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Comparative Evaluation of Defects on Twisted Files and Wave One Reciprocating System After Single and Multiple use in Root Canals: SEM Analysis

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ABSTRACT

Background: Aim: To evaluate two single file systems for superficial defects after instrumentation in 3,6 and 9 canals respectively. **Methods**: 30 extracted mandibular molars were selected in the study and assigned into two groups, Group I- Twisted Files and Group II- Wave One Files. Both the groups were further subdivided into subgroups A,B,C consisting of 5 teeth each for instrumentation in 3,6 and 9 canals respectively. Access cavities were prepared with a slow speed bur, the canals were then irrigated with 2.5% NaOCl and negotiated using a size 10 K-file. The canals were shaped to WL using either the Twisted or the Wave One file as a single file, both according to the groups, until achieving the working length. Both the instruments were introduced in 3, 6 and 9 canals for preparation. All instruments were observed under a scanning electron microscope before use and after preparing three, six and nine root canals at x500 magnification. The number of instruments with superficial defects and type of defects were noted and percentage was calculated. Statistical Analysis: The superficial defect scores were summarized by mean values and standard deviations and the intergroup comparison was done using Two-way ANOVA (Analysis of Variance). **Results**: The file groups had defects on their surfaces, tips and blades. Wave One Files showed more number of defects than Twisted File on examination using SEM. **Conclusion**: The defects were exhibited by both the types of Files with an advantage of fewer defects involved with Twisted Files.

Keywords: Cyclic fatigue, reciprocating motion, deformation, rotational motion, Twisted File, Wave One file, SEM

INTRODUCTION

The ultimate goal of root canal preparation is to clean and shape the root canal system while maintaining the original configuration. Nickel titanium (Ni–Ti) instruments used to improve root canal preparation are available in various designs that differ in tip and taper design, rake angles, helical angles, pitch, and presence of radial lands.[1] They are more flexible and have increased cutting efficiency than conventional stainless steel files. Despite these advantages, NiTi instruments have a high risk of separation, mainly because of fatigue and torsional shear stresses.[2] Manufacturing process of rotary Ni-Ti file can also influence the distortion of Ni-Ti endodontic instrument. These distortions can be in the form of unwinding of flutes, micro-cracks, pitting or surface wear. In order to avoid instrument fracture, it is important to check the instruments for signs of wear and deformation every time it is used.[3] There is consensus that Ni-Ti instrumentation systems can produce well-centered and flared root canal preparations. Having a wide range of Ni-Ti file systems to select from requires a clinician to understand the physical properties, design characteristics, and motion mechanics within the confines of the canal system before using a particular system.[4]

In recent years the reciprocating motion of the NiTi rotary instrument has been shown to decrease the impact of cyclic fatigue compared with rotational motion. The reciprocation actually used with NiTi instruments is an alternating movement in which the file rotates a certain angle in the cutting direction and shortly after, in the opposite direction over a much smaller angle.[5] Scanning Electron Microscopic (SEM) studies have been carried out to evaluate distortion of nickel-titanium endodontic instruments after in vitro and in vivo use. Single file system is used in a reciprocal motion that consists of a series of cutting direction motions (counterclockwise) and instrument-releasing motions (clockwise motion), where the angle of the cutting direction is greater than the angle of the reverse direction.[6] Two brands of Ni-Ti instruments adopting the single-file system have been considered for the study.

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Twisted File (TF; SybronEndo, Orange, CA, USA), is manufactured from a proprietary process of heating, cooling and twisting of nickel titanium in the rhombohedral crystalline phase configuration (an intermediate phase between austenite-the phase at rest and martensite-the phase present during function).[7] It comes in come in 25,0.10 taper, size 25 , 0.08 taper and size 25,0.06 taper and are used in continuous motion.[8] It possessed higher resistance to cyclic fatigue and removed dentine efficiently with more uniform cutting than other NiTi files with a grinding manufacturing process.[9]
Wave One (Dentsply-Maillefer, Ballaigues, Switzerland) is made of a special Ni-Ti alloy called M-wire that is created by an innovative thermal treatment process. The benefits of M-wire are increased flexibility of the instruments and resistance to cyclic fatigue. It consists of three instruments made from M-Wire nickel-titanium alloys, called Small (21.06), Primary (25.08) and Large (40.08). They have a modified convex triangular cross-section at the tip and convex triangular cross-section in the middle and coronal portion. The Wave One instruments alternate between 170° counterclockwise and 50° clockwise rotation.[10]

MATERIALS AND METHODS

30 mandibular molars with no sign of internal or external root resorption were selected for the study. Visual and radiographic (mesio-distal and bucco-lingual) evaluations were done
The specimens (n=30) were initially divided into two groups.

