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Comparison of Cyclic Fatigue Resistance of Revo-S and G-Star NiTi Files

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Abstract
Aim: *To compare the cyclic fatigue resistance of Revo-S and G-Star 25/.06 NiTi files using artificial canals.*
Materials and Methods: *Twenty Revo-S (25/.06) and 20 G-Star 25/.06 NiTi files were included to this study. Two artificial stainless steel canals with 60° and 90° radii of angle, 5 mm radii of curvature and 1.5 mm inner diameter were used in the present study. Files were divided into 4 groups (n: 10) and rotated until fracture occurs using an artificial canal with torque-control endodontic motor. Time to failure of the files was recorded by a digital chronometer. Than the number of cycles to failure were calculated. The data were analyzed statistically using Independent-Samples t test. A total of 8 specimens from 2 per groups were observed under scanning electron microscope to confirm the failure of cyclic fatigue.*
Results: *There was no significantly difference between the cyclic fatigue resistance of Revo-S SU (1480.6 ± 118.9) and G-Star 25/.06 (1427.1 ± 104.2) groups in 60° artificial canal and also there was no significantly difference between the cyclic fatigue resistance of Revo-S SU (396.1 ± 31.8) and G-Star 25/06 (367.4 ± 27.8) groups in 90° artificial canal (P> 0.001).*
Conclusion: *Within the limitation of the present study, there was no significantly difference between the cyclic fatigue resistance of Revo-S and G-Star 25/.06 files in 60° and 90° artificial canals.*
Keywords:*Cyclic fatigue; Static model; Revo-S; G-Star; Endodontics*

I. Introduction

During the root canal treatment procedure, the nickel titanium (NiTi) rotary files might fracture and stuck in the root canals without any prior sign, and negatively affect the success of treatment (1,2). NiTi file fractures occur through 2 mechanisms; torsional and cyclic fatigue (3). In torsional fractures, the tip or a part of file becomes stuck in the canal and the shaft keeps rotating, so the fracture occurs (4). In cyclic fatigue, the internal part of file is exposed to compression stress and the external surface is exposed to tension stress while rotating within a curved canal. The cyclic fracture occurs upon the continuance of this condition (5).

Revo-S (Micro Mega, Besancon, France) is a NiTi file system made of conventional NiTi alloy and it consists of 6 files (SC1, SC2, SU, AS30, AS35 and AS40). Under favor of its asymmetric cross section, Revo-S performs snake-like movement, and the manufacturer alleges that this motion increases the file's cyclic fatigue resistance (6). Like Revo-S, G-Star file system is made of conventional NiTi alloy (Golden Star Medical, Shenzhen, China) and it consists of 12 rotary files havingapical diameters of #20-25-30-35-40-45 and 0.4 and 0.6taper (7).

In our literature review, no study examining the cyclic fatigue of G-Star files could be found. For this reason, the aim of present study wasto compare the cyclic fatigue resistances of Revo-S SU and G-Star 25/.06files. The null hypothesis wasthere would be no difference between the cyclic fatigue resistances of Revo-S SU and G-Star 25/.06files within the canals having same curvature.

II. MaterialsAnd Methods

20 Revo-S SU (25/.06) NiTi files and 20 G-Star 25/.06 NiTi files were involved in the present study. Prior to the cyclic fatigue test, the surfaces of files were examined under x20 magnification by using stereomicroscope (Olympus BX43, Olympus Co., Tokyo, Japan) in terms of the presence of any defect.

Two different stainless steel artificial canals having 60° (Canal 1) and 90° (Canal 2) angles of curvature, 5mm radii of curvature and 1.5mm internal diameter were used. The curvature center of artificial canals was located at 5mm coronal to the end of artificial canals. In order to minimize the friction between the artificial canals and the file surface and to ensure free rotation of file within the canal, a synthetic lubricant (WD-40 Company, Milton Keynes, England) was utilized.

The files were randomly divided into 2 experiment groups (n:20), and then the following procedures were executed:

Group 1: Revo-S SU

The files in this group were randomly divided into 2 sub-groups (n: 10) and, according to the instructions of manufacturer, files were used with torque-controlled endodontic motor (VDW Silver; VDW, Munich, Germany), which was mounted on the cyclic fatigue test device, at 300rpm speed and 80 gcm^{-1} torque in artificial canals 1 and 2 until the fracture occurred.

Group 2: G-Star 25/.06

The files in this group were randomly divided into 2 sub-groups (n: 10) and, according to the instructions of manufacturer, they were used with torque-controlled endodontic motor (VDW Silver; VDW, Munich, Germany), which was mounted on the cyclic fatigue test device, at 300rpm speed and 200 gcm^{-1} torque in artificial canals 1 and 2 until the fracture occurred.

The durations until the files fatigue were recorded using a digital chronometer. Then, the "Number of Cycles to Fracture (NCF)"values of files were calculated using the formula below;
NCF= [Rotation per Minute (rpm) x Duration to Fracture (sec.)]/60.

Fractured surfaces of 8 files (2 files from each group) were examined under scanning electron microscope (JEOL, JSM-7001F, Tokyo, Japan)in order to determine the type of fracture caused from cyclic fatigue.

The statistical analyses of obtained data were made via Independent-Samples t test by using SPSS 21.0 program (IBM-SPSS Inc., Chicago, IL, USA). Statistical significance was set at 95%.

III. Results

The mean and standard deviation values of NCF parameter of files in Canals 1 and 2 are presented in Table 1. No statistically significant difference could be found in Canal 1 between Revo-S SU (1480.6 ± 118.9) and G-Star 25/.06(1427.1 ± 104.2) and in Canal 2 between Revo-S SU (396.1 ± 31.8) and G-Star 25/.06 (367.4 ± 27.8) in terms of cyclic fatigue resistance ($P > 0.05$).

