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ORIGINAL RESEARCH

Fracture Strength of Roots Instrumented with ProTaper Universal, ProTaper Next and ProTaper Gold Systems: An *In Vitro* Study

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ABSTRACT

Background: This study compared the fracture strength of roots instrumented with ProTaper Universal (Dentsply Maillefer, Ballaigues, Switzerland), ProTaper Next (Dentsply Maillefer, Ballaigues, Switzerland) and ProTaper Gold (Dentsply Maillefer, Ballaigues, Switzerland) files and obturated with corresponding gutta-percha points using the single cone technique and a resin sealer.

Method: The study included 42 mandibular premolar teeth. The roots were sectioned to obtain roots 13 mm in length. The roots were covered with additive silicone and placed in Eppendorf tubes which were filled with a self-curing acrylic. The tubes were separated into 4 groups: prepared with the ProTaper Universal (F4 40/.06) (group 1), ProTaper Next (X4 40/.06) (group 2), ProTaper Gold (F4 40/.06) (group 3) and uninstrumented Control (group 4). After the preparations were completed, all the teeth were filled with corresponding gutta-percha points and AH Plus sealer (Dentsply DeTrey, Konstanz, Germany). The force (N) was applied at a 1- mm/min crosshead speed until the roots fractured. Differences among the groups were analyzed by Tukey and analysis of variance tests.

Results: Group 2was the most resistant to fracture and group 4 was the least resistant. Fracture resistance of group 3 was less than group 2 and that of group 1 less than that of group 3 but the difference was not statistically significant.

Conclusion: The roots instrumented with ProTaper next were most resistant to vertical root fracture.

Keywords: Fracture strength, Protaper Universal, Protaper Next, Protaper Gold, Vertical root fracture

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INTRODUCTION

Vertical root fracture is one of the most challenging complication and usually leads to a poor prognosis in case of a root canal filled tooth.(1)Several hypothesis have been formulated to explain that endodontically treated teeth are weak and more susceptible to fractures. Mechanical instrumentation of the root canal leads to weakening of the dentinal walls and microcrack formation. This structure loss together with the increased prevalence of microcrack formation in a non vital tooth increases the risk of vertical root fracture. The possibility of vertical root fracture may further be enhanced by dehydration of dentin, structural loss of hard tissue and deleterious effects of irrigation solutions. It has also been reported that the root canal filling procedures can also contribute to vertical root fracture by propagation of cracks in the apical areas.(2) However, numerous studies (3,4) contradict this and hence this statement remains controversial.(5)

Over the past few decades, numerous advances in rotary nickel-titanium instruments have been made for easier, faster and better biomechanical preparation with minimal procedural errors. ProTaper Universal (Dentsply Maillefer, Ballaigues, Switzerland)rotary files are made from a conventional superelastic NiTi wire and have a convex triangular cross-section and increasingly tapered design that enables active cutting motion and removes relatively more dentin coronally.(8) Then came the

ProTaper Next (Dentsply Maillefer, Ballaigues, Switzerland) instruments that have an off-centered rectangular design and progressive and regressive percentage tapers on a single file, which is made from M-Wire technology. Recently, ProTaper Gold (Dentsply Maillefer, Ballaigues, Switzerland) instruments were introduced. These files have a design that features identical geometries as ProTaper Universal but are more flexible and have been developed with proprietary advanced metallurgy.

The fracture strength of roots instrumented with ProTaper Gold have not been evaluated. The purpose of this study is to compare the effect of instrumentation with ProTaper Universal, ProTaper Next and ProTaper Gold on the fracture strength of roots.

MATERIALS AND METHODS

Forty two human mandibular premolar teeth orthodontically extracted from patients aged 17-24 years were collected and stored in distilled water for the study. A periapical radiograph verified that the teeth had 1 straight canal and a maturated apex. The coronal parts of all the teeth were removed using a diamond-coated bur under water cooling, leaving the roots 13 mm in length. The samples were examined under a stereomicroscope at 10 magnification to detect craze lines or cracks. The samples with such features were discarded and replaced with roots having similar specifications.

