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EFFECT OF SELF-ADJUSTING FILE (SAF) VERSUS FANTA AUSTENITE FINISHING FLAT FILE (FAFFF) ON APICAL EXTRUDED DEBRIS IN MANDIBULAR PREMOLARS: IN VITRO STUDY

Abdelkareem Qawasmi*, Sherif ElKhodary** *and* Dina A Morsy***

ABSTRACT

Aim: The aim of this study was to compare the amount of apically extruded debris of (SAF) versus (FAFFF) during mechanical preparation of mandibular premolars.

Methodology: Forty-eight extracted human mandibular premolars with single canals and standardized lengths were instrumented using FAFFF 20 taper 4%. Then samples were randomly divided into 4 groups (n=12 teeth) as follow: ***Group (A)*** Root canals were prepared by SAF (1.5mm) file, ***Group (B)*** Root canals were prepared by SAF size (1.5mm) file, followed by SAF size (2.0mm), ***Group (C)*** Root canals were prepared by (FAFFF) 25 taper 6%, followed by (FAFFF) 35 taper 4% and ***Group (D)*** Root canals were prepared by (FAFFF) 25 taper 6%. Debris extruded during instrumentation were collected into pre-weighed Eppendorf tubes. The Eppendorf tubes were then stored in an incubator at 37°C for 15 days for complete dehydration of extruded debris. Each Eppendorf tube with extruded debris was then weighed three consecutive times to obtain the final weight. Then the average weight of extruded debris was calculated.

Results: Group B (SAF 2.0mm) showed Statistically the highest mean and standard deviation of extruded debris when compared to the other three groups. While, there was no statistically significant difference between group A, C and D.

Conclusion: Under the conditions of this study, all systems caused apical debris extrusion. SAF (2mm) instrumentation was associated with the highest amount of debris extrusion compared to the other groups.

* Master Student Endodontic Department, Faculty of Dentistry, Cairo University, Cairo, Egypt
** Associate Professor, Endodontic Department, Faculty of Dentistry, Cairo University, Cairo Egypt
*** Lecturer of Endodontic Department, Faculty of Dentistry, Cairo University, Cairo, Egypt

INTRODUCTION

Inflammation, postoperative pain and delay of periapical healing are the result of extrusion of debris, like dentin chips, pulp tissue, microorganisms and irrigants into the periradicular tissues during root canal treatment **(Seltzer and Naidorf, 2004)** [(1)]**.**

All instrumentation systems extrude debris beyond the foramen; the amount of debris extruded depends on the preparation technique, diameter of the apical preparation, canal preparation up to the apex, the use of different kinematics (rotation, vibration) and design of the instrument such as radial land, flute depth, different tapers and cross section **(Tanalp and Güngör, 2014)** [(2)]**.**

Currently, there is an ongoing debate comparing rotary and vibration systems, in which some studies concluded that rotary systems extrude more debris than vibration systems **(Kirchhoff *et al.,* 2015)** [(3)] and other studies conclude the opposite **(Farmakis *et al.,* 2016)** [(4)]**.**

Self-Adjusting File (SAF) (ReDent-Nova, Biberach, Germany) is a NiTi (nickel-titanium) instrument composed of a lightly abrasive, vibrating metal lattice encasing a metal mesh that has a scrubbing effect by adapting itself to all types of canal walls, especially oval canals, with a back-and-forth grinding motion. SAF extrudes debris coronally through its irrigation system due to its hollow metal lattice. This is advocated to that it simultaneously performs chemo-mechanical preparation of the root canal space by continuous irrigation with a peristaltic pump **(Metzger, 2014)** [(5)]**.**

Recently, Fanta Austenite Finishing Flat File (FAFFF) (Shanghai Fantal Dental Material, China has been introduced to the market. It is a thermally-treated, NiTi rotary, continuous taper, controlled memory (CM) wire system. It has an S-shaped, flat-sided cross-section, in which one side is flat and the other side has flutes. This design is claimed to reduce blade engagement with dentin walls and reduces stress by sweeping the debris from the flutes to the flat side, which creates a space for debris to be extruded easily by irrigation. **(Pedulla *et al.,* 2019)** [(6)]**.**

Presently, there are no studies comparing SAF to FAFFF on the amount of apically extruded debris in mandibular premolars in terms of taper and kinematics. Therefore, the aim of this *in vitro* study was to compare the amount of debris extrusion of SAF versus FAFFF in mandibular premolars.

