SCIENTIFIC ARCHIVES OF DENTAL SCIENCES (ISSN: 2642-1623)

Volume 3 Issue 1 January 2020

Research Article

Comparative Study of Resistance to Cyclic Fatigue of Two Nickel-Titanium Instruments

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Received: November 08, 2019; **Published:** December 26, 2019

Abstract

We analyzed the time required to fracture, fractured portion size and numbers of cycles at two nickel-titanium instruments Revo-S™ and K3XF™ in fatigue test device fracture. Fifteen files of both number 25, 25 mm long and 0.06 taper driven in electric motor with speed (400 rpm) and controllable torque (0.8N.cm) brands were coupled in a handpiece with 16:1 reduction. The range of motion of the instrument within 1.5 mm into the artificial canal and canal out. The 1.5 mm stainless steel canal with bending angle of 45° and radius of 5 mm. In tests, the instruments performed small transpassive 1 mm tip allowing visualization of the instrument at the time of fracture. Files Revo-S™ and K3XF™ statistically significant difference ($p < 0.05$) in all analyzed items. It was concluded that the time to fracture, fractured size and numbers cycles to fracture was lower portion of the instruments Revo-S™ than K3XF™.

Keywords: Endodontic Instruments; Nickel; Titanium

Introduction

Surface modifications of nickel-titanium instruments, such as electropolishing, may reduce fracture incidence but could potentially alter the instruments' mechanical properties. We studied the impact of two surface types, machined and electropolished, of ProTaper™ (Dentsply, Weybridge, UK) shaping files on torque and force during simulated root canal preparation. For all three tested instruments, peak torque was higher for electropolished files; apically exerted forces were similar, except for Sx (ProTaper™), in which machined instruments developed higher forces. The surface treatment by electropolishing alters the cutting ability of nickel-titanium rotary instruments [1]. The influence of electropolishing surface treatment on the number of cycles to fracture of BioRace™ (FKG, La Chaux-de-Fonds, Switzerland) rotary nickel-titanium endodontic instruments. Polished instruments displayed a significantly higher number of cycles to fracture when compared with unpolished instruments. Electropolishing surface treatment of BioRace endodontic instruments significantly increased the cyclic fatigue resistance [2]. Therefore, resistance allows greater enlargement of the canal, especially in curved canals, improving cleanliness and subsequent greater treatment success.

The fatigue behavior of two types of nickel-titanium (NiTi) instruments made from a novel controlled memory NiTi wire under various environment conditions were examined. The vast majority of controlled memory instruments showed multiple crack origins, whereas most instruments made from conventional NiTi wire had one crack origin. Concluded that the type of NiTi metal alloy (controlled memory files vs. conventional superelastic NiTi files) influences the cyclic fatigue resistance under various environments. The fatigue life of controlled memory instruments is longer in liquid media than in air [3].

It was assessed, by using SEM, 20 endodontic instruments of Niti rotary system: Twisted File™ (Kerr, CA, US), BioRaCe™, Mtwo™ (VDW, Munich, Germany) and EndoWave™ (Morita, Dietzenbach, Germany), before and after using them, considering their cleanness, defects and deformities. There was not statistically significant difference on deformities between the groups ($p > 0.05$). On the other hand, all groups of instruments evaluated showed similar deformation. Found that the presence of irregular edge, groove, burr and microcavity even before the use of the instruments except EndoWave™ [4,5].

An *in vitro* study compared the cyclic fatigue resistance of ProFile Vortex™ rotary instruments (Dentsply, Tulsa, OK, US) made of two different raw materials: M-Wire and regular superelastic wire (SE-wire) at two different rotational speeds. Two rotary-based Profile Vortex™ (Dentsply, Johnson City, TN, US) instruments with taper 0.04 and 0.06 (25 mm in length and #30 in size) were compared. The development of new manufacturing processes especially in improving the resistance of NiTi instruments fracture. Cyclic fatigue testing was performed by rotating instruments in an artificially constructed stainless steel canal with a 5 mm radius and a 90º angle of curvature at two different test frequencies: 300 and 500 rpm. Fracture surfaces of broken instruments were also observed under scanning electron microscope. Over 50% of broken files made of SE-wire exhibited multiple crack initiation sites compared with the single crack initiation on files made of M-Wire. ProFile Vortex™ files made of M-Wire exhibited superior cyclic fatigue resistance (approximately 150% longer in fatigue life) compared with those made of regular SE-wire at two test frequencies (300 and 500 rpm) [6].

