Final Irrigation Regimens Affect Fracture Resistance Values of Root-filled Teeth

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Abstract

Introduction: The purpose of this study was to compare the effect of different final irrigation solutions on fracture resistance values (FRVs) of endodontically treated teeth. Methods: Eighty extracted decoronated human incisors were used. Ten randomly selected roots were used as the negative control group. The remaining roots were prepared by the ProTaper system (Dentsply Maillefer, Ballaigues, Switzerland) up to F2. Ten prepared roots were selected as the positive control. The other prepared roots were divided into 6 (n = 10) groups according to the final irrigation solution used: 5 mL saline, 17% EDTA, EDTA with a surfactant (REDTA), chlorhexidine, QMix (Dentsply Tulsa Dental Specialties, Tulsa, OK), and BioPure MTAD (Dentsply Tulsa Dental Specialties). In all groups, the final irrigation was performed for 1 minute except for the BioPure MTAD group; in this group, it was applied for 5 minutes according to the manufacturer’s instructions. The specimens were filled with a single gutta-percha cone and AH 26 sealer (Dentsply, De Trey, Konstanz, Germany). After being stored under 37°C and 100% humidity for a week, the specimens were loaded in a vertical direction at 1 mm/min speed until they were vertically fractured. The results were analyzed by the Kruskal-Wallis and Siegel Castellan tests. Results: The negative control group showed the highest FRV. There were statistically significant differences between the negative and positive control groups (P < .05). Specimens irrigated with REDTA and QMix showed a higher FRV compared with the positive control group (P < .05). Specimens exposed to chlorhexidine and BioPure MTAD showed a lower FRV compared with the negative control group (P < .05). Conclusions: Root canal preparation weakens the tooth. The final irrigation regimen has an impact on the FRV. A short time exposure to irrigation solutions (REDTA and QMix) that include surfactants probably contributed to the higher FRV, instead of a long time exposure as done with BioPure MTAD. (J Endod 2016;42:493–495)

Key Words

Fracture resistance, root canal irrigants, vertical root fracture

Chemomechanical preparation is the causative factor that weakens the tooth during endodontic treatment and results in a reduction of the fracture strength of the tooth (1, 2). It is thought that the risk of fracture is reduced by the adhesion and mechanical interlocking between the filling material and the root canal dentin (3). Although the use of gutta-percha with an insoluble root canal sealer can be seen as the gold standard of root canal fillings, the ability of these materials to reinforce an endodontically treated root is still discussed because of controversial results (4–6). Resin-based dental materials have been proposed as a means to reinforce an endodontically treated tooth through the use of adhesive sealers in the root canal system (6).

Root canal irrigation solutions are used to remove pulp remnants and the smear layer formed after root canal preparation and to open the dentinal tubules in order to clean the root canal thoroughly and obtain a superior situation for adhesion and canal obturation. Removal of the smear layer may allow root canal filling materials and root canal sealers to contact the canal wall and penetrate into the dentinal tubules (7), which may increase the strength of the roots. However, recent studies have reported the negative effects of irrigation solutions on the bond strength of resinous materials to dentin (8, 9). Furthermore, final irrigation procedures negatively affect various physical properties of root canal dentin including microhardness, elasticity, and flexural strength (10–13). They also alter the bond strength of root canal filling materials to root canal dentin, which is effective in the wettability of residual root canal dentin (7). Hence, fracture resistance of the teeth may be affected by the use of irrigation solution.

In endodontic practice, many irrigation solutions with various distinct advantages and disadvantages are used for final irrigation purpose such as EDTA, EDTA with a surfactant (REDTA), sodium hypochlorite (NaOCl), and chlorhexidine (CHX). QMix (Dentsply Tulsa Dental Specialties, Tulsa, OK) is a new antibacterial agent designed for smear layer removal; it contains a combination of EDTA, CHX, and cetrimide. BioPure MTAD (Dentsply Tulsa Dental Specialties) is another product used for a final irrigation solution. Its formulation contains a mixture of 3% tetracycline isomer (doxycycline), 4.25% citric acid, and 0.5% detergent. These solutions have been assessed and compared with each other considering smear layer removal (14), antibacterial potential (15), cytotoxicity (16), effects on bond strength (13, 17), and wettability of root canal sealers (7). However, no study has been reported regarding the efficacy of these novel irrigants on the fracture resistance of endodontically treated teeth.

Therefore, the aim of this study was to evaluate whether different irrigation protocols have an effect on the fracture resistance of roots filled with gutta-percha and...
epoxy resin sealer (AH 26; Dentsply, De Trey, Konstanz, Germany). The null hypothesis of this study was that final irrigation regimens did not affect the fracture resistance values of endodontically treated teeth.