The weights of the roots were measured with a sensitive precision balance and the buccolingual and mesiodistal diameters were also measured. Roots with similar specifications were selected for standardization of the samples. The pulp tissue was eliminated using a #25barbed broach. The roots were covered with aluminum foil. Eppendorf tubes were separated from their stoppers and a hole was made in each stopper. The roots were placed into the stopper upto the level of the cementoenamel junction and fixed tothe stoppers with cyanoacrylate. They were then placed in Eppendorf tubes filled with self-curing acrylic. After the acrylic had polymerized, the roots were taken out, and the aluminum foil was removed from the roots. The roots were then covered with additional silicone impression material (Hydrorise Light, Zhermack, Italy) and returned to the tubes to create an artificial periodontal ligament similar to that of *Cicek et al* (6). The tubes were categorized into 3 experimental and 1 control groups.

Group 1: The root canals were prepared with the PTU system used at 300 rpm and 2 Ncm, with a torque-controlled endodonticmotor (X-Smart; Dentsply Maillefer). An SX file was used at one half of the working length (WL); S1 and S2 files were usedat two thirds of the WL; and F1 (20/.07), F2 (25/.08), F3 (30/.06), and F4 (40/.06) files were used at the full WL. The SX,S1, and S2 files were used with a brushing motion. The other fileswere used with a gentle in-and-out motion. Irrigation was performed after every file using distilled water and an open-ended needle.

Group 2: The root canals were prepared with the PTN system usinga gentle in-and-out motion at 300 rpm and 2-Ncm torque with atorque-controlled endodontic motor. The first SX file was used atone half of the WL, and the X1 (17/.04), X2 (25/.06), X3 (30/.06), and X4 files (40/.06) were used at the full WL. Irrigation was performed after every file using distilled water and an open-ended needle.

Group 3: The root canals were prepared with the PTG system used at 300 rpm and 2 Ncm, with a torque-controlled endodonticmotor (X-Smart; Dentsply Maillefer). An SX file was used at one half of the working length (WL); S1 and S2 files were usedat two thirds of the WL; and F1 (20/.07), F2 (25/.08), F3 (30/.06), and F4 (40/.06) files were used at the full WL similar to PTU system. Irrigation was performed after every file using distilled water and an open-ended needle.

Group 4: The root canals were left uninstrumented. They were used as control.

All the roots were obturated with the corresponding gutta-percha points using the single-cone technique and AH Plus (Dentsply DeTrey, Konstanz, Germany).The canals were sealed with a temporary filling material, and the roots were kept in an environment of 100% moisture for 2 weeks. A force was applied with a 1-mm/mincross head speed with a universal testing machine until the roots fractured. The load necessaryto fracture was recorded in Newtons.

Statistical Analyses

Descriptive and comparative statistics were performed using IBMSPSS v21 (SPSS, Inc, Chicago, IL). Differences among the groups were analyzed by Tukey and analysis of variance tests. A P value <.05 was considered statistically significant for all tests. Variables were expressed as means ± standard deviation.

Results

The mean fracture load and standard deviation are given in Table 1. In the experimental groups Group 2 was the most resistant to fracture followed by group 3 and then group 1, the difference was not statistically significant. The vertical root fractures in all the roots occurred in buccolingual direction. The comparison between each group is given in Table 2.

Table 1. Fracture load of the roots as mean, standard deviation, maximum and minimum in Newton (N)

	N	Mean	Std. Deviation	Maximum	Minimum
PTU	10	277.705	65.611	372.60	149.14
PTN	10	339.949	79.407	483.71	218.35
PTG	10	330.574	84.918	470.11	211.33
CONTROL	12	222.536	9.751	240.21	211.36

PTU = ProTaper Universal, PTN = ProTaper Next, PTG = ProTaper Gold

Table 2. Mean difference between each group and its significance

	Mean Difference	Significance
PROTAPER UNIVERSAL VS PROTAPER NEXT	-62.244	Non-significant
PROTAPER UNIVERSAL VS PROTAPER GOLD	-52.869	Non-significant
PROTAPER UNIVERSAL VS CONTROL	55.169	Non-significant
PROTAPER NEXT VS PROTAPER GOLD	9.375	Non-significant
PROTAPER NEXT VS CONTROL	117.413	Significant
PROTAPER GOLD VS CONTROL	108.0382	Significant

