a zinc oxide powder and viscous solution of polyacrylic acid in water as liquid. Glass ionomer cement consist of a calcium aluminosilicate glass containing fluoride powder mixed with poliacrylic acid liquid, which forms chemical bonds with tooth structure. Resin cement establishes a strong bond to the dentinal walls of the root canal and to the post surface, thereby increasing retention (29, 21).

The purpose of this study was to compare the apical leakage with using the biomolecular characteristics of the methylene blue technique in root canals obturated with a stainless-steel post system (ParaPost System) cemented with zinc-policarboxilate cement, glass-ionomer cement and resin cement.

Materials and Methods

To evaluate the microleakage of different luting agents, 3 different luting agents, zinc-policarboxilate cement (Poly-F Plus, Dentsply De Trey), glass-ionomer cement (Aqua–Cem, Dentsply De Trey), composite (self-cured) resin cement (Unite ™ Bonding Adhesive, 3 M Unitek, Inter-Unitek GmbH) were selected (Table 1) (Fig. 2).

Fifty mandibular first premolar teeth with straight root canals, anatomically similar root segments (root lengths 17 mm.), and fully developed apices, extracted for periodontal reasons, were selected and divided into 5 groups of 10 each (Table 2).

The teeth were cleaned of soft tissue and calculus, decoronated apical to the cemento-enamel junction with a slow-speed dia-
TABLE 2
Experimental groups. (n=10)

<table>
<thead>
<tr>
<th>Group</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Empty canals (negative control)</td>
</tr>
<tr>
<td>2</td>
<td>Para Post without cement (positive control)</td>
</tr>
<tr>
<td>3</td>
<td>Para Post cemented with zinc polycarboxylate cement</td>
</tr>
<tr>
<td>4</td>
<td>Para Post cemented with glass ionomer cement</td>
</tr>
<tr>
<td>5</td>
<td>Para Post cemented with composite resin cement</td>
</tr>
</tbody>
</table>

A diamond saw (Isomet; Buehler, Lake Bluff, Ill.), and stored in eau-distile water until used. For all teeth, the pulp tissue was removed with a barbed broach (Dentsply-Maillefer, Ballaigues, Switzerland). Canal patency was determined by passing a file (size 10 K-file; Dentsply-Maillefer) through the apical foramen. Canal working lengths were established 1.0 mm short of the apical foramina. A step-back technique was used for canal instrumentation. The same operator instrumented all root canals to the same size (#55 file; Dentsply-Maillefer). Every file was replaced by a new one after the preparation of two canals. During instrumentation, canals were irrigated with 2 ml of freshly prepared 2% solution of sodium hypochlorite (NaOCl, 2% active chlorine) by using a syringe. Before obturation, the root canals were dried with paper points (Dentsply-Maillefer). In Group 1, the canals were left empty to serve as a negative control.

Fort the other forty teeth, the dowel spaces were prepared in each root using a 1.50-mm-diameter drill supplied with the prefabricated dowel to a dept of 7 mm. (ParaPost System, Lot MT 32102; Coltene/Whaledent, Cuyahoga Falls, Ohio) (Fig. 3).

For zinc-policarboxilate cement (Poly-F Plus, Dentsply De Trey), and glass-ionomer cement specimens, the cements were mixed according to the manufacturer’s instructions and then introduced into each dowel space using a lentulo spiral instrument (Dentsply-Maillefer). Then the dowels were coated with cement and slowly seated by finger pressure. Finger pressure was maintained until the cement set. Excess cement was removed, and each specimen was cleaned with a moist cotton roll. For composite (self-cured) resin cement specimens, asit-etching was applied to the walls of the roots and thinned with a brush, allowed to etch for 30 seconds, and gently air-water dried. Before obturation, the root canals were dried with paper points (Dentsply-Maillefer). Composite (self-cured) resin cement (Unite ™, 3 M Dental) was then placed in the root canals. Dowels were coated with cement and slowly seated by finger pressure. Excess cement was removed with an explorer. For the specimen selected for Group 2, procedures for selection and instrumentation were the same as those described for the experimental groups, except dowels were seated into the prepared root canal space without using luting cements to serve as a further positive control.

The samples were subjected to a thermal cycle by immersion into water baths 500 times of 5 ºC ±1 ºC and 60 ºC ±1 ºC for 30 seconds each time with intervals of 30 seconds between two immersions (4).
The post surface that were in the crown part of the teeth and the cervical part of the teeth were coated and sealed then with sticky wax and the root sections of the teeth received a double coating of nail polish (VEPA nail polish, TR.). All samples were then subjected to staining for 24 hour at 37 °C in a 2% methylene blue solution (The stock solution was prepared with 4.75 g/l of methylene blue at pH 6.98 with the help of a H$_2$PO$_4$-/HPO$_4^{2-}$ buffer.) and in a ST400 thermostatic shaker bath at the Chemistry Department of the Faculty of Sciences in Dicle University (4) (Fig. 4).

All speciments were then, buried in to acrylic resin blocks, and the teeth were split longitudinal in labiolingual direction (Fig. 5). The degree of microleakage was determined by measuring the linear extent of the methylene blue penetration from the apical end of the preparation (Figs. 6, 7). The measurements were made at two different periods by the same evaluator, using a Ni­con SMZ-2T stereomicroscope (Nico, Tokyo, Japan) at a magnification of ×1 to 6.3 with a millimeter ruler (Union Broach) and an ocular micrometer with a precision of 0.25 mm. To determine the most coronal point of linear leakage, two measurements were made. First, after splitting the roots, dye penetration was measured from the apex to the most coronal extent of dye visible on the cements or root canal walls. Second, after the luting cement has been removed with an endodontic explorer, dye penetration was measured on the canal walls. The measurements of dye penetration were compared, and the larger one of the value was used as the most coronal point of linear dye leakage.

