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Araştırma/ Research Article

THE EFFECT OF OPERATOR'S EXPERIENCE ON THE CYCLIC FATIGUE RESISTANCE OF ONE CURVE, 2SHAPE AND RECIPROC NITI FILE SYSTEMS

OPERATÖR DENEYİMİNİN ONE CURVE, 2SHAPE VE RECİPROC EĞE SİSTEMLERİNİN DÖNGÜSEL YORGUNLUK DİRENCİNE ETKİSİ

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ABSTRACT
Aim: The objective of this study was to compare the resistance to cyclic fatigue of One Curve (OC), 2Shape (TS), and Reciproc (RC) files by considering the operator's experience.
Materials and methods: Mesial root canals of ninety mandibular molar teeth were prepared by three endodontic residents during the first 6 months of their training (IE) or by three professionals with min. 5 years of endodontic training at postgraduate level (E). Then, 45 files used by the inexperienced group (IE-OC, IE-TS, and IE-RC), 45 files used by the experienced group (E-OC, E-TS, and E-RC), and new 45 files (control group; C-OC, C-TS, and C-RC) were rotated in simulated canals until separation failure occurred. (n=15) The time to fracture was calculated. For statistical analysis, ANOVA and Tukey's post hoc tests were used (P<0.05).
Results: When compared to the experienced and inexperienced groups, the time-to-fracture of control group files was found to be significantly higher (P<0.05). Comparing the experienced and inexperienced operator groups, no significant difference was found for RC files, whereas significant differences were determined for TS and OC files (P<0.05).
Conclusions: The residual fatigue life of TS and OC instruments may be decreased by inexperienced operators more than experienced operators. Single file RC instrument was, however, not affected by the operator's experience.
Keywords: Cyclic fatigue, experienced operator, Reciproc, OneCurve, 2Shape

ÖZ
Amaç: Bu çalışmanın amacı, operatör deneyimini dikkate alarak One Curve (OC; Micro-Mega, Besancon, Cedex, Fransa), 2Shape (TS; Micro-Mega) ve Reciproc (RC; VDW, Münih, Almanya) eğelerin döngüsel yorulma direnclerini karşılaştırmaktır.
Gereç ve Yöntem: Doksan mandibular molar dişin mezial kök kanalları, eğitimlerinin ilk 6 ayındaki üç endodonti uzmanlık öğrencisi (IE) tarafından veya doktora düzeyinde min. 5 yıllık endodontik eğitim almış üç uzman (E) tarafından prepare edildi. Ardından, deneyimsiz grup tarafından kullanılan 45 eğe (IE-OC, IE-TS ve IE-RC), deneyimli grup tarafından kullanılan 45 eğe (E-OC, E-TS ve E-RC) ve yeni 45 eğe (kontrol grubu; C-OC, C-TS ve C-RC) kırık oluşana kadar simüle edilmiş kanallarda döndürüldü. (n = 15) Eğelerin kırılma süreleri hesaplandı. ANOVA ve Tukey's post hoc testleri istatistiksel analiz için kullanıldı (P <0.05).
Bulgular: Kontrol grubundaki eğe sistemlerinin kırılma zamanı deneyimli ve deneyimsiz grubunkine göre anlamlı derece daha yüksek bulunmuştur (P<.05). Deneyimli ve deneyimsiz operatörlerin grupları karşılaştırıldığında RC eğeleri için anlamlı fark bulunmamışken, TS ve OC eğeleri için anlamlı fark bulunmuştur (P<.05).
Sonuç: Bu çalışmada, TS ve OC eğelerin rezidüel yaşam ömrü deneyimli operatörlere kıyasla deneyimsiz operatörlerde daha fazla azaltılmıştır. Tek eğe RC sistemler ise operatörün deneyiminden etkilenmemiştir.
Anahtar Kelimeler: Döngüsel yorgunluk, deneyimli operatör, Reciproc, OneCurve, 2Shape

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INTRODUCTION

Nickel-titanium (NiTi) files have been mostly utilized to shape the curved root canals due to their high flexibility. However, NiTi instruments are likely to be subject to fractures in clinical use. Fractured file can eventuate as a result of cyclic or torsional fatigue.[1,2] The torsional fracture occurs as a result of the continuance of shaft's rotation motion while the tip of instrument is stuck in the canal. The cyclic fatigue, however, occurs when a specific portion of instrument is subject to repetitive compressive and tensile forces especially during the preparation of curved canals.[1,2] The cyclic fatigue is one of the main reasons for NiTi rotary files' failure during clinical use. Removal of fractured files is both difficult from technical aspect and time-consuming; thus, it is very important to limit the possibility of failure.[3] Various factors such as curvature angle of file, file design, and operator's experience have significant effects on the performance and failure resistance of files. The operator's experience is one of the agents that might influence the instrument failure and a higher failure rate was reported in procedures performed by inexperienced operators.[4]

