The Influence of a Glide Path on the Lifespan of WaveOne Reciprocating Files

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Abstract Background: Nickel-titanium instrument separation is a serious concern in endodontic therapy. A significant reduction of rotary instrument separation could be obtained when use of rotary file is anticipated by an initial manual preflaring and glide path. Normally this procedure is carried out by stainless steel hand files but new rotary nickel-titanium instruments (PathFiles) for mechanical glide path has been recently introduced. **Methodology/Principal Findings:** Canal preparation was performed on 100 Endo-Training Block simulators divided in two equal groups, depending on the used technique (with and without a glide path). Average lifespan and cumulative survival at the time of WaveOne (Dentsply Maillefer) files before and after the creation of a glide path with PathFiles (Dentsply Maillefer) were tested. Following the instructions of the producer all the files were operated using The WaveOne™ Endodontic system (Dentsply Maillefer). All WaveOne 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. Eight WaveOne reciprocating files were used in canals' preparation and six of them broke: 4 files before the creation of a glide path and 2 after the initial enlargement of the canals with PathFile system. The average lifespan of one WaveOne file without a creation of a glide path was 10.25 ± 2.50 canals and after a creation of a glide path – 17.50 ± 2.12 canals. The difference was statistically significant ($p < 0.05$). The instruments used after a glide path was created presented a significantly longer survival at the time ($p < 0.05$). **Conclusions:** Within the limits of this study, NiTi rotary Path Files appear to be suitable instruments for safe and easy creation of the glide path before use of WaveOne reciprocating files. The initial enlargement of the canals increases significantly the average lifespan and the survival rate of WaveOne files.

Keywords: nickel-titanium instruments, WaveOne, PathFiles, glide path, lifespan, cumulative survival

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1. Introduction

The endodontic treatment outcome depends on root canal cleaning and shaping. The introduction of nickel-titanium rotary files has changed radically the root canal instrumentation techniques and the prognosis of endodontic complex cases. It is clearly demonstrated in many "in vitro" [7,9,23,24,25,31,36] and "in vivo" [17,26,29] studies that they are superior to stainless-steel files, especially during enlargement of the apical third of severely curved canals. At the same time, they had to be used with caution, because of the high risk of unexpected intracanal separation [29,30].

The usage of NiTi instruments in curved canals is one of the most important reasons for their fractures [18]. These separations are caused by torsional [1,5,6,39] and fatigue stresses [4,5,16]. The majority of torsional separations occurs when the tip of the instrument is engaged into the canal wall while the handpiece is still rotating [1,4,6,16]. Low torque motors and reduced axial pressure are ways to avoid the "taper lock" of the

instruments with lower taper and/or diameter of the tip [4,16]. Repeated subthreshold loads, especially in the point of maximum flexure, result in metal fatigue and fracture [21,22]. In this case, the instrument stays loose into the canal space and rotates freely, without binding to the canal wall.

Manual preflaring and creation of a glide path before using nickel-titanium rotary instrumentation increases the canal diameter and thus reduces the risk of fracture [2,14,19,33]. Stainless steel hand files can be used for this procedure, though rotary nickel-titanium instruments are preferred lately, especially in the process of shaping of curved and/or calcified canals. An example of such system is the PathFiles (Dentsply Maillefer, Ballaigues, Switzerland), which consists of three instruments with square cross section, 21-25-31 mm length, 0.02 taper and size of the tip ISO 13, 16 and 19. According to the manufacturer the first PathFile can be used immediately after the root canal has been scout to full working length with a #10 hand K-file.

The reciprocating way of motion may also decrease the impact of cyclic fatigue on nickel-titanium rotary instrument life [13,34,40]. The new WaveOne NiTi

single-file system, manufactured with M-Wire NiTi alloy (Dentsply Tulsa Dental, Tulsa, OK), has been introduced by Dentsply Maillefer (Ballaguess, Switzerland) and is designed to be used with a reciprocating motion motor. The reciprocating motion has different angles of rotation - 170° counterclockwise and then 50° clockwise at a speed of 350 rpm. The system consists of 3 single-use files: 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 aim of the present study was to examine the lifespan of one nickel-titanium WaveOne reciprocating file used for the instrumentation of artificial curved canals before and after the creation of a glide path.

2. Materials and Methods

Canal preparation was performed on 100 Endo-Training Block simulators (Dentsply Maillefer) divided in two equal groups, depending on the technique 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 (Dentsply Maillefer) files before and after the creation of a glide path with PathFiles (Dentsply Maillefer) were tested. Following the instructions of the producer all the files were operated using The WaveOne™ Endodontic system (Dentsply Maillefer), which is pre-programmed with settings for the WaveOne reciprocating file system. The amount of pressure applied to the file 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 the canals were scouted initially with a #10 hand K-file to full working length and then were shaped with the small (ISO 21 tip and 6% taper) WaveOne file. In the second group after scouting the canals with a #10 hand K-file to full working length, a glide path was created using the PathFile system. The preparation was finished with the small (ISO 21 tip and 6% taper) WaveOne file. All WaveOne 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.

3. Results

Table 1. The Usage Number of WaveOne Reciprocating Files

File №	Preparation technique	Number of uses, including the separation	Number of successfully treated canals
	WaveOne		
1		8	7
2		11	10
3		14	13
4		12	11
5		*	5
	WaveOne+PathFile		
6		17	16
7		20	19
8		*	13

*Instruments #5 and #8 were the last used for the preparation of the 50 canals in each group and were not separated during their shaping.

