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Fracture Resistance of Teeth Obturated with RealSeal™ Using Two Different Chelating Agents: An *in vitro* Study

Ahmed M. Al-Kahtani, BDS, MS, FRCD(C); Hussam Al-Fawaz, BDS; Mohammed Al-Sarhan, BDS; Khalil Al-Ali, BDS, MS

Abstract

Objectives: The aim of this study was to evaluate the fracture resistance of endodontically treated teeth filled with a resin-based obturation material using two different chelating agents.

Methods and Materials: Forty extracted single-canal human teeth were prepared, instrumented, and randomly divided into three groups: Group 1 (n=15) received a final flush with 10 ml of neutralized 17% EDTA, followed by 10 ml of sodium hypochlorite (NaOCl), then obturated using lateral condensation with RealSeal. Group 2 (n=15) received a final flush of BioPure™ MTAD™, followed by 10 ml of NaOCl, then obturated using lateral condensation with RealSeal. Group 3, the control group (n=10), was instrumented but not obturated, then the root canal opening was sealed with a temporary filling material. The specimens were stored in 100% humidity for 10 days, mounted in polyester resin, and loaded to failure.

Results: The ANOVA revealed a significant difference between the control group and the experimental groups, although there was no statistically significant difference between Group 1 and Group 2 (p=0.05). The MTAD group displayed higher mean fracture load values than the EDTA group.

Conclusions: It can be concluded that filling the root canals with RealSeal™ increased the *in vitro* resistance to fracture of single-canal extracted human teeth when compared to instrumented and unobturated teeth. Teeth treated with MTAD demonstrated high fracture-resistance values when compared to teeth treated with 17% EDTA, but they were not statistically significant.

Clinical Significance: Filling the root canals with RealSeal™ with increased bonding to roots will increase resistance to fracture of these teeth.

Keywords: RealSeal™, MTAD™, fracture resistance, obturation

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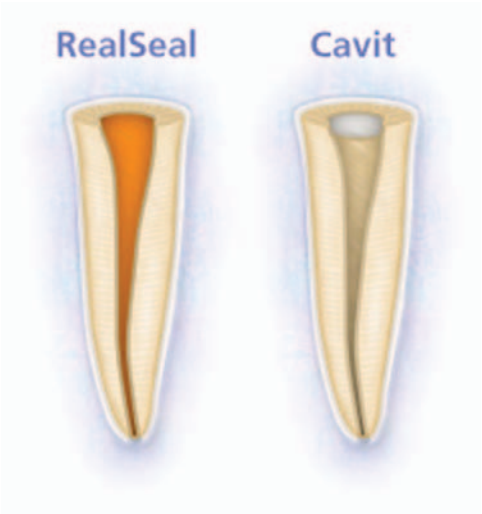
Introduction

Endodontically treated teeth are widely considered to be more susceptible to fracture than vital teeth. Dehydration of dentin after endodontic therapy, excessive pressure during obturation, and the removal of the tooth structure during endodontic treatment are the most often reported reasons for this phenomenon.[1–3]

In restorative dentistry, numerous studies have demonstrated coronal reinforcement of the tooth through bonded restorations. Bonded amalgams, composites, and glass ionomers all have been shown to reinforce the remaining tooth structure by bonding to dentin and enamel.[4–6] Resin-based dental materials have been proposed as a means to reinforce an endodontically treated tooth. However, for a dental material to reinforce the tooth, the material must bond to dentin. Therefore, an essential attribute of a good dentin adhesive system is the adhesive's ability to wet and infiltrate dentin. Similarly, bonding endodontic obturation materials could enhance the ability of endodontically treated teeth to resist fracture.

In recent years, an endodontic obturation material based on polyester chemistry and containing bioactive and radiopaque fillers has been developed and tested. Representative brand names of this material include Epiphany (Pentron Clinical Technologies, Wallington, CT, USA), Resilon™ (Resilon Research, North Branford, CT, USA), Next (Heraeus-Kulzer, Hanau, Germany), and RealSeal™ (SybronEndo, Orange, CA, USA). This endodontic obturation material performs and looks like gutta-percha. In addition, when used in conjunction with a resin-based sealant or bonding agent, it forms a monoblock within the canals that bonds to the dentinal walls. Because the resin core, sealant, and dentinal wall all are attached, it appears logical that they have the potential to strengthen the walls against fracture.[7]

The strength of this chemical bond depends on the wetability and penetration of the bonding agent



into the etched dentin that in part depends on the ability of the chelating agent to remove the smear layer. The commonly used material to remove the smear layer is 17% ethylenediaminetetraacetic acid (EDTA), although recent reports have shown that BioPure™ MTAD™is an excellent chelating agent with better penetration than 17% EDTA.[8]

The aim of this study was to compare the fracture resistance of teeth obturated with RealSeal™ using two different chelating agents (EDTA and MTAD™).

