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CLEANING ABILITY OF THREE DIFFERENT ROTARY FILES SYSTEMS; (AN IN-VITRO STUDY)

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ABSTRACT

Introduction: Over the past years root canal treatment was done using different systems that uses multiple filing systems and this was a long procedure causing discomfort to both patient and dentist but lately rotary filing systems introduced to the market to provide comfort and saves time.

Aim: Assessment of cleaning effectiveness of (Race) rotary system versus Fanta AF blue S1 and Fanta F1 blue rotary systems, regarding smear layer and debris amount present after mechanical preparation of the root canals.

Methods: The in vitro investigation was performed on a sample of thirty molar teeth , which were chosen and divided randomly and evenly into three groups., Group I (Race), Group II (Fanta AF blue S1) and Group III (Fanta F1 Blue). Access cavity was carried out to all teeth and k- file size 10 was utilized to check the patency of the root canals.

Results: For smear layer as well as debris; Race file system showed better results for all sections than did the Fanta F1 blue and Fanta AF Blue S1 file systems. Fanta F1 blue showed highest values of remaining debris. However, The Fanta AF blue S1 rotary file system demonstrated the most significant creation of smear layer. For Race file system: The race files exhibit elevated levels of smear layer scores. in apical third subsequently, the middle and coronal thirds come after .in addition race files showed higher debris scores in the coronal third ,then middle and lastly in the apical third. For Fanta AF Blue S1 system: Fanta AF blue S1 file system had higher smear layer on the middle third and then come apical and coronal thirds. In addition, the file showed higher debris score in the apical third then the coronal and middle third. For Fanta F1 Blue file system: Fanta F1 Blue file system exhibit elevated levels of smear layer scores on the apical third then comes middle and coronal third at last . In addition: the file showed higher debris score in middle part then the apical third followed by the coronal third.

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Conclusion; Fanta F1 Blue showed highest values of remaining debris during chemo-mechanical preparation. Fanta AF Blue S1 rotary file system exhibited the highest values of smear layer development during chemo-mechanical preparation. The race file system exhibited reduced smear layer and debris generation. Than did the Fanta AF Blue S1 and Fanta Blue F1 during chemo-mechanical preparation along the coronal as well as middle and also the apical thirds.

KEYWORDS: Root canal treatment; Rotary Files; Fanta F1 blue rotary; Fanta AF blue S1; Race rotary

INTRODUCTION

The primary goal of canal preparation is to remove irritants and ensure the preservation of healthy periapical tissues. Preparing the root canals is a crucial step in endodontic treatment. Efforts have consistently been made to find faster, safer, and more effective techniques for preparing root canals. The utilisation of automated Ni-Ti instruments was a rational progression aimed at enhancing effectiveness .of the treatment[1].

Rotary tools has a proclivity to draw debris into their grooves, causing them to be lifted outside of root canal space in the direction towards the crown, so diminishing the amount of material pushed towards the apex[2].

One of the major objectives in endodontic treatment is to eliminate debris as well as smear layer from root canal system before filling it. The smear layer is distinct from the superficial debris pattern since it consists of a layer of muddy material. This material is made up of a disorganised mixture of organic and inorganic debris, and occasionally bacteria. It is formed when endodontic instruments scrape against the dentine walls, causing the material to get compacted. There is a suggestion that the existence of a smear layer might hinder the entry of bacteria into the dentinal tubules beneath it. Conversely, the existence of an infected smear layer can impede the entry of antimicrobial agents into the infected dentinal tubules. Moreover, eliminating the smear layer can improve the seepage of sealer material into the dentinal tubules and the fitting of obturation filling materials to the walls of the root canal[3].

The degree of debris as well as smear layer generation in newly developed NiTi rotary endodontic tools is not well-known[4].

Using instruments alone is insufficient in completely eradicating bacteria from the root canal system, and contemporary rotary instrumentation methods generate a significant amount of smear layer that coats the walls of the root canal. Over the past ten years, numerous nickel -titanium (NiTi) rotary instruments have been introduced. Studies have demonstrated that all NiTi rotating instruments generate a significant amount of smear layer .There are many factors affecting smear layer formation such as rotary file design(helical and rake angle, flute depth, cross section…etc.), file speed as well as file kinematics (rotation and /or reciprocation)[5].

It is widely recognised today that using NiTi instruments in conjuction with chemical materials of cleaning significantly decreases the number of pathogens that are left in the root canal system. Complete elimination of the smear layer enhances the spread of the irrigants and medications throughout the root canal system, leading to better bonding of the filling materials to the dentine of the root canal. This ultimately reduces the leakage of the filling materials at both the apex and the crown of the tooth[6].

