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Research Article

Ex-vivo Evaluation of the Torque Force on Periodontal Tissues During Endodontic Treatment

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Abstract

Objective: To examine the torque force generated on periodontal tissues by three different Ni-Ti endodontic file systems during root canal preparation in freshly extracted teeth.

Methods: Sixty single root teeth with an apical diameter corresponding to the size 15K-file were included to this study. Three experimental groups (n=20) were arranged. After establishing the working length teeth were placed on a digital torque-meter via self-curing polymethylmetacrylate adaptor. Thereafter, the following Ni-Ti file systems were tested: WaveOne Primary File (WO), WaveOne Gold Primary file (WOG) and size 25 OneShape (OS). In all groups, canals were prepared with the manufacturers' recommendations. The values measured with the torque meter were recorded.

Results: There was no statistical difference at WO-WOG groups comparisons ($p>0.05$). However, there were statistical differences at WO-OS and WOG-OS groups comparisons ($p<0.016$). The minimum torque value was at OS Group (2.0 Ncm) while maximum torque value was at WO Group (5 Ncm).

Conclusion: The results of this study showed that torque forces generated with reciproc files were significantly higher than that of Ni-Ti rotary file. Further we can speculate that eliminating inflammation-related tooth mobility through phase I periodontal therapy before endodontic treatment can reduce the risk of damage caused by rotational forces during endodontic treatment.

Key words: Endodontics, periodontium, root canal preparation, trauma, torque.

Özet

Amaç: Yeni çekilmiş dişlerde kök kanal hazırlığı sırasında üç farklı Ni-Ti endodontik eğe sistemi tarafından periodontal dokularda oluşan tork kuvvetinin incelenmesidir.

Yöntem: #15 K-tipi eğeye karşılık gelen apikal çapa sahip altmış tek köklü diş üç ayrı deney grubuna (n = 20) ayrılmıştır. Çalışma uzunluğu oluşturulduktan sonra dişler, polimetilmetakrilat adaptör ile dijital bir torkmetre üzerine yerleştirildi. Daha sonra dişler WaveOne Primary File (WO), WaveOne Gold Primary file (WOG) ve size #25 OneShape (OS) olmak üzere üç farklı Ni-Ti eğe sistemi ile şekillendirildi. Tüm gruplarda kanallar üreticilerin önerilerine göre şekillendirildi. Torkmetre ile ölçülen değerler kaydedildi.

Bulgular: WO-WOG grup ile karşılaştırıldığında istatistiksel olarak anlamlı fark bulunmadı ($p > 0.05$). Bununla birlikte, WO – OS ve WOG – OS grup karşılaştırmasında istatistiksel anlamlı fark bulundu ($p < 0.016$). Minimum tork değeri OS grubunda (2.0 Ncm) iken, maksimum tork değeri WO grubunda (5 Ncm) görüldü.

Sonuç: Bu çalışmanın sonuçları, reciproc eğeler ile üretilen tork kuvvetlerinin, döner aletlere göre daha yüksek olduğunu göstermiştir. Ayrıca, endodontik tedaviden önce periodontal inflamasyon kaynaklı diş hareketliliğinin faz I periodontal tedavi ile ortadan kaldırılmasının endodontik tedavi sırasında rotasyonel kuvvetlerin neden olduğu hasar riskini azaltabileceği düşüncesindeyiz.

Anahtar kelimeler: Endodonti, kök kanal preparasyonu, periodonsiyum, travma tork

Introduction

The periodontium supports teeth during function and maintains its structural integrity via stimulation by external forces. There is a homeostatic and constant equilibrium between functional forces and periodontal structures. The periodontal ligament is one of those structures that transmit external forces to the bone and resist occlusal forces. In patients with severe or untreated periodontitis, periodontal tissue destruction makes periodontium vulnerable to external forces (1).

During function; an approximate force of 1N applied at the crown is enough for the movement of a tooth in the dentoalveolar socket and this movement ranges from 0.05 to 0.10 mm at central incisors (2). In case of higher force, (5N) the tooth moves by 0.10 to 0.20mm and this results in reversible damage. Forces higher than 5N may lead to irreversible damage to healthy periodontium. However, if the periodontium has already been reduced, even a force of 5N may cause irreversible damage (2, 3).

Periodontal ligament fibers have been anatomically arranged to meet occlusal forces best along the long-axis of the tooth (4). The risk of damage to the periodontium is greater with lateral and torque forces. Studies showed that rotational torque forces cause two times more apical stress at central incisors (5, 6). Para-functional habits, bite anomalies orthodontic/endo-dontic therapy, tooth extractions are some of these conditions which cause torque forces on teeth and supporting tissues.

