RESEARCH

Effect of Different Torque Settings Selected During Instrumentation on Fracture Strength of Endodontically Treated Teeth

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Selcuk Dent J, 2022; 9: 851-855 *(Doi: 10.15311/selcukdentj.10333713)*

Başvuru Tarihi: 08 Aralık 2022
Yayına Kabul Tarihi: 17 Kasım 2022

ABSTRACT

Effect of Different Torque Settings Selected During Instrumentation on Fracture Strength of Endodontically Treated Teeth

Background: This study evaluated the effect of root canal instrumentation at low and high torque settings on the fracture strength of endodontically treated teeth.

Materials and Methods: Ninety extracted single-rooted human mandibular incisors were randomly divided into one control group and two experimental groups (n=30): no instrumentation or filling (control group), instrumentation with ProTaper Universal files at low torque settings, and instrumentation with ProTaper Universal files at high torque settings. Root canal filling was performed with an epoxy resin-based sealer and gutta-percha using a single-cone technique in the experimental groups. Each specimen was tested for fracture strength. The analysis of variance and Tukey test were used to analyze the obtained data. The significance level was set at 0.05.

Results: Statistically significant differences were observed between the groups ($p = 0.001$). While the difference between the control and low torque groups was not significant ($p = 0.288$), the difference between the control and high torque, low and high torque groups was significant ($p = 0.001$).

Conclusion: According to these results, since the lowest fracture strength value was observed in the high torque group, clinicians may be advised to choose the lowest torque settings recommended by the manufacturers for rotary systems.

KEYWORDS

Endodontics, Root canal preparation, torque

ÖZ

Enstrümantasyon Sırasında Seçilen Farklı Tork Ayarlarının Endodontik Tedavi Görmüş Dişlerin Kırılma Dayanımına Etkisi

Amaç: Bu çalışma, düşük ve yüksek tork ayarlarında yapılan kök kanal enstrümantasyonunun endodontik tedavi görmüş dişlerin kırılma dayanımı üzerindeki etkisini değerlendirdi.

Gereç ve Yöntemler: Doksan adet çekilmiş tek köklü insan mandibular kesici dişi rastgele bir kontrol ve iki deney grubuna ayrıldı (n=30): enstrümantasyon veya kök kanal dolumu yok (kontrol grubu), düşük tork ayarlarında ProTaper Universal eğelerle enstrümantasyon ve yüksek tork ayarlarında ProTaper Universal eğelerle enstrümantasyon. Deney gruplarında kök kanalları epoksi rezin esaslı pat ve güta-perka ile tek kon tekniği kullanılarak dolduruldu. Her örnek kırılma dayanımı açısından test edildi. Varyans analizi ve Tukey testi elde edilen verilerin analizinde kullanıldı. Anlamlılık düzeyi 0.05 olarak belirlendi.

Bulgular: Gruplar arasında istatistiksel olarak anlamlı farklılıklar gözlendi ($p = 0.001$). Kontrol ve düşük tork grupları arasındaki fark anlamlı değilken ($p = 0.288$), kontrol ve yüksek tork, düşük ve yüksek tork grupları arasındaki fark anlamlıydı ($p = 0.001$).

Sonuç: Bu bulgulara göre, yüksek tork grubunda en düşük kırılma dayanımı değeri gözlemlendiğinden, klinisyenlere üreticilerin döner sistemler için önerdiği en düşük tork ayarlarını seçmeleri önerilebilir.

ANAHTAR KELİMELER

Endodonti, kök kanal preparasyonu, tork

INTRODUCTION

Biomechanical preparation of the root canal system, which determines the effectiveness of all subsequent procedures, is one of the most important steps in root canal treatment.[1] Clinicians may encounter serious complications such as perforation, root canal transportation, ledge, zip formation, and instrument breakage during initial root canal treatment or retreatment procedures.[2-4] However, structural alterations in root dentin, such as a decrease in elasticity, micro hardness, and fracture resistance, can be observed due to biomechanical preparation. Excessive loss of tissue, negative effects of irrigation solutions on physical properties of dentin, excessive pressure during filling procedures, and anatomical features may also lead to vertical root fractures during or after root canal treatment procedures. This complication often results in tooth extraction.[5-10]