Group I: Instrumentation was done using Twisted Files (TF), (n=15)

Group II: Instrumentation was done using Wave One files (WO), (n=15)

Both Groups I and II were further subdivided into Subgroups A, B and C consisting of 5 teeth each for instrumentation in 3, 6 and 9 canals respectively.
Access cavities were prepared in all the teeth and the working length was determined 0.5 mm short of the radiographic apex. In Group IA- the root canals were prepared using the Twisted files for 3 canals; in Group IB- the root canals were prepared using the Twisted files for 6 canals and in Group IC- the root canals were prepared using the Twisted files for 9 canals respectively.
Similarly, In Group IIA- the root canals were prepared using the Wave One files for 3 canals; in Group II B- the root canals were prepared using the Wave One files for 6 canals and in Group II C- the root canals were prepared using the Wave One files for 9 canals respectively.
All instrumentation was performed by the same operator using the X-Smart Plus endomotor (Dentsply Maillefer) as per specific program for each instrument. During preparation, irrigation was done with 2.5% sodium hypochlorite at each 3 mm advance of the instrument inside the root canal.
The Scoring Criteria has been depicted in [Table 1].
[Table 2] denotes the Defects on the Twisted File Before Use and After Use in 3, 6 and 9 canals respectively. Group I A, B and C were observed under SEM before and after use in 3, 6 and 9 canals respectively. Fig1a, 1b and 1c demonstrate the SEM photograph of the same at 500X magnification
[Table 3] denotes the Defects on Wave One Files Before and After Use in 3, 6 and 9 canals respectively. The same Criteria was followed for Group II WO. Group II A, B and C were observed under SEM before and after use in 3, 6 and 9 canals respectively. Fig. 2a, 2b and 2c demonstrate the SEM photograph of the same at 500X magnification
[Table 4] denotes the Mean and Standard Deviation for both the groups. The Data obtained was then subjected to statistical analysis using Two-way ANOVA (Analysis of Variance).

RESULTS

- Both Group I and Group II had defects on their surfaces, tips and blades after use.
- Group II (Wave One) showed more number of defects than Twisted File which was found to be statistically significant.

Table 1: Scoring criteria for superficial defects

Score	Criteria
1	No fracture, no plastic deformation, no micro-cracks, no large craters, no disruption of the cutting edges or blunt edges along the shaft examined
2	Plastic deformation, micro-cracks, large craters ,disruption of the cutting edges or blunt edges along the shaft examined of which one spiral along the shaft examined
3	Plastic deformation, micro-cracks, large craters, disruption of the cutting edges or blunt edges along the shaft examined of two spiral along the shaft examined
4	Plastic deformation, micro-cracks. large craters, disruption of the cutting edges or blunt edges along the shaft examined of more than two spiral along the shaft examined
5	Fracture

Table 2: Defects on the Twisted Files Before and After Use in 3, 6 and 9 canals

	Plastic deformation	Complete fracture	Microcracks	Creters	Blunt edges	Disruption of cutting edges
TF						
Before usage	0	0	0	0	0	0
After three canals	0	0	0	0	0	0
After Six Canals	3	0	2	0	1	0
After nine canals	4	0	3	0	3	2

Table 3: Defects on Wave One Files Before and After Use in 3, 6 and 9 canals

	Plastic deformation	Complete fracture	Microcracks	Creters	Blunt edges	Disruption of cutting edges
Wave						
R25 before usage	0	0	0	0	0	0
After three canals	0	0	0	0	0	0
After Six Canals	4	1	4	0	2	0
After nine canals	5	2	4	0	3	3

Table 4: Two-Way ANOVA

Group	n	0 canals	3 canals	6 canals	9 canals
		Mean±SD	Mean±SD	Mean±SD	Mean±SD
TF	5	1.00±0.00	1.00±0.00	1.20±0.20	1.90±0.48
Wave One	5	1.00±0.00	1.00±0.00	1.75±0.35	2.20±0.80