In modern endodontics, rotary Ni-Ti endodontic file systems are widely used for the advantage of reducing chair-side time, minimizing iatrogenic damage and risk of complication, and providing improved root canal shaping (7-9). Torque forces in these systems preserves rotation speed of the file against resistance that occurs during the preparation of root canal surface and provides efficient shaping. Recent reviews have emphasized that torque generation in Ni-Ti instruments is multifactorial, influenced by alloy type, taper, cross-sectional geometry, and motion kinematics (10). Abnormal torque values increase the risk of fracture and deformation of the file (11). Rotary instruments have different cutting tips and this variability may have effects on the torque force produced.

In recent years, Ni-Ti file systems which complete root canal preparation with only 1 instrument has been introduced. WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) (WO) and recently introduced WaveOne Gold (Dentsply Maillefer, Ballaigues, Switzerland) (WOG) are single-file systems working in reciprocating motion while OneShape (Micro-Mega, Besancon Cedex, France) (OS) files are the ones working in a continuous rotation motion (12). To the best of our knowledge, no study has examined the effects of rotary endodontic file system-induced torque force on the periodontal tissues. Considering the lack of research on this issue, we aimed to investigate the torque force generated on periodontal tissues by three different rotary endodontic file systems during root canal preparation in freshly extracted teeth.

Materials And Methods

This study was carried out, between November 2018 - May 2019 at Galata University, Faculty of Dentistry, Department of Periodontology, and Department of Endodontics. (Ethical Approval Number: 5402245-0.50.05.04). Also the study was conducted in accordance with the Helsinki Declaration as revised in 2013. The teeth used in this study were maxillary central, lateral, and canine teeth which were scheduled for extraction due to severe periodontal destruction. Extracted teeth were placed in sterile saline solutions and measurements were performed on the prefabricated experimental setup in 2 hours following extraction. The inclusion criteria comprised maxillary incisors and canine teeth having root canal diameters that correspond to a #15 K-type file (M-Access, Dentsply Maillefer, Ballaigues, Switzerland) which stopped at the apical foramen and root canal working length of less than 25 mm. Periapical radiographs were taken in the bucco-lingual and mesio-distal directions to ensure that the tooth has single root canal. Teeth with internal or external resorption, caries, and calcified canals and root canal curvature of more than 10° were excluded from the study.(13) The working length (WL) was established by using a #15 K-type file ® that was inserted into the canal until the file tip became visible at the apical foramen. Teeth that had the root canals with an initial apical size equivalent to size #10 K-file and working length less than 25 mm were used in the study. Based on the criteria above, 60 teeth were selected and divided into three experimental groups with 20 teeth each: WO; WOG and OS files. Teeth were randomly assigned to one of the three groups consisting of 7 central incisors, 7 lateral incisors and 6 canines by drawing from a pool of lots. The group which completed the designated tooth number was excluded from randomization. The teeth were placed on a previously calibrated torque meter giving a torque value in newton per centimeter (Ncm) with the aid of an adapter constructed of self-polymerizing polymethylmethacrylate. (Figure 1).



Figure 1. Digital Torque Meter

Root canal preparation protocol

All the root canal preparations were done by using a single file in each tooth at the three groups. The highest torque value reached during the preparation procedure was also recorded.

WO and WOG files: The root canals were instrumented with the setting "WaveOne All" mode of the X-Smart Plus endomotor (Dentsply Maillefer, Ballaigues, Switzerland). The preparation was performed with in-and-out pecking motion at an amplitude of 3 mm until the WL was reached. The canal was then irrigated with 5% sodium hypochlorite (NaOCl) solution and the patency was checked with a #10 K-file.

OS file: #25 One Shape file with a taper of 0.06 was used in continuous rotation until the WL was reached taking into consideration the instructions of the manufacturer. The endomotor operated at rotation speed- 350 rpm and torque 2.5N cm. The canal was then irrigated with 5% NaOCl and patency were checked with a #10 K-file. Each instrument was used for one canal.

Statistical Analysis

Statistical tests were performed using statistical software (IBM SPSS Statistics for Windows, Version 21.0 (IBM Corp., Armonk, NY, USA)). The median 25-75 percentiles were calculated for canal length and torque values, and the tooth was taken as the unit of analysis. $p < 0.05$ was considered to be statistically significant.