Methods and Materials

Forty extracted human teeth with a single canal were collected and stored in saline containing 0.2% chlorohexidine gluconate (Corsodyl, GlaxoSmithKline Consumer Healthcare, Brentford, UK) to prevent bacterial growth. Radiographs for all teeth were taken, then examined under 25x magnification with a dental operating microscope to rule out any teeth with preexisting root fractures or anomalies.

All selected teeth were sectioned at the cementoenamel junction using a straight fissure bur. The working length was established visually by placing a size 15 K-file (Dentsply Maillefer, Tulsa, OK, USA) into the canal until observed at the apical foramen, then decreasing the file length by 1 mm. All specimens were flared using sizes 2, 3, and 4 Gates Glidden burs (PulpDent, Watertown, MA, USA), then instrumented with a 0.04 taper profile rotary system (Dentsply, Maillefer, Tulsa, OK, USA) using the crown-down technique. Irrigation during instrumentation was carried out using 5.25% NaOCl with a 27 gauge needle.

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Specimens were randomly assigned into two experimental groups and one control group. Group 1 (n=15) received a final flush with 10 ml of neutralized 17% EDTA (PulpDent, Watertown, MA, USA), followed by 10 ml of NaOCl to remove the smear layer, then the canals were dried with paper points and obturated using lateral cold condensation with RealSeal™.

Group 2 (n=15) received a final flush of BioPure™ MTAD™ (Dentsply, Tulsa Dental, Tulsa, OK, USA), followed by 10 ml of NaOCl to remove the smear layer, then the canals were dried with paper points and obturated using lateral cold condensation with RealSeal™. Obturations were done according to manufacturer's instructions.

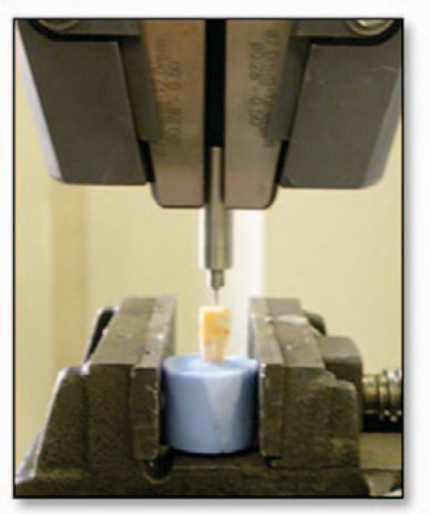

Figure 1. Resin cylinders mounted on the Instron machine.

Figure 2. The loading fixture.

Group 3 (control group, n=10) received no obturation. The root canal opening was sealed with Cavit (Premier Dental Products, Plymouth Meeting, PA, USA) as a temporary filling material. All the specimens were stored in 100% humidity for 10 days to allow the sealer to set.

Preparation for Mechanical Testing

After 10 days, the root specimens were prepared for mechanical testing (Instron 8500, Canton, MA, USA). The apical root ends were embedded individually in metallic rings with polymethylmethacrylate resin (Bosworth Fastray™, Skokie, IL, USA) leaving 9 mm of each root exposed. All the roots aligned vertically in the resin cylinders were mounted in the testing machine one at a time (Figure 1).

The application of the vertical loading force was similar to the technique used by Sedgley and Messer.[9] A loading fixture was mounted and aligned with a spherical tip (r=2 mm) that contacted the coronal surface of the roots (Figure 2). Each specimen was subjected to load at a crosshead speed of 1.0 mm per minute until the root fractured. The test was terminated at this point and the value of the force was recorded in newtons.

The data were subjected to analysis of variance (ANOVA) for all groups and a t test for the two groups with significance difference tests at the 95% level of confidence.

Results

The mean and standard deviation for each of the three experimental groups are presented in Table 1. The ANOVA revealed a significant difference between the control group and the experimental groups, although there was no statistically significant difference between Groups 1 and 2 (p=0.05). The MTAD™ group displayed higher mean fracture load values than the EDTA group.

Discussion

Root canal preparation has been proven to be a factor in decreasing the fracture resistance of teeth.[4–6,10,11] Any material that can compensate for this weakening effect would be useful.

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Table 1. Mean and standard deviation for each of the experimental groups.