A new generation of nickel-titanium (NiTi) rotary instruments including the Twisted File™ (Sybron Dental Specialties, Orange, CA, US) and ProFile GT Series X™ (Dentsply, Tulsa, OK, US) and if these new NiTi instruments were more resistant to cyclic fatigue compared with traditionally ground NiTi rotary instruments such as EndoSequence™ (ES™: Brasseler, Savannah, GA, US) and ProFile™. These instruments were tested in a simulated canal with 60 degrees angle of curvature and a 3 mm radius until fracture was recorded for each instrument. Among both 0.04 and 0.06 tapered files, #20 ProFile GT Series X™ files performed significantly better than all other files tested with tip sizes of #25 ($p < 0.001$); this may be because of the increased flexibility in the #20 files compared with #25 files. Twisted File™ was significantly more resistant to cyclic fatigue than EndoSequence™ ($p < 0.05$) but not different from ProFile™ ($p > 0.05$) with the same tip size. The new manufacturing processes appeared to offer greater resistance to cyclic fatigue in a simulated canal model [7].

Moreover, the cyclic fatigue resistance of four nickel-titanium rotary systems and to evaluate their surface, fractographic, and matrix morphology were compared. Show that all samples of NiTi files evaluated showed surface irregularities and non-metallic inclusions and the angle of curvature was confirmed to influence the fatigue life of NiTi instruments of rotary nickel-titanium systems of brands Easy Shape™ (Komet, Lemgo, Germany), ProTaper™, NRT™ (Mani, Takanezawa-Machi, Japan) and AlphaKite™ (Komet, Lemgo, Germany) were subjected to fatigue tests in artificial canals angle of 45° and 60° and radius of 5 mm to the fracture. NRT™ files had the highest fatigue resistance followed by AlphaKite™, EasyShape™ and ProTaper™. Under light microscopy, austenitic grains appeared larger near the handle and smaller near the tip in all instruments. All new instruments showed surface imperfections composed of carbon and oxygen in addition to nickel and titanium. Under light microscopy, austenitic grains appeared larger near the handle and smaller near the tip in all instruments [8].

The resistance to cyclic fatigue of three NiTi files after the immersion in sodium hypochlorite (NaOCl) solution in conditions similar to those used in clinical practice were investigated. A total of 150 new Twisted Files™ (SybronEndo, Orange, CA, US), Revo-S SU™ files (Micro Mega, Besancon, France), and Mtwo™ files, size 25.06, were tested. Fifty files of the same brand were randomly assigned to five groups ($n = 10$) and submitted to the following immersion protocol in 5% NaOCl at 37°C for 16 mm: no immersion (control), 5 minutes statically, 1 minute statically, 5 minutes dynamically (300 rpm/min), and 1 minute dynamically. Resistance to cyclic fatigue was determined by counting the numbers of cycles to failure in a 60° curve with a 5 mm radius. Resistance to cyclic fatigue of the same NiTi file was not significantly affected by immersion in NaOCl ($p > 0.05$). The Twisted File™ showed a higher resistance in all groups than Revo-S SU™ ($p < 0.001$). The comparison between the same groups of Twisted Files™ and Mtwo™ files or between Mtwo™ and Revo-S™ files did not show significant differences ($p > 0.05$) except for two cases: group 2 of the Twisted Files™ and Mtwo™ files and group 5 of the Mtwo™ and Revo-S SU™ files ($p < 0.05$). Static or dynamic immersion in NaOCl for 1 minute or 5 minutes did not reduce the cyclic fatigue resistance of NiTi significantly. However, the type of instrument influences cyclic fatigue resistance. In this study, Twisted Files™ were more resistant followed by Mtwo™ and Revo-S SU™ files [9].

