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Original Research Article

Effect of Torque Settings of ProTaper Next Files on Microcrack Formation

ProTaper Next Eğelerin Farklı Tork Değerlerinin Mikroçatlak Oluşumuna Etkisi

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ABSTRACT

Aim: The purpose of this study is to evaluate the effect of different torque settings of ProTaper Next files on microcrack formation.

Materials and Method: Ninety mandibular anterior teeth were used. Fifteen teeth served as control and 75 teeth were divided into three groups according to the torque settings (n=25). In group 1; the root canals were instrumented using ProTaper Next files at a rotational speed of 300rpm and 2.0 Ncm torque. In group 2; the files were used with 3.5 Ncm torque, and in group 3; the files were used with 5.2 Ncm torque. Teeth were horizontally sectioned at 3, 6, and 9 mm and examined with a stereomicroscope. The Chi-square test was performed to compare microcrack formation between all groups.

Results: The percentage of total cracked teeth in the 2.0, 3.5, and 5.2 Ncm groups were recorded at 24%, 28%, and 32%, respectively, without any significant difference (p>0.05).

Conclusion: The use of ProTaper Next files with high torque settings did not affect the amount of microcrack occurrence. The clinicians may use the rotary systems within different torque values suggested by manufacturers in reliance upon their clinical experiences.

Keywords: Microcrack; Protaper next files; Torque setting

ÖZET

Amaç: Bu çalışmanın amacı, ProTaper Next eğelerinin farklı tork ayarlarının mikroçatlak oluşumuna etkisini değerlendirmektir.

Gereç ve Yöntem: Doksan adet alt çene anterior diş kullanıldı. On beş diş kontrol olarak, 75 diş ise tork ayarlarına göre (n=25) üç gruba ayrıldı. 1. grupta; kök kanalları ProTaper Next eğeleri kullanılarak 300rpm dönüş hızında ve 2.0 Ncm torkta enstrümante edildi. 2. grupta; eğeler 3.5 Ncm torkla ve grup 3'te; eğeler 5.2 Ncm tork ile kullanıldı. Dişler yatay olarak 3, 6 ve 9 mm'de kesildi ve stereomikroskop ile incelendi. Tüm gruplar arasında mikroçatlak oluşumunu karşılaştırmak için Ki-kare testi yapıldı.

Bulgular: Toplam kırık diş yüzdesi 2.0, 3.5 ve 5.2 Ncm gruplarında, anlamlı bir fark olmaksızın sırasıyla %24, %28 ve %32 olarak kaydedildi (p>0.05).

Sonuç: ProTaper Next eğelerinin yüksek tork ayarlarında kullanılması, mikroçatlak oluşum miktarını anlamlı olarak etkilememektedir. Klinisyenler, klinik deneyimlerine dayanarak üreticilerin önerdiği farklı tork değerlerinde döner sistemleri kullanabilirler.

Anahtar Kelimeler: Mikroçatlak; Protaper next eğeler; Tork değerleri

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INTRODUCTION

Instrumentation of the root canal system is a crucial stage during root canal treatment. Effective instrumentation requires the complete removal of pulp tissue and the infected root canal dentine. However, root canal shaping procedures have the potential of inducing dentinal defects like microcracks and craze lines.[1,2] Such defects have been investigated as major causes which propagate and lead to the formation of vertical root fractures.[3,4]

Shaping the root canal with rotary nickel-titanium instruments result in frictional forces related to the resistance of dentin to cutting action, creating microcracks in the radicular dentine.[5] Numerous studies have reported that nickel-titanium instruments cause cracks in root dentine.[1,6-8] Although, various improvements have been provided in the design and kinematics of nickel-titanium instruments, the issue of the formation of dentinal defects during instrumentation still exists. Therefore, evaluation and elimination of such a problem are required for the success of root canal treatment.

