http://dx.doi.org/10.5272/jimab.2014201.494

Journal of IMAB
ISSN: 1312-773X (Online)
http://www.journal-imab-bg.org

Journal of IMAB - *Annual Proceeding (Scientific Papers)* 2014, vol. 20, issue 1

INSTRUMENT LIFE OF TWO ROTARY NiTi SINGLE-FILE TECHNIQUES WITH RECIPROCATING AND CONTINUOUS ROTATION USED IN CURVED CANALS AFTER A GLIDE PATH CREATION

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ABSTRACT:

Purpose: Manufacturers have introduced instruments made with new alloys and with reciprocating motion trying to improve the fracture resistance of rotary NiTi files. The aim of this study was to compare instrument life of WaveOne and One Shape single-file techniques used for the instrumentation of artificial curved canals after a glide path creation.

Material/methods: Canal preparation was performed on 100 Endo-Training Block simulators divided in two equal groups, depending on the file used. Average lifespan and cumulative survival at the time of WaveOne files (Dentsply Maillefer) with reciprocating rotation and One Shape files (Micro Mega) with continuous rotation, after a glide path creation, were tested. All shaping instruments worked till fracture occurred. During mechanical instrumentation each file was coated with Glyde™ (Dentsply Maillefer) to act as a lubricant, and copious irrigation with 5.25% NaOCl was carried out.

Results: Twelve shaping files were used in canals' preparation, after their initial enlargement, and ten of them broke: 2 WaveOne files and 8 One Shape files. The average lifespan of one WaveOne file was 17.50±2.12 canals and of one One Shape file–4.63±1.30 canals. The difference was statistically significant ($p<0.001$). The WaveOne instruments presented a significantly longer survival than the One Shape files ($p<0.05$).

Conclusions: Within the limits of this study, the WaveOne files showed significantly higher resistance to fracture compared with the One Shape files. Instrumentation with files with reciprocal motion increases significantly instruments life and makes them safer during shaping of root canals.

Key words: Continuous rotation, Fracture, Nickel-titanium instruments, One Shape, Reciprocating motion, WaveOne

INTRODUCTION

Nickel-titanium (NiTi) rotary instruments are commonly used by specialists and generalists for thorough cleaning and shaping of the root canal system [1]. Despite their undeniably favorable qualities, there is a potential risk of unexpected fracture [2-8]. Fracture of NiTi rotary instruments occurs by torsional stress or cyclic flexural fatigue [9, 10]. The majority of torsional separations occurrs in the last millimetres of the files when the tip or any other part of the instrument binds to the canal walls whereas the handpiece keeps turning [6, 11-13]. Consequentely, the files with lower taper and/or diameter of the tip present the higher risk of torsional fracture and should be protected from engaging root dentin ("taper lock"). Fracture resulting from flexural fatigue occurs when an instrument has already been weakened by metal fatigue after repeated subthreshold loads. The instrument does not bind to the canal wall but rotates freely until fracture occurs in the point of maximum flexure [7, 14].

File distortion and breakage are more likely to occur during cleaning and shaping of severely curved root canals. The chance of removing the broken file is very small and in some cases may be impossible without compromising the tooth itself [15]. There is strong evidence in the literature [16-18] that fracture incidence might be reduced by preflaring and creation of a glide path before using nickel-titanium rotary instrumentation. As a result of this procedure, the root canal diameter becomes bigger than or at least the same size as the tip of the first shaping rotary instrument used [17, 18].

Attempting to improve the fracture resistance of rotary NiTi files, manufacturers have introduced instruments made with new alloys and the use of reciprocating motion. Reciprocating motion was shown to extend the lifespan of a NiTi instrument and its resistance to fatigue in comparison with continuous rotation [19- 22]. Recently, two different reciprocating systems were introduced: Reciproc (VDW, Munich, Germany) and WaveOne (Dentsply Maillefer), with the recommendation to be used by a specific motor and an unchangeable and appropriated settings. The WaveOne files are used with "WAVEONE ALL" mode which has different angles of rotation - 170º counterclockwise and then 50º clockwise rotation with a speed of 350 rpm. It is probable that rotation type and rate can affect the fatigue resistance [23]. The system consists of 3 sterile single-use files with noncutting modified guiding tips: small (ISO 21 tip and 6% taper) for small canals, primary (ISO 25 tip and 8% taper) for the majority of canals, and large (ISO 40 tip and 8% taper) for large canals. The last two have fixed tapers of 8% from D1 to D3, whereas from D4 to D16, they have a unique progressively decreasing percentage tapered design. This design serves to improve flexibility and conserve remaining dentin in the coronal two thirds of the finished preparation. Another unique design feature of the WaveOne files is they have a reverse

helix and 2 distinct cross-sections along the length of their active portions (a modified convex triangular cross section from D1 to D8 and a convex triangular cross section from D9 to D16). The design of the 2 WaveOne cross sections is further enhanced by a changing pitch and helical angle along their active portions [24].