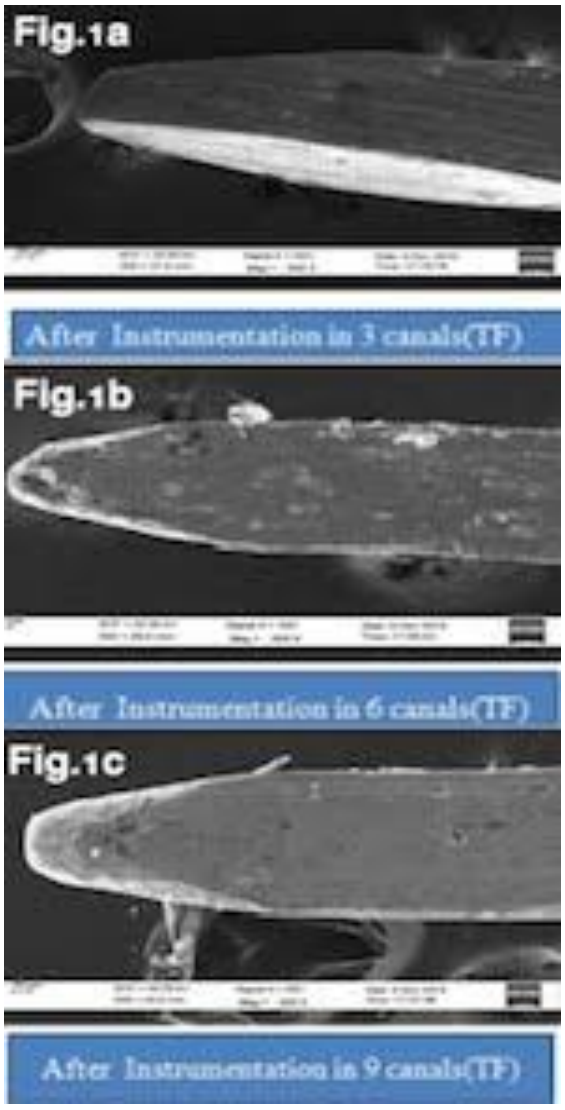

Figure 1: a,b,c- SEM analysis for twisted files after use in 3,6 and 9 canals respectively

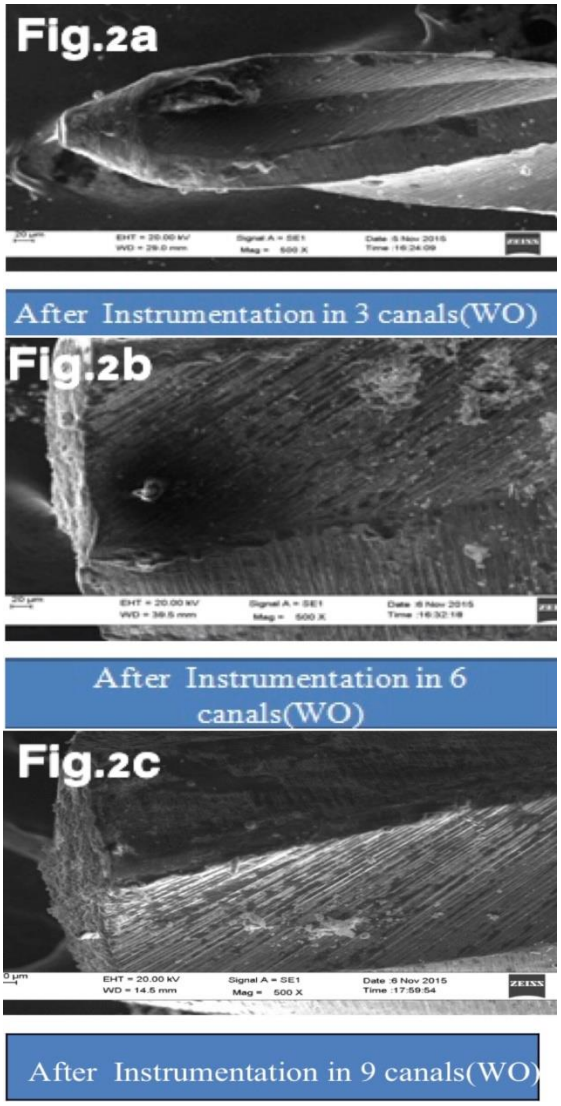

Figure 2: 2a,2b,2c-SEM analysis for wave one files after use in 3,6 and 9 canals respectively

