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Comparison of cyclic fatigue resistance of old and new generation one shape NiTi instruments

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Abstract
The aim of the present study was to compare and evaluate the resistance of old and new generation One Shape single file systems that work with continuous rotation to cyclic fatigue under a dynamic model. Twenty pieces of old generation and 20 pieces of new generation One Shape (25.06) files were included in the study. The files were used at 400 rpm and a 400 g cm^{-1} torque for OGOS and 400 rpm and a 200 g cm^{-1} torque value for NGOS according to the manufacturer's instructions until fracture. Two files from each group were examined with a SEM device to determine the fracture type. NGOS had a significantly higher cyclic fatigue resistance compared with OGOS ($P<0.001$). Within the limitation of the present study, the new generation One Shape NiTi file has been found more resistant to cyclic fatigue than the old generation One Shape NiTi file.

Keywords: One shape, cyclic fatigue, dynamic model, endodontics

1. Introduction

The purpose of root canal preparation, which is an important stage of endodontic treatment, is removing the organic residues inside the root canals and shaping the root canal system in a way that allows a three dimensional hermetic obturation and an effective chemical irrigation [1].
Stainless steel hand files and nickel-titanium (NiTi) rotary instrument systems are used for this purpose. NiTi rotary instruments have reduced the iatrogenic complications that occur during the preparation to minimum and have become more commonly preferred than stainless steel files [2]. Their superelastic form, effective cutting in the root canal walls and developed root canal shaping abilities of NiTi rotary instruments are among the most important advantages of these systems [3-6].
The biggest disadvantage of rotary NiTi instruments is that instruments can be fractured without showing any signs during root canal preparation [7, 8]. The fractures that occur in NiTi rotary instruments are seen due to torsional or cyclic fatigue [9]. Fracture due to torsional fatigue occurs as a result of the tip of the file getting stuck in the root canal and the shaft continuing to rotate, fracture due to cyclic fatigue occurs as a result of repeated compression and tension forces that the file in curved root canals [10, 11].
With the progress in technology and recent work, innovations are being made in the design of NiTi alloyed endodontic root files and thanks to changing working principles, the way is being paved for canal shaping that can be completed with fewer mistakes and in less time and that is more compatible with the anatomical canal form [12, 13].
One Shape (OS; MicroMega, Besancon, France) is the rotary instrument system that makes it possible to do root canal shaping with a single file. It is made up of 3 different horizontal cross-sections that vary along the file shaft. The first of these areas is the area that is at the apical third of the file and that consists of 3 cutting edges. The number of cutting edges in the horizontal cross-section located in the middle third of the file varies from 3 to 2. Lastly, 2 S-shaped cutting edges are found in the horizontal cross-section in the coronal third part [14-16].
According to the manufacturer, the variable horizontal cross-section design of the file reduces the effect of the file being screwed into canal walls. Also, the manufacturer claims that by increasing the pitch length between the variable horizontal cross-sections in the One Shape file, the flexibility of the file has been increased and therefore the file's resistance to cyclic fatigue has increased.
A review of the literature reveals that there is no study comparing the resistance of old (OG) and new (NG) generation One Shape files to cyclic fatigue. Therefore, the aim of the present

study was to compare and evaluate the resistance of old and new generation One Shape single file systems that work with continuous rotation to cyclic fatigue under a dynamic model. The hypothesis of the present study was that there would be no difference in the resistance of old and new generation One Shape files to cyclic fatigue.

2. Materials and Method

Twenty pieces of old generation One Shape (25.06) files (OGOS; lot number: 021213) and 20 pieces of new generation One Shape (25.06) files (NGOD; lot number: 020515) were included in the study. Before the files were subjected to a cyclic fatigue test, they were checked under a stereomicroscope with x20 magnification (Olympus BX43, Olympus Co., Tokyo, Japan) to determine whether there was any deformation on their surfaces.

Cyclic fatigue tests were performed with the specifically designed dynamic cyclic fatigue-testing device. The device has an artificially prepared canal with a curvature angle of 60° and a curvature radius of 5 mm. The curvature center of the canal is situated 5 mm in the coronal direction from the apex of the canal and has an internal diameter of 1.5 mm. The files were used at 400 rpm and a 400 g cm^{-1} torque for OGOS and 400 rpm and a 200 g cm^{-1} torque value for NGOS with the VDW Silver Motor (VDW, Munich, Germany) secured to the device according to the manufacturer's instructions. In order to simulate clinical conditions, the cyclic fatigue test of the files placed in the device was performed by moving the file back and forth in the axial direction at a speed of 3 mm/sec with the file remaining inside the canal. Synthetic oil (WD-40 Company; Milton Keynes, England) was used as a lubricant to reduce the friction effect between the files used and the artificial canal walls and to freely rotation. When the file in the cyclic fatigue test setup was fractured, the device automatically stopped and the time in seconds on the device screen was recorded. The number of cycles until fracture (NCF) for each file was calculated using the formula (NCF = Rotation speed (rpm) x Time (sec) / 60).