Stresses in root dentin generated during instrumentation have been associated with an increased risk of root fracture. Root canal instrumentation alone significantly weakens the roots, and shaping forces could lead to cracks and fracture formation in the apical region.[11] Although rotary NiTi files cause fewer complications during instrumentation, they may produce significant forces on root dentin.[12] The physical properties of the files are likely to affect the stresses on root dentin.[13] It has been reported that the ProTaper Universal (PTU; Dentsply Maillefer, Ballaigues, Switzerland) system induces higher stress values and increases dentinal crack and fracture formation more than other NiTi file systems during shaping.[12,14-16]

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Previous studies[17,18] also reported that using the PTU system or the RaCe system at low torque settings reduces the formation of cracks. The higher rate of crack formation at high torque settings may be associated with greater stress on the dentin surface. Different torque settings are recommended by manufacturers for different types and sizes of instruments because each instrument has a specific ideal torque. Low torque values are usually recommended for the smallest and less tapered instruments, but the largest and more tapered ones can be used with high torque values. Theoretically, higher torque values enable the instrument to operate more actively. In contrast, the instrument cutting efficiency would be reduced with low torque values, and the progression of the instrument in the canal would be more difficult.[19]

The present in vitro study was designed to evaluate the fracture strength of teeth instrumented using the PTU system at low or high torque settings. The null hypothesis tested was that torque settings did not affect the fracture strength of teeth.

MATERIALS AND METHODS

Approval for the present study was obtained from the Clinical Research Ethics Committee of Sivas Cumhuriyet University, Sivas, Turkey (Decision no: 2017-02/01). Ninety extracted, straight, single-rooted human mandibular incisors having approximately similar dimensions were used. After removing the soft tissues and calculus from the root surfaces, the teeth were stored in distilled water until use.

Root canal anatomy of the teeth was evaluated using mesiodistal and buccolingual preoperative radiographs. Samples with calcification, resorption, open apices, or fractures were not included in this study. The crowns of the teeth were removed to obtain approximately 13 mm standardized root length. The patency was verified with a size 10 K-file. Working lengths were established by subtracting 1 mm from the measurement at which a size 10 K-file appeared at the major foramen. The ninety samples were then randomly divided into a control group (no instrumentation or filling) and two experimental groups (n=30).

In the experimental groups, instrumentation was performed with the PTU system using an electronic torque-controlled motor (X-Smart; Dentsply, Maillefer) at 300 rpm. Root canals were instrumented up to F3 file at low torque settings (SX=3, S1=2, S2=1, F1=1.6, F2=2, and F3=2 Ncm) or high torque settings (SX=4, S1=3, S2=1.4, F1=2, F2=3, and F3=3 Ncm) according to the manufacturer's instructions. Files were used to enlarge only four canals. All operating procedures were performed by the same endodontist.

The root canals were irrigated with 2 mL of 5% sodium hypochlorite (NaOCl) after each file change. Finally, canals were rinsed with 2 mL of 5% NaOCl, followed by 2 mL of distilled water. They were then obturated with AH Plus sealer (Dentsply DeTrey, Konstanz, Germany) and gutta-percha (Diadent, Chongju, Korea) using a single-cone technique. Finally, the access cavities were sealed with temporary filling material, and all specimens were kept at 100% humidity for seven days to ensure the complete hardening of the sealer.

The roots were covered with stretch film and embedded in acrylic resin set in a plastic mold. The apical 4 mm of the root was covered and 9 mm of the coronal portion was exposed as described previously.[20] The teeth and stretch film were removed after curing the acrylic resin. The space created by the stretch film was filled with a light-body condensation type silicone impression material (BONASIL Light; DMP Dental Industry SA, Markopoulo Industrial Zone, Greece) to simulate the periodontal ligament, and the teeth were immediately repositioned. The fracture strength test was performed using a universal testing machine (LR10K Plus, LLOYD Instruments, Ametek Inc, UK) with a conical stainless steel tip. The device was activated at a speed of 1 mm/min. The force required to fracture each sample was recorded in Newtons (N).