DISCUSSION

Standardization of sample is an important aspect in any study. The samples in the present study were standardized with respect to buccolingual and mesiodistal dimensions and the weight of the roots similar to *Capar et al* (7). Extraction time and the storing conditions might also influence the results of the study (3). To eliminate these factors, teeth extracted for orthodontic purpose with patients aged between 17-24 years were included in the study. The files tested in the study had similar recommended speed and torque values.File design and its features greatly affect the amount of strain exerted on dentin and thus play a role in formation of microcracks which predispose to vertical root fractures. All of the tested instruments in the present study have non cutting tips and a variable pitch. The purpose of the present study was to compare the fracture strength of roots instrumented with ProTaper Universal, ProTaper Next and Protaper Gold. There are no available data from the literature comparing ProTaper Gold system to the other two rotary systems with regard to fracture strength of roots instrumented with the same.

The properties of masticatory force absorption through the bone and periodontal ligament should be reproduced in laboratorial tests to simulate the clinical reality more accurately.[8]Additional silicone was used to simulate the periodontal ligament around the teeth in the present study. The periodontal ligament is elastic and absorbs some of the applied force due to its compressive nature. The force applied to fracture the roots was not directly reflected by acrylic; the additional silicone absorbed some of the force thus mimicking the clinical conditions.

In the study conducted by Ismail Davut Capar *et al*[7]in 2014, it was seen that after root canal preparation with the ProTaper Universal and ProTaper Next, the incidence of cracks observed in root dentin was 56% and 28 % respectively. Liu *et al*[9] reported cracks in 50% of the roots instrumented with ProTaper. Bier *et al*[10] found cracks in 16% of the roots of the mandibular premolars instrumented with the ProTaper system. Thus, in the previous comparison of the prevalence of microcracks with the ProTaper system, ProTaper Next system caused slightly fewer microcracks than the ProTaper Universal system. The results of the present study also indicate that the fracture resistance of roots instrumented with ProTaper Next is more than that of ProTaper Universal though it is not statistically significant.

ProTaper Universal rotary files, made from a conventional superelastic NiTi wire have a convex triangular cross-sectional design and variable percentage taper that enable an active cutting motion and removal of relatively more dentin coronally [11]. ProTaper Next files are the convergence of three design features, including progressive percentage tapers on a single file, M-wire technology and the offset design. The ProTaper Gold files have a design that features identical geometries as ProTaper Universal but are more flexible and have been developed with proprietary advanced metallurgy. Both PTUand PTG have a triangular cross-section but PTG has a greater ability to maintain dentin thickness as shown by *Gagliardi et al* (12). PTU and PTG are manufactured from different alloys and the more flexible alloy of the PTG, enhanced through a proprietary heat treatment technology, imparts a reduced restoring force (13,14). This might be the reason why these instruments remain more centered in the canal than PTU during use. Better centering ability leads to lesser dentin removal and hence lesser detrimental forces on remaining dentin.

The fracture strength of roots instrumented with PTN was more than those with PTU which is similar to the study conducted by *Cicek et al* (5). The difference in

the fracture resistance of roots treated with PTG and PTN was not significant. The slight difference between both the groups might be due to the different cross sectional designs of both files. PTG and PTN share neither geometric design nor metallurgy but have a comparable centering ability (9).
The root canals were filled with single corresponding gutta-percha cones. In accordance with the results of a recent study,[15] the single cone filling procedure in the present study did not have a significant effect on apical crack initiation and propagation. This might be because of the minimal pressure exerted during single-cone filling compared with other filling techniques, which place compaction forces on root canal walls.[16]

CONCLUSION

Within the limitations of this study, the fracture strength of roots instrumented with Protaper Next was more than ProTaper Gold though the the difference was insignificant. Both Protaper Next and ProTaper Gold demonstrated more fracture strength as compared to Protaper Universal. Differences in measured parameters were small.

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