Four pieces of fractured files, in the form of 2 from each group, were examined with a SEM device (JEOL, JSM-7001F, Tokyo, Japan) to determine the fracture type and photomicrographs of the fracture surfaces were taken under different magnifications.

2.1 Statistical Analysis

The data were first verified with the Anderson-Darling test for normality of the data distribution and the Levene test for the homogeneity of variances. Then, statistical analyses (SPSS 21.0; IBM-SPSS Inc., Chicago, IL, USA) of the cyclic fatigue resistance data were analyzed using the Student t-test. The statistical significance level was set at $P<0.05$.

3. Results

The mean and standard deviations of the cyclic fatigue resistance for each group are presented in Table 1. NGOS had a significantly higher cyclic fatigue resistance compared with OGOS ($P<0.001$).

Scanning electron microscopic (SEM) analysis of the fractured cross-sectional surfaces revealed typical features of cyclic failure including crack origins, fatigue zone, and an overload fast fracture zone (Fig 1, 2).

Table 1: Number of cycles to failure (means and standard deviations) of two instruments during static cyclic fatigue test

Group	n	Mean	Standard Deviation	*P* value
Old Generation OS	20	2042.0 ^{a}	264.2	< .001
New Generation OS	20	2525.6 ^{b}	317.2	

* Different superscripts letter were statistically significant ($P<.05$).

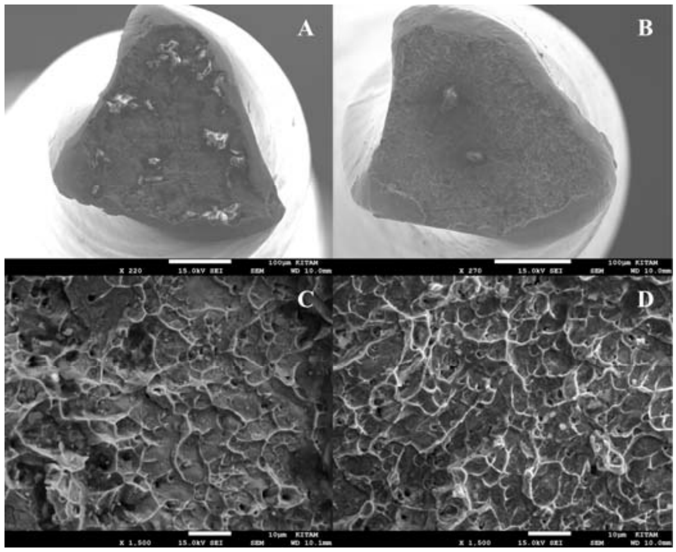

Fig 1: SEM views of fracture surface of tested files (A-C) New generation OS (B-D) Old generation OS

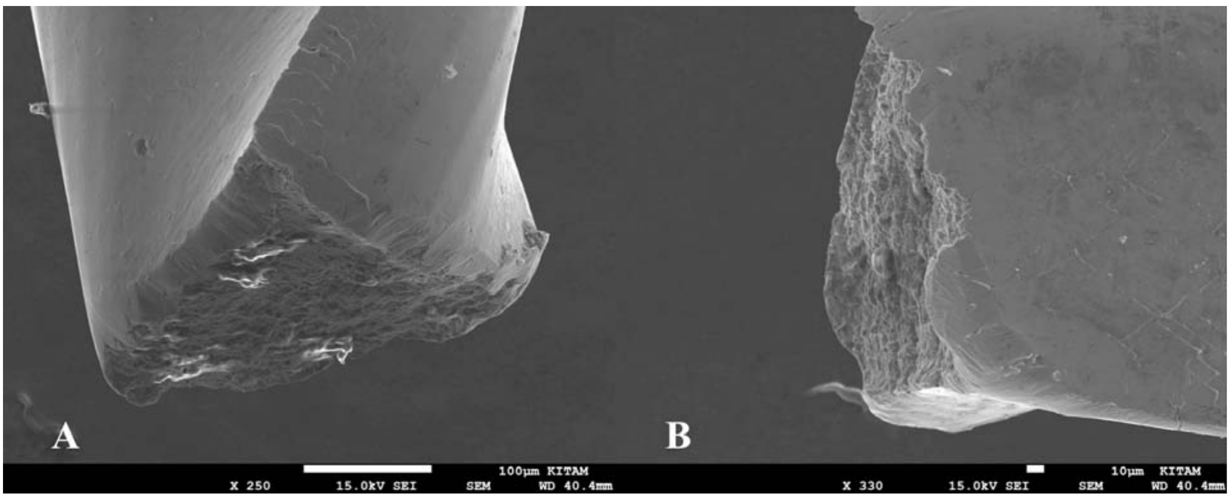

Fig 2: Lateral SEM views of fracture zones of tested files (A) New generation OS (B) Old generation OS

4. Discussion

Although NiTi rotary instruments show more flexibility and endurance compared to stainless steel instruments, instrument fractures that occur during root canal preparation still pose a high risk [17, 18]. Recently developed NiTi files have made possible the shaping of root canals with a single file by making a reciprocating or rotating movement, depending on the type of manufacture. According to manufacturers' claim, this will allow clinicians to save on time and cost. However, because the recently developed NiTi files try to complete root canal preparation with a single file, the increased stress placed on them makes their resistance against fractures even more important [19]. For this reason, it was aimed in the present study to compare the resistance of OGOS and NGOS NiTi single file systems to cyclic fatigue.