The experience and clinical skills of the operator are considered as an important significant clinical factor for the file failure. The results of various studies suggest that having a good command of new methods is necessary and it is important to improve the operator's competence through training and experience.[5,6] Actually, these researches reported that complete training is required for minimizing the frequency of complications such as file failure.[6]

After the introduction of Reciproc (RC; VDW, Munich, Germany) files to the market, the single-file systems gained popularity. The system files are manufactured using 'M' wire technology. The remarkable advantage of this method is that it is capable of preparing the curved canals at low risk of failure by using a single file.[7] One Curve (OC; Micro-Mega, Besancon, Cedex, France) and 2Shape (TS; Micro-Mega) systems have been introduced to be manufactured using heat-treatment technology. OC instrument is a new-generation file system using C. Wire technology. C. Wire is a proprietary process, exclusively developed for OC.[8] According to the manufacturer, TS file is made of T-Wire technology involving proprietary heat-treatment and electropolishing.[8,9] The instrument system employs novel asymmetrical cross-section with triple helix which reduces the fracture risks and improves the efficiency of brushing motion.

To the best of our knowledge, there is no information in the literature about the influence of the operator's experience on the resistance to cyclic fatigue of OC, TS, and RC instruments. The goal of this study was to evaluate the influence of operator's experience on the resistance to cyclic fatigue of these instruments. The null hypothesis was that there would be no significant differences in cyclic fatigue resistance.

MATERIALS AND METHODS

For the present study, the approval was obtained from the Ethics Committee of Hatay Mustafa Kemal University (Approval Nr. 31.10.2019/13). Ninety mandibular molar teeth, which have been extracted due to periodontal reasons, were selected. Then, the selected teeth were randomly separated into two groups for the use of experienced and inexperienced operators. Mesial canals were prepared by three endodontic residents during the first 6 months of their training (inexperienced group) or by three professionals with at least 5 years of endodontics training at the postgraduate level (experienced group). The participants in the inexperienced group had theoretical knowledge on the systems and they received practical training on the teeth for 10 days before the study. Thirty instruments from each of OC, TS, and RC files were used in root canal preparation. The inexperienced and experienced groups are divided into three sub-groups according to the instrument system used: inexperienced (IE-OC, IE-TS, IE-RC) and experienced (E-OC, E-TS, E-RC) groups. 45 files (IE-OC, IE-TS, IE-RC) used by inexperienced group, 45 files (E-OC, E-TS, E-RC) used by experienced group, and 45 new files (control group; C-OC, C-TS, and C-RC) were prepared for the cyclic fatigue tests. (n=15)

Root Canal Preparation

In order to determine the root canal curvature of the extracted teeth, the radiographs were taken using the parallel method and in buccolingual and mesiodistal directions. Using Schneider's method, the teeth with similar chronoapical length (19 ± 1 mm) and curvature angle of 25°–35° were selected.[10] The teeth having 2 different mesial apical foramina and mature apices were involved in this study. The teeth with resorption/calcification, open apex, and

fractured root were excluded. Moreover, the teeth in which 15 # K-type file passively passed through the apical opening of the mesial canals were excluded from the study.

In inexperienced and experienced groups, the operators prepared traditional access cavity to the mandibular molar teeth. The root canal orifices were detected using #10 K-file (VDW) manual files. All the root canals were first irrigated using 1 mL 5.25% NaOCl. The apical opening was achieved by pushing #10 K-type file forwards in the canal until the tip is seen at the apex. The working length was determined to be 1mm shorter than the apical foramen. After determining the working length, the mesial root canals of all the molar teeth were shaped using #15'lik K-file. By using one of three different file systems, the mesial canals were prepared until reaching the working length. Every file was used in only 1 tooth and 2 mesial canals.

OC (25/.06) files were used with 3mm-width pecking and brushing motions in continuous rotation mode and with VDW Silver Reciproc endodontic motor in accordance with the manufacturer recommendations (300rpm speed and 2.5Ncm torque). The motor, motion, mode, speed, and torque settings used in OC were also used in TS files. The root canals were prepared first with TS (25/.04) files and then with TS (25/.06) files until reaching the working length. RC (25/.08) files were operated in "Reciproc all" mode with the same endodontic motor. The files were driven with light apical pressure and slow in-and-out pecking motion not exceeding 3-4mm width. For all the file systems, the debris was removed from the files by using NaOCl-soaked gauze after every three motions and the canals were irrigated using 1 mL 5.25% NaOCl. The working length was re-checked after the treatment procedure. In mesial root canals, 10 mL 2.5% NaOCI was used in total for each system.

