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A Stereomicroscopic Analysis of Dentinal Micro Cracks after Root Canal Preparation Using Four Different Rotary Instruments

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Abstract

A variety of single-engine driven files and kinematics have been introduced to improve the clinical performance of NiTi rotary files. The purpose of this in vitro study was to measure and compare the incidence of dentinal defects after root canal preparation with different single file systems.

Keywords*: Root canal preparations, Root canal instrumentation, Tooth cracks*

Introduction

During and after chemomechanical root canal preparation with rotary instruments that aimed to remove infected soft and hard tissue through the enlarged root canal; [1] the root canal wall can be harmed with the development of dentinal defects in the form of dentinal cracks or craze line which serves as localized sites of increased stress. [2]

Through the application of repeated tension via occlusal forces or when further clinical procedures are required such as post placement, these dentinal defects may have the potential to develop into vertical root fracture (VRF)[3,4 ,5].

Most shaping systems are categorized as to whether the file has active or passive cutting edges, a fixed or variable taper along its active portion, or a more traditional or unique cross-sectional design [6]. In addition to that whether the file has benefited from heat treatment that improves flexibility and the resistance to cyclic fatigue [7]. Also described whether it has a centered or offset mass of rotation, works with a rotary or reciprocation, whether the clockwise (CW) and counter clockwise (CCW) angles are equal or unequal [8,9,10]. A single file technique in conjunction with a novel reciprocating movement of unequal bidirectional angles that complete a full forward rotation of 360 degrees after four 90-degree cutting cycles of reciprocation can start and fully complete the preparation of a canal to a perfect shape [11].

It operates at 350 rpm speed in 170ºCCW and 50ºCW direction and completes 360º, torque 5 Ncm in 3 cycles, also it has parallelogram cross-section with two cutting edges at apical end [12].

F 6 Sky Taper (Komet Brasseler GmbH and Co., Lemgo, Germany) is a NiTi system that performes root canal treatment with continuous clockwise rotation, speed 300 rpm and torque 2.2 Ncm. It is available in five different sizes (20, 25, 30, 35 and 40) with a constant taper of 0.06 with S-shape section [13].

When using this instrument alone. It performs root canal preparation with continuous rotation at speed 800 rpm and torque 1 Ncm [14].

AF Blue R3 (Shanghai Fanta Dental Materials Co., Ltd) is a rotary AF- R wire- 3- files- system suitable for curved canals, it performs root canal preparation with a reciprocating motion. It operates at 300 rpm speed, torque 2.6 Ncm in 150ºCCW and 30 º CW direction with 06 taper design and improved file flexibility while still retaining the cutting efficiency [15].

Root sectioning at different levels and inspection through a digital stereomicroscope allows direct inspection of dentinal defects on the root surface and provides information regarding the extension pattern and direction of cracks [16, 17].

To the best of our knowledge, little information has been found regarding the incidence of dentinal defects

resulting from the use of AF Blue R3, and F6 Sky Taper systems. Thus, the purpose of this study was to measure and compare the incidence of dentinal root defects after root canal shaping with four automated file systems: Wave One Gold, AF Blue R3, F6 Sky Taper and XP-Endo Shaper. The null hypothesis was that there would be no significant difference in dentinal defects amongst the studied groups.

Materials and Method

Seventy-five freshly extracted human mandibular premolars with approximately similar bucco-lingual and mesio-distal. The teeth were disinfected in a 0.1% thymol solution at room temperature for 24 h and were kept in purified filtered water until they were used [19]. Savannah, GA USA) under copious water coolant approximately 17mm from the apex to the facial CEJ [20]. The patency of the canal was ensured before and after instrumentation [21]. All the roots were imbedded in its simulated socket in impression materials [22].

Seventy-five root samples were randomly divided into five groups.

Group I: Specimens were instrumented by Wave One Gold (25 \ 0.07), length 25mm in a reciprocating movement.

Group II: Specimens were instrumented by AF Blue R3 (25\0.06), length 25 mm in a reciprocating movement using endodontic micromotor (speed: 300rpm and torque: 2.6 Ncm).

Group III: Specimens were instrumented by F6 Sky Taper (25\0.06), length 25 mm in a rotation movement at WL with gentle in-and out- motion using endodontic micromotor (speed: 300rpm, torque: 2.2Ncm).

Group IV: Specimens were instrumented by XP-Endo Shaper (30\0.04), length 25 mm in a rotation movement at WL with gentle in-and out- motion using endodontic micromotor (speed: 800 rpm, torque: 1Ncm).

Group V: Specimens without instrumentation (control group).

The glide path was performed using size #15 K-file (DentsplyMaillefer) up to the working length.. A total amount 12 ml of 1% NaOCl was used per canal [23, 24].

A final flush of 5 ml of distilled water was administered to the prepared specimens to remove the remnant debris and irrigating solutions inside each canal. All root canals were dried with a sterile paper points to ensure that a complete instrumentation was achieved [25].

All the root samples were sectioned perpendicularly to the long axis in 3, 6, and 9 mm slices from the root apex [26, 27] using diamond disc (0.1 mm) under water cooling to avoid heating and to minimize smearing [28].

''Defect'' was defined if any craze lines, microcracks, or fractures were present in root dentin or extending to outer root surface [18].

