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Comparing Fracture Resistance of Endodontically Treated Teeth Using Different Preparation-Obturation Combinations

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Abstract

Background: One of the main reasons for extraction of endodontically treated teeth is vertical root fracture (VRF). Some factors such as root canal treatment are involved in vertical root fracture because of their potential to weaken the tooth structure. Therefore, this study aimed to investigate the effect of combining different obturation materials and rotary systems on the fracture resistance of treated teeth.

Methods: Eighty extracted maxillary central incisors were selected. The coronal portions of all teeth were removed at the cemento-enamel junction leaving the root segment of nearly 13 mm length. Roots were randomly divided into 2 groups according to the system used in root canal preparations, Group I: ProTaper, Group II: Wave 1. Each main group was further subdivided into 2 equal subgroups according to the obturation system being used, Subgroup A: ProTaper, AH26 obturator, Subgroup B: ProTaper, Bioceramic, Subgroup C: Wave 1, AH26 obturator and Subgroup D: Wave 1, Bioceramic. Fracture resistance of each sample was measured by loading in universal testing machine. The results were analyzed with two-way ANOVA followed by multiple comparison Tukey HSD test.

Results: The highest mean fracture resistance value (256.7N) was associated with Soft-Core/AH26 obturation and wave one (subgroup C), while the lowest value (239.8 N) was for Bioceramic sealer and Wave 1 (subgroup D); however, there was no statistical significant difference (P>0.05) among all tested subgroups.

Conclusion: All instrumentation techniques caused weakening of the root structure and made them susceptible to fracture without any significant difference and therefore alternative strategies should be considered to reinforce endodontically treated roots.

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Introduction

The success of root canal therapy depends on several factors including preparation, disinfection and root canal filling (1). Cleaning and shaping of the canal system is the most important step for successful treatment. One of the reasons for extraction of endodontically treated tooth is vertical root fracture (VRF). Vertical root fracture is a fracture in the longitudinal direction of the root canal toward periodontium

(2). Prognosis of roots with VRF is very poor and almost always leads to tooth extraction or root resection (3). Some factors such as root canal treatment are involved in vertical root fracture because of their potential to weaken the tooth structure (4). Experimental studies have shown that excessive removal of dentin during root canal preparation and using spreader by force in the filling process may cause increased susceptibility to root fracture (5,6). Advances in rotary Nickel-Titanium (NiTi) instruments lead to the introduction of preparation systems with different file designs and motions. Besides the benefits of these systems in comparison with traditional hand instrumentation techniques, these files can cause different levels of stress in roots (7-9). Protaper (Dentsply Maillefer, Ballaigues, Switzerland) is a modified rotary NiTi system with progressive taper that can form canals much faster than devices with a constant taper. In use, this unique feature of progressively tapered design replicates the Schilderian Envelope of Motion technique and serves to significantly improve flexibility, cutting efficiency, and safety. Another feature of the ProTaper instruments relates to their convex, triangular cross-section, which enhances the cutting action while decreasing the rotational friction between the blade of the file and dentin. ProTaper files have a changing helical angle and pitch over their cutting blades. They reduce the potential of an instrument from inadvertently locking into the canal (10). WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) is a single-file system. It has a reverse taper, variable helical angle and a non-cutting end. It is used with 170° counter clockwise rotations (direction of cutting) and 50° clockwise rotations at a speed of 300 rpm. Wave One is also available in different tip sizes and tapers (11). Since the endodontically treatment of roots leads to reduced fracture resistance (12), one of the aims of root canal filling is strengthening the root canal and increasing the resistance to fracture (13).

Recently, bioceramic-based sealers containing calcium silicate and/or calcium phosphate attracted considerable attention because of their physical and biological properties such as their alkaline pH, chemical stability within the biological environment, and lack of shrinkage. Bioceramic materials contain calcium phosphate which enhances the setting properties of bioceramics and results in a chemical composition and crystalline structure similar to tooth and bone apatite materials, thereby improving sealer-to-root dentin bonding (5).

Therefore, the introduction of rotary file systems that have less effect on fracture resistance of roots and root filling material that strengthens the roots will have a positive effect on the therapeutic process. Previous studies focused on the effects of preparation or filling of root canal on the quality of treatment and a few studies have examined the interaction of these factors together. Thus, this study aimed to investigate the effect of combining different filling materials and rotary files on the fracture resistance of treated teeth. In this study, we evaluated fracture resistance of roots prepared with two different rotary systems and filled by two different obturation materials.

The null hypothesis was that the fracture resistance of the root canals would not be significantly different with combining different preparation-obturation systems.

