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Original Article

Vertical Fracture Resistance of Endodontically Retreated Teeth Using Two Instrumentation Systems

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Abstract

Introduction: Vertical root fractures are the most challenging complication associated with endodontically treated teeth. Different nickel-titanium (NiTi) instrument designs are associated with different levels of stress and resistance of roots to fractures.

Purpose: This study was designed to evaluate the fracture resistance of retreated roots using two different rotary retreatment systems.

Materials and Methods: Sixty freshly extracted human mandibular premolar with single, straight roots were randomly divided into four groups of fifteen specimens each. Samples of negative control were left untreated. Samples of positive control were cleaned and shaped with ProTaper files up to F_3. Obturation was done using gutta-percha and AH Plus sealer (Dentsply Detrey, Konstanz, Germany). For the samples of experimental groups three and four, removal of gutta-percha was performed using ProTaper Universal (Dentsply Maillefer, Ballaigues, Switzerland) and Mtwo (Sweden and Martina, Padova, Italy) rotary retreatment systems. The specimens were then embedded in a self-curing polymethyl methacrylate resin, and the force required to cause vertical root fracture was measured using a universal testing device. The force of fracture of the roots was recorded, and the results in the various groups were compared. Statistical analysis was accomplished by one-way analysis of variance and a *post hoc* Turkeys tests.

Results: There were statistically significant differences between the control groups and experimental groups ($P < 0.05$). However, there were no significant differences among the experimental group.

Conclusion: Type of rotary files used for retreatment does not significantly alter the fracture resistance of the tooth.

Key words: Endodontically retreated tooth, Fracture resistance, Retreatment files

INTRODUCTION

Residual necrotic tissue or bacteria existing in an obturated canal can be responsible for recurrent periapical inflammation and pain.[1] Thus, the main objective of nonsurgical retreatment is to regain access to the apical foramen and eliminate persistent organisms.[2] Efficient removal of the existing root canal filling material is essential for optimal non-surgical retreatment. The techniques applied to remove gutta-percha are varied and include the use of hand or rotary instruments, with or without heat, solvents, and/or ultrasound.[3] However, manual removal of gutta-percha using is time-consuming, especially in well-condensed canals. Thus, the use of contemporary rotary nickel-titanium (NiTi) instruments is more efficient and less fatiguing to the patient and operator.

Vertical root fractures (VRF) are the most challenging complication associated with endodontically treated teeth.[4] True vertical root fracture is defined as a longitudinal fracture confined to the root that usually initiates on the internal canal wall and extends outward

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onto the root surface.[5] Bender and Freedland have suggested that the highest incidence of vertical root fracture occurs in endodontically treated teeth.[6] Aggressive instrumentation of the root canal leads to loss of dentin, which may structurally weaken the tooth. Retreatment procedures might cause more damage to the root canal wall and weaken the root canal with further biomechanical preparation.[7] Furthermore, the alterations in the mechanical features of dentin, such as low plasticity due to dehydration, decreased strength, and toughness due to microbe-induced degradation or modification of collagen, predisposes endodontically treated teeth to fracture.[8]

The literature contains numerous studies about the effect of various nickel-titanium rotary files on root dentin and fracture formation. Different NiTi instrument designs are associated with different levels of stress and resistance of roots to fractures. However, studies on Mtwo retreatment systems and their effect on the fracture resistance of roots are few. Thus, the main aim of this *in vitro* study was to compare the fracture resistance of endodontically retreated teeth instrumented using two different rotary retreatment file systems, namely, ProTaper R and Mtwo R.

MATERIALS AND METHODS

A total of 60 extracted mandibular premolars with fully formed apices were used in this study. The teeth were decoronated using a diamond disk at the cementoenamel junction to obtain standard root lengths of 14 mm. They were then divided into four groups with 15 specimens each.

Group 1 (negative control) – Intact teeth.