Results

Table 1 : The distribution of incidence of dental defects by the experimental groups at each level (apical, middle, and coronal) is shown in Table (1).

Total group	Status	Apical level(3mm)		Middle level (6mm)		Coronal level (9mm)	
		No.	%	No.	%	No.	%
Group I (Wave One Gold)	Defects	6	40%	4	26.67%	2	13.33
	No defects	9	60%	11	73.33%	13	86.67%
	Total	15	100%	15	100%	15	100%
Group II (AF Blue R3)	Defects	2	13.33%	1	6.67%	1	6.67%
	No defects	13	86.67%	14	93.33%	14	93.33%
	Total	15	100%	15	100%	15	100%
Group III (F6 SkyTaper)	Defects	5	33.33%	3	20%	2	13.33%
	No defects	10	66.67%	12	80%	13	86.67%
	Total	15	100%	15	100%	15	100%

Group IV (XP- Endo Shaper)	Defect	1	6.67%	1	6.67%	0	0%
	No defects	14	93.33%	14	93.33%	15	100%
	Total	15	100%	15	100%	15	100%

Table (1): Number and percentage of dentinal defects by the experimental groups at each level (n=15)

Table (2): Chi-Square test for the incidence of dentinal defects among different groups at the apical level (3mm). p>0.05 Non-Significant (NS), p<= 0.05 Significant (S)

Groups	Defect	No Defect	Total	Chi-Square test	d.f.	P-value	Sig
Wave One gold	6	9	15				
AF Blue R3	2	13	15				
F6 SkyTaper	5	10	15	11.77	4	0.02	S
XP-EndoShaper	1	14	15				
Control	0	15	15				

Table (3): Chi-Square test for the incidence of dentinal defects among different groups at the middle level (6mm)

Groups	Defect	No Defect	Total	Chi-Square test	d.f.	P-value	Sig
Wave One gold	4	11	15				
AF Blue R3	1	14	15				
F6 SkyTaper	3	12	15	6.818	4	0.211	NS
XP-EndoShaper	1	14	15				
Control	0	15	15				

Table (4): Chi-Square test for the incidence of dentinal defects among different groups at the coronal level (9mm)

Groups	Defect	No Defect	Total	Chi-Square test	d.f.	P-value	Sig
Wave One gold	2	13	15				
AF Blue R3	1	14	15				
F6 SkyTaper	2	13	15	4.285	4	0.404	NS
XP-EndoShaper	0	15	15				
Control	0	15	15				

Table (5): Chi-Square test for the incidence of dentinal defects among different level of Wave One Gold group

Wave one cold	Defect	No Defect	Total	Chi-Square Test	d.f.	p-Value	sig
Apical level	6	9	15	2.727	2	0.27	NS
Middle level	4	11	15				
Coronal level	2	13	15				

Discussion

During the root canal instrumentation using engine driven instruments, high stress concentration in the wall of the root canal system is applied. This may increase the risk of dentinal damage predisposing the tooth to vertical root fracture [29].

Dentinal defects and then root cracking are a complex procedure because it is affected by many factors such as the design feature of the file used and its kinematics in addition to the alloy from which the instrument was manufactured. Since the primary aim of chemomechanical root canal preparation is to decrease the bacterial load and prepare the root canal for obturation, at the same time; the preservation of tooth structure and increase its resistance to fracture that lead to a long-term survival rate to the tooth [30]. The length of the canal and lower overall stresses, also to facilitate comparison of the results with several previous studies in which similar teeth had been used [27,31].

Adorno *et al*., found that apical cracks occurred in 50% of mandibular premolars after root canal preparation [32].

The teeth samples were selected from young adult patients because aging result in changes in the dentinal microstructure which in turn change the mechanical behavior of dentin resulting in average reduction of its strength predisposing it to crack growth and dentinal defects [33], [34].Unlike the use of SEM that requires section treatment which may change the actual status of the tissue [35].

Although high resolution micro CT scans method is conservative and non-destructive, it is a complex procedure that lasts for an hour or more, this may increase dehydration of the samples resulting in spontaneous cracks in dentin [36].

The control group after sectioning was not shows any dentinal defects. This finding comes in line with several studies [4, 18].

The largest number of dentinal defects promoted by Wave One Gold instruments may be related to its high level of flexibility due to the heat treatment of NiTi alloy and its parallelogram-shaped cross section [37]. During root canal preparation [40], which agrees with previous reports [16, 18].However; reciprocating movement could prevent the continuous rotary force and constant torque that are applied to the walls of the canal [41].

The occurrence of dentinal defects is independent on the kind of the instrument used. The experimental groups varied in their design, cross section, tip design and taper but similar only in size (#25) of the tip, therefore; the null hypothesis of the present study has been partially accepted.

Conclusions

Within the scope of this *in vitro* study, it can be concluded that Wave One Gold system generated the significantly higher incidence of dentinal defects in mandibular premolarscompare to the other tested file systems. While XP-EndoShaper system generates the lowest incident of defects in the rotating file systems compare to F6 SkyTaper file systems. The highest incidence was at the apical level in all of the tested groups. Additional researches may be required to assess these instruments on crack propagation and the fracture

resistance of the root canal treated teeth.

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Ethical Clearance – Not required

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