Effect of different root canal sealers on fracture strength of simulated immature roots

Özgür Ilke Atasoy Ulusoy, DDS, PhD,a Yelda Nayır, DDS,b and Sis Darendeliler-Yaman, DDS, PhD,c Ankara, Turkey
GAZI UNIVERSITY

Objective. The objective of this study was to compare the effects of different root canal sealers on fracture resistance of simulated immature teeth.

Study design. One hundred eight roots were divided into 9 groups. The roots were instrumented except the negative controls. Four millimeters of mineral trioxide aggregate (MTA) barriers were placed apically. The roots were backfilled as follows: group 1, AH Plus/gutta-percha; group 2, EndoREZ/gutta-percha; group 3, EndoREZ/Resilon; group 4, Hybrid Root SEAL/gutta-percha; group 5, Hybrid Root SEAL/Resilon; group 6, iRootSP/gutta-percha; group 7, iRootSP/Resilon; group 8, No obturation other than MTA barrier; group 9, No instrumentation, no obturation. A compressive loading was applied at a speed of 1 mm/min. Data were compared with ANOVA and Duncan tests.

Results. Group 5 showed the highest resistance to fracture. The fracture values of group 3 were lower than those of the other experimental groups.

Conclusions. Hybrid Root SEAL and iRootSP reinforce the simulated immature roots against fracture when used with either gutta-percha or Resilon. (Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:544-547)

Endodontic treatment of immature teeth poses a challenge for the practitioners because of the open apices, long-term use of calcium hydroxide, and flared root canals accompanied by thin dentinal walls that are susceptible to fracture.1–2 Therefore, in the management of such weakened teeth, it would be advantageous to reinforce the roots to increase their resistance to fracture.2

The use of mineral trioxide aggregate (MTA, ProRoot, Dentsply, Tulsa Dental, Tulsa, OK) has been recommended in root-end fillings following periradicular surgery, perforation repairs, vital pulp capping, and apexification because of its higher sealing ability and biocompatibility.3–5 Because long-term use of calcium hydroxide may weaken the immature roots, immediate apical barrier formation using MTA offers several advantages over conventional apexification.1,6 Studies vary depending on the type of material to best reinforce and seal the remainder of the root after an apical barrier of MTA.6–8

Many root-filling systems have been developed to enhance the strength of root against fracture after endodontic treatment. In recent years, root canal materials, such as methacrylate resin-based sealers were reported to create “monoblock,” in which the sealer is bonded to both the canal wall and the core material, which in turn improves the fracture resistance of compromised roots.9

Hybrid Root SEAL (Meta SEAL; Sun Medical, Tokyo, Japan), containing 4-methacryloxyethyl trimellitate anhydride (4-META), has recently been introduced to the market. This dual-cured and self-etching sealer was suggested to form a hybrid layer that creates a strong bond to the dentinal walls.10,11

EndoREZ (Ultradent, Inc, South Jordan, UT) is a hydrophilic, urethane dimethacrylate-based resin sealer that has been developed aiming to create a “monoblock.” It is a tertiary monoblock system that uses gutta-percha cones coated with resin.12 The hydrophilic nature of EndoREZ was reported to enhance sealer penetration into dentinal tubules.13

iRoot SP (Innovative BioCeramix Inc., Vancouver, Canada) is an aluminum-free, hydrophilic, calcium silicate– and resin-based material that has recently been developed for root canal obturation.14 The material has similar physical properties as white MTA and requires the presence of water to set and harden.14,15 The manufacturer recommends the use of iRoot SP alone or in combination with appropriate core materials in the obturation of root canals. Apical sealing ability, antimicrobial activity, and biocompatibility of iRoot SP were
investigated recently. However, there is no study indicating the root reinforcement capacity of iRoot SP against fracture.

The aim of this in vitro study was to evaluate the effects of different root canal sealers used with either gutta-percha or Resilon cones on the vertical fracture resistance of simulated immature roots with an apical MTA barrier.