MATERIAL & METHODS

The trial was a double blinded study, where the outcome assessor and statistician were blinded during outcome evaluation.

Forty-eight recently extracted human single rooted mandibular premolars after extraction due to periodontal or prosthetic reasons from department of oral & maxillofacial surgery, Faculty of dentistry, Cairo University were collected.

Pre-operative radiograph was taken from Bucco-Lingual & Mesio-Distal aspects to evaluate the internal anatomy & confirm fulfilling eligibility criteria without any complexities or defects.

- The external root surfaces of the selected teeth were cleaned from any hard deposits by an ultrasonic scaler and were immersed in 5.25% sodium hypochlorite (NaOCl) solution for 30 minutes to remove any soft tissue debris that remained on the root surfaces. The prepared teeth were then kept in distilled water until the time of testing.
- The occlusal surface of all teeth was flattened by using low speed diamond stone to obtain 18 mm uniform tooth length.
- Coronal access cavity was accomplished using a round diamond and tapered stone with a round end mounted on a high-speed handpiece.
- K-file#15 was inserted into root to check

patency, then working length was adjusted by subtracting 1mm, so a standardized working length of 17 mm was obtained.

- All samples were prepared by using (FAFFF) # 20 taper 4% under constant speed of 300 rpm and torque of 2.0 Ncm. The FAFFF file was mounted in the rotary handpiece of endo SAF system.

Debris collection setup

A) Pre-weighing of Eppendorf was done according to the method described by **Myers & Montgomery 1991.** A total of 48 Eppendorf tubes were used. Each Eppendorf tube was weighed using a digital microbalance with a precision of 0.00001gm (AT21 comparator; Mettler Toledo, Zurich, Switzerland) to measure the weight for each tube. Three consecutive readings were taken in order to calculate the mean reading for each Eppendorf tube (*Initial Weight*).

B) After teeth preparation, 48 cut Eppendorf tube caps (taken from other Eppendorf tubes) were modified by cutting holes corresponding to the teeth being tested.

C) Each tooth was then inserted tightly into the hole of the modified cap up to the level of the cemento-enamel junction. Furthermore, a 25-gauge needle was inserted alongside the tooth in order to equalize the pressure inside and outside the Eppendorf tube. The discrepancies between the tooth, needle and the hole where sealed using composite resin material

D) Then, the modified cap with the tooth and the needle were inserted into the pre-weighed Eppendorf tube, so that the root hung in the Eppendorf tube without touching the tube.

E) Moreover, the Eppendorf tube with the attached tooth was fitted into a larger dark glass vial to prevent the operator from touching the tube directly and for blinding.

Grouping and canal instrumentation

The samples were randomly divided into 4 groups (n= 12) according to the files used:

Group (A) Root canals in this group were prepared by SAF (1.5mm) file, according to manufacturer's instructions in a transline (in-and-out) vibrating handpiece adapted in an RDT3 head at a frequency of 83.3Hz (5000 vibrations/min) and an amplitude of 0.4 mm. The time spent for the shaping procedure was 4 minutes. Continuous irrigation with distilled water was applied throughout the procedure at a rate of 4 mL/min using an irrigation apparatus (Endostation).

Group (B) Root canals were prepared by SAF size (1.5mm) file, followed by SAF size (2.0mm) according to manufacturer's instructions as mentioned before in group A.

Group (C) Root canals were prepared by (FAFFF) 25 taper 6%, followed by (FAFFF) 35 taper 4% under constant speed of 300 rpm and torque of 2.0 Ncm using a gentle in-and-out motion with an electric and torque-controlled endodontic motor SAF system, also the Irrigation was done using a 30-gauge side vented endodontic irrigation needle using distilled water. During irrigation, the needle was passively inserted 2mm short of the working length before commencing irrigation. The total amount of the irrigant used was 16 ml and the irrigation solution was delivered 2mm short of the working length.