In SEM evaluation, the fatigue lines, which are the typical characteristics of fracture caused from cyclic fatigue, were observed in fractured surfaces of files in all of the groups (Figure 1).

IV. Discussion

The file fracture is one of the most important problems observed during the endodontic treatment procedures. Even though many factors play role in file fractures, the cyclic fatigue is one of the most important reasons for file fractures, especially when they are used in curved canals (1, 5, 8). For this reason, in the present study, it was aimed to compare the cyclic fatigue resistances of Revo-S and G-Star filesin artificial canals having 60° and 90° curvature angles.

The cyclic fatigue test devices allow the files to rotate until the fracture occurred. The cyclic fatigue life of files tested in cyclic fatigue test device decrease as the angles of curvature increases (9). Moreover, the cross section area of files at the point corresponding to curvature center of artificial canals is another factor playing role in cyclic fatigue life of files (10). For these reasons, in order to ensure the standardization, the taper(0.06) and apical diameters (0.25 mm) of tested NiTi files were chosen to be same.

According to the results of present study, it was determined that there was notstatistically significant difference between Revo-S SU and G-Star 25/.06 NiTi files in terms of cyclic fatigue resistance. For these reasons, the null hypothesis of present study was accepted. In our literature review, no study examining the cyclic fatigue resistance of G-Star files could be found. For this reason, the results of present study cannot be directly compared to those of other studies. It was reported in previous studies that the cyclic fatigue resistance of files decreases as the angles of curvature increased (1, 11). Similarly, it was also concluded in present study that the cyclic resistance of tested NiTi files in Canal 1 (60°) was significantly higher than the resistance in Canal 2 (90°).

Çapar et al. (12) examined the cyclic fatigue resistances of ProTaper Next (Dentsply Maillefer, Ballaigues, Switzerland), HyFlex CM (Coltene-Whaledent, Allstetten, Switzerland), OneShape (Micro Mega) and Revo-S NiTi files, and reported that Revo-S files made of conventional NiTi file had lowest cyclic fatigue resistance. Researchers attributed the reason for this difference to the difference between the alloys, of which the files were made. Despite that, in their study examining the cyclic fatigue resistances of ProTaper Next, Gentlefile (MedicNRG, Kibbutz Afikim, Israel) and Revo-S NiTi files, Moreinoset al. (13) reported that there was no statistically significant difference between the cyclic levels of ProTaper Next and Revo-S. The reason for this difference might be attributed to the methodology differences between two studies. In their study, where they investigated the cyclic fatigue resistances of Twisted File (SybronEndo, Orange, CA, USA), BioRaCe

(FKG, La Chaux de Fonds, Switzerland), Mtwo (VDW) and Revo-S NiTi files, Pedullàet al. (14) reported that Revo-S and BioRaCe files had the lowest level of cyclic fatigue resistance. Researchers attributed the reason for this to the differences between the cross section of files. In the present study, we believe that the reason for statistically non-significant difference between the cyclic fatigue resistances can be attributed to the triangular cross section of both NiTi files and also the conventional alloy used in manufacturing the files.

V. Conclusion

Within the limitation of present study, it was determined that there wasn't any statistically significant difference between the cyclic fatigue resistances of Revo-S SU and G-Star 25.06 files in canals having 60° and 90° canal curvatures.

Acknowledgements

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

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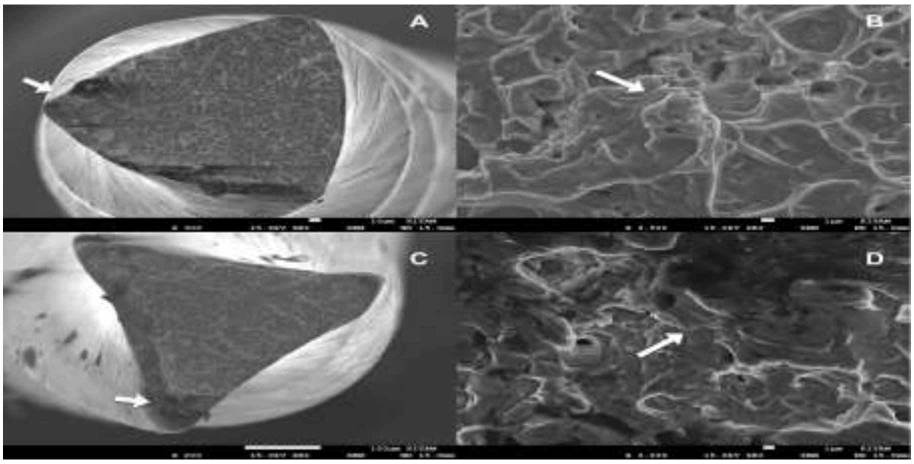

Figure 1. The scanning electron microscopy images of the Revo-S SU and G-Star 25/.06NiTi files after cyclic fatigue testing. Generalviewof(A)G-Star 25/.06, (C) Revo-S SU, and high-magnification view of (B) G-Star 25/.06, (D) Revo-S SU instrumentsshowing fatigue striations typical of cyclic fatigue (white arrows).

Table 1. The mean and standard deviations of the number of cycles to failure of the tested files in 2 canals.

Group	NCF		*P* - value
	Canal 1	Canal 2	
	Mean± StandardDeviation	Mean± StandardDeviation	
G-Star	1427.1 ± 104.2	367.4 ± 27.8	>0.05
Revo-S	1480.6 ± 118.9	396.1 ± 31.8	

* There is no statistically significant difference between the groups (*P*> 0.05).