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The effects of canal preparation by different NiTi rotary instruments and reciprocating WaveOne file on the incidence of dentinal defects

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Abstract

The purpose of this study was to compare dentinal defect formation while using hand files (HFs), two brands of nickel-titanium (NiTi) rotary files and the WaveOne file. Eighty mandibular first molars were selected and divided into 4 groups. Hand file (HFs), WaveOne reciprocating file (WO), EndoSequence file (ES), ProTaper file (PT), were used to prepare the 2 mesial canals. Roots were then sectioned 3, 6, and 9 mm from the apex, and the cut surface was observed under a microscope and checked for the presence of dentinal defects. HF group showed the lowest percentages of dentinal defects (5%). In roots prepared with the WO, ES, and PT, dentinal defects were observed in 25%, 10%, and 50% of teeth, respectively. There was a significant difference between HFs group and both of WO group and PT group ($P < 0.05$). However, no significant difference was found between HFs group and ES group ($P \geq 0.05$). Also a non significant difference was found between WO group and ES group ($P \geq 0.05$). All rotary files created defects in the root dentin, whereas hand instrumentation presented with satisfactory results.

Keywords: Dentinal defects, NiTi instruments, root canal preparations, WaveOne file, vertical root fracture

Introduction

Biomechanical preparation of root canals is one of the main steps in achieving endodontic success due to enabling bacterial elimination, removal of debris, and facilitating obturation[(1)]. Perforations, canal transportation, ledge and zip formation [(2)], and separation of instruments [(3)] are some of the complications encountered during root canal preparation and retreatment cases. Vertical root fracture and crack formation can also be seen in root dentin during and after endodontic procedures.

Vertical root fracture is one of the frustrating complications of root canal treatment, which often results in tooth extraction [(4)]. The root fracture might occur as result of a microcrack or craze line that propagates with repeated stress application by occlusal forces. Bier et al., [(5)] showed dentinal damage (microcracks) in teeth that were prepared with several nickel-titanium (NiTi) rotary instruments with the exception of S-Apex rotary files. They found the highest defect ratio when ProTaper was used, whereas no defect was observed with hand files. It has been shown that root canal filling procedures could also create cracks [(6)]. Shemesh et al [(7)] observed significantly more dentinal defects (microcracks) in teeth that were obturated with spreader

than when no spreader was used. Retreatment procedures, biomechanical preparation, and obturation techniques could all lead to dentinal damage in different degrees.

In the last decades, many generations of NiTi rotary instruments have been developed and introduced by various manufacturers. Light speed system considers the first generation of NiTi rotary file. The next generation of rotary files (2nd generation) were those files that had radial lands (ex: ProFile, GT, Quantec). ProTaper and Race both of these files are considered third generation due to their lack of radial lands and their individual attempts at addressing increased cutting efficiency [8].

The introduction of the forth generation rotary file begins with EndoSequence file which based on precision and simplicity that adheres to the conventional length of the cutting flutes, 16mm and to larger tapers, .04 and .06 to be used in crown-down approach. EndoSequence files have a unique longitudinal design called alternating contact point (ACP) that reduce torque requirements and keep the file centered in the canal. The surface quality of the file has been modified by electropolishing[8].

Most clinicians prefer these systems because of their advantages such as saving time [9] and better cutting efficiency [10]. Nevertheless, some functions of NiTi rotary systems such as cleaning ability, increased stress, and the inability to adequately prepare oval canals are still controversial. Additionally, Kim et al [11] have found a potential relationship between the design of NiTi instruments and the incidence of vertical root fractures. They concluded that file design affected apical stress and strain concentrations during root canal instrumentation.

Recently, the WaveOne reciprocating system was introduced into the NiTi instrument family with a new design. WaveOne is a single-file shaping technique, regardless of the length, diameter, or curvature of any given canal. The three WaveOne instrument, are termed small (yellow 21/06), primary (red 25/08) and large (black 40/08), the small file has a fixed taper of 6% over it is active portion, the primary and the large WaveOne files have fixed tapers of 8% from D1-D3, where as from D4-D16, they have a unique progressive decrease percentage design[12]. No previous studies evaluate the incidence of dentinal defects in WaveOne file. The purpose of the present study was to compare the dentinal microcrack formation while using hand files, different brands of NiTi rotary files, and the WaveOne file.

Materials and Methods

Eighty mandibular first molars were selected and stored in purified filtered water. Roots with angles of curvature ranging between 10^0 and 20^0 (moderate curvatures) were selected. The coronal portions and distal roots of all teeth were removed by using a diamond coated bur with water cooling, leaving roots approximately 10 mm in length. All roots were inspected with transmitted light and stereomicroscopy under 12X magnification to detect any preexisting craze lines or cracks. Teeth with such findings were excluded from the study and replaced by similar teeth. A silicon impression material was used for coating the cemental surface of roots to simulate periodontal ligament space. Then, all roots were embedded in acrylic blocks. Canal patency was established with a #15 K-File (Dentsply, Maillefer, Switzerland) in

both mesiobuccal and mesiolingual canals.