Group (D) Root canals were prepared by (FAFFF) 25 taper 6%, according to manufacturer's instructions as mentioned before in group C.

Debris Collection & processing

- After instrumentation, the modified cap with the attached tooth and the needle were partially removed from the Eppendorf tube using a locking tweezer and the root apex was flushed with 1ml of distilled water then was collected in the Eppendorf tube.

- Following that, the Eppendorf tube was removed from the glass vial and stored in an incubator at 37 ºC for 15 days in order to allow the distilled water to desiccate.
- The Eppendorf tubes were weighed again with the same digital microbalance to obtain the final weight of the tube containing the collected debris (*Final Weight*). Three consecutive readings were taken for each tube in order to calculate the mean value. Then the Initial Weight was subtracted from the Final Weight to obtain the weight of the extruded debris.

Weight of the extruded debris = final weight – initial weight

- All the instrumentation procedures were performed by the practitioner. While evaluation and weighing of the samples were done by independent examiner who was blind with respect to the study.
- All the collected data was tabulated, calculated and statistically analyzed by the statistician who was blind.

Statistical analysis

Mean, standard deviation, median, minimum and maximum values were used for data description. Kruskal Wallis test was used for comparison between the four groups followed by Mann – Whitney U test for pairwise comparison.

The level of significance was set at $p \leq 0.05$.

Statistical analysis was performed using **SPSS software version 25.**

RESULTS

Weight of extruded debris (in gm): (Table 1)

Group B showed the highest mean and standard deviation (SD) weight of debris (14.26 ± 5.67) followed by group A as (7.05 ± 4.21) then group C (3.83 ± 4.23) while the least mean was attributed to group D (4.27 ± 2.76)

There was a statistically significant difference between the amount of debris extrusion in the four groups ($p < 0.001$).

Pairwise comparison:

- **Group A** showed significantly less weight of debris extrusion than **group B** ($p < 0.001$).
- There was no statistically significant difference in debris extrusion between **group A and group C** ($p = 0.065$).
- There was no statistically significant difference in weight of debris extrusion between

Group A and Group D ($p = 0.094$).

- **Group C & D** showed significantly less weight of debris extrusion than **group B** ($p < 0.001$).
- There was no statistically significant difference in the weight of debris extrusion between

group C and group D ($p = 0.326$).

TABLE (1): The results of Mann Whitney U test for pairwise comparison of the weight of extruded debris.

Groups	Mean	SD	P-Value
Group A	0.0070	0.0042	**0.001***
Group B	0.0143	0.0057	
Group A	0.0070	0.0042	**0.065**
Group C	0.0043	0.0028	
Group A	0.0070	0.0042	**0.094**
Group D	0.0038	0.0042	
Group B	0.0143	0.0057	**0.001***
Group C	0.0043	0.0028	
Group B	0.0143	0.0057	**0.001***
Group D	0.0038	0.0042	
Group C	0.0043	0.0028	**0.326**
Group D	0.0038	0.0042	

**Significant at p<0.05*

DISCUSSION

Postoperative pain following endodontic treatment is multifactorial. It remains one of the most challenging aspects for endodontists to avoid. Among the causes of postoperative pain; the inflammatory reaction which occurs by forcing dentin chips and necrotic pulp tissue or microorganisms into the periapical area following instrumentation. **(Seltzer and Naidorf, 2004) [1].**

The amount of debris extruded depends on the preparation technique, diameter of the apical preparation, canal preparation up to the apex, the use of different kinematics (rotation, vibration) and design of the instrument such as radial land, flute depth, different tapers and cross section **(Tanalp and Güngör, 2014) [2].**

