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How do Reused Glide Path Files Affect the Cyclic Fatigue Resistance?

¿Cómo afecta la reutilización de limas tipo glide path su resistencia a la fatiga cíclica?

Burçin Arıcan DDS, PhD[1]; Ayfer Atav Ateş DDS, PhD[2]

1. Assist. Prof., İstanbul Okan University, Faculty of Dentistry, Department of Endodontics, Turkey.
https://orcid.org/0000-0001-5757-0571
2. Assist. Prof., İstanbul Okan University, Faculty of Dentistry, Department of Endodontics, Turkey.
https://orcid.org/0000-0003-0270-8646

Correspondence to: Dr. Burçin Arıcan - burcin.arican@okan.edu.tr

ABSTRACT: The aim of this study was to compare the cyclic fatigue resistance (CFR) of PathFile (Dentsply Sirona, Ballaigues, Switzerland) and ScoutRace (FKG Dentaire, La Chaux-de-Fonds, Switzerland) glide path files which were either new or previously used. Forty PathFile (PF) 19/.02 and 40 ScoutRace (SR) 20/.02 instruments were used for this study. Half of the files in each group were used (PF-U and SR-U) in the 3D demo tooth models (FKG Dentaire, La Chaux-de-Fonds, Switzerland) for creating glide paths, while the other half was new (PF-N and SR-N) and directly subjected to the cyclic fatigue test. The new and used files (n=80) were rotated in the cyclic fatigue test device with an artificial stainless-steel canal (60° curvature, 5 mm radius 1.5 mm width and 3.0 mm depth) under the continuous irrigation with distilled water at 37°C until fracture occurred. Time to fracture was recorded and the Weibull reliability analysis was performed. Data were statistically analysed. Conformity to normal distribution was examined using the Shapiro-Wilk test. A paired two-sample t-test was used to compare the TTF values according to the time within the groups. The new instruments (PF-N and SR-N) showed better CFR than the used groups (PF-U and SR-U) ($P<0.05$). The TTF values of PF were statistically higher than SR in both new and used groups ($P<0.05$). The predicted time for %99 survival for the files was PF-N> SR-N>PF-U >SR-U. Reuse of both glide path instruments reduced the time to fracture and the cyclic fatigue resistance of the files.

KEYWORDS: Cyclic fatigue resistance; Demo model; Glide path; PathFile; Reuse; ScoutRace.

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RESUMEN: El objetivo de este estudio fue comparar la resistencia a la fatiga cíclica (CFR en inglés) de las limas PathFile (Dentsply Sirona, Ballaigues, Suiza) y ScoutRace (FKG Dentaire, La Chaux-de-Fonds, Suiza) de tipo glide path, nuevas o ya previamente utilizadas. Para este estudio se utilizaron 40 instrumentos PathFile (PF) 19/.02 y 40 ScoutRace (SR) 20/.02. La mitad de las limas de cada grupo se utilizaron (PF-U y SR-U) en los modelos dentales de demostración 3D (FKG Dentaire, La Chaux-de-Fonds, Suiza) para crear trayectorias de deslizamiento, mientras que la otra mitad se utilizaron nuevas directamente a la prueba de fatiga cíclica (PF-N y SR-N). Las limas nuevas y usadas (n=80) se hicieron girar en el dispositivo de prueba de fatiga cíclica con un canal artificial de acero inoxidable (curvatura de 60°, radio de 5mm, anchura de 1,5mm y profundidad de 3,0mm) bajo irrigación continua con agua destilada a 37°C hasta que se produjo la fractura. Se registró el tiempo hasta la fractura y se realizó el análisis de fiabilidad de Weibull. Los datos se analizaron estadísticamente. La conformidad con la distribución normal se examinó mediante la prueba de Shapiro-Wilk. Se utilizó una prueba t de dos muestras pareadas para comparar los valores de TTF según el tiempo dentro de los grupos. Los instrumentos nuevos (PF-N y SR-N) mostraron una mejor CFR que los grupos previamente utilizados (PF-U y SR-U) ($p<0{,}05$). Los valores de TTF de PF fueron estadísticamente superiores a los de SR tanto en los grupos nuevos como en los usados ($p<0{,}05$). El tiempo previsto de supervivencia del 99% para las limas fue PF-N> SR-N >PF-U >SR-U. La reutilización de ambos instrumentos tipo glide path redujo el tiempo hasta la fractura y la resistencia a la fatiga cíclica de las limas.

PALABRAS CLAVE: Resistencia a la fatiga cíclica; Modelo de demostración; Trayectoria de deslizamiento; PathFile; Reutilización; ScoutRace.