The primary outcome variable-torque value could not be used to determine the sample size and the power of the study since, no precise information was available on torque value. Therefore, the current estimates were based on a pilot study which included 10 teeth in each experimental group. It was determined that a sample size of 16 teeth in each group would allow for a type II error level of $b = 0.20$ (80% power) and a type I error level of $a = 0.05$ (5% probability). Taken into consideration the possible dropouts, 20 teeth were included in each group. Since no sample size calculation could be performed a priori, a retrospective power analysis was calculated.

The Shapiro–Wilk test was used to test for normality of data. Intergroup comparisons in terms of root canal length and torque values were performed using the Kruskal–Wallis non-parametric test. Bonferroni adjusted Mann Whitney-U test was used to find out which of the

two groups showed a significant difference. For the Bonferroni correction, $\alpha=0.05/3=0.016$ was considered to be statistically significant.

Results

The mean root canal length and torque values for each file are presented in Table 1. There was no statistically significant difference between the groups in terms of root canal length values ($p>0.05$) but a statistically significant difference existed between the groups in relation to the torque values ($p<0.05$). Post hoc pair sample test revealed that there was no significant difference between reciprocal files ($p>0.016$). However, a significant difference was observed between OS file and WO/WOG file groups ($p<0.016$) (Figure 2). The minimum and maximum torque values for the study groups are given in Table 2. While the maximum torque value was observed in the WO file group; OS file group had the minimum torque value. No correlation was found between root canal length and torque values ($p>0.05$).

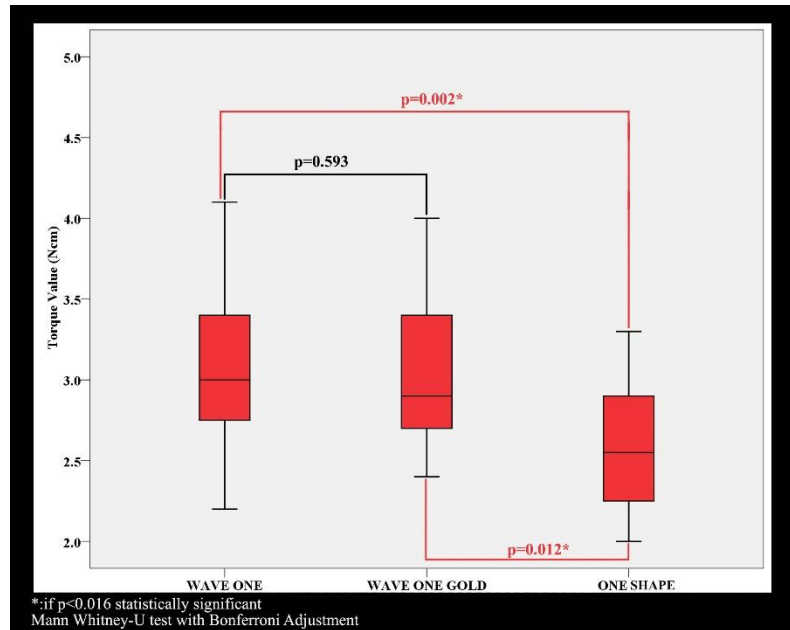


Figure 2. Intergroup comparison in terms of torque values

* Statistically significant difference between groups (Bonferroni-adjusted Mann–Whitney U test).

Data are presented as box and whisker plots. The median value is indicated by the line within the box plot. The box extends from the 25th to the 75th percentiles. Whiskers extend to show the highest and lowest values.

Table 1. Distribution of root canal length and Torque values among the groups

	Groups			p value
	WO	WOG	OS	
Root Canal Length (mm)	23 (21.6-23)	22.5 (21.4-23)	22 (21-23)	0.410
Torque Value (Ncm)	3.00 (2.73-3.4)	2.90 (2.65-3.43)	2.55 (2.25-2.90)	0.006*

Kruskall-Wallis H test

Values given as median (%25-%75) percentiles

* Statistical significance with a confidence of 95 % (p value <0.05)

Table 2. Minimum and maximum torque values (Ncm) during root canal preparation

	Minimum	Maximum
WO	2.2	5.0
WOG	2.4	4.5
OS	2.0	3.3

Discussion

The principal fibers of the periodontal ligament are arranged so that they best tolerate occlusal forces along the long axis of the tooth. The change in the direction of the occlusal forces causes a change in the distribution of the stress and occlusal load on periodontium and this may have different outcomes (i.e., lateral (horizontal) and torque (rotational) forces have the potential to injure the periodontium). Studies have shown that rotational torque forces generate 2 times more stress on the periodontal tissues compared to forces from different directions (5, 6).