Eighty teeth were divided into 4 experimental groups (n=20) according to the instrument system that used for preparation.

Canal preparation:

Hand file (HFs) group: in this group stainless steel K-file (Dentsply, Maillefer Switzerland,) were used to prepare the canals with step-back technique to master apical file size #30. Then the middle and coronal third were flared four sizes larger the master apical file.

WaveOne file (WO) group: in this group the following sequence of WaveOne reciprocating files (Dentsply, Maillefer, Switzerland) were used to prepare the canals with WaveOne motors and 6:1 reducing handpiece (WaveOne motor was specially engineered and programmed to drive the new WaveOne reciprocating files):

With an estimated working length and in the presence of a viscous chelator, size #10 file was inserted and simply worked within any region of the canal until it was completely loose. The primary 25/08 WaveOne file was used with a gentle apically pressure to allow this instrument to run,2, 3, 4, mm inward with a brushing motion to eliminate interferences, remove internal triangle of dentine. Once the 25/08 file moved to working length, it was removed, and the finished shape was confirmed when the apical flutes of the file were loaded with dentin and size #30 file was snug the working length[12].

EndoSequence file (ES) group: in this group the canal were prepared with EndoSequence files as follow:

The root canals were prepared with Crown-Down technique to Master apical file size#30 using 0.04 taper EndoSequence nickel-titanium rotary instruments (Real World Endo, Brasseler USA, Savannah, G). The root canal was first flooded with 2.5% NaOCL solution delivered with needle tip placed passively into the canal without binding. Instrumentation started with the ‘‘expeditor’’ instrument at 500 rpm and 1.2 Nc torque. The instrument was inserted until up to two thirds of the working length. After that, the size #30/.04 instrument was used, successively followed by instruments size #25 which opened up the coronal half of the root canal system[13, 14]. Then size #20, and #15 used in straight crown down fashion to full working length. A light up and down motion was used to advance each file to two or three engagements of dentin. No files were left in the canal for longer than 2 to 3 seconds. Finally, canals were once again instrumented up to the #30/.04 instrument to full working length, completing the EndoSequence procedure [13, 14].

ProTaper file (PT) group: in this group the following sequence of PT (PT, Dentsply Maillefer) rotary NiTi files were used to prepare the canals at 300 rpm:

The Shaping file X was used in coronal enlargement, and S1, S2, F1, F2, and F3 files, which correspond to apical size 30, was used at the working length.

In all groups irrigation was performed with 2.5% sodium hypochlorite between each instrument during the preparations of root canals.

Sectioning and Microscopic Examination:

All roots were sectioned perpendicular to the long axis at 9, 6, and 3 mm from the apex using a

diamond coated saw under water cooling. Digital images of each section were captured at 40X magnification using a digital camera (Olympus,Tokyo, Japan) attached to a Stereomicroscope. Each specimen was checked by 2 operators for the presence of dentinal defects ‘‘No defect’’ was defined as root dentin devoid of any craze lines or microcracks either at the external surface of the root or at the internal surface of the root canal wall. ‘‘Defect’’ was defined if any lines, microcracks, or fractures were present in root dentin [(15)]. A total of 60 sections were examined in each group.

The results were expressed as the number and percentage of roots in each group. The chi-square test was used for statistical analysis of differences between groups.

Results

The percentages of root with defects, in each group are shown in table (1). The HFs group had the lowest number of defects(1/20) followed by; WO (5/20), ES (2/20), and PT had the highest incidence of defects (10/20). Figure(1).

There was a statistically significant difference (P <0.05) between hand file group and WaveOne group. Also there was a significant difference between hand file group and ProTaper group (P <0.05). While there was anon significant difference (P > 0.05) between hand file and EndoSequence group table (2).

Discussion

When NiTi rotary instruments are used, a rotational force is applied to root canal walls. Thus, they can create microcracks or craze lines in root dentin. The extent of such a defect formation may be related to the tip design, cross-section geometry, constant or progressive taper type, constant or variable pitch, and flute form[(5)]. The present study was aimed to compare the extent to which different NiTi rotary instruments, HFs, and WavOne files induce dentinal damage in the form of microcracks in root dentin[(5)].

Resistance to tooth fracture is an important aim in endodontics because such fractures may decrease the long-term survival rate. Experimental studies have shown that excessive removal of dentin during root canal preparation, post space preparation, and obturation procedures with spreader can create fractures in teeth [(16, 15)].

