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Influence of a Manual Glide Path on Survival of a Single-File Reciprocating System

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Abstract: ***Survival of Reciproc files used for instrumentation of 100 artificial curved canals before and after creation of a glide path was examined. The average lifespan of one Reciproc file without a creation of a glide path was 7.17±1.72 canals and after a glide path creation – 12.67±1.53 canals. The difference was statistically significant. Within the limitations of this study, instrumentation with files with unequal angles of reciprocal motion is a reliable and safe procedure. Preliminary creation of a glide path with C-Pilot hand files increases significantly the lifespan of Reciproc files in the course of shaping of severely curved root canals.***

Keywords: glide path, lifespan, reciprocation, Reciproc, severely curved canals

1. Introduction

The endodontic treatment outcome is highly dependent on thorough cleaning [26, 31], proper shaping and efficient chemical disinfection of the entire root canal space. [12, 26] Preparation of the apical part of the root canal, especially when severely curved, still remains a challenge to dental practitioners. [9, 59] A constant quest for overcoming the limitations of stainless-steel instruments and for creation of the best device for root canal instrumentation is registered in the last decades. [35, 42] Immense improvements have been made in the manufacturing of new engine-driven NiTi systems [1, 16, 33, 34, 56] which changed radically the root canal instrumentation techniques and the prognosis of endodontic complex cases. Many "in vitro" [9, 14, 43-45, 48, 54] and "in vivo" [36, 46, 47] investigations demonstrate their superiority to stainless-steel ones and their ability to shape with lowered risk of ledging and straightening even severely curved canals.

Following the current tendency of simplifying the preparation protocol, new single file systems have been introduced on the market [7, 15, 35, 57], some of them driven by reciprocating motion. [23, 27, 56] Reciprocation imitates "balanced force concept" of hand instruments and is defined as a repetitive back-and-forth motion of rotary instruments. Such files work under their elastic limit, and thus extend instruments lifespan and increase their fracture resistance [10, 53, 56, 59], regardless of the alloy used by manufacturers. [33, 51, 59] Utilization of unequal bidirectional angles in reciprocating systems results in significantly increased life of instruments. [13]

Reciproc (VDW, Germany) was one of the recently manufactured systems working with a specific motor with unchangeable settings, generating different angles of rotation – greater in cutting direction than the one in reverse direction, allowing the file to continuously progress towards the apex. One complete rotation of 360° is completed in several reciprocating movements. The instrument is driven first in a cutting direction and then reverses to release the instrument. It is probable that rotation type and rotation rate can affect the fatigue resistance. [24, 25] The precise angles of reciprocation in Reciproc System are designed to be smaller than the angle settings where the elastic limit of the instrument would be met, thus minimizing the risk of instrument fracture.

In the course of shaping of root canal curvature instruments undergo simultaneously the influence of torsion and flexure and despite their superelasticity and flexibility can unexpectedly fracture. NiTi instrument separation is a serious concern in endodontic therapy and is caused by torsional overloading [2, 6, 8, 58] and cyclic fatigue stresses. [5, 6, 35] Torsional separation is due to binding of the tip or any other part of the instrument to the walls of the canal whereas the handpiece keeps rotating. [2, 5, 8, 35] In case of fracture resulting from flexural fatigue the instrument rotates freely in the canal but has already been weakened by metal fatigue after repeated subthreshold loads and breakage occurs in the point of maximum flexure. [40,41] One of the most important reasons for instruments fractures in clinical practice is curvature of the canals to be shaped. [37]

The risk of instrument fracture might be reduced by manual preflaring and creation of a glide path before shaping with nickel-titanium rotary systems. [3, 18, 19, 38, 50] Stainless steel hand files or rotary NiTi instruments can be used for making the root canal diameter bigger than or at least the same size as the tip of the first rotary instrument used. [18, 19, 50] . The aim of the present study was to examine the lifespan of one Reciproc file used for instrumentation of artificial curved canals before and after creation of a glide path.

2. Materials and Methods

One hundred Endo-Training Block simulators (0.02 taper, 0.15 apical diameter, a 65-degree curvature and a 7.5 mm curvature radius) were shaped with Reciproc files (VDW) and divided in two equal groups, depending on the technique used.

R25 file was selected for shaping of the canals in the

experiment as scouting with an ISO 20 hand K-file did not reach passively full working length. All training blocks were initially scouted with an ISO 10 hand K-file to full working length. R25 prepared the root canals to a diameter of 0.25 mm with a taper of .08 over the first apical millimeters. The instrument has a S-shaped cross-section and a non-cutting tip and is produced with a M-Wire NiTi alloy.

Shaping of the first group of canals (n=50) was performed directly after scouting with a R25 file, adjusted to the measured working length. In the second group (n=50), a glide path was preliminary created using stainless steel C-Pilot files (VDW, Germany) up to size ISO 15. Their inactive pilot tip conducts the instrument safely along the canal and enables creation of a smooth glide path prior to rotary preparation. The instrumentation was finished with a R25 file. All Reciproc files worked till fracture occurred.

Average lifespan of Reciproc files before and after the creation of a glide path was tested. Following the instructions of the manufacturer all NiTi instruments were operated using The WaveOne™ Endodontic motor (Dentsply Maillefer), which is pre-programmed with settings for the Reciproc system. The files were never forced into the canal and were used with slow in-and-out pecking motion.