Analysis of variance (ANOVA) was used to determine whether significant differences existed between the means of the different groups. Multiple comparisons and rankings were done using Duncan’s multiple range test.

Results and Discussion

The microleakage values (mean ± Sds) for the controls and experimental groups are summarized in Table 3. The measures ANOVA indicated that fluid microleakage values varied according to the luting agents used (zinc-policarboxilate cement, glass-ionomer cement, resin cement) (p<0.001). Duncan’s multiple range test (p<0.001)
demonstrated that significant differences between the means of luting agents was present. The negative controls and positive controls all leaked significantly more than all of the experimental groups. Glass ionomer cement had significantly less microleakage than zinc-polycarboxylate cement. Composite resin (self-cured) cement had significant more microleakage than all of the cements at (p<0.001).

The method, utilizes the molecular characteristics of the methylene blue in which pH adjusted to 6.98, and the surface area covered by the methylene blue dye adsorbed in the areas where leakages have occurred subsequent to the thermal conversion similar to the traditional methods. The theory underlying the use of biomolecular characteristics of methylene blue as a different approach for the measurement of microleakage surface areas is the adsorption phenomenon, which is the collection of the molecules, atoms or ions in any solution on the surface of a solid surface when they turn into gas, vapour or liquid phase (15).

Specimens for testing were prepared using human teeth. The manufacturer’s instructions were followed carefully when dowels were cemented to ensure that in vitro procedures were the same as those used clinically. In this study, test specimens were not completely restored nor subjected to mechanical stress. These factors may limit the direct application of study results to in vivo situations.

Wu et al. (22) advised controlling the length of the specimens, as well as canal diameters and canal anatomy, to reduce variation in microleakage studies. In this study, root lengths (17 mm.) and dowel space lengths (10 mm.) were standardized to avoid anatomical variations and to obtain standardization.

In this study, the root canals were not obturated with gutta-percha and sealer before post space preparation and post placement. These materials and technique of obturation of the gutta-percha would contribute more variables to the study and make comparisons more difficult to analyze. In addition, incomplete removal of root canal sealer from the post space may reduce bond strength of resin cements to dentin. This may have an influence on microleakage.

Although in this study, statistical analysis showed significant differences in microleakage between the groups, the measurements of microleakage demonstrated high variations within the groups. Certain clinical factors were challenging the controls, such as the differences in root canal anatomy, volume of the prepared spaces, the character of the smear layer, the pathology of the dentinal tubules (23). In addition, the root surface area of the canal walls, and the amount of remaining dentin may have influence on the permeability of the dentin (24). Consequently, some of the fluid filtration measured may have actually been fluid movement into root canal ramifications, or into dentinal tubules rather than microleakage (24). In addition, although an apical plug was placed in all of the experimental group specimens, there may be

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**TABLE 3**

Microleakage of all groups (mm)

<table>
<thead>
<tr>
<th>GRUP</th>
<th>N</th>
<th>$X_i$</th>
<th>$S_i$</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>10</td>
<td>4.3500</td>
<td>1.5000</td>
<td>1.7300</td>
<td>14.3700</td>
</tr>
<tr>
<td>Group 2</td>
<td>10</td>
<td>3.0890</td>
<td>0.1080</td>
<td>2.6780</td>
<td>3.6000</td>
</tr>
<tr>
<td>Group 3</td>
<td>10</td>
<td>0.1278</td>
<td>0.0035</td>
<td>0.1136</td>
<td>0.1460</td>
</tr>
<tr>
<td>Group 4</td>
<td>10</td>
<td>0.1557</td>
<td>0.0068</td>
<td>0.1186</td>
<td>0.1896</td>
</tr>
<tr>
<td>Group 5</td>
<td>10</td>
<td>2.0312</td>
<td>0.0713</td>
<td>1.8140</td>
<td>2.4921</td>
</tr>
</tbody>
</table>
variations in the amount of cement placed in the post space, in the distribution of the cement in the post space, and in the adaptation of the cement to the post and canal wall.

In the experimental groups, the dentinal walls within the canals were not treated with a conditioner of polyacrylic acid to remove the smear layer. Glass Ionomer cement demonstrated the less microleakage. The adhesion of glass ionomer to dentin occurs by the presence of carboxyl groups from the polyacrylic acid, which is contained in the liquid used in glass ionomer cements (25). The results demonstrated that the microleakage values of composite resin cement were the highest. Composite resin cement may create polymerization shrinkage stresses within the dowel space. Composite resin cement have lower elastic moduli compared to the dowel they join. Thus, a zone of highly concentrated loads and stresses is created. In in vitro studies the polycarboxylate cements show chemical bonding to properly prepared human enamel and dentin. And also, the components of glass ionomer cements react to form a cross-linked gel matrix surrounding the partially reacted powder particles. Chelation between the polycarboxylate molecules and calcium on the surface of the tooth result in a chemical bond (26, 27).

**Conclusions**
Within the limitations of this study, the following conclusions were drawn.
1. The dowel systems must be used with a luting cement on the root canal.
2. The results demonstrated that the microleakage values of composite resin cement were the highest (p<0.001), so that the composite resin cements is not recommended for clinical use alone. Composite resin cements may be used with using adhesive luting agents.
3. Achieving these goals will not only improve the restoration of endodontically treated teeth, but also will ensure a higher degree of microleakage prevention and improve the prognosis on endodontic therapy.

**REFERENCES**