Only one dentinal defect was observed with HFs group in comparing to other NiTi rotary instruments. Significantly more rotations in the canal are necessary to complete a preparation with rotary NiTi files as compared with HFs [(17)]. This, in itself, may contribute to the formation of dentinal defects. Additionally, it has been suggested that the total volume of dentin removed from the root canals was significantly greater with NiTi rotary systems in comparison with hand files, which implicates more problems that might affect prognostic stability of the teeth, but HFs’ cleaning ability and inefficiency in preparing canals are still controversial [(18)].

With ES group only (2/20) cases showed dentinal defect with no significance difference with HFs group. Kim et al [(11)] suggested that file design affected apical stress and strain concentrations during instrumentation, which were linked to an increase in dentinal defects and canal deviations.

The basic design of ES file is that of a reamer, not a file, and designed in such away that there are alternate contact points (ACPs) along the shank of the instrument. These designs not

only keep the file centered in the canal, but also decrease the contact area with the canal wall as compared to other NiTi rotary instruments used in the study[19,20]. In addition ES file has a non cutting tip that becomes fully engaged 1mm from the tip (D1). This design allows the instrument to be both safe and efficient. The lack of radial lands in this file results in decreased thickness of metal which in-turn increase its flexibility[19].

Although WO files have combined a reveres helix and 2 distinct cross-section (modified convex triangular & convex triangular cross-section), and also have a non cutting modified tips [12]. The incidence of defects in this group is more than the incidence of defects in group ES (5/20) (2/20) respectively which none significantly.

This may be attributed that the use of primary size file #25 with greater tapering .08 after using size # 10 file with .02 tapering may result in such defect that result from the differences of tapering between 25/08 and 10/02 files. Moreover in ES group constant and moderate taper files (.04) were used, they believed that preparing canal with a constant tapering file result in less dentinal defects [19].

The highest incidence of defects was shown in PT group, with 2 cases of complete fracture. The high level of stiffness of the PT may be explained by a larger cross-section because of its progressive taper [21]. Furthermore the progressive tapering of PT instrument results in excessive removal of dentinal wall, which in turn result in weakening of instrumented root.

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Table(1): Number and percentages of roots with defect in each group

	Group HFs		Group WO		Group ES		Group PT	
	No.	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Defect	1	5.0	5	25.0	2	10.0	10	50.0
No defect	19	95.0	15	75.0	18	90.0	10	50.0
Total	20	100	20	100	20	100	20	100

Chi-squire=2.103 p=0.048 P<0.05 Significant

Table(2): Chi-square between groups

Groups	Chi-square	P-value	Sig
HFs&WO	**2.012**	**0.047**	**S**
HFs&ES	**0.078**	**0.879**	**NS**
HFs&PT	**2.324**	**0.042**	**S**
WO&ES	**1.873**	**0.098**	**NS**
WO&PT	**2.224**	**0.041**	**S**
ES& PT	**2.387**	**0.043**	**S**

S: Significant P<0.05 NS: Non significant P ≥ 0.05

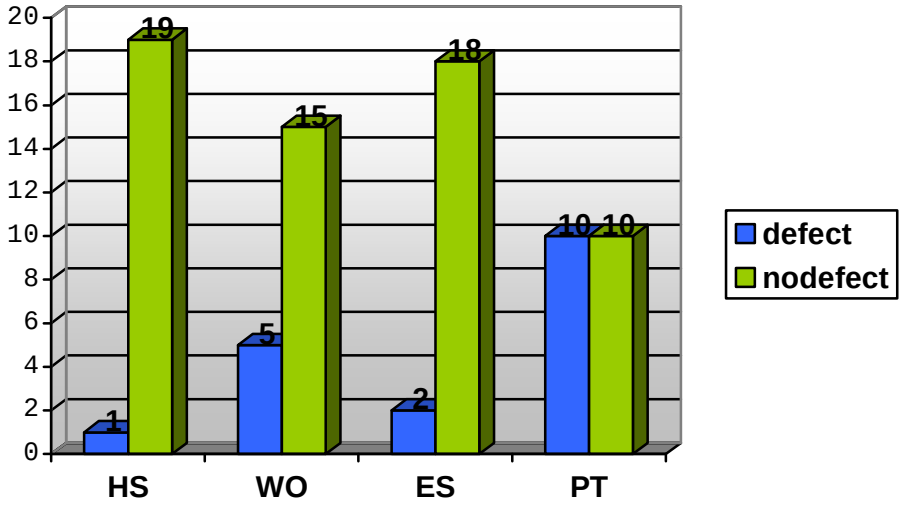

Fig.(1): Barchart present the No. of root defect in each group