The flexibility and cyclic fatigue resistance were increased for NiTi instruments produced by a new manufacturing technique. Forty K3™ (SybronEndo, Orange, CA, US) tip size 25, .06 taper NiTi rotary instruments were randomly selected and divided into two groups (n = 20). One group served as control, being the commercially available instruments produced with a traditional grinding process (K3). The second group of instruments (K4 prototypes) were then subjected to a proprietary thermal treatment after the grinding process. For the stiffness test, a statistically significant difference ($p < 0.05$) was noted between K3 and K4 prototype instruments. K4 prototype instruments were significantly more flexible when compared to K3 instruments. For the cyclic fatigue test, a significant difference ($p < 0.05$) was noticed between K3 and K4 prototype instruments. K4 prototype instruments demonstrated a significant increase in the mean number of cycles to failure when compared to K3 instruments. The new manufacturing technique resulted in the K4 prototype instruments having enhanced mechanical properties, compared to K3 instruments, manufactured with a traditional grinding process [10].

Twisted File™ with 3 traditionally manufactured systems to determine whether changes in the manufacturing process improved the cyclic fatigue resistance. Four rotary file systems, (1) ProFile™ (PF), (2) Mtwo™, (3) K3, and (4) Twisted File™, were tested in artificial canals with 45° and 90° angles of curvature. Ten instruments each of the 4 file systems were tested in both angles of curvature (n = 10). All instruments had identical size and taper (0.06/0.25 tip diameter). A statistically significant difference ($p < 0.05$) was noted between Twisted File™ and other nickel-titanium instruments in both 45° and 90° angles of curvature. Twisted File™ showed the greatest mean number of cycles to failure. There was no statistical difference between ProFile™ and K3 ($p > 0.05$) in both canal curvatures; however, statistically significant difference ($p < 0.05$) was observed between Mtwo™ and the other 2 traditionally manufactured instruments. Mtwo™ showed the lowest mean number of cycles to failure. Conclude that size 0.06/0.25 Twisted File™ was significantly more resistant to fatigue than the other 3 instrument systems produced with the traditional grinding process [11].

Cyclic fatigue resistance of four nickel-titanium rotary instruments produced by a new method or traditional grinding processes. Twisted File™ produced by a new thermal treatment of NiTi alloy; Revo-S SU™; Mtwo™ and BioRaCe BR3™ produced by traditional grinding processes. Twenty for each group were tested for cyclic fatigue resistance inside a curved artificial canal with a 60º angle of curvature and 5 mm radius of curvature. Time to fracture from the start of the test until the moment of file breakage and the length of the fractured tip was recorded for each instrument. Means and standard deviations of time to fracture and fragment length were calculated. Group 1 (Twisted File™) showed the highest value of time to fracture means. Cyclic fatigue resistance of Twisted File™ and Mtwo™ was significantly higher than group 2 (Revo S SU™) and 4 (BioRace BR3™), while no significant differences were found between group 1 (Twisted File™) and 3 (Mtwo™) or group 2 (Revo-S SU™) and 4 (BioRaCe BR3™). The cyclic fatigue resistance of Twisted File™ was significantly weaker than instruments produced with traditional grinding process except of Mtwo™ files [12].

The effect of autoclave sterilization on cyclic fatigue resistance of rotary endodontic instruments made of traditional and new NiTi alloys was evaluated. Four NiTi rotary endodontic instruments of the same size diameter 0.40 mm and constant 0.04 taper were selected: K3™, Mtwo™, Vortex™ and K3XF prototypes. Each group was then divided into 2 subgroups, unsterilized instruments and sterilized instruments. The sterilized instruments were subjected to 10 cycles of autoclave sterilization. Twelve files from each different subgroup were tested for cyclic fatigue resistance. Means and standard deviations of number of cycles to failure and fragment length of the fractured tip were calculated for each group, and data were statistically analyzed ($p < 0.05$). Comparing the results between unsterilized and sterilized instruments for each type of file, differences were statistically significant ($p < 0.05$) only between sterilized and unsterilized K3XF files (762 versus 651 number of cycles to failure). The other instruments did not show significant differences ($p > 0.05$) in the mean number of cycles to failure as a result of sterilization cycles (K3, 424 versus 439 number of cycles to failure; Mtwo™, 409 versus 419 number of cycles to failure; Vortex™, 454 versus 480 number of cycles to failure). Comparing the results among the different groups, K3XF (either sterilized or not) showed a mean number of cycles to failure significantly higher than all other files ($p < 0.05$). The concluded that repeated cycles of autoclave sterilization do not seem to influence the mechanical properties of NiTi endodontic instruments except for the K3XF prototypes of rotary instruments that demonstrated a significant increase of cyclic fatigue resistance [13].