ProTaper Next (PTN; Dentsply, Maillefer, Ballaigues, Switzerland) is a multi-file system manufactured with M-Wire nickel-titanium (NiTi) alloy that consists of 5 files with an off-centered rectangular cross-section with variable tapers (X1; #17/.04, X2; #25/.06, X3; #30/.075, X4; #40/.06, and X5; #50/.06). The files were manufactured through a thermal alloying process to improve file strength and flexibility.[9] The instrument demonstrates a snake-like movement as it is advanced through the root canal.[10] According to the manufacturer's quick reference guide, for the optimal use of PTN instruments, torque control endodontic motors were recommended at 2.0 Ncm. Additionally, the settings can be adjusted up to 5.2 Ncm according to practitioner experience.[10]

A comprehensive literature search reveals that there is limited information in the literature evaluating the efficacy of different torque settings of PTN instruments on microcrack formation. Thus, the purpose of this study was to evaluate the effect of different torque settings of PTN instruments on dentinal microcrack formation. We hypothesized a positive correlation between the increase in torque value and the formation of dentin cracks.

MATERIALS AND METHOD

The protocol of the study was approved by the Non-Interventional Clinic Research Ethics Committee of the Zonguldak Bülent Ecevit University (protocol date and number: 02/11/2022, 2022/19). 90 freshly extracted mandibular anterior teeth with single straight root canals were used. Two radiographs were taken from the buccolingual and mesiodistal angles to examine and verify the existence of the single straight canal for each tooth. Calculus and soft tissue remnants on the external root surface were mechanically cleaned. Defects or cracks on the external root surfaces were determined with a stereomicroscopic examination (Olympus SZ61, Olympus, Melville, NY, USA). During the experiment, the specimens were kept in distilled water.

The crowns were removed 1 to 2 mm above the cementoenamel junction with a diamond disk to obtain a standardized root length. A size 10 K file was advanced in the root canal until the tip of the file was visible through the apical foramen. The working length was obtained by subtracting 1 mm from this length.

The methodology was previously described by Lui *et al*.[11] The roots were wrapped with a single layer of aluminum foil, then the teeth were embedded in acrylic resin (Imicryl, Konya, Turkey). After the resin was cured, the root was removed and the aluminum foil was peeled off. The root was covered with light-body silicon-based impression material (Speedex, Coltene, Switzerland) and repositioned into the resin. In this way, a silicon-based material was replaced with the void formed by the foil, and the periodontal ligament was simulated. In order to avoid dehydration the apical part of the root was uncovered and submerged in distilled water throughout the experimental procedures.

All instrumentation steps were completed by a single experienced operator. Fifteen teeth served as control and 75 teeth were randomly divided into three equal groups (n=25). In group 1; the root canals were instrumented using PTN X1 and X2 files at a rotational speed of 300 rpm and 2.0 Ncm torque. In group 2; the files were used at a rotational speed of 300 rpm and 3.5 Ncm torque, and in group 3; the files were used at a rotational speed of 300 rpm and

5.2 Ncm torque. The files were used up to the working length. After the root canal instrumentations were completed, horizontal sections were obtained at 3, 6, and 9 mm from the apex Then, all the specimens were evaluated with a stereomicroscope (Olympus SZ61, Olympus, Melville, NY, US) under ×25 magnification to determine the presence of microcracks. Data were analyzed using SPSS Version 19 (SPSS Inc., Armonk, NY, USA). The results were reported as the number and percentage of cracks in the 3 sections for each group (Fig.1). The Chi-square test was used to compare the 3 groups in terms of microcrack formation, with P<0.05 considered statistically significant.

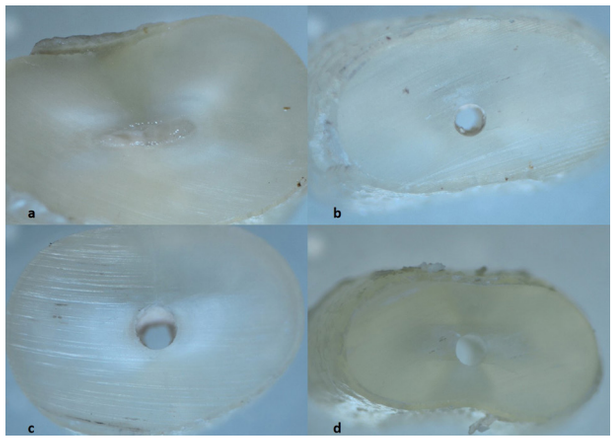

Figure 1. Representive images for each groups. (a) control group, (b) preparation with 2 Ncm, (c) 3.5 Ncm, (d) 5.2 Ncm torque settings.