Materials and Methods

Eighty single-canalized human mandibular incisor teeth—stored in 0.2% sodium azide after extraction—were selected so that the buccal-lingual dimension at the cementoenamel junction (CEJ) measured 5.5 ± 0.5 mm. The crown of each tooth was removed so that the cor-onal surface was perpendicular to the long axis of the root, and the re-maining root length measured 13 ± 1 mm. Ten of the specimens were randomly chosen as the negative control group without any further pro-cedures. The working length of each remaining root was determined to be 1 mm less than the length of size 10 K-file just exiting the foramen. The root canals were instrumented using the ProTaper NiTi rotary sys-tem (Dentsply Maillefer, Ballaigues, Switzerland) up to size F2. Throughout instrumentation, irrigation was performed using 1 mL 2.5% NaOCl after each file via a 30-G irrigating tip (Endo-Eze; Ultradent, South Jordan, UT). When root canal preparations were completed, all samples were irrigated with 5 mL 2.5% NaOCl and 2 mL saline. Patency of the apical foramen was maintained throughout canal preparation with the size 10 K-file. Before and after instrumentation, each sample was examined under magnification and fiberoptic lighting to ensure there were no cracks or craze lines in the samples. At this time, 10 randomly selected specimens were assigned as the positive control group (prepared, not obturated). The remaining samples were randomly separated into 6 groups of 10 teeth each according to the final irrigation regimens. In the following groups, the final irrigation was per-formed for 1 minute except for the BioPure MTAD group in which MTAD was applied for 5 minutes according to manufacturer’s instruc-tions:

1. **Saline group**: 5 mL saline
2. **EDTA group**: 5 mL 17% EDTA
3. **REDTA group**: 5 mL REDTA (17% EDTA + 0.84 g cetyltrimethylam-monium bromide)
4. **CHX group**: 5 mL 2% CHX (CHX; Drogsan Medicine, Ankara, Turkey)
5. **QMix group**: 5 mL QMix
6. **BioPure MTAD group**: 5 mL BioPure MTAD

A final rinse of 5 mL distilled water was used to remove any residual irrigating solution. Canals were dried using paper points. All canals were filled with the single-cone technique using F2 gutta-percha (Dentsply Maillefer, Ballaigues, Switzerland) and AH 26 root canal sealer. Once obturation was completed, excess gutta-percha was removed to 1–2 mm below the CEJ, and the access cavities were sealed with tempo-rary filling material (Coltosol; Colene/Whaledent Inc, Altstaetten, Switzerland). The root canal fillings were checked for the obturation qual-ity using periapical radiographs. Completed teeth were wrapped in moist gauze and stored in separate jars in a 37° C incubator for 1 week to ensure the proper setting of the sealer cement. Before the fracture test, root surfaces were covered with silicone material (Oranwash L+; Indurent-gel catalyst for C-silicone; Zhermack, Badia Polesine, Italy) up to 2 mm apical to the CEJ to simulate the periodontal ligament (18) and were kept in 100% humidity for 24 hours. The roots were then mounted vertically in a thick Teflon ring (CoorsTek, El Segundo, CA) by using a self-cured acrylic resin (Meliodent; Bayer Dental, Leverkusen, Germany) to a depth of 2 mm below the CEJ. The acrylic blocks were placed on the lower plate of the Universal testing machine (LR 30K, Lloyd, West Sussex, UK). The upper plate included a steel spherical tip with a diameter of 5 mm. Compressive loading was applied vertically to the coronal surfaces of roots with a loading rate of 1 mm/min until fracture occurred. The force when the fracture occurred was recorded as newtons.

**Statistical Analysis**

Data were analyzed using the Kruskal-Wallis test for the experi-mental groups. Significance between the groups was tested with the Sie-gel Castellan test. All statistical analyses were performed using the SPSS software package (version 21.0; SPSS, Chicago, IL). A P value below .05 was considered to be significant.

**Results**

The median, minimum, and maximum fracture values are shown in Table 1. The Kruskal-Wallis test showed a significant difference among all groups (P < .05). Fracture resistance values of negative control group were significantly greater than the positive control group and roots irrigated with CHX and BioPure MTAD (P < .05, for all comparisons). Roots irrigated with REDTA were significantly more resistant to fracture than the positive control group and those irrigated with Bio-Pure MTAD (P < .05, for both comparisons). The fracture resistance of roots irrigated with QMix was higher than the positive control group (P < .05). All samples from this study were examined for the pattern of fractures. The majority of samples fractured in a labiolingual direction regardless of the final irrigant.