MATERIAL AND METHODS

One hundred eight freshly extracted, single-rooted mandibular premolar teeth with similar dimensions were used in this study. All teeth were stored in distilled water until use. The crowns were removed at the cementoenamel junction (CEJ) to standardize the root length of 14 mm with a high-speed bur under water cooling. Twelve roots were not instrumented and served as negative controls. The roots of the remaining 96 teeth were standardized to a length of 12 mm as measured from the apex to the facial CEJ by cutting the root-end with high-speed diamond burs under water cooling. Following root canal access preparation, the root canals were instrumented with ProTaper rotary files (Dentsply, Maillefer, Ballaigues, Switzerland) to a master apical size of 40 (F4). To simulate immature teeth, Peeso reamers were used to enlarge the root canals until a no. 5 Peeso could be passed beyond the apex. After instrumentation, the root canals were irrigated with 2 mL of 2.5% NaOCl (Wizard, Rehber Chemistry, Istanbul, Turkey) and 2 mL 15% EDTA (Wizard, Rehber Chemistry) using a 30-gauge needle; 2 mL of sterile water was used as the final rinse. Calcium hydroxide–based intracanal dressing (Ultradent) was applied in the root canal with a lentulo spiral to simulate disinfection procedures. The access cavity was sealed with a temporary filling material (Cavit, ESPE, Seefeld, Germany). The teeth were stored at 37°C and 100% humidity for 7 days. The calcium hydroxide was removed by flushing the prepared canals with 3 mL 2.5% NaOCl and 3 mL 15% EDTA; 5 mL of sterile saline was used as final rinse with a 30-gauge needle. To mimic immediate barrier formation, a 4-mm white Pro Root MTA plug (ProRoot, Dentsply, Tulsa Dental, Tulsa, OK) was placed apically using Schilder pluggers and condensed with a hand plugger. Teeth were placed in flower arrangement foam (Aquafoam, Syndicate Sales, Inc., Kokoma, IN) for easy handling and to prevent MTA extrusion. After 72 hours, the roots were mounted vertically in a self-cure acrylic (Meliodent, Bayer Dental, Leverkusen, Germany) blocks using a surveyor, exposing 6 mm of the coronal part. Before filling the root canals, they received a final rinse of 2 mL 2.5% NaOCl, 2 mL 15% EDTA, and 2 mL of distilled water and dried with paper points. The roots were divided into 9 groups (n = 12) and backfilled with the following filling materials: group 1, AH Plus (Dentsply de Trey, Konstanz, Germany) + gutta-percha cones; group 2, EndoREZ Sealer + gutta-percha cones; group 3, EndoREZ Sealer + Resilon cones; group 4, Hybrid Root SEAL (MetaSEAL) + gutta-percha cones; group 5, Hybrid Root SEAL (MetaSEAL) + Resilon cones; group 6, iRootSP root canal sealer + gutta-percha cones; group 7, iRootSP root canal sealer + Resilon cones; group 8, prepared but not obturated roots, MTA barrier only (positive control); and group 9, roots received no treatment (negative control).

The obturation of all roots in the experimental groups was performed as follows.

All the sealers were prepared according to the manufacturer’s instructions. The sealer was placed onto the canal walls by rotating the master apical file counterclockwise. The apical 3 to 4 mm of an appropriate master gutta-percha or Resilon cone was resected. The cone was grasped with a hemostat, and placed into the canal 2 to 3 mm short of the MTA plug. The tip of the master cone was softened in chloroform for 2 seconds. The cone was placed again into the root canal and gently tamped to length until an adequate impression of the canal was obtained. This custom-made gutta-percha or Resilon cone was dipped in the sealer and inserted into the instrumented root canal. Excess material was seared off 1 mm below the canal opening and compacted with a heated hand instrument.

After root canal obturation, in groups 2, 3, 4, and 5, light-curing was applied to the canal orifices for 40 seconds. The openings of the root canals were covered with a temporary filling material. The specimens were stored in 100% humidity at 37°C for 72 hours until mechanical testing to allow complete setting of the sealers.