INTRODUCTION

Cleaning and shaping the root canal system is the main stage of endodontic treatment. The use of Ni-Ti instruments in endodontic practice has brought a new dimension to dentistry. The superelasticity property of Ni-Ti instruments makes the instrument more flexible than stainless steels, more compatible with canal curvature, and more resistant to breakage and wear (1). However, these instruments have the risk of breakage during the preparation of the root canals due to torsional or cyclic fatigue (2). By creating a "glide path" before using Ni-Ti rotary tools a significant reduction in instrument breakage and a decrease in the risk of creating a "taper lock" was reported (3,4). So that, Ni-Ti instruments can reach the working length more easily (3).Glide path means creating a smooth sliding path from the coronal to the apical of the canal (5). It is less time-consuming and easier to succeed with small-size engine-driven instruments than hand files (6). For this reason, many glidepath instruments have been produced with the help of developing technology and their cyclic fatigue resistance has been evaluated in studies (7-11). The cyclic fatigue resistance studies have been generally focused on the shaping files and the effect of their metallurgic and/or kinematic features (7,12-14). It should be kept in mind that the root canal therapy starts with checking the apical patency and creating the glide path. Any instrument fracture during creating the glide path can block the root canal space. Furthermore, this may cause undesirable outcomes such as prolonged treatment time (15), failure in cleaning the root canal system completely (7), limitation in the irrigation and shaping procedures (16).

PathFile (Dentsply Sirona, Ballaigues, Switzerland) (PF) and ScoutRace (FKG Dentaire, La Chaux-de-Fonds, Switzerland) (SR) sequenced glide path files are popular and have been used safely for years. Both are manufactured from conventional Ni-Ti and have 4 cutting edges with a square cross-section (17,18). The main differences between the two are the tip size of the instruments, working speed and the flute designs (7). Both have three instruments (PF sizes are #13, #16 and #19 while SR sizes are #10, #15 and #20) with 0.02 taper which are used in a row (17, 18).

According to the manufacturers PathFiles are single patient use devices (17) and ScoutRace files may be recommended for multiple patients if appropriate sterilization is done (18). To date, several studies compare these file systems regarding cyclic fatigue, torsional resistance, bending, and buckling properties of the files (7-11). While in some studies cyclic fatigue of PathFile was higher than ScoutRace (7, 8), Topcuoglu *et al*. indicated no statistically significant difference between them (9). So that the clinicians may consider to use PathFile instruments more than one tooth because of financial worries. But still, there is no study comparing cyclic fatigue resistance of these file systems that are previously used. From this point of view, it was aimed to compare the CFR of two different glide path files which were either new or used once in 3D models of maxillary molars with 4 canals. In the literature, there are some studies that compared CFR of various new and used Ni-Ti instruments (19, 20). And the results were showed that the CFR decreased after usage. So that; the null hypotheses were as follows:

1. The cyclic fatigue resistance of PF and SR used for the first time is higher than the previously used ones in the clinic.

2. There would be no difference between the tested glide path instruments regarding the fracture time.

MATERIALS AND METHODS

The power analysis performed with the G* power 3.1 program for Macintosh (Heinrich Heine, Universitat Dusseldorf, Dusseldorf, Germany) using data from another study by Plotino *et al*.(19) (Alpha=0.05, Power=0.95). The minimum sample size required was found to be 24 (n=6 for each group). Taking into consideration other studies (13, 20) and possible dropouts the number of samples increased to 20 in each group.

Forty sequenced PathFile (PF) (13/.02, 16/.02, and 19/.02), and 40 sequenced ScoutRace (SR) (10/.02, 15/.02, and 20/.02) instruments were examined under a dental operation microscope (Leica M320, Leica microsystems, Wetzlar, Germany) with 40X magnification to identify visual defects. No imperfect instrument was detected. Groups were as follows:

Group 1. (PF-N) Twenty new PF (19/.02) instruments were directly subjected to cyclic fatigue test.

Group 2. (PF-U) Twenty new PF instruments (13/.02, 16/.02, and 19/.02) were used with long back-forth gentle strokes and light touches at the WL at a speed of 600 rpm and 1.5 N/cm torque, respectively in 3D demo tooth models (FKG Dentaire, La Chaux-de-Fonds, Switzerland) for creating glide paths. Then these used PF (19.02) instruments (n=20) subjected to cyclic fatigue test.

Group 3. (SR-N) Twenty new SR (20/.02) instruments were directly subjected to cyclic fatigue test.

Group 4. (SR-U) Twenty SR instruments (10/.02, 15/.02, and 20/.02) were used during 3-4 seconds at the WL in a row at 300 rpm and 1.5 N/cm in 3D demo tooth models for creating glide paths. Then these used SR (20/.02) files (n=20) were subjected to cyclic fatigue test.