Group 2 (positive control) – Teeth that underwent endodontic treatment. The working length of the canal was obtained by subtracting 1 mm of a #10 K-file inserted until the tip was visible at the apical foramen. Canal shaping was done using ProTaper Universal NiTi rotary files following the manufacturer's instructions in the sequence of S_x, S_1, S_2, F_1, F_2, and F_3 to obtain a final apical size of 0.30 mm. The canals were irrigated with 2 ml of 2.5% sodium hypochlorite during instrumentation. Seventeen percent ethylenediaminetetraacetic acid irrigant was used for 1 min after completion of instrumentation to remove the smear layer. A final rinse was done with 10 ml 2.5% sodium hypochlorite followed with saline. Canals were dried with paper points. A #30; 6% master cone was selected and canals were then obturated using single cone technique and AH plus sealer (Dentsply DeTrey; Germany). Excess gutta-percha was removed to 1 mm below the canal orifice and condensed. The canal orifice was then sealed using, Cavit and the teeth stored at 37°C in 100% humidity for 2 weeks. Specimens for the experimental groups were retreated 48 h after endodontic treatment to ensure complete sealer setting.

Group 3 – Retreatment was done using ProTaper Universal NiTi rotary retreatment instruments (Dentsply Maillefer, Ballaigues, Switzerland) at 300 rpm and 3 N/cm torque. The retreatment files were used in the recommended sequence; D1 file (tip size 30, 0.09 taper) for removal of root filling in the coronal third, followed by D2 file (size 25, 0.08 taper) for the middle-third, and finally, D3 file (size 20, 0.07 taper) for gutta-percha removal to working length. Root canal refinement was then accomplished using the F_2, F_3, and F_4 ProTaper Universal rotary.

Instruments. The instruments were used in a gentle brushing action at a speed of 300 rpm with sodium hypochlorite irrigation during instrumentation.

Group 4 – Retreatment was done using Mtwo retreatment files. The root canal obturating material was gradually removed first using Mtwo R_2 (5% taper, tip size 25) and Mtwo R_1 (5% taper, tip size 15) files, respectively, until slight resistance was encountered. These two instruments were used with circumferential filing movements and without downward pressure. After the working length was reached, conventional Mtwo rotary instruments were used in a circumferential filing motion in the sequence of Mtwo 6% taper #20; Mtwo 6% taper #25, and Mtwo 5% taper # 30 with copious irrigation with sodium hypochlorite.

All specimens in Group 3 and Group 4 received a final rinse similar to the positive control and dried. A #30 6% master cone was placed to the appropriate working length and confirmed with a radiograph. Obturation was completed using the gutta-percha master cone and AH plus sealer. The excess gutta-percha was seared off and condensed with a plugger 1mm below the orifice and the orifice sealed with Cavit. The teeth were stored at 37°C in 100% humidity for 2 weeks.

Mounting of Specimens for Mechanical Testing

The roots were coated with 0.3 mm layer of polyvinylsiloxane to simulate the periodontal ligament. Each teeth were mounted individually on a custom made acrylic blocks such that the apical root ends were embedded to a depth of 3 mm and was allowed to polymerize for 1 h. This was in accordance with the model proposed by Apicella *et al.*[8] Each acrylic block was mounted on the universal testing machine with the roots aligned vertically. A circular stainless steel rod

of 3 mm diameter and 45° bevel tip was fixed to the upper stage of the Instron universal testing machine. The rod was centered over the access opening. Vertical compressive force was applied at a crosshead speed of 0.5 mm/min. In this study, "fracture" was defined as the point at which a sharp and instantaneous drop was observed. For most specimens, an audible crack was also heard. The test was terminated at this point and the force applied was recorded and measured in Newtons as the force needed to fracture the tooth. [Figure 1]. The mode of application of the vertical loading force required to fracture the root specimens was similar to the technique proposed by Sedgley and Messer to test the brittleness of endodontically treated teeth.[9]

Statistical Analysis

Mean (±standard deviation) was calculated for each group. The inter groups comparison was done using one-way analysis of variance, and a multiple comparison test was performed using Turkey *post hoc* test (SPSS software version 20, SPSS (Inc., Chicago, IL).

RESULTS

The mean fracture load required for Group 1 (negative control) was 303.46 ± 80.25 N, Group 2 (positive control) 278.58 ± 66.08 N, Group 3 (ProTaper R) 143.55 ± 70.78, and Group 4 (MTwo R) was 151.25 ± 63.4.9 [Table 1].