Cyclic fatigue resistance of K3™ (SybronEndo, Orange, CA, US), K3XF™ (SybronEndo), and Twisted File™ files under continuous rotation and reciprocating motion were assessed and compared. A total of 210 files (30-tip diameter, 0.06 fixed taper), 60 K3™, 60 K3XF™, and 90 Twisted File™ files, were divided into 7 groups (30 files each): K3™ -C, K3XF™ -C, and Twisted File™ 1-C were rotated at 300 rpm; Twisted File™ 2-C was rotated at 500 rpm; and K3™ -R, K3XF™-R, and Twisted File™ 1-R were used in a reciprocating motion. Cyclic fatigue resistance was tested in stainless steel, curved canals (60°, 3 mm radius) until fracture, and the time to fracture was recorded. The probability of a longer mean life was greater under reciprocating motion for all of the files (100% for K3™, 87% for K3XF™, and 99% for Twisted File™). Under continuous rotation, K3XF™ was more resistant than K3™ and Twisted File™. Twisted File™ lasted significantly longer than K3™. Twisted File™ was more resistant to cyclic fatigue when rotated at 300 rpm instead of 500 rpm. Under reciprocating motion, there were no significant differences between K3XF™ and Twisted File™ mean lives, but both were significantly longer than the K3™ mean life (78% for Twisted File™ and 86% for K3XF™). Reciprocating motion and R-phase increase cyclic fatigue resistance [14].

More recently, the cyclic fatigue resistance of F6 SkyTaper™ (Komet Brasseler, Lemgo, Germany), K3XF™, new generation OneShape™ (Micro Mega, Besancon, France) and TRUShape™ 3D conforming files (Dentsply, Johnson City, OK, USA) were evaluated. Ten instruments from each group were selected and allowed to rotate using a low-torque motor in a stainless steel block with 1.5 mm diameter, 3 mm radius of 60° angle of curvature at the manufacturer's recommended speed, and the number of cycles from the beginning to the fracture was recorded. The data were analyzed using one-way ANOVA followed by post-hoc Tukey's test ($p = 0.05$). The ranking of the groups from the highest to the lowest number of cycles was as follows: F6 SkyTaper™ (959 ± 92), K3XF™ (725 ± 71), TRUShape™ (575 ± 84) and OneShape™ (289 ± 58). Statistically significant differences were detected between all groups ($p < 0.05$). Within the limitations of this study, F6 SkyTaper™ instruments presented the highest cyclic fatigue resistance among the tested instruments. The S-shaped cross-sectional design of F6 SkyTaper™ instruments could be the most important factor on the superior cyclic life span of these instruments. In endodontic practice, preferring the instruments with higher cyclic fatigue resistance would help to minimize the risk of instrument fractures; therefore, especially during the preparation of curved canals, instruments with smaller core area and less cross-sectional metal mass, which could lead higher flexibility, can be proposed [15].