DISCUSSION

Most metallic materials exhibit an elastic behavior in which, within certain limits, the deformation caused is directly proportional to the force applied. This relationship is known as Hooke's Law. According to Hooke's Law, most metal alloys can be elastically deformed by up to 0.1 or 0.2% beyond their elastic limit, or yield strength. Any deformation above this limit, known as the yield point, will be permanent.[11]

Nickel-titanium alloys, however, can be deformed up to 8% beyond their yield strength without showing any residual deformation.[12,13] Super-flexibility, or pseudo-elasticity, can thus be defined as the ability of certain materials to recover their original shape after the load is removed even when they are deformed beyond their yield strength.[14]

At its best, recent NiTi rotary systems solve most of the deficiencies of traditional stainless steel instruments. Undoubtedly, NiTi rotary instruments, if used properly, can achieve a final root canal preparation that conforms to the general shape and direction of the original canal.[15]

TF instruments are manufactured using a proprietary heat treatment technology which changes the crystalline structure completely so the triangular cross section NiTi file blank can be twisted while maintaining the natural grain structure. More precisely, TF instruments are created by taking a raw NiTi wire in the austenite crystalline structure phase and transforming it into a different phase of crystalline structure (R-phase) by a process of heating and cooling. In the R-phase, NiTi cannot be ground but it can be twisted. Once twisted, the file is heated and cooled again to maintain its new shape and convert it back into the austenite crystalline structure, which is super elastic once stressed. Because of the increased flexibility, the Twisted Files maintains the original canal shape better, minimizes canal transportation and stays centered even in severely curved root canals.[16-18]

In addition to the development of heat treated Twisted File™ technology to improve the performance and safety of NiTi instruments, the file design has also been changed with respect file dimensions, tip configuration, cross-section and flute design. More recently, a third factor has become important in this search for stronger and better instruments: Movement Kinematics, the branch of motion in which the objects move.

The new Wave One NiTi file system from DENTSPLY Maillefer is a SINGLE-use, SINGLE-file system to shape the root canal completely from start to finish. Shaping the root canal to a continuously tapering funnel shape not only fulfils the biological requirements for adequate irrigation to rid the root canal system of all bacteria, bacterial by-products and pulp tissue.[19] In most cases, the technique only requires one hand file followed by one single Wave One file to shape the canal completely.

The specially designed NiTi files work in a similar but reverse “balanced force” action4 using a pre-programmed motor to move the files in a back and forth “reciprocal motion”. The files are manufactured using M-Wire technology, improving strength and resistance to cyclic fatigue by up to nearly four times in comparison with other brands of rotary NiTi files.[20]

At present, there are three files in the Wave One single-file reciprocating system available in lengths of 21, 25 and 31mm:

1. The Wave One Small file is used in fine canals. The tip size is ISO 21 with a continuous taper of 6%.
2. The Wave One Primary file is used in the majority of canals. The tip size is ISO 25 with an apical taper of 8% that reduces towards the coronal end.

3. The Wave One Large file is used in large canals. The tip size is ISO 40 with an apical taper of 8% that reduces towards the coronal end.
   The canals in this study were shaped with a length 21mm files to the working length using either the Twisted files or the Wave One file as a single file until achieving the working length.
   The reciprocating movement of WO showed a longer cyclic fatigue life than conventional rotary movement of TF. In addition, the new manufacturing twisting process of TF produced NiTi rotary instruments more resistant to fatigue than ProTaper instruments produced with the traditional NiTi grinding process. Further studies are required to standardize the method for fatigue testing in NiTi instruments with reciprocating motion.[21]

CONCLUSION

Within the limitations of the present in-vitro study, it can be concluded that the Twisted Files show better resilience than the Wave One files in terms of plastic deformation, micro-cracks, fractures, large crater, disruption of the cutting edges and blunt edges. The highest value in defects was shown by the Wave One Files.

The presence of plastic deformation and micro-cracks typically indicates weak resistance and the rapid propagation of the cracks, resulting in their fracture.

Based on these results, it can be concluded that Twisted Files exhibit better defect resistance to Wave One Files.

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