The mechanical behavior of NiTi alloy is determined by the relative proportions and characteristics of the microstructural phases. Changes to improve flexibility and resistance to fatigue fracture of endodontic instruments have been proposed, including different thermomechanical treatments, modified chemical composition of the NiTi alloy, different cross-sectional designs and changes in the manufacturing process. One important modification of the NiTi alloy includes the M-Wire alloy [3, 25], which is used in the production process of WaveOne files.

The producers of One Shape rotary NiTi files (MicroMega) with continuous rotation try to increase their flexibility and to reduce instrument screwing effects using a variable cross-section along the blade of the instrument. One Shape files have 3 different cross-section zones : the first zone presents a variable 3-cutting-edge design; the second, prior to the transition, has a cross-section that progressively changes from 3 to 2 cutting edges and the last (coronal) is provided with 2 cutting edges. Anti Breakage Control (ABC) increases safety and avoids separation by unwinding of the instrument. The system consists of one sterile single file for root canal shaping (ISO 25 tip and 6% taper) with variable pitch and non-working (safety) tip.

The aim of this study was to compare instrument life of WaveOne and One Shape single-file techniques used for the instrumentation of artificial curved canals after a glide path creation.

MATERIALS AND METHODS

Canal preparation was performed on 100 Endo-Training Block simulators (Dentsply Maillefer) divided in two equal groups, depending on the file used. The canals had a 0.02 taper, an apical diameter of 0.15, a 65 degree curvature and a 7.5 mm curvature radius.

Average lifespan and cumulative survival at the time of WaveOne files (Dentsply Maillefer) with reciprocating rotation and One Shape files (Micro Mega) with continuous rotation after a glide path creation were tested. PathFile System (Dentsply Maillefer) was used for the creation of a glide path at the WaveOne group and G-files (Micro Mega) - at the One Shape group.

Following the instructions of the producer all files were operated using The WaveOne™ Endodontic system (Dentsply Maillefer), which is pre-programmed with settings for the WaveOne reciprocating file system. The One Shape files were used with a rotation speed of 400 rpm and torque 2.0 gr/cm^2. The amount of pressure applied to all files was the pressure that could be applied to a sharp #2 pencil without breaking the lead. The files were never forced into the canal.

In the first group, after scouting the canals with a #10 hand K-file to full working length, a glide path was created using the PathFile System (rotation speed – 300 rpm and torque - 0.6 gr/cm^2). Then the canals were shaped with the small (ISO 21 tip and 6% taper) WaveOne file, following the instructions of the producer (a #10 Hand K-file was very resistant to movement at the initial inspection of the root canals). In the second group, after a working length determination with a #10 hand K-file, a glide path was created with G-files (rotation speed – 300 rpm and torque - 0.6 gr/cm^2) and the preparation was finished with One Shape file (ISO 25 tip and 6% taper). All shaping files worked till fracture occurred.

During mechanical instrumentation each file was coated with Glyde™ (Dentsply Maillefer) to act as a lubricant, and copious irrigation with 5.25% NaOCl was carried out.

The instrumentation of all canals was performed by a single operator.

RESULTS

Average Lifespan of Shaping Files

Twelve shaping files were used in canals' preparation, after their initial enlargement – 3 WaveOne files and 9 One Shape files. During the instrumentation ten of them broke: 2 WaveOne files and 8 One Shape files.

The longest lifespan of a single file from the first group was 19 canals and from the second group – 6 canals. The shortest lifespan was measured in the second group and was only 2 canals. (Table 1)

After the creation of a glide path, the average lifespan of one WaveOne file was **17.50±2.12** canals and of one One Shape file**–4.63±1.30** canals. The difference was statistically significant ($p<0.001$) (t-test). (Table 2)

Table 1. The Usage Number of WaveOne Reciprocating Files

File No.	Preparation technique	Number of uses, including the separation	Number of successfully treated canals
	WaveOne+PathFile		
1		17	16
2		20	19
3		*	13
	One Shape+G-Files		
4		3	2
5		6	5
6		6	5

7		6	5
8		5	4
9		5	4
10		7	6
11		7	6
12		*	5

* Instruments #3 and #12 were the last used for the preparation of the 50 canals in each group and were not separated during shaping.