SAF system consists of self-adjusting file operated with special RDT handpiece-head and an irrigation pump (the VATEA pump or the all-in one Endostation unit) that delivers a continuous flow of irrigant through the hollow file. The file is built as a lattice-walled cylinder, no central metal core, hollow and compressible NiTi lattice. The file design is a hollow tube, their walls are made from thin Ni-Ti lattice with a rough outer surface, the file has asymmetrical position tip located at the wall of the tube which differs from the conventional Ni-Ti rotary file which has symmetrically central tip **(Hof *et al;* 2010) [7].**

The SAF file is available in two diameters: 1.5 and 2.0 mm. Both are extremely compressible. The 1.5mm-diameter file may be compressed to dimensions similar to those of a size 20 K-file while the 2.0-mm diameter file can be compressed to dimensions similar to those of a size 35 K-file **(Lin, Shen and Haapasalo, 2013) [8].** The flexibility and compressibility of SAF enables the file to adapt to the cross-sectional shape of oval canals mesiodistally and thus spread buccolingually as far as 2.4 mm. Hence, the name self-adjusting file.

The Endostation all-in-one endodontic unit is a compound machine specially designed for SAF using RDT handpiece. The RDT handpiece allows the transformation of the rotation of micro-motor into transline in and out vibration with 0.4 amplitude. The micro-motor operates at 5000 rpm resulting in 5000 vibration/ minutes. The file rotates till engagement inside the root canal where in and out vibration is created by the RDT handpiece **(Metzger *et al.*, 2010) [9].**

FAFFF is a heat-treated CM rotary system. It is characterized by S- shaped flat sided cross section. As claimed by the manufacture, the S-shape and flat design has the advantage of decreasing blades engagement and increase fatigue resistance. Also, it reduces stress by brushing away the debris from the relived area (**Gambarini *et al.,* 2019) [10].** The FAFFF, forces debris coronally instead of extruding it beyond the apex. Their design and motion guides debris toward the canal orifice, packing them onto the flutes of the instrument and forces them outside, thus avoiding their compaction inside the root canal. This characteristic feature makes them efficient in cleaning root canals while avoiding debris extrusion beyond the apex **(Pedullà E, *et al.,* 2019) [6].**

All samples were standardized in length (18mm) and by preparing them to #20/.04 (FAFFF) to eliminate any discrepancies between groups. Moreover, the SAF manufacturer's instructions is to use pre- SAF rotary instrument #20/.04 as SAF has no penetration abilities. Several studies evaluated debris extrusion associated with SAF **(Farmakis *et al.* 2016; Kirchhoff *et al.* 2015 and Vyavahare *et al.* 2016) [4,3,11].** however, none evaluated the SAF without Pre-SAF to evaluate debris extrusion.

In group (C) and (D) of FAFFF; side vented 30-gauge needle was passively inserted 2mm short of the working length for irrigation. This to avoid high apical pressure, thus; decreasing risk of debris extrusion **(Mittal *et al.,* 2015, Silva *et al.,* 2016) [12,13]. Gawdat & Elkhodary[14]** In 2017 demonstrated that; irrigation needle gauge had the greatest influence on debris extrusion and that side vented needle significantly produce less debris extrusion than PUI. Therefore; a 30- gauge side-vented irrigation was used.

Distilled water was used in this study for irrigation in all experimental groups because it has no solvent effect. While the use of NaOCl irrigant leads to sodium crystallization phenomenon which can affect the result of the study **(Koçak *et al.*, 2013; Tanalp and Güngör, 2014; Mendonça *et al.*, 2019)** [15,2,16]**.** Thus, distilled water was used in our study to avoid any possible weight increase due to NaOCl crystal formation and to be certain that, the results of extrusion of debris depends only on mechanical action of the instrument.

The Myers and Montgomery method for evaluation of apically extruded debris was used in this study as was used by previous studies for its efficiency, simplicity and practicality in its evaluation **(Myers and Montgomery, 1991; Brown *et al.,* 1995)** [17,18]**.** This method prevents fingertip contamination because it may alter the weight of the extruded debris significantly.