Table 1: Means and standard deviations (SD) of fracture resistance of the groups

Groups (*n*=15)	Mean (N)	SD
Group 1 – Unprepared tooth [negative control]	303.64	80.25
Group 2 – Root canal treated with Protaper Universal NiTi rotary files	278.58	66.08
Group 3 – Retreated with ProTaper Universal NiTi rotary retreatment\files	143.55	70.78
Group 4 – Retreated with Mtwo rotary retreatment files	151.25	63.45

Figure 1: Fracture resistance test of specimens using universal testing machine

All the specimens exhibited fracture. However, it was observed that the fracture resistance was significantly reduced after primary endodontic treatment in comparison with the negative control. Fracture resistance was further reduced after retreatment.

There was no statistically significant difference in the fracture resistance between MTwo and ProTaper-retreatment files [Figure 2].

DISCUSSION

Endodontic success is related to the appropriate execution of the different treatment phases. During root canal instrumentation, the removal of dentin is necessary to promote cleaning and disinfection, as well as to prepare the root canal system to receive the obturating material. It is generally accepted that this unavoidable loss of dentin may weaken the root and create an increased risk of fracture.

The result of this study showed a significant reduction in the fracture resistance after primary endodontic treatment. Vertical root fracture is a sequel of gradual propagation of microcracks in the tooth. Kim *et al.*[10] reported that there is a relationship between the design of the Ni-Ti instruments and the incidence of VRF. ProTaper Universal rotary files (PTU; Dentsply Maillefer, Ballaigues, Switzerland) facilitate active cutting motion and remove relatively more dentin coronally compared with other systems. After canal shaping, a 30% reduction in vertical fracture resistance can occur.[11] During canal instrumentation with NiTi rotary files, momentary stresses are concentrated in dentin due to contact and friction between the instrument and canal walls. This causes cracks, which have been observed and reported at various levels.

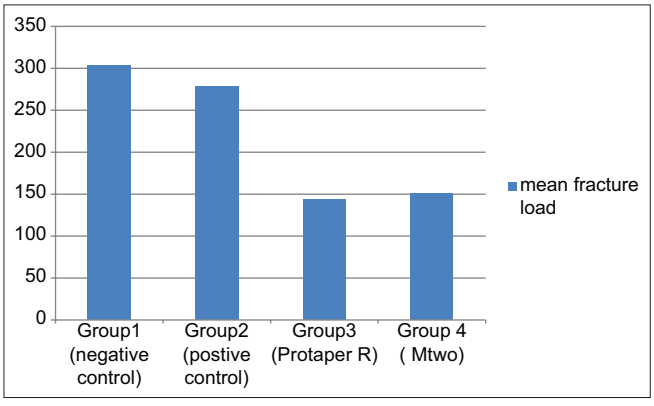

Figure 2: Bar graph showing the mean fracture load in four groups

The persistence of bacterial colonies within the complexity of the root canal system leads to apical pathology in endodontically treated teeth. Such circumstances advocate non-surgical retreatment by employing techniques for removal of obturating material followed by sufficient cleaning and reshaping procedures to provide adequate disinfection.

The results of our study, which shows that the fracture resistance in all retreatment groups was lesser than un retreated groups. This result is supported by Shemesh *et al*.[12] who found that the retreatment groups had more defects than the unretreated groups. Using finite-element analysis, Ricks-Williamson *et al.* found the magnitude of generated radicular stresses to be directly correlated with the simulated canal diameters. During retreatment or after long-term functional stresses such as chewing, craze lines occur in 4–16% and these may develop into fractures.[13] Wilcox *et al.* found that root surface craze lines formed on roots in areas of greater percentages of dentin removal. Hence, during the re-treatment procedures, care should be exercised to prevent excessive loss of dentin that may occur from aggressive re- instrumentation of root, which substantially weakens the structural integrity of the tooth making it more susceptible to fracture.[14]

ProTaper, universal retreatment file, not only cut gutta-percha but also the superficial layer of dentin during root filling removal. The instrument is designed to drive the debris coronally while in rotary motion.[11] The Mtwo R files have an S-shaped cross-section, an increasing pitch length in the apical-coronal direction and characterized by a positive rake angle with two cutting edges, which are claimed to improve cutting efficiency. It has a cutting tip to allow the instrument to progress easily into the filling material. Unlike other NiTi instruments, the Mtwo rotary instruments do not require a crown-down instrumentation sequence. Mtwo retreatment files are R2 (5% tip size 25) R1 (5% tip size 15) with uniform taper.