A Universal Testing Machine (Lloyd LR 30K, Fareham England), in which the acrylic blocks were mounted, was used to apply a compressive vertical loading at a speed of 1 mm/min. The force when the fracture occurred was recorded in Newtons. The data were analyzed with 1-way analysis of variance (ANOVA) and Duncan tests with a significance level of .05.

RESULTS

Most of the fractures that occurred after loading were vertically or oblique oriented. The mean fracture load values derived from the mechanical testing are shown in Table I. The Hybrid Root SEAL and Resilon cone combination showed higher fracture load values compared with the other experimental groups. Use of EndoREZ sealer with Resilon cone showed signifi-
significantly lower fracture resistance than the other test groups except for AH Plus + gutta-percha (P < .05).

DISCUSSION

Immature teeth with large apices and thin dentinal walls become more susceptible to fracture owing to the loss of tooth structure. The results of the present study can be comparable with that of other studies regarding the reinforcement capacity of different root fillings of simulated immature teeth.2,6-8 When treating such teeth, apical placement of MTA barrier is a widely used treatment option because of the sealing ability and enhanced physical properties of MTA. The minimal thickness of ProRoot MTA for apexification is suggested to be 4 mm, therefore we used 4-mm MTA as the apical filling material to simulate clinical conditions.17

The methods for the simulation of immature teeth and preparation of the models in the experiments differed widely.2,6-8 We performed a simulated immature tooth model similar to that of Stuart et al.6 and Wilkinson et al.;2 however, the technique used for instrumentation and enlarging the root canals was different. The teeth used in the present study may simulate the shape of immature teeth, but may not simulate the tissue composition and physical properties exactly, which may be a limitation of this study. Because dentinogenesis is halted on the stage of root development of immature teeth, the thin root wall possesses incomplete peritubular and intertubular dentin with higher tubular density toward the cementum, unlike mature teeth where the outer parts of the roots involve lower tubular density and more intertubular dentin.18

In the present study, the simulated immature roots filled with the Hybrid Root SEAL/Resilon combination showed the highest resistance to fracture and superiority to the conventional AH Plus + gutta-percha. Also, the mean fracture load values of this group were similar to those of intact teeth that were not instrumented. This finding indicates that use of Hybrid Root SEAL has created a successful monoblock system. Although lack of knowledge about the root-strengthening effect of Hybrid Root SEAL complicates the comparison, Onay et al.11 showed that Hybrid Root SEAL/Resilon combination has superior bonding ability to root dentin, which supports the results of the present study.

The lowest fracture load values were obtained from the roots that were filled with EndoREZ + Resilon. Hammad et al.19 showed that obturation of roots with EndoREZ sealer and EndoREZ points increased the fracture resistance, which contradicts the results of our study. This discrepancy may have resulted from the difference in the experimental design, in that they applied load with spreaders instead of steel spherical tips used in the present study. Also, use of traditional gutta-percha and Resilon core materials in the current study may have affected the creation of monoblock and resulted in bonding failure and decrease in fracture resistance, because EndoREZ is a tertiary monoblock system that uses gutta-percha coated with resin. Similar to our results, Babb et al.10 showed that MetaSEAL and RealSeal SE (SybronEndo, Orange, CA) have higher push-out strengths than nonetching EndoREZ. The self-etching potential of Hybrid Root SEAL (MetaSEAL) may have increased the bond strength and root-reinforcing capacity of the material.

The manufacturer of iRoot SP claimed that the material can form a hermetic seal inside the root canal. The mean fracture load values obtained from iRoot SP groups were similar to those of Hybrid Root SEAL, which means that the new calcium silicate–based material has root-strengthening ability. In addition, the fracture resistance of roots filled with iRoot SP was higher than that of AH Plus + gutta-percha, although it was not significant. The similarity in the composition and physicochemical properties of iRoot SP and MTA may have caused a tight seal at the apical region,

Table 1. Mean, SE, SD, and minimum and maximum values of fracture resistance (in Newtons) for the experimental and control groups