Eppendorf tubes were stored in an incubator at 37 ºC for 15 days to make certain that there will be no changes in the weight of the tubes which may affect the final results. This is based on the findings of a pilot study by **Elsadat and Refai, 2017**[19]**.** which found that incubation of the tubes at ≥ 50°C for 5 days following other studies **(Bürklein and Schäfer, 2012; Kirchhoff, Fariniuk and Mello, 2015)** [20,3]**.,** resulted in decrease of the tubes' weight when compared to the pre-incubation weight. While, other studies **(Kustarci *et al.*, 2008; Kuştarci, Akpinar and Er, 2008)** [21,22]**,** found no change in weight of the tubes when incubated at 37°C for 15.

According to the results of this study, both SAF and FAFFF resulted in apical debris extrusion. There was no statistically significant difference between group A (SAF 1.5mm) and groups C and D (FAFFF 35.04 and 25.6 respectively) in debris extrusion. While Group B (SAF

2.00 mm) showed statistically the highest amount of apical debris extrusion. Our results are in accordance to the results found by **Kirchhoff *et al.,* 2015**[3]**,** they concluded that SAF was associated with the highest amount of debris extrusion compared to PTN, Wave one, and twisted file adaptive. While, **Koçak *et al.,* 2013**[15] reported no statistical significant difference between ProTaper, SAF, Revo-S and Reciproc. Whereas, **Farmakis *et al.,* 2016**[4]**,** stated that the amount of debris extruded by wave one was 4.4 times greater than that extruded by SAF.

There was a statistically significant difference in Group B (SAF 2.00mm) compared to group A (SAF 1.5mm) in which group B extruded more debris than group A which may be advocated to the use of multiple files in group B. **Kirchoff *et al,* in 2015**[3]**,** stated that multiple file systems have the potential to produce more debris. This result may also be supported by the difference in apical size preparation, as showed by other studies ***(Lambrianidis et al, 2001*; Tinaz *et al,* 2005)** [22.23] where increasing the apical diameter may result in increase in debris extrusion.

There was no statistically significant difference between group A SAF (1.5mm) and groups C and D (FAFFF 25.06 and 35.4) in debris extrusion. This may be due to the absence of cutting edges and flutes in the SAF system and the flat surface of the FAFFF which leads to debris extrusion coronally. FAFFF produced the least amount of debris which could be attributed to the flutes being on only one side of the instrument which may have produced less debris causing more space to direct debris coronally. This is in agreement with **Koçak *et al.,* 2013**[15] who compared SAF with ProTaper, Revo S and Reciproc and concluded that there was no significant difference despite of the difference in instrument design and working principles.

There was a statistically significant difference between group B (SAF 2mm) and group C and D (FAFFF 25.06 and 35.4) in which group B (SAF 2mm) extruded more debris. **Paqut *et al,* 2010**[24] studied the efficacy of shaping oval canals using rotary ProTaper files with circumferential motion and brushing in which 69% of the canal wall was unaffected by the procedure. When SAF was used in similar canals with the same methods, 23% of the canal wall was unaffected by the procedure. The cutting of dentin walls may explain the high amount of debris extrusion in the present study.

Tanalp *et al,* 2014[2]**;** found that, tapering is considered an important factor in debris extrusion. **Aksel *et al,* 2017 and Priyank *et al.,* 2017**[25,26]**,** found that there is no significant difference between taper 4 and 6 on debris extrusion, which is in agreement with the results regarding FAFFF #25 taper 6 and #35 taper 4.

There were statistically significant differences among the groups; where Group B (SAF1.00 mm) showed statistically the highest amount of apical debris extrusion. Therefore, the null hypothesis that there would be no difference among both instrumentation techniques in apical extrusion of debris was rejected. The results of previous studies showed that no instrumentation technique completely avoids debris extrusion, and the present study is in agreement with them. **(De-Deus *et al.*, 2010; Kustarci *et al.*, 2008; Tanalp and Güngör, 2014; Ahn, Kim and Kim, 2016)** [2,21,27,28]**.**

CONCLUSION

Within the limitations of this study, it could be concluded that:

1. All kinematic system produced extruded debris apically.
2. SAF system extruded debris more than FAFFF.
3. Vibration kinematics resulted in more apical debris extrusion than the rotary kinematics

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