Several features of endodontic instruments - F360™ (Komet, Lemgo, Germany), F6-SkyTaper™, Hyflex-EDM™ (Coltene, Altstätten, Switzerland), iRACE™ (FKG, La Chaux-de-Fonds, Switzerland), Neoniti™ (Neolix, Evron, France), O.Shape™ (MicroMega, Besançon Cedex, France), ProTaper Next™ (Mani, Takanezawa-Machi, Japan), Reciproc™ (VDW), Revo-S™ and Wave-One-Gold™ (Dentsply Sirona, Charlotte, US) size 25 files were compared about the cutting are, root canal anatomy preservation and non-instrumented areas. Three hundred teeth with a single straight root and a circular or elliptical root canal were divided into 10 groups (1-F360™, 2- F6-SkyTaper™, 3-Hyflex-EDM™, 4-iRACE™, 5-Neoniti™, 6-O.Shape™, 7-P.Next™, 8-Reciproc™, 9-Revo-S™ and 10-Wave-One-Gold™) cut into three cross sections using an ultrafine cutting disc. They were photographed under a stereo microscope and pre-instrumentation analyses were made before rebuilding the teeth with# 10 K-File and epoxy glue. A glide path was created with #10 and #15 K-files and each group was instrumented using rotary or reciprocating systems. Cutting areas, root canal anatomy preservation and non-instrumented areas were analyzed using the AutoCAD 2015 Levene's test, the Welch's test, and the Games-Howell's test. The Pearson's chi-squared test was used for statistical analysis. Levene's test showed no equality of variances ($p < 0.05$), therefore Welch´s and Games-Howell's tests were applied to cutting areas, showing significant differences in all thirds and overall ($p < 0.05$). No differences in root canal anatomy preservation were observed ($p > 0.05$). In non-instrumented areas, significant differences were found ($p < 0.05$) in middle third being better in Reciproc™, Neoniti™ and WaveOneGold™, and in apical thirds being higher ProTaper Next™, Reciproc™, HyflexEDM™, Neoniti™ and WaveOneGold™. In cutting area, ProTaperNext™ and Reciproc™ were superior in coronal third, Neoniti™ and Hyflex EDM™ medially and apically and Neoniti™ and Reciproc™ overall. Regarding the root canal anatomy reservation, all systems were similar. For non-instrumented areas, all systems achieved similar results coronally, but Reciproc™, Neoniti™ and Wave One Gold™ were superior in middle third and ProTaper Next™, Reciproc™, Hyflex EDM™, Neoniti™ and Wave One Gold™ were superior in apically [16].

Aim of the Study

The aim of this study was to evaluate and compare the cyclic fatigue resistance considering the time required to fracture, number of cycles required to fracture and the fractured portion size of two nickel-titanium instruments, Revo-S™ system and K3XF™.

Materials and Methods

Fifteen files from two different rotary nickel-titanium instruments were selected both Revo-S™ (MicroMega, Besançon Cedex, France) (Group A) and 15 files rotary NiTi K3XF™ (SybronEndo, Orange, CA, USA) (Group B) all of them number 25 to 25 mm long and 0.06 taper.

The outline of cyclic fatigue testing device designed Machining Laboratory, Department of Mechanical Engineering, University of Taubaté similar other studies [17,18].

The figure 1 shows the device consisting of a base of iron 20 X 20 X 7 centimeters, supported on four rubber feet to prevent vibration during the test. Within this basis, lies the engine which regulates axial movement of the artificial canal. On it, fixing brackets contra-angle endodontic micro-motor and the artificial canal (Figure 2) and a power supply that contains the devices rotation adjustment and pulse counter that are coupled and positioned near the test database are positioned.

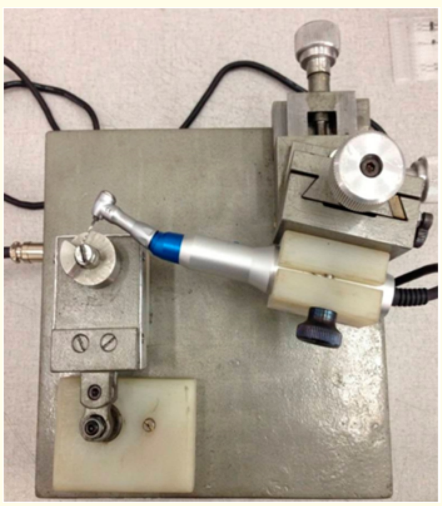

Figure 1: *Apparatus and engine cycle counter EndoMax™ used in the test of cyclic fatigue.*

Figure 2: *Cycle counter.*

The device to test cyclic fatigue was coupled to an instrument of both groups the handpiece one by one electric motor EndoMax™ (Adiel, Ribeirão Preto, São Paulo) with speed (400 rpm) and controllable torque (0.8N.cm) a handpiece with 16:1 reduction. These instructions are based on information supplied by the manufacturer (Figure 1). The range of motion of the instrument within the artificial steel canal was 1.5 mm into the artificial canal and 1.5 mm for that canal out with bending angle of 45° and radius of 5 mm. During the tests, the instruments were positioned in such a way that there was a small transpassive (about 1 mm) from the tip of the instrument beyond the end walls of the artificial canal, allowing visualization of its ends, a fact that makes dialing the precise moment of instrument fracture.