In the previous studies, it has been reported that when a dynamic test was performed without consideration for the brand and manufacture type of the files, the number of cycles until fracture of the files increased significantly compared to the static test [20-23]. Because the file does not move axially (back and forth) in the static test model, the pressure and tensile stresses concentrate in just an area along the file. These cumulative stresses induce microstructural changes. In the dynamic test model, the file moves axially, causing the stress to be distributed along the shaft of the file. Researchers state that with stress accumulation being prevented in this way, the resistance of the file against fracturing increases [22-24]. For this reason, in several studies, cyclic fatigue tests have been performed with the dynamic test model [22-25].

Also, in the studies, the amount of movement back and forth in the axial direction in the dynamic test models was determined as 3 mm per second [25, 26]. For these reasons, a dynamic cyclic fatigue test device simulating clinical use was used in the present study and the axial back and forth distance was determined as 3 mm. per second.

In the previous studies, artificial canals made in different shapes and from different materials such as a glass tube [24, 27], curved metal tube [28, 29] and grooved blocks, with different canal internal diameters, curvature angles and radii were used [30, 31]. Similar to previous studies, stainless steel canals with a curvature angle of 60° and a curvature radius of 5 mm, the curvature center of which were situated 5 mm in the coronal of the canal from the apex and with an internal diameter of 1.5 mm were used in the present study [14, 32, 33].

According to the present results, the resistance of NGOS to cyclic fatigue was found to be statistically higher than OGOS. Therefore, the null hypothesis of the present study was rejected. In the literature there are a limited number of studies investigating the cyclic fatigue of One Shape (OS) NiTi files [14, 34-36]. Çapar *et al.* [14] have reported in their study that NGOS files showed a similar resistance to cyclic fatigue as ProTaper Next (Dentsply Maillefer, Ballaigues, Switzerland) files.

In their study in which they compared OGOS and WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) NiTi files, Elsaka and Elnaghy [35] found the resistance of the WaveOne file to cyclic fatigue to be statistically higher than that of OGOS. However, Karataş *et al.* [34] compared the cyclic fatigue of NGOS and WaveOne files according to different rotational kinematics and reported that NGOS files were statistically more resistant. As a result of these two studies it can be seen that the new generation of the OS file has a better cyclic fatigue and these findings support the present study.

One Shape instruments made of a conventional NiTi alloy. One Shape instrument has three variable cross-section zones, which change from three cutting edges near the tip region to two cutting edges at the end of the working part. Moreover, the asymmetric portion of the One Shape instrument is only in the 2 mm of the tip. The type of alloy that the files are made of is not the sole determining factor of the resistance shown by the files to cyclic fatigue. Design qualities of the files such as the cross-sectional shape, cross-sectional diameter, grooves and the spiral form can also affect the resistance to cyclic fatigue. The fundamental difference of the NGOS NiTi files we used in our study from OGOS is their longer pitch. We think that the reason for the resistance against strong fatigue that was revealed in the present study is the flexibility gained by the file from the longer pitch of the new generation (Fig 3).

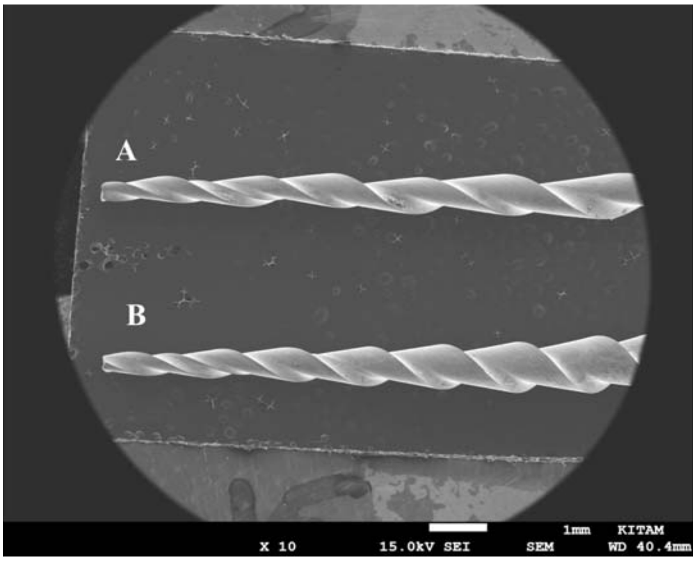

Fig 3: Lateral SEM views of tested files (A) New generation OS (B) Old generation OS

5. Conclusion

Within the limitation of the present study, the new generation One Shape NiTi file has been found more resistant to cyclic fatigue than the old generation One Shape NiTi file. *In vivo* studies are needed in order to determine the clinical performance of new generation One Shape files.

6. Reference

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