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ASSESSMENT OF CLEANING ABILITY OF TWO ROTARY FILES IN DIFFERENT MOTIONS: A SEM VITRO STUDY

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ABSTRACT

Introduction: Adequate cleaning and shaping is mandatory to achieve successful endodontic treatment. Smear layer is formed because of dentin cutting and consists of pulp tissue remnants, dentin chips and bacteria which must be removed before root canal obturation. Continuous improvement in Ni-Ti rotary instrument is crucial to decrease the working time, cost and provide safer shaping process. **Aim:** This study meant to evaluate the cleaning action of AF F-One blue and RECIPROC blue files to eliminate smear layer using Scanning-Electron Microscope. **Materials and Methods:** This study was conducted on 60 Disto-buccal root canals of extracted human permanent maxillary molars. Roots were prepared using RECIPROC blue file in half the samples and AF-F one blue file in the other half, roots were then divided vertically and examined using scanning electron microscope then scores were recorded using Hulsman scoring system, the mean number of both groups was tested using Mann–Whitney U-tests at significant levels of 0.05 (P value ≤0.05). The existence of smear layer in both groups was compared by chi-square test. **Results:** No significant difference was detected between the two systems concerning root canal cleanliness according to the Mann-Whitney statistical test **(P>0.05)**. **Conclusion:** The new flat sided design file AF F-One blue seems to be a promising rotary file system but need further in-vivo studies with larger sample size.

INTRODUCTION

Throughout years, various instruments were developed to facilitate the shaping process, from hand carbon steel files to stainless steel files to Nickel titanium (NiTi) files and eventually rotary files were invented to start a new era in shaping process [(1)].

NiTi files undergo different variations such as different heat treatment conditions, changing the metallurgical properties of the instrument, geometric adjustments (changing the cross-sectional form, taper, pitch measurement), operational settings and manufacturing circumstances to change its mechanical properties to be more convenient for daily use in different situations during root canal treatment [(2,3)].

Another technique to increase safety and performance of NiTi instruments is using it in a reciprocating action. The usage of files in

reciprocating movement with uneven forward and backward rotation was announced in 2008 [4].

RECIPROC blue (VDW GmbH, Munich, Germany) is a single file for the root canal preparation, it is used in reciprocating motion, it has S-shape cross section with a non-cutting tip and two cutting ends [2]. When comparing RECIPROC Blue to conventional M-wire RECIPROC, RECIPROC Blue showed enhanced all-around performance regarding microhardness, resistance to fatigue and flexibility [5,6].

RECIPROC blue file receives specific heat treatment producing a delicate titanium oxide surface layer which is blue in color and having a small range of transition temperature. The back conversion to austenite while heating is nearly done at the body temperature (37 °C) [7].

One more innovative NiTi rotary instrument that is similarly thermally treated has been introduced, the AF F-One blue file (Eighteeth, Changzhou, China), The AF F-One is a single-file system and represents a novel heat-treated wire called AF-R wire, which ensures more cutting efficiency and greater torsional resistance and cyclic fatigue than other NiTi files. It also has a flat sided design, S-shaped cross section, two active cutting spots, and a non-cutting end. This file was designed to be used in rotational movement [8].

Researchers claimed that the new design provide more cutting efficiency, in which the debris can escape from flutes away to the safe- side area via the vertical blades, and later outside the canal, providing less accumulation of debris around the file and more debris removal during instrumentation. AF F-One file is also claimed to promote more efficient cutting and less stress subjected on the file, so decreasing the chance of file separation. The flat side-cut design also is believed to offer more room for irrigation solutions during instrumentation and decrease contact among the canal walls and the file, which offers less stress subjected on the file [9,10].

Smear layer is formed because of dentin cutting regardless of the type of instrument used [11]. the smear layer is densely packaged inside the dentinal tubules because of rotary instrument and may reach a depth of 40 μm and hence, it is advised to try to eliminate this smear layer prior to processing to the root canal filling and obturation [12,13].