Table 2. The Average Lifespan of Shaping Files

Wave One+PathFile (n=2)		One Shape+G-Files (n=8)		P
Mean	SD	Mean	SD	
17,50	2,12	4,63	1,30	<0.001

Cumulative Survival at the Time of Shaping Files

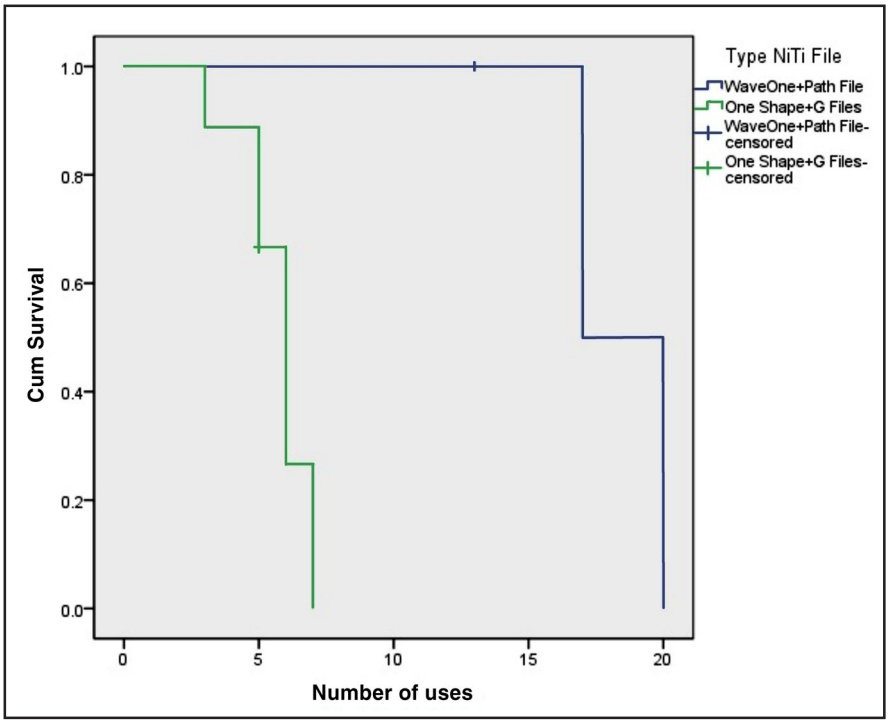
The cumulative proportion surviving at the time for WaveOne files, after the creation of a glide path, was 50% at the instrumentation of the 17th canal with one and the same file. All files were broken at the shaping of the 20th canal.

The cumulative proportion surviving at the time for One Shape files, after the creation of a glide path, was 88.9% at the instrumentation of the 3rd canal, 66.7% at the instrumentation of the 5th canal, 26.7% at the preparation of the 6th canal and all files were separated at the instrumentation of the 7th canal.

When comparing the results from both groups, it is found out that at the instrumentation of the 7th canal all WaveOne files were intact (100% survival), while all One Shape files were broken.

Figure 1. shows the survival curves of the two shaping instruments with different mode of rotation, using the log-rank test. The WaveOne instruments presented a significantly longer survival than the One Shape files ($p<0.05$). (Fig.1)

Fig. 1. Cumulative Proportion Surviving at the Time of WaveOne and One Shape Files.



DISCUSSION

This study compares the instrument life of WaveOne and One Shape NiTi files with reciprocating and continuous rotation, respectively. They were selected because they are single-file techniques, with non-working (safety) tip and variable cross-sections along the blade of the instrument. Both producers claim their products are safe and ensure an effective apical progression avoiding obstructions. The size of the tip of the instruments used differs, as on one hand, One Shape files are offered only in one size and, on other hand, we followed strictly the instructions of the manufacturer of WaveOne to use the small WaveOne file, if #10 hand K-file doesn't easily move toward the terminus of the canal.

Although the two files are distributed in sterile packages and are offered for single use, because of their high cost many clinicians are forced to reuse them, which, in turn, leads to a higher incidence of fractures. A recent retrospective study [26] showed that most fractures occurred in curved root canals, especially in the mandibular molars.