With the introduction of rotary instruments to endodontics, torque forces generated by the cutting edges of the rotary files gained increasing importance. There are numerous studies on the effects of these torque forces both on the deformation of the rotary file itself and on the occurrence of stress-related adversities such as cracks and fractures generated in the root canal (14). There is no study that has yet examined the effects of these rotational forces on the supporting tissues of the tooth. Therefore, we aimed to investigate the force exerted on periodontal tissues by 3 different rotary Ni-Ti endodontic file system during root canal instrumentation in a specially developed experimental set-up. The results of our study showed that torque forces induced with both types of reciproc files were significantly higher than that of rotary file.

In our study, we used freshly extracted teeth instead of simulated canals in resin blocks because we think that it best represents the real conditions from the point of the structure of the instrumented material. Since one must not forget that great differences exist between the

two structures regarding physical properties. Heat generated during instrumentation could soften the resin material in resin blocks (15).

Recently, Jamleh et al. evaluated the amount of vertical force in the apical and coronal directions induced with WO and WOG systems during the canal shaping of extracted teeth. The authors concluded that WOG system had significantly lower apically and coronally directed peak force values compared with the WO system (11). The findings of our study are inconsistent with the findings of this study.

The cross-section, taper, NiTi alloy properties and motion kinematics may affect the amount of vertical force (i.e. torque values) (16). Although both WO and WOG file systems work with reciprocating motion, they differ from each other in terms of taper and cross-section design. Moreover, recent studies demonstrate that rotational speed settings can significantly alter torque values and fracture resistance during instrumentation, underscoring the clinical relevance of motor parameters (17). WO file has a modified convex triangular cross-section with 8% taper while WOG file has a parallelogram-shaped off-centered cross-section with 7% taper. (18) On the other hand, OS file system works with continuous rotary motion and has variable cross-section design with 6% taper (19). The lower taper design of the OS files may have been responsible for the lower torque values in this study. In the endodontic treatment of a tooth with reduced periodontium which is more vulnerable against external forces, the latter may serve as an option.

One plausible explanation for the observed differences in torque values between file systems lies in their taper designs. Instruments with larger tapers inherently possess greater stiffness and cross-sectional mass, which increases their contact area with dentin and thus elevates frictional resistance, requiring higher torque to maintain rotation. This concept is supported by Faus-Llácer et al. (20), who demonstrated that increased taper and apical diameter lead to decreased cyclic fatigue resistance, implicitly indicating greater internal stresses at higher taper levels. Moreover, in retreatment settings, Kim et al. (21) found that NiTi systems with greater taper may generate higher torque and are more susceptible to buckling, suggesting that taper not only influences cutting mechanics but also structural stability under load. In the context of our results, the file systems with steeper tapers likely encountered more resistance in dentin walls, contributing to their higher torque readings. Conversely, lower taper instruments would engage less frictional surface area, reducing the load required to rotate, which

could explain why in our study the system with smaller taper consistently showed lower torque values. Clinically, this implies that when shaping teeth with compromised periodontium, selecting instruments with reduced taper may mitigate excessive torque-induced stress on root surfaces

Additionally, operator-dependent variables such as the amplitude of reciprocating pecking motions have been shown to influence torque and stress distribution, suggesting that clinical technique is also a determinant of mechanical load on the periodontium (22).

Limitations of the Study

Our study has some limitations that should be considered. First, an existing periodontal ligament could not be simulated in the body of the experimental set-up. In other words, rigid fixation of the tooth to the adapter just resembling an ankylosed tooth was accomplished by using self-polymerized acrylic resin. Second, the presence of external forces from gingival fibers (dento-gingival, circular, transseptal, intra-papillary), root surface area-related differences between teeth due to their rigid attachment on the experimental set-up and variations in apico-coronal orientation of periodontal ligament fibers could not be modeled. Along with the listed factors above, the rigid model is far from distinguishing adversities such as the reduction of resistance to strength caused by reduced periodontium.

Despite all the shortcomings of, this model is important in terms of giving a general idea about the resultant rotational forces generated on the external root surface by endodontic Ni-Ti files during root canal therapy of single rooted teeth. However, a more advanced engineering model is needed that highlights the effects of these forces on periodontium.

Conclusion

The results of this study showed that torque forces generated with reciproc files were significantly higher than that of rotary file. However, a definite conclusion cannot be drawn such that files which work in reciprocating motion should be preferred over those working in continuous rotation motion in clinical practice. Since, there is a need for a more advanced engineering model incorporating components mimicking periodontal structures that meet torque forces in order to examine the behavior of periodontal tissues against such forces.