Statistical Analysis

Statistical analysis was performed in SPSS software (v22.0, IBM Corp., New York, USA). The data normality was assessed with the Kolmogorov-Smirnov test, and measurements were analyzed using analysis of variance and Tukey test. The level of significance was defined as 0.05.

RESULTS

Fracture strength values of the control and experimental groups are shown in Table 1. There were significant differences between the groups (p=0.001). Teeth instrumented using high torque settings were significantly less resistant to fracture than the control and low torque groups (p=0.001). The fracture strength of teeth instrumented using low torque settings was not statistically different from the control group (p=0.288).

Table 1.

Fracture strength values [mean and standard deviation (SD)] of the control and experimental groups.

	n	Mean (N)	SD
Control Group	30	427.00^{a}	86.14
Low-torque	30	388.97^{a}	91.40
High-torque	30	285.60^{b}	111.75
p-value		0.001*	

*Different superscript lowercase letters indicate a statistically significant difference (*p<0.05).*

DISCUSSION

Although rarely observed, vertical root fracture (VRF) due to endodontic treatment ultimately results in tooth loss. The iatrogenic and non-iatrogenic factors that

cause vertical root fractures have been investigated in previous studies.[6,9,21,22] The forces generated on the root canal walls, which may affect root fracture and dentinal crack formation, depend on instrument design, the preparation kinematics, or the preferred torque setting during root canal instrumentation.[13,23,24] Yoldaş et al.[25] reported that no dentinal defects were observed when the canals were prepared with the self-adjusting file (SAF) system and hand files, while dentin cracks occurred with all the other rotary files tested. They stated that not applying rotational movement in the hand file and SAF groups and applying the SAF system with constant precise pressure using in and out grinding motion might be why dentin cracks did not occur in these groups. Bier et al.[15] also reported that rotary NiTi files caused significantly more dentin defects than hand files. This result was attributed to the significantly more rotations of rotary instruments.

The amount of instrument contact with the canal walls, the forcing of the instrument apically, the instrument diameter, and the root canal volume affect the torque induced by a rotary instrument during instrumentation. Exceeding the maximum permissible torque can result in undue stress, leading to unpredictable fracture of the instrument as well as dentin damage.[26,27] The present study evaluated the effect of torque level, one of the changeable parameters during root canal preparation, on the reduction in fracture resistance of the root. Thus, the PTU system that significantly caused more dentinal defects in previous studies[28-30] was preferred to prepare root canals in the present study. The results revealed that the fracture strength of teeth instrumented using high torque settings decreased significantly, and the null hypothesis was rejected. This finding confirms the previous study[17] that found dentinal crack formation during the instrumentation with the PTU system increased when using the high torque settings. They stated that more crack formation in the high torque group might be associated with increased stress on the dentinal surface. Studies[18,31] that evaluated the effect of different torques on dentinal crack formation using the RaCe system or the Neoniti system have also reported that more dentin cracks occurred at high torque values.

The previous studies[17,18,31] also reported no dentinal crack in the control group and significant cracks in the experimental groups (low and high torque groups). However, according to the present study results, the teeth instrumented using low torque settings showed similar fracture strength to the control group. Thus, this finding showed that dentin defects that might have occurred when a low torque setting was used did not affect the fracture strength of teeth.

To avoid variation and eliminate bias during fracture strength assessment, standardization of the methodology used is necessary. In the present study, teeth were selected considering their type, dimensions, number of canals, and curvature. The working lengths of the samples were standardized. A single operator performed all instrumentation and irrigation procedures to reduce operator variability. Also, root canals were obturated using a single-cone technique to avoid the pressure that could cause a defect in the root dentin during filling procedures.

CONCLUSION

According to this study, high torque values decreased the fracture strength of teeth. It was seen that the preferred torque settings in root canal preparation play a crucial role in root fracture formation during or after root canal treatment. Since the lowest fracture strength value was observed in the high torque group, clinicians may be advised to use the lowest torque settings recommended by the manufacturers for rotary systems.

ACKNOWLEDGMENTS

The authors thank Dr. Ziynet Çınar for statistical analysis.

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