While performing the dynamic test the handpiece remained in a fixed position, attached by brackets bolted to the iron base. The bracket that held contra-angle has an adjustable mechanism, both vertically, and horizontally allowing their movement into three XYZ axes and angular motion. After the instruments were coupled in the handpiece and regulated the height of the bracket so that the instrument was inserted into the artificial canal in a straight path without tensions, allowing free rotation clockwise.

The artificial canal was moving toward the instrument by means of a movement of translocation which was driven by a DC motor 24 volts. The rate of axial displacement of the artificial canal was adjusted by means of an adjustable spring. Thus, when the panel of this adjustable font marked number 5, the artificial canal was moving towards the instrument to be tested a number of times per minute, and, hence, recorded in the pulse counter a number of cycles. Regardless of speed of displacement of the artificial canal instruments commuted an amplitude of 1.5 mm into the artificial canal and 1.5 mm in the opposite direction.

The artificial canal was made from a piece of stainless steel [19-21] (Figure 3) spiced and machined in the form of an arc whose curvature set a guide cylinder, 25 mm long and made of the same material, with a bending angle of 45° and radius of 5 mm [22]. Both the arc as the roller guide groove of a 1 mm deep, located 5 mm from its upper end to coincide with the time when it was positioned the handpiece. This groove serves as a guide path for the instrument, which will remain curved and free to rotate between the cylinder and the outer arc.

The positioning of instruments in artificial canal (Figure 3) was made in order to define the point of maximum curvature around 4 mm tip, was made considering the region of the instrument subjected to the most severe conditions of cyclic deformation during the preparation of root canals curved [23].

Figure 3: *Artificial canal and the active part of the adapted instrument and positioned inside the artificial canal steel.*

At the time the electric motor is triggered, also activated the motor responsible for the displacement of the artificial canal begun its axial movement allowing the tools in continuous rotation, entering or leaving the canal so that the simulated fracture was noticed by visual inspection. Thus, the time between the drive motor and visual observation of the fracture was recorded on a digital stopwatch [18,19]. The number of cycles to fracture was recorded by pulse counter [20] according to figure 2 while withdrew from the handpiece the instrument and took up the measure with a ruler the size of the file.

Mean data were statistically analyzed by using Kolmogorov-Smirnov test to check the normality of the data and parametric "t" test for comparison of two independent samples cases the data are normally distributed. Comparison to ascertain any significant differences between groups ($p < 0.05$).

Results

The mean and standard deviation values of the cycle fatigue resistance data were computed. A statistically significant difference was observed for cyclic fatigue resistance of the between K3XF™ and Revo-S™ ($p < 0.05$). Thus, the time required to fracture K3XF™ instrument is greater than the time to fracture of the instrument Revo-S™ while the size of the fractured portion of K3XF™ instrument is larger than the size of the fractured portion of the file Revo-S™ and the number of cycles required to fracture K3XF™ files is larger than the number of cycles of files Revo-S™ (Table 1-3).

	Time (Seconds)			
	$\bar{X}$	**σ**	**CV (%)**	**K-S Pvalue**
Revo-S™	45,19	14,99	33,18	> 0,05
K3XF™	134,53	70,71	52,57	> 0,05
	t = -4,7863 p value < 0,05			

Table 1: *Statistics of instruments Revo-S™ and K3XF™ as a function of time in seconds for the occurrence of fracture.*

	Portion Fractured (Millimeters)			
	$\bar{X}$	**σ**	**CV (%)**	**K-S Pvalue**
Revo-S™	3,46	0,69	20,00	> 0,05
K3XF™	4,86	0,63	13,15	> 0,05
	t = -5,7460 Pvalue < 0,05			

Table 2: *Statistics of instruments Revo-S™ and K3XF™ according to the size of the fractured portion.*

	Number of cycles			
	$\bar{X}$	**σ**	**CV (%)**	**K-S Pvalue**
Revo-S™	94,80	31,16	32,88	> 0,05
K3XF™	319,13	155,39	48,69	> 0,05
	t = -5,4821 Pvalue < 0,05			

Table 3: *Statistics of instruments Revo-S™ and K3XF™ according to the number of cycles required to fracture.*

Table 1 provides in numbers, the average time in seconds, standard deviation, coefficient of variation and Kolmogorov-Smirnov test with regard to fracture of instruments Revo-S™ compared to K3XF™, according to tests performed. Our data in this table indicate that the K3XF™ and Revo-S™ files and the time required to fracture showed a statistically significant difference ($p < 0.05$). This means that, on average, group A instruments take less time to fracture than group B tools, which in turn took about three times longer to fracture.