Average Lifespan of WaveOne Reciprocating Files

Eight WaveOne reciprocating files were used in canals' preparation and six of them broke: 4 files before the creation of a glide path and 2 after the initial enlargement of the artificial canals with PathFile system. The longest lifespan of a single file from the first group was 13 canals and from the second group – 19 canals. The shortest lifespan was measured in the first group and was 7 canals. (Table 1).

The average lifespan of one WaveOne file *without a creation of a glide path* was 10.25 ± 2.50 canals and *after a creation of a glide path* – 17.50 ± 2.12 canals. The difference was statistically significant ($p < 0.05$) (t-test). (Table 2).

Table 2. The Average Lifespan of WaveOne Reciprocating Files

Wave One (n=4)		Wave One+Path File (n=2)		P
Mean	SD	Mean	SD	
10.25	2.5	17.50	2.12	0.025

Cumulative Survival at the Time of WaveOne Reciprocating Files

The cumulative proportion surviving at the time for WaveOne files, without the creation of a glide path, was 75% at the instrumentation of the 8th canal with one and the same file, 50% of the 11th one and 25% at the shaping of the twelve one.

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 and all files were separated at the instrumentation of the 20th canal.

At the instrumentation of the 14th canal, after the creation of a glide path, all WaveOne Files were intact (100% survival), while all of them from the first group (without a glide path) were broken.

Figure 1 shows the survival curves of the instruments with and without a creation of a glide path using the log-rank test. The instruments used after a glide path was created presented a significantly longer survival ($p < 0.05$). (Figure 1).

Figure 1. Cumulative Proportion Surviving at the Time of WaveOne Reciprocating Files

4. Discussion

Rotary nickel-titanium instruments allow the instrumentation of curved canals more predictably well

centered, with lesser risks of transportation, ledging, and perforations than stainless-steel instruments [28]. Nevertheless, despite all the aforementioned benefits, there is a higher risk of instrument separation with rotary NiTi instruments, specifically during the instrumentation of curved canals [10,27,40]. It was shown in *in vitro* investigations that a stronger curvature and a smaller radius of the root canal increase the risk of rotary instrument fracture [11,18,41]. In a curvature, fracture occurs because of the repeated tensile and compressive stresses that lead to cyclic flexural fatigue by work hardening within the metal and the initiation of cracks from the outer surface of the instrument [12]. That is why, most clinical guidelines and manufacturers' recommendations for instrumentation with rotary NiTi instruments insist on the reduction of canal curvature by creating straight-line access and by reduction of the interference of the instrument with canal walls. However, clinically, a perfect straight-line access is not always possible, so initial enlargement of the canal should be performed. Fine hand instruments are usually used for the creation of a smooth glide path which will make subsequent use of the larger rotary NiTi instruments safer and more effective [8,20]. Negotiation and glide path preparation are the initial phases of chemomechanical procedures and can be regarded as crucial steps for assessment of the root canal anatomy and establishment of unimpeded access to the apical part of the canal [15]. Occurrence of canal modifications and aberrations seems to be significantly reduced when previous glide path is performed [2,3,33].

We used in our investigation standardized artificial canals, which according to Yao et al. [37] minimize the influence of other variables. In the present study, all instrument breakage occurred in the apical portion of the canal, a few millimeters from the tip of the file. Our findings are in agreement with the observations of Tygesen et al. [32] and Varela et al. [33] and can be explained with the fact that instruments break at the point of maximum flexure within the canal (e.g. the curvature), precisely where the stress is greatest. The broken files showed no visible defects, other than the breakage itself and did not seem to bind within the canals. Following the results from the work of Sattapan et al. [21], the lack of signs of deterioration above the fracture point, indicates that files broke because of fatigue rather than torsional stress.

The results from our study confirm the findings from other investigations, concerning the role of preliminary preflaring and creation of a glide path for safer use of rotary NiTi instrumentation [2,33]. The comparison between the two examined groups showed a statistically significant difference. The average lifespan of WaveOne file from the first group (without a creation of a glide path) increased from 10.25 ± 2.50 canals to 17.50 ± 2.12 canals (with created glide path) in the second group. The number of broken files in the second group decreased twice and it is worth mentioning how great the number of successfully treated canals with one file was – 16 and 19. The longest lifespan for the files from the first group was 13 canals and the mean number successfully treated canals was 10 canals, the same as the results found out by Varela-Patino et al. [35]. It can be hypothesized that the use of small size hand K-file followed by more flexible and less tapered

rotary NiTi PathFiles could provide advantages in the form of the canal, making the subsequent instrumentation with WaveOne single-file technique safer and less invasive.

The cumulative proportion at the time revealed that half of the files were intact at the instrumentation of the 11th canal in the first group and at the 17th canal in the second one. At the instrumentation of the 14th canal, after the creation of a glide path, all WaveOne files were intact (100% survival) while all of them from the other group (without a glide path) 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 and their design, as well. 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 [13,34,35,40]. The lifespan of an instrument is directly proportional to the stress accumulated during work in the root canal [5]. The torsional stress is reduced by using reciprocating motion and taper-lock phenomenon is prevented by unsymmetrical repeating of the clockwise and counterclockwise rotations [39]. In combination with initial preflaring, torsional stress is decreased and the area on which the stress is exerted on is shifted (from the tip to the body of the file), further reducing any torsional stress.

In conclusion, within the limitations of this study, NiTi Rotary PathFiles are suitable instruments for safe and easy creation of the glide path before use of NiTi rotary instruments for shaping the canal. The PathFiles System is less technique-sensitive and increases significantly the lifespan and survival rate of WaveOne reciprocating files.

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