In the present investigation, we used standardized artificial canals, which according to Yao et al. [27] minimize the influence of other variables. All instrument breakage occurred in the apical portion of the canal, a few millimeters from the tip of the file as occurred in the work of Pruett et al. and Varela Patino et al. [17, 28]. This might be explained by the fact that we used Endo-Training Blocks with high degree curvature in the apical 1/3, and thus, it is more likely that a breakage will take place at the point of maximum flexure within the canal, where the stress is greatest.

Fracture of NiTi files occurs in one of two ways: flexural and torsional failure. Flexural fracture is a result of repeated compression and tension in curved canals. Torsional fracture occurs when the tip or any other part of the instrument binds to the canal walls whereas the handpiece keeps turning. In fact, NiTi files exposed to torsional stress are prone to fracture at a lower cyclic fatigue [29], and torsional resistance decreases in used files [30].

One possible method for preventing file fracture is to reduce torsional stress in the process of canal preparation. For this purpose preflaring and the crown-down preparation have been suggested [16]. Preliminary creation of a glide path has been shown to be fundamental for safer use of NiTi rotary instrumentation [17, 18]. The root canal diameter becomes bigger than or at least the same size as the tip of the first rotary instrument used, reducing the stress the instruments suffer.

For glide path creation we used two rotary NiTi instruments, each offered by the producer for initial preflaring. In the WaveOne group glide path was created with PathFile System (Dentsply Maillefer) and in the One Shape group – with G-Files (MicroMega). The PathFile System, consisting of three instruments with square cross section, four cutting angles, 21-25-31 mm length, 0.02 taper and size of the tip ISO 13, 16 and 19, creates a good combination of flexibility, strength and efficacy that allows a safe and fast use even in severely curved and/or calcified canals. G-Files consist of two instruments 21-25-29 mm long, with 0.03 taper, size of the tip ISO 12 and 17 and variable cross-section throughout the length of the instrument. The 3 cutting edges are on three different radiuses relative to the axis of the canal, leaving a large and efficient area for upward debris removal.

The two systems for glide path creation create different apical sizes of the canal - for the WaveOne group it is closer to the size of the shaping file used when compared with the One Shape group. This situation can explain to some extent the results from our study.

The average lifespan of one WaveOne file was 17.50±2.12 canals and of one One Shape file - 4.63±1.30 canals. The difference was statistically significant ($p<0.001$) (t-test). In the WaveOne group we found out only two broken files during the instrumentation of fifty canals and the longest lifespan in the observation - 16 and 19 canals. The most usual number of uses in the One Shape group was 5 to 6 canals and there we have the shortest instrument life of only two uses. The results of our investigation are in agreement with the findings of the work of Varela Patino et al. [22] in which the incidence of instrument fracture in blocks of resin was lower with alternating rotation than with continuous rotation. The mean number of uses in their study was 10 with alternating movement compared with 4-5 uses with continuous movement. The lifespan of an instrument is directly proportional to the stress accumulated during work in the root canal [31]. Theoretically, the clockwise and counterclockwise movements should reduce the incidence of torsional fracture caused by taper lock [32].

The cumulative survival at the time revealed that half of the WaveOne files were intact at the instrumentation of the 17th canal and all were broken at the shaping of the 20th canal. The WaveOne instruments presented a significantly longer survival than the One Shape files ($p<0.05$). We found out that at the instrumentation of the 7th canal all WaveOne files were intact (100% survival), while all One Shape files were broken. The great number of uses can be attributed not only to the creation of a glide path but to the specific reciprocal way of rotation of WaveOne files, along with new alloys and new manufacturing process that have been introduced [33, 34]. M-Wire is a NiTi alloy prepared by a special thermal process that is claimed to increase flexibility and resistance to cyclic fatigue [35]. It is well documented that the incidence of instrument fractures (in resin blocks and natural teeth) is lower with alternating rotation than with continuous rotation [19, 21, 22, 36]. The torsional stress is reduced by using reciprocating motion and taper-lock phenomenon is prevented by unsymmetrical repeating of the clockwise and counterclockwise rotations [22, 32].

In conclusion, within the limitations of this study, the WaveOne files showed significantly higher resistance to fracture compared with the One Shape files. Instrumentation with files with reciprocal motion increases significantly instruments life and makes them safer during shaping of root canals.

Acknowledgement:

The study is sponsored by the Scientific Council of Medical University, Sofia, Bulgaria.

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