The same was true the table 2 and 3 which indicate that when comparing Revo-S™ and K3XF™ files the fractured portion of the instrument as well as the number of cycles required to fracture showed a statistically significant difference ($p < 0.05$).

Discussion

Unused test instruments (just removed from their boxes) were introduced in contra-angle and rotated in the artificial canal in continuous rotations with curvature of 45° and radius of 5 mm, unlike authors [9,12] who used the artificial canal with curve of 60° and radius of 5 mm. It is believed that the greater the degree of curvature, the greater the possibility of fracture of the instrument. This aspect may influence the use of the instrument.

Maybe the rotational speed of apparatus which has been given the instrument Revo-S™ during the test was 400 rpm and this speed resulted in reduced time to fracture as well as the number of cycles required to fracture was also reduced, however, is in standards of speed indicated by the manufacturer.

The mechanical properties of this instrument are its flexibility. Thus, it was noted that these instruments Revo-S SU™ 25 with diameter 25 mm and length of taper 0.06 fracture in a short time due to its low flexibility compared with SC1 and SC2 instruments, since the perform manually bending the instrument (with a finger tip and the other finger on the instrument cable) one realizes that this instrument SU is less flexible than the instruments of their series. The most flexible files are more resistant to fracture than the less flexible which seems to indicate that the instrument manufactured with the surface treatment of NiTi alloy plus provides greater resistance to cyclic fatigue also greater flexibility [7].

Regarding to the portion of the fractured fragments (Table 2) observed in this study no correlation between the fracture time, number of cycles to fracture and the length of the fractured portion. Change the size of the portions of the fractured instruments Revo-S™ located between 2 to 4.5 mm in size, with 6 files the length of the fractured portion was 3 mm, 4 files length was 4 mm, a file broke the 2 mm to 3.5 mm 2 files and 2 files to 4.5 mm in length of the fractured portion. On the other hand, the fragments of the fractured portion of instruments K3XF™ listed in table 2 was also variation in the size of the fractured portions of these instruments so located 1 instrument fractured to 6 mm in size from the tip of third files in the length of the portion 3 mm was fractured while in 3 of them the length of the fractured portion was 5 mm; 4 files length was 4.5 mm and in 4 of them broke the 5.5 mm.

Therefore, the K3XF™ file greater flexibility in fractured is further from its tip, less than the flexible instrument represented by the file Revo-S™ that the average breaking closer to its tip, i.e. the less flexible portions, and therefore, this portion of its shaft is harder than the K3XF™ instrument. The reason why the instrument fracture is closer or less close to its tip is due probably to their greater or lesser flexibility as well as its larger or smaller diameter. Incidentally, the K3XF™ instrument is more flexible thanks to the thermal treatment of its NiTi alloy and therefore this instrument fracture is far from its tip, i.e., the toughest portions and larger diameter above its tip. Conversely, the less flexible instrument, such as the file Revo-S™, which lacks the thermal treatment of a NiTi alloy break closer to its tip, i.e. the less flexible portions, and therefore tougher points or larger diameter near its tip.

The reasons reported above show that the new manufacturing process that includes heat-treating the surface of the NiTi alloy produces greater resistance to cyclic fatigue and greater flexibility such file K3XF™ showed that longer fracture and a higher number of cycles needed to fracture compared with the file Revo-S™ that has no thermal treatment in your cutting surface. Incidentally both the twisting process such as machining plus heat treatment of the surface of the alloy is enhanced by increasing the resistance to cyclic fatigue [7,9,11-13,19]. Therefore, it is that the present K3XF™ files on its surface new machining process plus heat treatment than the Revo-S™ instruments that do not have such treatment. Thus, the present investigation attests that the heat treatment performed on the surface of nickel-titanium Twisted File™ compared to Revo-S™, according to Bhagabati., *et al.* [11], gives the first instrument longer fracture time and greater resistance to cyclic fatigue. Regarding the hypothesis it was expected that the Revo-S™ files presented not only a lower number of cycles required to fracture as well as time needed to fracture than K3XF™, since the latter has thermal treatment on its surface and this circumstance was confirmed.