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>Mean</th>
<th>SE</th>
<th>SD</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>AH Plus/gutta-percha</td>
<td>12</td>
<td>508.8CD</td>
<td>39.9</td>
<td>138.2</td>
<td>316.1</td>
<td>758.8</td>
</tr>
<tr>
<td>EndoREZ/gutta-percha</td>
<td>12</td>
<td>561.5C</td>
<td>22.6</td>
<td>78.4</td>
<td>402.1</td>
<td>684.8</td>
</tr>
<tr>
<td>EndoREZ/Resilon</td>
<td>12</td>
<td>404.5D</td>
<td>30.5</td>
<td>105.8</td>
<td>234.3</td>
<td>567.1</td>
</tr>
<tr>
<td>Hybrid Root S + gutta-percha</td>
<td>12</td>
<td>619.1BC</td>
<td>61.5</td>
<td>212.9</td>
<td>344.2</td>
<td>1004.0</td>
</tr>
<tr>
<td>Hybrid Root SEAL + Resilon</td>
<td>12</td>
<td>702.9AB</td>
<td>58.8</td>
<td>203.8</td>
<td>500.1</td>
<td>1083.4</td>
</tr>
<tr>
<td>iRootSP + gutta-percha</td>
<td>12</td>
<td>580.5BC</td>
<td>42.0</td>
<td>145.6</td>
<td>353.2</td>
<td>825.4</td>
</tr>
<tr>
<td>iRootSP + Resilon</td>
<td>12</td>
<td>610.0BC</td>
<td>47.0</td>
<td>162.9</td>
<td>406.5</td>
<td>951.0</td>
</tr>
<tr>
<td>Positive control</td>
<td>12</td>
<td>391.2D</td>
<td>20.9</td>
<td>72.4</td>
<td>297.1</td>
<td>497.9</td>
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<tr>
<td>Negative control</td>
<td>12</td>
<td>772.9A</td>
<td>37.8</td>
<td>130.8</td>
<td>592.4</td>
<td>1026.1</td>
</tr>
</tbody>
</table>

Different letters indicate significant differences between the groups (P < .05).
resulting in a more homogeneous root filling and increased resistance to fracture. The calcium silicate-based composition of the iRoot SP avoids shrinking of the material during setting. This might be another possible explanation for the material’s reinforcement capacity. The manufacturer suggested that iRoot SP can be used in root canals without any core material. The higher fracture strength values may be attributable to the combined use of iRoot SP and Resilon/gutta-percha points.

In the present study, vertical forces led to vertical and oblique fractures. If the orientation of the applied force was different from vertical, the resultant fracture line may have had a different direction. In studies on the effects of obturation materials on fracture resistance, forces directed at an angle of 50° to 130° to the long axis of the tooth resulted in cervical horizontal fractures in immature teeth. Because the premolar and molar teeth sustain vertical forces more than lateral forces during root canal obturation, mastication, and occlusion, we preferred to use vertical forces on the premolar roots in this study.

The present mechanical testing was performed with great effort to simulate the exact clinical conditions and achieve standardization; however, in vitro conditions do not completely reflect in vivo conditions. Further studies, including in vitro and in vivo are required to assess the accurate reinforcing capacity of calcium silicate– and methacrylate-based root canal sealers in immature teeth.

CONCLUSIONS

Within the limitations of this in vitro study, the simulated immature roots obturated with Hybrid Root SEAL and Resilon showed the highest resistance to fracture. This combination seems to be superior to the conventional AH Plus and gutta-percha system. Use of iRootSP with either gutta-percha or Resilon reinforces the weakened roots against fracture when compared with the positive control. However, the EndoREZ + Resilon combination showed the lowest fracture load values, suggesting that this system does not enhance root canals with thin dentinal walls.

REFERENCES


Reprint requests:
Özgür Ilke Atasoy Ulusoy, DDS, PhD
Gazi University Dental Faculty Department of Restorative Dentistry and Endodontics 82 Street, 06510 Emek Ankara, Turkey ilkeatasoy@yahoo.com