Up to our knowledge, no previous studies analyzed the efficiency of AF F-One file in cleaning the root canals. Thus, the goal of the concurrent study was to evaluate the cleaning ability of AF F-One in comparison to RECIPROC blue files using Scanning Electron Microscopy (SEM).

The null hypothesis was that no significant difference between AF F-One or RECIPROC blue files regarding cleaning ability and the smear layer formation.

MATERIALS AND METHODS

This study was waived from The Research Ethical Committee, Faculty of Dentistry, Suez Canal University (number: 287/2020).

I. Sample size calculation:

Sample size calculation was completed using G*Power version 3.1.9.2 [14]. The effect size was 0.45 using alpha (α) level of 0.05 and Beta (β) level of 0.05, i.e., power = 80%; the approximate least sample size (n) was a sum of 60 samples.

II. Collection of samples:

The study was performed on extracted unidentified human maxillary molars; Teeth were

examined under magnifying loupes (3.5x) to exclude any cracks restricting to these inclusion and exclusion criteria:

The inclusion criteria include none-fused roots**,** separate distobuccal canals (Vertucci type I) with root curvature ranged from 10-25° (The curvature was evaluated using Schneider's method where teeth were radiographed first to assess canal morphology) [15], mature root and patent canal. **The exclusion criteria are** teeth having root resorption (external or internal), root caries, previous root canal treatment and any signs of cracks.

III. Randomization, allocation concealment and blinding:

A. The samples were numbered from 1-60.

B. Then samples were randomly assigned by the allocator into two groups, each with 30 samples using Microsoft Excel 365 (Microsoft, Redmond, WA, USA) and each file was coded A or B.

Group 1: AF F-One blue 25#6, **Group 2**: RECIPROC blue R25

C. The coded samples were sealed in an opaque envelope.

D. The operator was blinded for the coded samples but not for the files used. The observer who measured the data using SEM and the analyst who performed the statistical analysis were blinded.

IV. Canal preparation:

The teeth were collected and cleaned from any debris using a gauze soaked in saline then stored in distilled water until the time of use. All teeth were decoronated at right angles to the vertical axis at 3 mm above the proximal cemento-enamel junction to ensure standardization and straight-line access using a diamond bur accompanied with water cooling. The mesial and palatal roots were then sectioned. Lengths of the remaining roots were standardized to be 12 mm, Roots were fixed into elastomeric impression material and acrylic resin mold to imitate the periodontal ligament [16].

Canal preparation was held out by one operator (A.R) to maintain the uniformity. Apical patency was first ensured using Size 10 K-file (Dentsply Sirona, Charlotte, USA) which moved just outside the root apex, afterwards, 1 mm was deducted from this measurement to determine the working length (WL). Endodontic electric motor for rotary and reciprocating files E-connect S endomotor (Eighteeth, Changzhou, China) was used. The 60 samples were split up equally into 2 groups (n = 30) according to instrumentation systems used for root preparation as follows:

Group 1: AF F-One blue 25 with 0.25 mm tip diameter and 6% taper was used in continuous rotation at speed 500 rpm and torque 2.6 N with a balanced in and out brushing motion to reach the established working length.

Group 2: RECIPROC blue R25 with 0.25 mm tip diameter and 8% taper at the first 3mm followed by 6% continuous taper from D3 to D16 was used in a reciprocation mode with 150° in counterclockwise then 30° in clockwise direction at a speed of 300 rpm and torque 2 N, the instrument was used for 3 pecking motion then removed from the canal.

After each use, the file was removed from the canal, and flutes were cleaned from debris using gauze. Each canal was irrigated by 20 ml Sodium hypochlorite (NaOCl) 5.25% (Prevest dentpro, Mumbai, India) between pecking motions using side vented needle (Eighteeth, Changzhou, China)

gauge 30 (to 2-3 mm from the established working length). Then, after reaching the full working length a rinse using 5ml 17% EDTA (Prevest dentpro, Mumbai, India) followed by a final irrigation with 5ml of saline solution (Al mottahedon pharma, Cairo, Egypt) was done [8-17].