Kaynakça

1. Parfitt GJ. The dynamics of a tooth in function. *The Journal of Periodontology*. 1961;32(2):102-7.
2. Mühlemann HR. 10 years of tooth-mobility measurements. *The Journal of Periodontology*. 1960;31(2):110-22.
3. Mühlemann HR, Savdir S, Rateitschak KH. Tooth mobility—its causes and significance. *The Journal of periodontology*. 1965;36(2):148-53.
4. Glickman I, Roeber FW, Brion M, Pameijer JH. Photoelastic analysis of internal stresses in the periodontium created by occlusal forces. *Journal of periodontology*. 1970;41(1):30-5.
5. Hohmann A, Wolfram U, Geiger M, Boryor A, Sander C, Faltin R, et al. Periodontal ligament hydrostatic pressure with areas of root resorption after application of a continuous torque moment: a study using identical extracted maxillary human premolars. *The Angle orthodontist*. 2007;77(4):653-9.
6. Rudolph DJ, Willes MG, Sameshima GT. A finite element model of apical force distribution from orthodontic tooth movement. *The Angle Orthodontist*. 2001;71(2):127-31.
7. Bürklein S, Schäfer E. Critical evaluation of root canal transportation by instrumentation. *Endodontic Topics*. 2013;29(1):110-24.
8. Gavini G, Santos Md, Caldeira CL, Machado MEdL, Freire LG, Iglecias EF, et al. Nickel–titanium instruments in endodontics: a concise review of the state of the art. *Brazilian oral research*. 2018;32.
9. Shen Y, Cheung GS. Methods and models to study nickel–titanium instruments. *Endodontic topics*. 2013;29(1):18-41.
10. Kwak SW, Shen Y, Liu H, Kim H-C, Haapasalo M. Torque generation of the endodontic instruments: a narrative review. *Materials*. 2022;15(2):664.
11. Jamleh A, Alfadley A, Alfouzan K. Vertical Force Induced with WaveOne and WaveOne Gold Systems during Canal Shaping. *Journal of endodontics*. 2018;44(9):1412-5.
12. Elnaghy AM, Elsaka SE. Torsion and bending properties of OneShape and WaveOne instruments. *Journal of endodontics*. 2015;41(4):544-7.

13. Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral surgery, Oral medicine, Oral pathology. 1971;32(2):271-5.
14. A. Versiani M, Souza E, De-Deus G. Critical appraisal of studies on dentinal radicular microcracks in endodontics: methodological issues, contemporary concepts, and future perspectives. Endodontic Topics. 2015;33(1):87-156.
15. Kum K-Y, Spångberg L, Cha BY, Il-Young J, Seung-Jong L, Chan-Young L. Shaping ability of three ProFile rotary instrumentation techniques in simulated resin root canals. Journal of endodontics. 2000;26(12):719-23.
16. Bürklein S, Stüber J, Schäfer E. Real-time dynamic torque values and axial forces during preparation of straight root canals using three different endodontic motors and hand preparation. International endodontic journal. 2019;52(1):94-104.
17. Haimed TSA. The effect of rotational speed on force and torque during instrumentation of simulated root canals using ProTaper Next rotary files. Saudi Endodontic Journal. 2024;14(1):19-24.
18. Guillén RE, Nabeshima CK, Caballero-Flores H, Cayón MR, Mercadé M, Cai S, et al. Evaluation of the WaveOne Gold and one shape new generation in reducing *Enterococcus faecalis* from root canal. Brazilian dental journal. 2018;29(3):249-53.
19. Webber J. Shaping canals with confidence: WaveOne GOLD single-file reciprocating system. Roots. 2015;1:34-40.
20. Faus-Llácer V, Kharrat NH, Ruiz-Sánchez C, Faus-Matoses I, Zubizarreta-Macho Á, Faus-Matoses V. The effect of taper and apical diameter on the cyclic fatigue resistance of rotary endodontic files using an experimental electronic device. Applied Sciences. 2021;11(2):863.
21. Kim Y, Chang SW, Oh S. Buckling resistance, torque, and force generation during retreatment with D-RaCe, HyFlex Remover, and Mtwo retreatment files. Restorative Dentistry & Endodontics. 2023;48(1).
22. Hirano K, Kimura S, Maki K, Omori S, Ebihara A, Okiji T. Impact of Varying Amplitudes of Upward and Downward Motion on the Torque/Force Generation, Canal-Centering Ability, and Cyclic Fatigue Resistance of Nickel–Titanium Reciprocating Instrument. Applied Sciences. 2024;15(1):288.