ROOT CANAL PREPARATION PROCEDURES OF THE USED GROUPS (PF-U, SR-U)

These instruments were used in 3D demo maxillary molar tooth models which had 4 root canals and opened access cavity. The apical patency was checked with the #10K file. The working length (WL) was calculated by withdrawing 0.5 mm from the point where the #10K file was seen to exit the apical terminus. For both groups, the root canals were irrigated with 2ml 2.5 % NaOCl after each file was used. Each sequenced file in SR-U and PF-U group was used for only one 3D demo maxillary molar tooth. All shaping procedures were performed by the same experienced endodontist. The used files were cleaned with an alcohol sponge, were packaged singly and subjected to 1 cycle of autoclave sterilization at the temperature of 134 °C for 17 minutes (21). After the sterilization, the instruments were left to cool at room temperature. 20/.02 SR and 19/.02 PF files which were used according to the inclusion criteria and had no visible defect were selected from the pool for the cyclic fatigue test.

CYCLIC FATIGUE TEST

The new and used files (n=80) were objected to the cyclic fatigue test device with an artificial stainless-steel canal (60° curvature, 5mm radius 1.5mm width and 3.0 mm depth). All the instruments were rotated using a torque-controlled endodontic motor (X Smart Plus, Dentsply Sirona, Ballaigues, Switzerland) at the speed and torque which were instructed by their manufacturers. The endomotor was mounted on the cyclic fatigue test device that allowed reproducible and fixed positioning of each instrument inside canal. The files were freely rotated until a fracture occurred. During the test, the 37°C distilled water was used to reduce friction and mimic the clinical conditions. Time to fracture was recorded with a digital chronometer in seconds both visually and audibly. The Weibull reliability analysis was done to compare the groups (12).

STATISTICAL ANALYSIS

Data were analyzed with IBM SPSS V23 (IBM Corp, Somers, NY). Conformity to normal distribution was examined using the Shapiro-Wilk test. An Independent two-sample t-test was used to compare the normally distributed TTF values according to the files. A paired two-sample t-test was used to compare the TTF values according to the time within the groups. The evaluation of the variability of fracture times between samples was done by Weibull reliability analysis using Minitab 17 program (State College, PA, USA). The significance level was taken as $P<0.05$.

RESULTS

Comparison of TTF values between and within the groups are presented in Table 1. Re-usage of the glide path files dramatically reduced the CFR ($P<0.05$). The time to fracture of the PF file decreased by almost one-fifth after use, while that of the SR file decreased by approximately one-fourth. The new instrument groups (PF-N and SR-N) showed statistically better CFR than the used groups (PF-U and SR-U) (P <0.05). Time to fracture values of PathFile (PF-N and PF-U) groups were statistically higher than ScoutRace groups (SR-U and SR-N) (P < 0.05).

Weibull calculations (Weibull modulus, R2, and time for 99% survival), mean values, and standard deviations are shown in Table 2 and the Weibull reliability plots with the probability of survival values for TTF are given in Figure 1. According to these calculations, the predicted time for 99% survival for the files was PF-N>SR-N >PF-U >SR-U.

Table 1. Comparison of TTF values between and within the groups.

	PathFile			**ScoutRace**	
	Mean±Sd	**Median (min. - max.)**	**Mean±Sd**	**Mean±Sd**	**Median (min. - max.)**
Used	111.5 ± 5.7	112.6 (101.8-118.9)	89.7 ± 2.5	89.4 (85.7- 95.0)	<0.001
New	135.3 ± 8.8	137.9 (118.1-150.0)	120.6 ± 5.9	119.5 (111.2-128.8)	<0.001
p	<0.001	<0.001			

Table 2. Weibull calculations for TTF.

Groups	**n**	**Mean±Sd**	**Weibull modulus**	**R²**	**Predicted time for %99 survival**
Pathfile-used	20	111.5 ± 5.7	23.2	0.95	93.503
Pathfile-new	20	135.3 ± 8.8	18.2	0.97	108.130
Scout Race-used	20	89.7 ± 2.5	45.0	0.91	81.919
Scout Race-new	20	120.6 ± 5.9	25.3	0.91	102.686