Cyclic Fatigue Testing

Inexperienced group, experienced group, and control group were evaluated in simulated canals (n=15). A total of 135 instruments were used for this study. Cyclic fatigue test was carried out inside fabricated canals with a 3-mm radius of curvature and 60° angle of curvature. The insertion depth was uniformed to 19mm for each group. The back-and-forth movements were not employed. The files were operated with a torque-controlled motor (Silver; VDW, Munich, Germany) according to the manufacturers' recommendations as follows: OC (25/.06) at 300 rpm, TS (25/.06) at 300 rpm and RC (25/.08) in "Reciproc ALL" mode. To reduce friction, synthetic oil was used for lubrication. For all instruments, the time until failure was recorded in seconds and time to fracture was calculated.

Statistical Analysis

The data collected were analyzed using SPSS version 21.0 (SPSS Inc., Chicago, IL). The normality of variables was examined with the Shapiro-Wilks test. For statistical analysis, ANOVA and Tukey's post hoc tests were used ($P < 0.05$).

RESULTS

The time-to-fracture values of each group are exhibited in Table 1. Time-to-fracture values for control groups were significantly higher compared to other groups ($P<0.05$). For the control group, the highest time-to-fracture value was found in RC group (893.26± 79.82), followed by the OC (395.26 ± 52.25) and lowest in the TS group (205.33 ± 15.04). When comparing the experienced and inexperienced operator groups, statistically significant differences were determined for TS and OC files, whereas no statistically significant difference was found for RC system ($P<0.05$) (Figure 1). Besides that, no file fracture occurred during root canal preparation procedure.

Table 1. Mean values (± standard deviation) for the time to fracture

Groups	OneCurve	2Shape	Reciproc
Inexperienced group	204.93 ± 35.71[a]	79.66 ± 20.87[a]	615.80 ± 80.79[a]
Experienced group	242.40 ± 28.98[b]	126.73 ± 23.01[b]	679.53 ± 84.09[a]
Control group	395.26 ± 52.25[c]	205.33 ± 15.04[c]	893.26 ± 79.82[b]

Different superscript letters display a significant difference between groups.

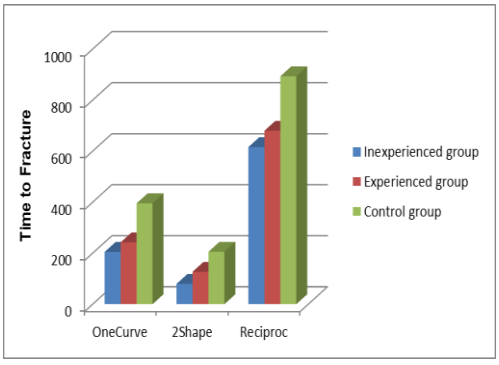

Figure 1. The fatigue life values of each group

DISCUSSION

The root canal preparation requires important skills especially in curved canals or complex anatomic cases. Despite the advancements in instrument design, the experience and skill of operator are still important.[7] The competence of clinicians for using endodontic instruments determines the rate of success in treatments.

The use of artificial canals for the root canal shaping procedures might be preferred in order to minimize the anatomic variations that the natural teeth have and to standardize the root canals.[11] When compared to the real teeth, the artificial canals in the resin blocks differ in terms of texture, hardness, and transverse cross-section.[12] The skill needed for shaping the canals of natural teeth is not the same as that required for shaping the artificial root canals in resin blocks.[7] Moreover, most of the complications observed during the root canal preparation occur in curved canals.[13] For this reason, in the present study, the mesial canals of mandibular molar teeth were selected in order to better represent the clinical cases.

In literature, the resistance to cyclic fatigue of endodontic files has been investigated using different study designs. Using the cyclic fatigue tests mimicking the clinical conditions has been an ideal target for researchers. Besides that, in this test method, it couldn't be possible to standardize the root canal system of the natural teeth and to ensure the reproducibility of test conditions for each instrument.[14] However, in this test analysis, the canals artificially simulated in a stainless-steel block were used reliably in static and dynamic models.[15] In the cyclic fatigue experiments based on static models, a file is rotated in a curved canal with fixed length until the failure. The dynamic experiment models, however, are based on the cyclic axial motion prolonging the lifetime of rotary instruments.[16] In this study, the static model was preferred since it ensures the standardization and reproducibility of experimental conditions.