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.

Statistical analysis

The distributions of continuous variables are expressed as means ± standard errors. The performed comparative analysis of the lifespan of the instruments was based on the number of uses of each file before withdrawal because of fracture.

3. Results

Table 1: The Usage Number of All Reciproc Files

File No.	Preparation technique	Number of uses, including the separation	Number of successfully treated canals
	Reciproc		
1		8	7
2		9	8
3		7	6
4		11	**10**
5		6	5
6		8	7
7		*	1
	C-Pilot + Reciproc		
8		15	**14**
9		12	11
10		14	13
11		*	9

*Instruments #7 and #11 were the last used for the preparation of 50 canal and were not separated during their shaping.

Average Lifespan of Reciproc Files

Eleven Reciproc files were used in canals' preparation and nine of them broke: 6 files without the creation of a glide path and 3 after the initial enlargement of the artificial canals with C-pilot files. The longest lifespan of a single file from the first group was 10 canals and from the second group – 14 canals. The shortest lifespan was measured in the first group and was 5 canals. (Table 1)

The average lifespan of one Reciproc file without a creation of a glide path was 7.17±1.72 canals and after a creation of a glide path – 12.67±1.53 canals. The difference was statistically significant ($p<0.05$) (t-test). (Table 2)

Table 2: The Average Lifespan of Reciproc Files

Reciproc (n=6)				C-Pilot Files + Reciproc (n=3)			
Mean	SD	Min	Max	Mean	SD	Min	Max
7.17	1.72	5	10	12.67	1.53	11	14

4. Discussion

The survival of Reciproc instruments, known for their unique combination of file design, alloy processing and mode of rotation, was tested on standardized artificial canals, which according to Yao et al. [55] minimize the influence of other variables. The breakage of all instruments in the present study appeared in the apical portion of the canal, at the point of their maximal flexure. The greatest stress for the instruments in our experiment was concentrated a few millimeters from the apex of the canal, at the location of the expressed curvature (65º curvature angle). Our findings are in agreement with the observations of Tygesen et al. [49] and Varela-Patino et al. [50]. Similar to the results in the work of Sattapan et al. [40], the broken files showed no visible signs of deterioration above the fracture point, indicating that fatigue was the potential reason of fracture rather than torsional stress.

Cyclic flexural fatigue, initiation of cracks and sometimes unexpected fractures are registered after a repeated tensile and compressive stresses on the instruments used in curvatures. [32] The manufacturers of Reciproc files claim that the alternating unequal angles of clockwise and counterclockwise movements reduce torsional stress and cyclic fatigue, minimally affecting cutting efficiency. This way of motion is considered superior to continuous rotation as it is well documented that the incidence of instrument fractures is lower with alternating rotation than with continuous rotation. [20, 21, 25, 33, 51, 52, 53, 59] The lifespan of an instrument is directly proportional to the stress accumulated during the work in the root canal [6]. 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.

The results from our study demonstrate high survival of tested files, especially in the group with the initially created glide path (12.67±1.53). Although lower, a great average number of uses (7.17±1.72) was registered in the group with direct shaping with Reciproc instruments, as well. Despite manufacturer's recommendations to use these instruments

for preparation only of a molar, it is obvious, that they can safely work in more canals. Similar results were registered in another experiment conducted by us in which survival of WaveOne files was tested. [20, 22] The lifespan of such a file was even greater, especially in cases with initial glide path creation and reached 17.50±2.12 canals. The great number of uses in both studies can be attributed to the specific asymmetrical rotation used by these systems, to the design of the files and the type of the NiTi alloy used. [29]

Both systems are manufactured by M-Wire which is a result of technological improvement in NiTi metallurgy. This alloy is produced by applying a series of heat treatments to the NiTi wire blanks, leading to increased flexibility and significantly improved resistance to cyclic fatigue. [17, 28, 30, 34]

The S-shaped cross section of Reciproc files reduces the contact with the walls of the canal during rotation thus decreasing additionally the stress over it.

According to producer's instructions for use of Reciproc files creation of a glide path for minimizing binding is not required for majority of canals as both angles of rotation are significantly lower than the angles at which the instrument would usually fracture (if bound). At the same time, in cases with expressed curvature and working length determination with a pre-curved ISO 10 K-file, initial enlargement of canal lumen is recommended. Most clinical guidelines for shaping 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. [3, 4, 11, 39, 50]

The stress over the instruments in this study was lowered by creating a glide path with C-Pilot hand files up to ISO 15. The average lifespan of a tested Reciproc file was almost doubled and reached 12.67±1.53 canals. The number of broken files in the second group decreased twice and it is worth mentioning the great number of successfully treated canals by one file – 12, 14 and 15. It can be hypothesized that the use of small size hand files makes the subsequent instrumentation with Reciproc files safer and less invasive. The results from our study confirm the findings from other investigations, concerning the role of a preliminary creation of a glide path for safer use of rotary NiTi instruments. [3, 50] The same tendency of an increased number of uses of tested files after the initial creation of a glide path was registered in our experiments with other instruments for single file instrumentation - WaveOne and One Shape files. [18, 19]

In conclusion, within the limitations of this study, instrumentation with files with unequal angles of reciprocal motion is a reliable and safe procedure. Preliminary creation of a glide path with C-Pilot hand files increases significantly the lifespan of Reciproc files in the course of shaping of severely curved root canals.

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