There was no statistically significant difference among the retreated groups in this study. Zandbiglari *et al*.[15] demonstrated that fracture resistance of instrumented roots is significantly lower when canals are prepared with instruments with an increasing taper. However, Sathorn *et al.* showed that the dentin thickness was not the only determining factor. Curvature of the external proximal root surface, canal size, and shape all interact to influence susceptibility and the pattern of fracture as well.[16] Pitts *et al.* demonstrated that no significant correlation exists between fracture load and size of the root, width of the canal walls after instrumentation, and taper of the root or of the canal.[17] Root canal filling material is removed during re-instrumentation. However, at the same time, an amount of extra dentine is removed from the root structure. This may explain the difference between the experimental and control groups in this study. In addition, during re-instrumentation, the coronal taper increases and the coronal third of root stresses tend to increase for masticatory loading.

CONCLUSION

Properly performed endodontic treatment is the cornerstone of restorative and reconstructive dentistry. After retreatment, the fracture resistance can be significantly reduced. Hence, conservative re-treatment with judicious use of the instrumentation systems and preservation of tooth structure is important.

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REFERENCES

1. Nair PR. Pathogenesis of apical periodontitis and the causes of endodontic failures. Critl Rev Oral Biol Med 2004;15:348-81.
2. Stabholz A, Friedman S. Endodontic retreatment-case selection and technique. Part 2: Treatment planning for retreatment. J Endod 1988;14: 607-14.
3. Ruddle CJ. Nonsurgical endodontic retreatment. In: Pathways of the Pulp. St. Louis: Mosby; 2002.
4. Testori T, Badino M, Castagnola M. Vertical root fractures in endodontically treated teeth: A clinical survey of 36 cases. J Endod 1993;19:87-90.
5. Walton RE, Torabinejad M. Cracked tooth and vertical root fracture. Princ Pract Endod 1996;28:474-91.
6. Bender IB, Freedland JB. Adult root fracture. J Am Dent Assoc 1983;107:413-9.
7. Friedman S, Stabholz A. Endodontic retreatment-case selection and technique. Part 1: Criteria for case selection. J Endod 1986;12:28-33.
8. Apicella MJ, Loushine RJ, West LA, Runyan DA. A comparison of root fracture resistance using two root canal sealers. Int Endod J 1999;32: 376-80.
9. Sedgley CM, Messer HH. Are endodontically treated teeth more brittle? J Endod 1992;18:332-5.
10. Kim HC, Kwak SW, Cheung GS, Ko DH, Chung SM, Lee W. Cyclic fatigue and torsional resistance of two new nickel-titanium instruments used in reciprocation motion: Reciproc versus Wave One. J Endod 2012;38:541-4.
11. Gu LS, Ling JQ, Wei X, Huang XY. Efficacy of Pro Taper universal rotary retreatment system for gutta-percha removal from root canals. Int Endod J 2008;41:288-95.
12. Shemesh H, van Soest G, Wu MK, Wesselink PR. Diagnosis of vertical root fractures with optical coherence tomography. J Endod 2008;34:739-42.
13. Ricks-Williamson LJ, Fotos PG, Goel VK, Spivey JD, Rivera EM, Khera SC. A three-dimensional finite-element stress analysis of an endodontically prepared maxillary central incisor. J Endodon 1995;21: 362-7.
14. Wilcox LR, Roskelley C, Sutton T. The relationship of root canal enlargement to finger-spreader induced vertical root fracture. J Endod 1997;23:533-4.
15. Zandbiglari T, Davids H, Schäfer E. Influence of instrument taper on the

resistance to fracture of endodontically treated roots. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;101:126-31.
16. Sathorn C, Palamara JE, Palamara D, Messer HH. Effect of root canal size and external root surface morphology on fracture susceptibility and pattern: A finite element analysis. J Endod 2005;31:288-92.
17. Pitts DL, Matheny HE, Nicholls JI. An *in vitro* study of spreader loads required tocause vertical root fracture during lateral condensation. J Endod 1983;9:544-50.

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