Moreover, Perez-Higueras., *et al.* [14] emphasize that K3XF™ file despite being idealized indicating restricted use in motor movements with continuous rotation this instrument can perform reciprocating motion and this gives the file K3XF™ greater resistance to cyclic fatigue than continuous rotation movement.

K3XF files that can undergo repeated cycles of autoclave sterilization which does not affect the mechanical properties of this type of instrument which makes spite of repeated autoclave cycles more resistant to cyclic fatigue instrument relative to other types of instrument [13].

At this point, one should not think that the instrument Revo-S SU™ is somewhat resistant to cyclic fatigue but harder since it is an instrument of a sequence which is the third and final series instrument being used after SC1 and SC2 and its function according to the manufacturer is to promote finishing the root canal during instrumentation, and so hence the reason for a less flexible tool with 25 mm diameter 0.06 taper compared to SC2 with 25 mm in diameter and 0.04 taper.

So, it is an instrument capable of performing finishing and so should this more subtle in order to perform this specific, i.e. to promote the surface finish of the walls of the root canal procedure. Therefore, it is not one instrument, i.e. exclusive use, but a sequence that ends with use of it. According to Celik., *et al.* [24] Revo-S™ files produce minimal changes in the morphology of the final canal after the use of the series, i.e. minimum promotes transport of the root canal walls maintaining the morphology of preparation.

Important to note that this study was the correlation between time to fracture and the number of cycles required to fracture (Table 1 and 3). The shorter the time the fracture lower the number of cycles required to fracture. Otherwise, the higher was the time required to fracture was the larger number of cycles required to fracture. The results of this study showed that K3XF™ under continuous rotation had significantly longer life than the Revo-S™ files. These findings indicate that the latest developments in the manufacturing process produced more resistant instruments, i.e. whether the improvement in these alloys is their constituents, especially in their design or in their manufacturing processes.

Very likely, these instruments may have unused surface imperfections which caused this event during its manufacture [8]. The instrument K3XF™ third generation has more radially symmetric guide the instrument Revo-S™ fifth generation who have a more asymmetric radial tab. Sometimes small differences in the characteristics of instruments like drawing of different rotary NiTi vary depending on the sectional area of the instrument tip design, taper, and these factors may influence the flexibility, cutting efficiency and resistance to twisting of the instrument [25]. Indeed, asymmetric cross-section of instruments Revo-S™ facilitates the penetration of movement that aims to reduce the torque on the instrument. By the way, accentuate Parashos., *et al.* [26] that the instrument design is a factor that influences the rate and other defects, however, to a lesser extent.

Details obtained through research on the mechanical properties of files is fundamental for the endodontic specialist guidance in the choice of NiTi files in the implementation of more effective methods in order to improve the use of these instruments and their suitability in certainty as to its use during instrumentation of root canals, especially the curved. When we use the newly introduced dental market instruments believe the information and instructions provided by the manufacturer. Moreover, as time goes on further investigations are being processed and thereafter better able to more safely use these new tools.

The ideal and most durable manufacturing instruments and improved mechanical properties and especially the quality in the production in order to recommend more security for those who use day-to-day at the office even when it makes use of instruments with chemical as hypochlorite sodium not reducing the resistance to cyclic fatigue especially of files produced by twisting and heat treatment, which were significantly more stress resistant as Pedulla., *et al* [9].

Conclusion

The instruments-Revo S SU™ had a mean time to fracture, the average size of the fractured portion and number of cycles required to fracture lower than K3XF™ instruments.

Acknowledgements

The authors thank Mega Micro-SC3 (Besançon Cedex, France) for their generous donation of files to facilitate this research. The authors deny any conflicts of interest related to this study. Thanks to the support of a scholarship for the Scientific Initiation Program, University of Taubaté (Case number: ODO-104/2012). The authors also wish to gratefully acknowledge to the technical Lamarino Vendramini Machining Laboratory, Department of Mechanical Engineering, University of Taubaté for all the help given.

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