Materials and Methods

In this experimental study, 80 freshly extracted human maxillary central incisors were selected. All teeth were decoronated by using slow speed water-cooled carburundum disc (Dentorium, New York, NY, USA) to obtain 13 mm long root segments. Stainless steel K-file (#15/0.02 taper) (Dentsply/Maillefer, Ballaigues, Switzerland) was introduced into the root canal until its tip was just visible at the apical foramen. WL was determined visually by subtracting 1 mm from this length. The roots were randomly divided into two main equal groups according to the system used in root canal preparation. Group I (ProTaper): Root canals were prepared using ProTaper rotary instruments in a crown down manner up to an apical size corresponding to F3 (# 30/0.09). Group II (Wave One): Root canal preparations were performed using Wave One files according to manufacturer's instructions. In all groups, each root canal was flushed with 5 ml of freshly prepared 1% sodium hypochlorite solution during instrumentation. The canals were then irrigated with 2 ml of 17% ethylenediamine tetraacetic acid in order to remove smear layer and were rinsed with 5 ml sterile saline solution and dried with paper points. Each main group was randomly subdivided into two equal subgroups according to the obturation system being used as follow: Subgroup A: ProTaper, AH26 obturator; Subgroup B: ProTaper, Bioceramic; Subgroup C: Wave 1, AH26 obturator; and Subgroup D: Wave 1, Bioceramic. Root canals were obturated using AH26 (Dentsply, De Trey, Konstanz, Germany) and Bioceramic (Sure Dent Crop., Gyeonggi-do, Korea) sealers according to manufacturers` instructions using lateral condensation technique (LCT).

Sample preparation

The specimens were stored at 37ºC and 100% humidity for 1 week. After this period, the middle third of each root was coated with uniform thickness of light body rubber base (Impregum F, ESPE, Seefeld, Germany) to provide a simulated periodontal ligament and then was embedded in acrylic resin cylinder using self-cured acrylic resin (Heraeus Kulzer, Dormagen, Germany) except for the coronal 4 mm (Figure 1).

Figure 1. Prepared samples mounted in acrylic resin cylinders

Evaluation of fracture resistance

A specially designed jig was constructed to align the root specimens at an angle of 90° to the horizontal plane and attached securely to the lower member of universal Testing Machine (Z020, Zwick/Roell, Um, Germany). Load was applied with a specially designed loading steel rod with a sharp tapered end and with a cross-head speed of 1mm/min. This rod was attached to the loading cell of the upper member of the UTM to apply equally distributed force in all directions (Figure 2). The maximum force required to fracture each specimen was recorded in Newtons (N).

Figure 2. Universal testing machine for compressive strength testing

Statistical analysis

Mean and standard deviation values (mean ± SD) of forces required for fracturing the roots of the tested groups and subgroups are expressed in Newtons and presented in Table 1. Statistical analysis was performed using two-way analysis of variance (two-way ANOVA) to determine significance differences among groups and subgroups, then multiple pairwise comparisons were performed using Tukey test to determine which mean value differed from one another with significance level of $P<0.05$.

Table 1. Means and standard deviations of forces essential for fracture of roots in all tested groups and subgroups

	Preparation technique		
Obturation system	ProTaper (Group I)	Wave I (GroupII)	**P-value**
Soft-Core/AH26	246±52 N	256±84 N	P>0.05
Bio ceramic	253±64 N	239±72 N	P>0.05

Results

Concerning root canal preparation using ProTaper system (group 1), the mean fracture resistance values for different subgroups were arranged from the highest to the lowest as 253±64 and 246±52 for Bio ceramic sealer and Soft-Core/AH26 subgroups, respectively. Two-way ANOVA demonstrated no statistical significant differences among tested subgroups (P>0.05). In addition, regarding root canal preparation using Wave 1 system (group II), the mean fracture resistance values for different subgroups were arranged from the highest to the lowest as 256±84 and 239±72 for Soft-Core/AH26 and Bio ceramic sealer subgroups, respectively. There was no statistical significant differences among tested subgroups (P>0.05). Obtained results also revealed no statistical significant differences between Bioceramic and Soft-Core/AH26. On the other hand, after root canal preparation and obturation using different materials, the highest mean fracture resistance value (256.7N) was associated with Soft-Core/AH26 obturation (subgroup C), while the lowest value (239.8 N) was for Bio ceramic sealer (subgroup D), however there was no statistical significant difference (P>0.05) among all tested subgroups (Figure 3). Therefore, regarding the effect of root canal preparation techniques on fracture resistance of endodontically treated roots for each root canal obturation system, there was no statistical significant difference (P>0.05) among all tested subgroups.

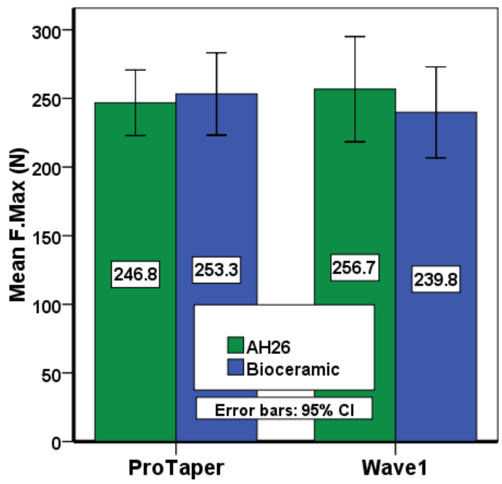

Figure 3. The effect of root canal preparation techniques on fracture resistance of endodontically treated roots for each root canal obturation system

Discussion

One of the main reasons for extraction of teeth is vertical root fracture. Experimental studies have shown that excessive dentin removal during the preparation of the canal and the pressure of the spreader during obturation increases the susceptibility of roots to fracture (14,15). Different designs of NiTi instruments induce different levels of stress in the root, which reduces its resistance to fracture. Therefore, one of the aims of root obturation is to strengthen the canal and increase its resistance to fracture. In this regard, introducing a rotary file system that has less effect on fracture resistance of root as well as a root filling material that reinforces the root will have a positive effect on the treatment process. Different studies have introduced a wide variety of techniques and materials used to improve root strength (16-19). This research was conducted to compare the fracture resistance of endodontically treated teeth by combining different rotary files and obturation materials.