The samples were split in longitudinal direction immediately after preparation using a chisel by making longitudinal grooves on the facial and lingual sides of the prepared teeth using a rotating disc with low-speed motor (SAESHIN, Daegu, Korea) [18].

V. Scanning electron microscopic evaluation (SEM):

The samples were first scanned using SEM (FEI company, Eindhoven, Netherlands) for estimation of the existence of smear layer. Representative sections at a magnification of 2,000× for the apical third of the canal was recorded. The images of the most representative area were stored in digital form. The cleaning ability of the files at the canal apical third were estimated by two endodontic examiners independently and blindly from the images, using the debris and smear layer score systems established by **Hulsmann *et al.*** [19] as follows:

- Score 1: Dentinal tubules (Dt) are open with no smear layer.
- Score 2: some Dt are open with small amount of smear layer.
- Score 3: only a few Dt are open with homogenous smear layer covering the root canal wall.
- Score 4: no open Dt with complete root canal wall covered by a homogenous smear layer.
- Score 5: non-homogenous, thick smear layer covering the complete root canal wall.

Statistical analysis:

Statistical evaluation was done using the computer program SPSS software for windows version 22.0 (Statistical Package for Social Science, Armonk, NY: IBM Corp) at significant levels of 0.05 (P Value ≤0.05). Mann-Whitney and Chi Square statistical tests were used in this study to compare study groups [20], Inter-observers' reliability analysis was performed for the examiners to assess their results agreement using Cronbach's alpha and Inter Class Correlation (ICC).

RESULTS

1. Inter-observers' reliability analysis

Regarding SEM scoring, in AF F-One blue file; a mean value of 2.40 and 2.33 of observers 1 and 2, with Cronbach's alpha of 0.869 and Inter Class Correlation of 0.811 with a statistically significant high reliability between the two observers indicating a high agreement between the observers. Furthermore, in RECIPROC blue file, the overall mean values of observers 1 and 2 was 3.00 and 2.47, with a Cronbach's alpha of 0.912 and ICC of 0.912 with a statistically significant high reliability between the two observers indicating a firm agreement between the observers shown in **Table 1.**

Table (1) *Inter-observer agreement using reliability analysis and ICC of SEM scoring.*

SEM Scores	Observers	Mean	Intra-observer agreement		Significance
			Cronbach's alpha	ICC	
AF F-One blue	1	2.40	0.869	0.811	<0.001***
	2	2.33			
RECIPROC blue	1	3.00	0.912	0.912	<0.001***
	2	2.47			