According to the results obtained in this study, it was revealed that the resistance to cyclic fatigue of all the file systems significantly decreased after used by experienced and inexperienced operators. Plotino *et al.*[17] compared the resistances to cyclic fatigue of new Mtwo rotary NiTi files and Mtwo files used in preparing the root canal of maxillary and mandibular teeth. According to the results obtained, it was revealed that the resistance to cyclic fatigue of Mtwo files significantly decreased after controlled clinical use. The results are consistent with the findings of the present study.

In this study, the cyclic fatigue resistances of three different file systems were compared considering the operators' experience. When comparing the experienced and inexperienced operator groups, no significant difference was found for RC files, whereas significant differences were observed with TS and OC files. Thus, the null hypothesis that there would be no difference in the resistance to cyclic fatigue of the used systems was rejected.

There is no published study on the effect of the operator experience on the resistance to cyclic fatigue of these instrument systems. The effect of operator experience on the cyclic fatigue of NiTi files was examined in a few studies in the literature. In a study carried out by Vieira *et al.*[18] an experienced endodontist used two different 10-set ProTaper (S1, S2, F1 and F2) rotary files (each set was used in five molar or eight molar teeth) and undergraduates used 10-set ProTaper files (each set was used in five molar teeth) for the root canal treatments of patients and then, the cyclic fatigue resistance of unused files in control group and the used instruments were compared. The use of ProTaper files by an experienced endodontist enabled cleaning and shaping 8 molar root canal systems. During the use by undergraduate students, 6 file failures occurred. The resistance to cyclic fatigue of all the instruments decreased during clinical use. Besides that, it was reported that there was no statistically significant difference between the cyclic fatigue resistance of ProTaper files used by experienced endodontists and that of files used by undergraduates. In another study, an experienced operator and an inexperienced operator used Mtwo NiTi rotary files in the preparation of mandibular and maxillary molar teeth and no difference was reported between the resistances after the cyclic fatigue tests of those files.[6] The limitation of these studies is that there were only 1 operator representing the experienced clinicians and 1 operator representing the inexperienced clinicians. In the present study, in order to overcome this limitation, 3 experienced and 3 inexperienced operators were involved. Given the operator experienced, significant differences were observed between the resistances to cyclic fatigue of instrument systems in this study. Differing from the previous studies, the increase in the

number of operators in the present study might have influenced the results. Besides that, in the present study, providing the inexperienced operators with 10-day practical training on the file systems for extracted teeth might have not been sufficient for complete learning.

Comparing the experienced and inexperienced operator groups, it was determined that there was no significant difference for the RC group, whereas there were differences between the other groups. This situation can be explained with the differences in motion kinematics employed in the file systems. When compared to the reciprocal motion, the rotary motion increases the possibility of fastening and locking of the file in the canal. In comparison to the reciprocal motion, the working time of file for reaching the working length is longer in the rotary motion.[19] Shorter working time reduces the possibility of file failure.[20] The inexperienced group might have caused the file to be subject to more repeated tensile or compressive strains. Typically, the inexperienced operators incline to use rotary files in the canal for a longer time or to apply excessive apical pressure.[6] In conclusion, the files might have been subject to higher levels of stress in the inexperienced group.

Operator skills can be enhanced by repetitively using the instrument. Besides that, when compared to the multiple-file systems, the RC single-file concept necessitates a shorter learning period. It was reported that the design and M-wire technology prolonged the lifetime of RC files. The reciprocal motion prevents or delays exceeding beyond the elastic limit of alloy.[19] Also, the reciprocating motion reduces the incidence of taper locking.[4] For these reasons, it was thought that the effect of experience is unimportant for the RC file systems.

Within the limitations of this study, the resistances to cyclic fatigue of files having different tapers were compared. In some studies, it was reported that the cyclic fatigue of instruments decreases with the increasing file diameter, whereas some other studies reported the opposite. In present study, the resistance to cyclic fatigue of RC files having a larger taper than the others was found to be higher. This result might be related with the characteristics of RC files such as production process, design, alloy composition, and heat treatment applied.

CONCLUSIONS

The residual fatigue life of TS and OC instruments was reduced by inexperienced operators compared to experienced operators. Single file RC instruments residual fatigue life was not affected by operator experience.

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Conflicts of interest statement
The authors declare no conflict of interest.

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