**Discussion**

Root canal irrigants may alter the chemical and structural composi-tion of dentin by changing its permeability and solubility characteristics (19, 20). Dogan Buzoglu et al (21) showed that EDTA decreased the wetting ability of dentin. Yilmaz et al (22) reported that the use of low-surface-tensioned EDTA compounds such as REDTA alone or in com-bination with NaOCl increased the wettability of root canal dentin. CHX has been shown to increase the surface-free energy of dentin (23, 24). BioPure MTAD produced a 10- to 12-μm thick zone of demineralized dentin compared with only a 4- to 6-μm thick zone produced by EDTA (25). These alterations can affect the bonding of sealers to dentin (26). It has been reported that root canal sealers must bond to dentin to rein-force root strength (6). Various studies showed that the root canal irrig-ants influenced the bond strength of resin sealers to dentin either by removing the smear layer or affecting the surface properties of the root canal dentin (10, 11, 22). The strength of the roots may increase via smear layer removal, which allows root canal sealers to contact the root canal wall by penetrating into the dentinal tubules (7). However, the study of Cobanlera et al (5) revealed no statistically significant differ-ence regarding fracture resistance among the roots obturated with AH 26 regardless of the absence or presence of the smear layer. Simi-ilarly, in the present study, there was no significant difference among sa-line, CHX, and other EDTA-based irrigants. CHX has been suggested as a final irrigant, but it is incapable of removing the smear layer (27).

**TABLE 1. Median, Minimum, and Maximum Fracture Values of Experimental Groups (Newton)**

<table>
<thead>
<tr>
<th>Experimental groups</th>
<th>n</th>
<th>Median</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative control</td>
<td>10</td>
<td>508.29b</td>
<td>466.18</td>
<td>608.74</td>
</tr>
<tr>
<td>Positive control</td>
<td>10</td>
<td>224.79b</td>
<td>176.51</td>
<td>293.18</td>
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<td>Saline</td>
<td>10</td>
<td>322.81abc</td>
<td>289.82</td>
<td>421.76</td>
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<tr>
<td>EDTA</td>
<td>10</td>
<td>356.74abc</td>
<td>277.90</td>
<td>398.76</td>
</tr>
<tr>
<td>REDTA</td>
<td>10</td>
<td>398.37ad</td>
<td>355.69</td>
<td>541.98</td>
</tr>
<tr>
<td>Chlorhexidine</td>
<td>10</td>
<td>302.56bc</td>
<td>236.42</td>
<td>383.99</td>
</tr>
<tr>
<td>QMix</td>
<td>10</td>
<td>414.23b</td>
<td>249.35</td>
<td>520.70</td>
</tr>
<tr>
<td>BioPure MTAD</td>
<td>10</td>
<td>257.15bc</td>
<td>209.09</td>
<td>418.96</td>
</tr>
</tbody>
</table>

Values with the same superscript letter are not statistically different.
et al (28) reported that the use of EDTA as the final canal irrigant results in a thin layer of demineralized collagen fibrils on the dentin surface. MTAD, REDTA, and QMix are EDTA-based irritants that also contain surfactants. Lui et al (29) reported that reducing the surface tension of endodontic solutions by surfactants improves their dentin wetting ability. In the absence of an accompanying surfactant, the presence of this layer of collagen fibrils is responsible for the poor wettability of root canal sealers on the EDTA-irrigated dentin (30). Previous studies reported that irrigation with NaOCl EDTA could be a better conditioner before using epoxy resin–based sealers compared with NaOCl MTAD (12, 31). Hashem et al (12) reported that Tween 80 detergent, a constituent of MTAD, permitted increased dentin surface energy and wetting ability, hence increasing intertubular dentin permeability as well as the exposure of collagen matrix and intertubular fluid, which could have negatively affected the adhesion of the hydrophobic epoxy resin–based sealer. Increased adhesive properties of root canal sealers to dentin may improve strength of the restored tooth, which may provide greater resistance to tooth fracture and clinical longevity of an endodontically treated tooth (32). There were many studies evaluating the bond strength of sealers to root canal dentin, which was treated with these irrigants (10–13). However, up to date, there was no current study that evaluates CHX, QMix, MTAD, and REDTA effect on root fracture resistance.

In the present study, the vertical root fracture resistance of MTAD-treated dentin was lower compared with EDTA-treated dentin. However, the vertical root fracture resistance of MTAD-treated dentin was also lower compared with detergent containing REDTA and QMix. One possible explanation for this result can be the difference in irrigation duration. Irrigation duration was 1 minute in all groups except MTAD, which was used for 5 minutes according to manufacturer instructions. It has been reported that the prolonged use of EDTA at high concentrations increases the risk for root fractures (33). The final rinse with Qmix promoted similar push-out bond strength values for epoxy resin–based sealer as with 17% EDTA (34). On the other hand, QMix compared with EDTA favors the wetting of root canal dentin by AH Plus (7). In the present study, specimens irrigated with Qmix showed higher resistance to vertical root fracture compared with specimens irrigated with EDTA.

Within the limitations of this study, results have shown that the root canal preparation and final irrigation influenced the vertical root fracture resistance. Roots that were only decoronized and not prepared showed the highest resistance to vertical root fracture. Regarding irrigation solutions, roots that were irrigated with either REDTA or QMix showed higher resistance to vertical root fracture. Further studies are needed to investigate the effect of different irrigants on bond strength of sealers and vertical root fracture resistance.

Acknowledgments

The authors deny any conflicts of interest related to this study.

References