2. Smear layer Scores using SEM:

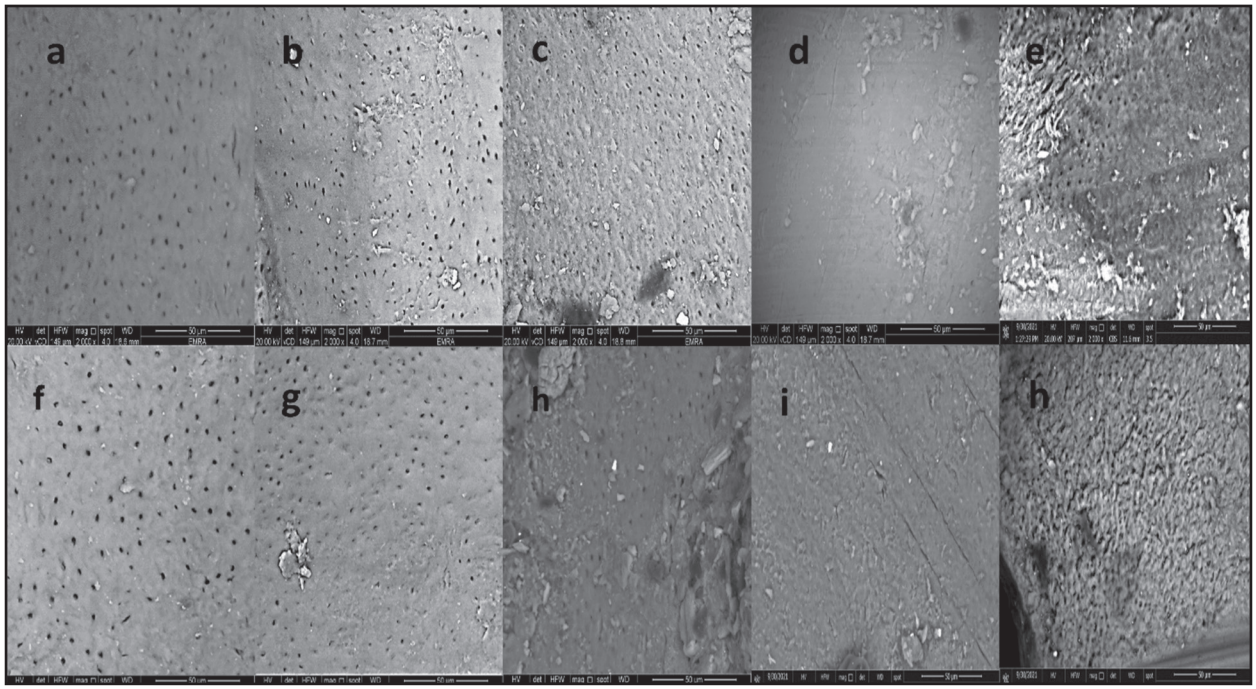

Fig. (1) Representative SEM microphotograph(magnification2000x) for the apical third of the canals prepared by a: AF F-One blue file with score (1). b: AF F-One blue file with score (2). c: AF F-One blue file with score (3). d: AF F-One blue file with score (4). e: AF F-One blue file with score (5). f: RECIPROC blue file with score (1). g: RECIPROC blue file with score (2). h: RECIPROC blue file with score (3). i: RECIPROC blue file with score (4). l: RECIPROC blue file with score (5). Scale bar: 50μm.

Table (2) *Comparison of smear layer removal scores using Mann-Whitney statistical test and frequency of each score using Chi Square statistical test between AF F-One blue and RECIPROC blue at significant levels of 0.05 (P Value ≤0.05):*

Scores		AF F-One blue		RECIPROC blue		Chi-square	
		score	frequency	score	frequency		
		N	%	N	%	Chi	Sign.
Scores	1	6	20	4	13.3	3.799	>0.05 ns
	2	12	40	13	43.3		
	3	8	26.7	5	16.7		
	4	3	10	3	10.0		
	5	1	3.3	5	16.7		
	Total	30	100	30	100.0		
Mann-Whitney U	P value	392					
	Sign.	>0.05 ns					

As seen in **Figure 1** and **Table 2**, the obtained results indicate that the smear layer induced by AF F-One blue file was most frequently assessed as score 2 (40%) followed by score 3 (26.7%), score 1 (20%), score 4 (10%), and score 5 (3.3%).

But the smear layer induced by RECIPROC blue file was most often rated as score 2 (43.3%) followed by score 3 (16.7%) and score 5 (20%) then score 1 (13.3%) and score 3 (10%).

Regarding, the comparison in smear layer scoring between AF F-One blue and RECIPROC blue files **Figure 2**, the mean number of both groups were tested for statistical significance using Mann–Whitney U-tests. The frequency of absence/presence of smear layer in both groups was compared by chi-square test. The comparison showed no statistically significant difference between the two file systems as shown in the **Table (2)**.