Group	No.	Mean (Newton)	Standard Deviation
EDTA group	15	362.61	41.3
MTAD™ group	10	396.21	59.8
Control group	10	162.22	36.2

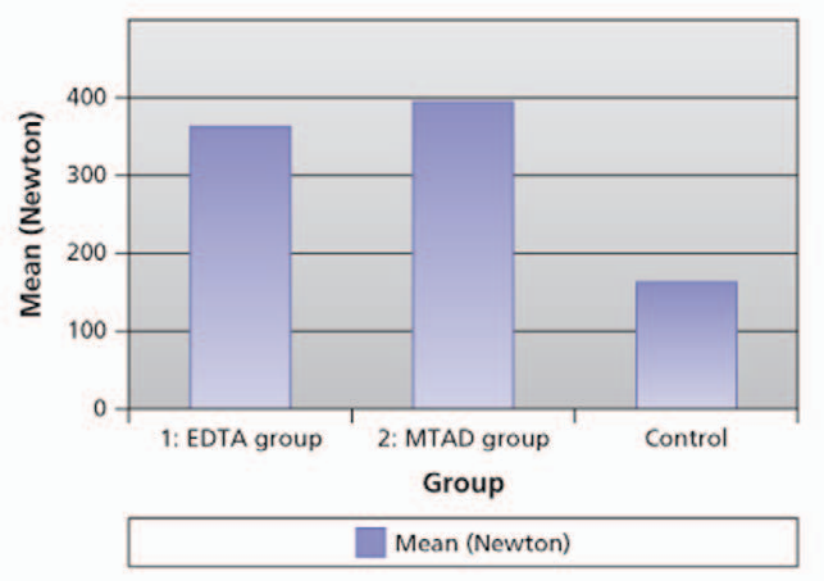

Figure 3. Mean chart of all the groups.

Figure 4. Mesiodistal fracture.

To minimize the sampling bias in this study, teeth with a single root, a single canal, and approximately the same root length were selected as was done in some other studies.[12,13] In order to have a uniform preparation, all the specimens were instrumented with the same technique. Similar teeth were selected and assigned randomly into groups. Moreover, the crowns of all the teeth were removed before strength testing. This created a situation that is certainly not clinically relevant. Thus, the reported force applied to the point of fracture is not absolute, but only relative between the different groups, and therefore cannot be transferred directly to an actual clinical situation.

It would be of valuable significance if the experimental groups of RealSeal™ were tested to the groups treated with gutta-percha, but previous studies[14,15] have shown that teeth treated with resin-based obturation materials have a higher resistance to fracture than those treated with gutta-percha, which is why this step was skipped.

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A final rinse of either EDTA for Group 1 or MTAD™ for Group 2 was used, followed by NaOCl to enhance the bonding of the material tested to the dentinal surface of the root. It was assumed that using MTADTM would enhance the bond strength, as the removal of the smear layer would be facilitated using MTAD™, as shown in other studies.[8] This study showed that the fracture resistance of teeth treated with MTAD™ and obturated with RealSeal™ was higher than for teeth treated with 17% EDTA but was not statistically significant (Figure 3).

In the present study, the force was applied along the long axis of the root with a rounded punch, which produced root fracture when contact was made between the punch and the walls of the canal opening. The majority of the fractures occurred in the mesiodistal direction. This could be due to the morphology of the selected root that had a narrow mesiodistal dimension (Figure 4).

The high standard deviation obtained in the present study may be due to the variations between the structures of the root dentin of the tested samples in relation to age or dentin sclerosis. Thus, it was very difficult to find a statistical difference between the experimental groups as shown in this study.

Based on the present results, root canal obturation with RealSeal™ resulted in an increase in the resistance to fracture compared with the instrumented but unfilled roots. This result was in agreement with the previous report of Schäfer et al.[15]

The result of the present study was in agreement with other studies,[14,15] which showed promising results regarding the ability of adhesive root canal filling material RealSeal™ to reinforce an endodontically treated root. However, care should be taken in the transfer of these findings to the long-term clinical situation because recent studies pointed out that these resin-based materials seem to be biodegradable under the attack of hydrolytic ester bond–cleaving enzymes, which may exist as a component of salivary enzymes or as extracellular enzymes from endodontically relevant pathogens such as *Pseudomonas aeruginosa*, *Enterococcus faecalis*, and several *Actinomyces* strains.[16] Moreover, there is some evidence that Resilon is also susceptible to alkaline hydrolysis.[17] It should be kept in mind that gutta-percha and conventional sealers have a history of extensive, long-term evaluation, which is not true of resin-based materials. Long-term clinical studies are needed to collect evidence-based data to support the use of these materials.

Conclusions

Within the limits of this study, the findings showed that filling the root canals with RealSeal™ increased the *in vitro* resistance to fracture of single-canal extracted teeth when compared to instrumented and unobturated teeth.

Teeth treated with MTAD™ demonstrated high fracture-resistance values when compared to teeth treated with 17% EDTA but were not statistically significant. Further studies should be performed to support these results and to evaluate the clinical significance of the method of obturation.

Clinical Significance

Filling the root canals with RealSeal™ with increased bonding to roots will increase resistance to fracture of these teeth.

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