RESULTS

No microcrack was determined in the control group. All the torque settings created microcracks. No differences were found between the torque settings at 3, 6, and 9 mm sections (p>0.05) (Table 1). The percentage of total cracked teeth in the 2.0, 3.5, and 5.2 Ncm groups were recorded at 24%, 28%, and 32%, respectively, without any significant difference (p>0.05).

DISCUSSION

Many factors such as instrumentation, irrigation solutions, root morphology, and post-space preparation are responsible for the formation of dentin defects.[1,2,12-14] Root canal shaping with rotary instruments requires torque, which caused stress on both the teeth and NiTi instruments.

In endodontics, torque can be described as the force required to rotate the instrument used with engine-driven motors. When shaping with NiTi files, the file must rotate at a constant rate of rotation within the canal, regardless of anatomical or structural conditions such as the degree of root canal curvature or calcification.[14] When the torque value is increased, instruments incline to reach working length with less automatic reversing act, which can increase the strain on the file and root dentin. Therefore, produced instruments should be assessed at varied torque values to define their impact on microcrack formation.[15]

In the present study, the effect of different torque settings of PTN files on microcrack formation during root canal instrumentation was evaluated under *in vitro* conditions. *In vitro* studies may have some limitations. As an example, there may be changes in dentin structure and quality with age, and the exact age of the patients whose extracted teeth were collected is unknown.[16] However, some variables such as kinematics, metal alloys, tapers, and speeds of instruments used in all groups were uniform which may provide a standardization.

The removal of root canal dentine in narrow or curved root canals may be difficult and may cause the stuck of the instrument in the root canal. In such a condition, excessive torque will be required for further preparation.[17] In the present study mandibular anterior teeth were used because of their narrow root canal anatomy which may result in a higher locking effect on the instrument.

Table 1. Number and percentage of cracks in the different cross-sectional slices

	3mm	6mm	9mm	Total cracks per group	p value
2.0 Ncm torque	6/24%	6/24%	8/32%	20/26.7%	0.761
3.5 Ncm torque	5/20%	5/20%	5/20%	15/20%	1.000
5.2 Ncm torque	4/16%	5/20%	5/20%	14/18.7%	1.000

Silicone impression material and resin were used to simulate periodontal ligament and bone, respectively, in the acrylic block prepared to mimic the clinical situation as reported previously.[7,18,19] Since the periodontal ligament acts as a stress absorber, the presence of a periodontal simulation may be crucial to reflect clinical conditions.

The instrumentation speed, force, kinematics, and torque values are several factors that may affect instrument failure.[20] The risk of instrument fracture increases when the instrument-typical torque limit is exceeded. It was reported that higher torque can cause the file to bind to dentin and result in torsional failure.[21] However, no failure occurred under test torque values. Gambarini suggested that a specific torque limit should be regulated for each file size and type.[17] For optimal usage, a 2.0 Ncm of torque setting was suggested by the manufacturer, additionally higher torque values were also recommended for experienced practitioners up to 5.2 Ncm for the PTN system.10 In the present study three different torque setting values, including the lowest and highest, recommended values were selected. Our results demonstrated that the increase in torque values did not affect the amount of microcrack formation. This result should be associated with the completion of all instrumentation procedures by an experienced operator as recommended by the manufacturer. In contradistinction to our results, Dane *et al*.[15] reported significantly fewer cracks in the low-torque value group than in the high-torque value group for the ProTaper Universal system in mandibular premolar teeth. In their study, Dane *et al*.[15] prepared the root canals up to size F4 instrument size 40, 0.06 taper. The difference between the two studies should be associated with the size of the apical diameter of the final instruments used. Additionally, our results were comparable with a recent study, in which the percentage of dentinal defect formation was reported as 28% after preparation with PTN instruments under 2.0 Ncm torque settings.[22]

The cutting efficiency of instruments may adversely affect by lower torque values. This may cause difficulty in the progression of the instrument into the root canal, and eventually deformation and separation of the instrument because of a possible locking as a result of tending to the force of the operator during the instrumentation.[21] Therefore, reliable use of instruments with higher torque settings without any deformation of file or root canal dentine may be favorable in clinical practice.

CONCLUSIONS

The use of PTN files with high torque settings did not affect the amount of microcrack formation. Thus, clinicians may use the PTN system with a 5.2 Ncm torque value in reliance upon their clinical experiences. The clinicians may use the rotary systems within torque values suggested by the manufacturers.

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