Two different rotary systems were considered (Wave one and ProTaper) that differed in the type of motion and the sequence of the used files to investigate whether the type of motion (rotary or reciprocating) and being single-file or multi-file system have an effect on the fracture resistance of roots. Also, a new bioceramic sealer was used that has the ability to bond to the dentinal walls of the canal strengthening the root compared with the AH26 sealer as the common obturation sealer. The results of this study showed that the mean of fracture resistance in ProTaper subgroup (B) was higher than Wave one (D), however there was no significant difference. This can be due to increased pressures for preparation with the Wave one single-file system. On the other hand, after root preparation with different systems and the use of different obturation materials, the highest and lowest fracture resistance was observed in the C and D subgroups (Wave one + AH26 and Wave one + bioceramic), but the difference was not statistically significant. In line with these results, many studies have been performed to evaluate the effects of various prepration and obturation systems on the fracture resistance of endodontically treated roots. Zamin C et al. evaluated the effect of cervical preparation on the fracture resistance of the roots (20). They concluded that the most cervical preparation using file number #70 with a 12% taper increased the susceptibility of roots to fracture and none of the obturation materials were able to restore this resistance. In addition, N.A. Shaheen et al. evaluated the fracture resistance of roots using combination of root canal preparation-obturation methods (21). Similar to the results of our study, there was no significant difference between preparation-obturation subgroups. However, samples from test groups compared to unprepared control groups had less resistance to fracture. This finding is not in line with our results because of numerous and various studies concerning this subject. In addition, in the mentioned study a 45-degree force was induced by the sharp rod of the UTM to the samples, which is more suitable for simulation of the forces in the anterior teeth. In our study, we used premolars which were under combination of the forces on anterior and posterior teeth. In the present study, it was not possible to produce a 45-degree force. Furthermore, in 2015, Nur BG et al. examined the fracture resistance of roots prepared with three single-file systems in curved canals (22). They demonstrated that the fracture resistance of the roots prepared with Wave one and the Reciproc file system were similar to the control group. While one shape rotary system reduced the fracture resistance of curved roots compared to control group, this study was done on the curved roots of posterior teeth. One shape is a rotary single-file system which probably weakens the roots in comparison to the multi file rotary systems. However, in the present study, there was no significant difference between the two systems of preparation. In another study by Hammad et al., a protaper- prepared and EndoRez obturated group showed a higher fracture resistance than the Resilon / Realseal, Gp / eugenol base sealer and Gp / GuttaFlow groups (23). Differences in results compared to the present study may be due to the different designs of the studies, so that in these studies, forces were introduced into the center of a sample which distributed more and better forces into the canal and into the filling material of the canal, while in our study a sharp steel rod was used.

In 2015, Topcuoglu HS et al. considered the fracture resistance of the roots filled with three different obturation techniques based on the AH26 sealer (24). The results showed that the canal preparation significantly reduced the strength of the tooth structure. However, no significant difference was observed between the groups and the obturation materials were not able to restore the root strength. In contrast, Langalia AK et al., indicated that newer resin systems such as Roseilon and Endorez increase the root fracture resistance even to the extent of intact tooth and have a significant difference with AH26 sealers (25). However, in the present study, the new bioceramic sealers did not increase the fracture resistance of roots in comparison to the typical AH26 sealers.

In 2015, Celiktan B et al. examined the fracture resistance of roots obturated with different materials including a sealer of GI-base and different commercial brands of bioceramic sealers (26). They concluded that all these materials increase the fracture resistance of roots compared with unfilled canals, which is probably due to the ability of these sealers to bond to the canal walls that may strengthen the root. However, in the present study, the increase in root strength by bioceramic sealers versus AH26 sealer was not observed. This can be due to different commercial brands of bioceramic sealers used in the mentioned studies (American sealers versus Korean). Based on the results of these studies, the effects of different systems of preparation and obturation on the fracture susceptibility of treated roots are different. This difference can be due to different sample sizes as well as the type of study designs.

This in vitro study had some limitations such as difficult simulation of the oral environment. More in vitro and in vivo investigations are necessary to evaluate other bioceramic sealers such as BCsealers to improve the fracture resistance.

Conclusion

This study showed that the resistance to fracture in different subgroups after the preparation of the canal by different systems and filling them with different materials had no significant difference. Therefore, more studies should be conducted with a larger number of samples and a different design to find new solutions to overcome the problem of decreased tooth strength to fracture.

Conflict of interest

The authors declare that there are no conflicts of interest related to this study.

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