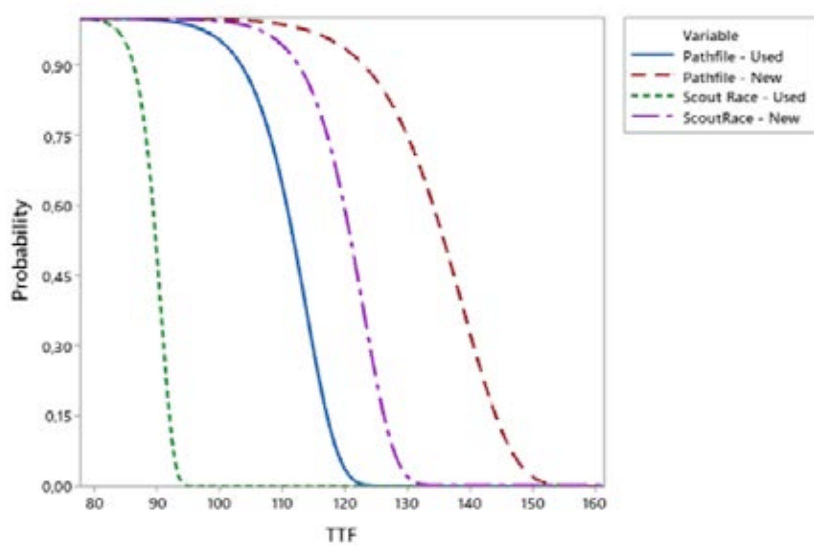

Figure 1. Survival graphics of TTF values

DISCUSSION

While Ni-Ti rotary instruments facilitate the work of dentists, they also brought a considerable cost. Increasing costs have been forcing dentists to reuse these files. Longsdon et al. reported that almost three out of every four endodontists reused the Ni-Ti rotary instruments (22). Another study showed that 41.3% of endodontists used the files until a visible defect was observed (23). Based on this, the assessment of the risk of file breakage arising from the reuse of glide path instruments will shed new light on the literature. The cyclic fatigue resistance of PF and SR used for the first time is higher than the previously used ones. For this reason, the first null hypothesis was accepted. TTF values of PathFile (PF-N and PF-U) groups were statistically higher than ScoutRace groups (SR-U and SR-N). Thus, the second null hypothesis was rejected.

It has already been shown that the design and size of the files, alloys, kinematics, operator experience, angle and radius of curvature, rotational speed, the number of use and glide path preparation have a remarkable effect on the file fractures (2,24). In the present study, first five criteria were aimed to keep constant and the last three were evaluated. PF 19/.02 and SR 20/.02 files which have the same taper, similar tip size, same kinematic motion and alloy were selected, and subjected to CFR test in a standard artificial stainless steel root canal by the same experienced operator. Besides, two variables (new and used) were tested and compared. Under these conditions, it was revealed that new or once used PF instruments either had better CFR than SR under the same conditions. Our results are in accordance with several other studies which showed new PF files were more resistant to cyclic fatigue than SR (7,8,10,11). The lower cyclic fatigue resistance of SR instruments may be associated with the higher rotational speed of SR. This result is in accordance with the Lopes *et al*. who reported that increasing the speed would decrease the cyclic fatigue resistance of instruments (25). And the constant pitch design of the PF may cause the higher CFR than SR that has alternating pitch design as mentioned by Çapar *et al*. (7).

On the other hand, Topçuoğlu *et al*. reported a contrary result to the present study and announced similar CFR results for PF and SR (9). The possible reason for this contradiction could be the experimental design of that study in which S-shaped root canals, and different size PF (16/.02) and SR (15/.02) instruments were used.

The cyclic fatigue resistance of the tested files can be represented with their number of cycle to failure (NCF) (13,14,16) and/or time to fracture (TTF) values (9,26). In the present study, the results were represented as TTF values. While TTF was directly recorded during the studies, some calculations are needed for the determination of NCF values. Since the main factor that determines the NCF value is the working speed of the instrument, when two files operating at very different speeds are compared, very distant NCF values are obtained. Therefore, compared to NCF, the TTF value offers more appropriate and interpretable values for the clinic. Özyürek *et al*. also suggested using TTF values which were more relevant to real conditions of the clinic (26).

The increased surrounding temperature generally results in lower NCF and TTF in cyclic fatigue studies (13,14,26). Therefore, the environmental temperature in CFR studies is the key factor to mimic the clinic conditions. In this study, continuous irrigation with distilled water at 37°C was performed to imitate the intracanal temperature. Beside this precaution, this study has some limitations. Even the 3D demo models present the properties close to dentine according to the manufacturer, it cannot mimic the natural teeth completely. Also, the artificial stainless-steel canal in cyclic fatigue test device cannot simulate the human root canals. Thus, the results should be interpreted to the clinic carefully.

CONCLUSION

Within the limitations of the present study, the time to fracture of the glide path files significantly reduced when they were reused. Furthermore, PF files were more resistant to fracture than SR files in both new and reused groups.

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ETHICAL APPROVAL

The authors declare that this study does not carry the qualification of experiments on humans and animals, biological materials (biological fluids such as blood, urine, extracted human teeth and tissue samples, etc.), observational and descriptive research without intervention (questionnaire, scale file scans, system model development, audio and video recordings).

CONFLICT OF INTEREST

The authors deny any conflicts of interest related to this study.

AUTHOR CONTRIBUTIONS

B.A., contributed to conception, design, data acquisition, analysis, and interpretation, drafted and critically revised the manuscript; A.A.A, contributed to design, data analysis and interpretation, critically revised the manuscript. All authors gave final approval and agree to be accountable for all aspects of the work.

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