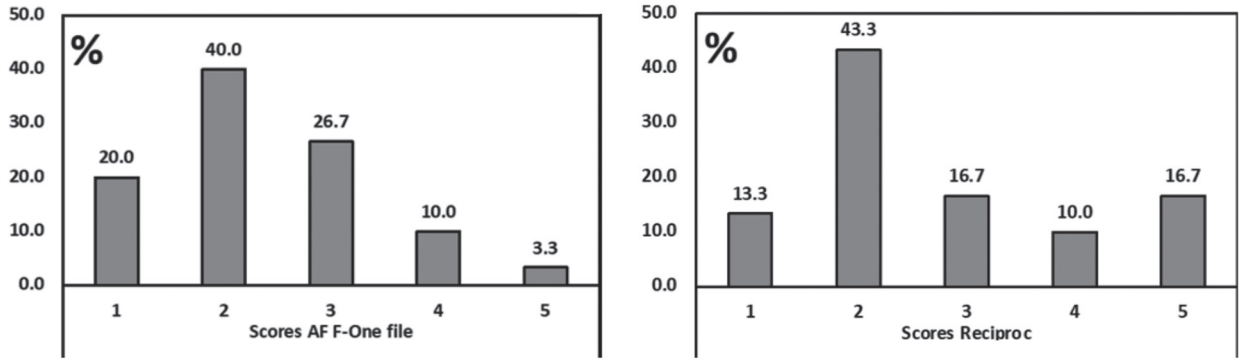

Fig. (2) Bar chart presenting the frequency percentage of smear layer formation using AF F-One blue file and RECIPROC blue file.

DISCUSSION

The purpose of root canal instrumentation is primarily to reduce the microbial load and eliminating pulp tissue remnants. It is well-understood that the shaping movement using endodontic instruments creates a smear layer during root canal preparation, which is packed alongside the dentinal walls in the form of superficial layer and smear plugs. Its elimination permits NaOCl to infiltrate further deeply inside the dentinal tubules, boosting its bactericidal activity. Otherwise, the smear layer might influence the sealing of root canal obturation, hindering adhesion of sealers to the canal walls [21]. Efficient canal cleaning is hard to attain, the cleaning quality is diminished starting from the coronal to the apical part which has the greatest smear layer accumulation. This was attributed to the inaccessibility and insufficient apical preparation and subsequently, the lesser effect of irrigating solution [22,23].

In the present study, two single file systems (The AF F-One blue file and RECIPROC blue file) were used in different motions; one rotating and the other reciprocating to assess quantitatively smear layer formation (root canal cleanliness) using the scanning electron microscope. Scoring system proposed by Hulsmann *et al*. [19] was used with the same methodology of smear layer detection and evaluation used by previous authors [17,24]. Moreover, inter observer reliability using Cronbach's alpha coefficient and interclass correlation (ICC) were

tested to avoid the subjective nature of the scoring systems and it showed high percentage of observers' agreement.

Sodium hypochlorite and EDTA are used as gold standard irrigant during root canal treatment for the removal of smear layer specifically in the apical one third [24]. Hence, these irrigants are used in our study in the two main groups.

Although the null hypothesis of the current study was maintained, canal walls were noticed to be cleaner after using file with reciprocation in comparison to rotatory files, but this difference was not statistically significant in agreement with some authors [26,27]. However, in another study, when comparing protaper full sequence as rotating file to protaper F2 as reciprocating file, protaper full sequence demonstrated better cleaning ability and smear layer removal [28].

Various studies [26,29] in the literature compared the reciprocating files to the full rotating files in term of root canal cleanliness and smear layer removal. Still, in agreement to our results, both files cannot ensure an entirely cleaned canal with no apparent difference between them. This raises a question about the impact of motion on the smear layer production and the root canal cleanliness.

In the present work, despite having different motions, both file systems have the highest scores as 2 which means that there was a minor quantity of smear layer with some open dentinal tubules. Thus, Fanta AF F-One blue seems to be a promising single file system regarding smear layer removal, though supplementary studies are needed to pass judgment on the newly unique designed file.

A limitation of this study is that the determination of smear layer can only provide an indirect evidence of cleaning ability since *in vitro* conditions may not reflect the *in vivo* accurately,

Considering the limitations of this study we recommend that further studies *in vitro* and *in vivo* are needed on larger sample size to evaluate the effect of the new designed AF-F one blue file on root canal cleaning ability and root canal transportation using μCT. Also, micro- computed tomography assessment of apical microcracks after root canal preparation using AF-F one blue file.

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