AIM OF THE STUDY

The goal of the present study was to compare the cleaning efficiency of multiple versus single file systems, in terms of debris as well as smear layer.

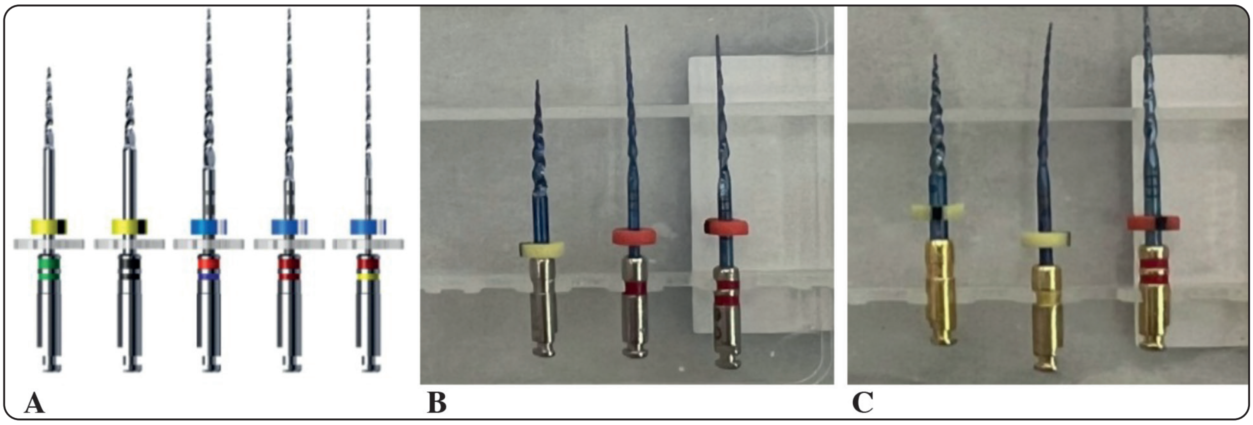

Fig. (1) A) Shows race file system with different tapers. B) Fanta F1 blue file system. C) Fanta AF blue S1file system.

MATERIALS AND METHODS

A-Materials:

1. Race endodontic file system*
2. Fanta F1 blue **
3. Fanta AF Blue S1***

Race endodontic file system: the Race instruments can be used to perform improvisational sequences based on the practitioner's requirements and are also available in prearranged sequences. The packets are available in both aseptic and non-aseptic variants. The Race family of instruments features a distinctive anti-screw-in design with alternately cutting edges, an electro-chemical polish that improves resistance to fatigue and corrosion, enhanced flexibility for navigating the curves of the canal, and an ergonomic safety tip for accurate centering within the canal as shown in **figure 1a.**

Fanta F1 blue & Fanta AF Blue S1: Both files are manufactured using AF-R wire technique exhibiting full rotational motion and obtaining improved resistance to cyclic fatigue and adequate cross section design for a better cutting efficiency. Fanta AF Blue S1 system is supplied with variant sizes 04/20, 04/25, 04/35, 06/20, 06/25, 06/35 while Fanta F[1] blue file has a size of 25/06 as shown in **Figure 1b&c**.

B- Methods:

Thirty fully developed mandibular molars for humans with intact apices as well as straight canals have been obtained from stocks of the endodontics department at faculty of dentistry in Ain-Shams University. All teeth were inspected to discard any teeth having immature roots, cracks resorptions, extensive caries or severe curves.in addition, teeth selected were mature, having moderate curves (20 to 40 degrees) as well as having patent canals without any calcifications.

To decontaminate the teeth, they were all submerged in a solution of sodium hypochlorite at a concentration of 5.25% for a duration of 15 minutes. Additionally, an ultrasonic scaler was used to eliminate any calculus deposits or tissue debris. For all teeth , Conventional access openings were created using a high-speed handpiece and an Endo-access bur.****. Sizes of 10#, 15# K-file***** had been used in each mesiobuccal root- canal to

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** Shanghai Fanta Dental Materials Co. Ltd.

*** Shanghai Fanta Dental Materials Co. Ltd.

**** Dentsuply Maillefer, Ballaigues, Switzerland

***** Mani, Japan

verify its patency. In order to ascertain the precise measurement of the working length the k-file was extended beyond the apex and then retracted until it aligned with the apical foramen. The teeth were evenly and randomly divided into 3 groups. The 16:1 gear reduction handpiece was utilised for all instruments.* powered by a (3.0 n.m. torque) electric motor** at a constant speed of 400 rpm in a vertical position.

Group I was instrumented by Race file system as follows: The race instruments had been employed in a " crown-down way" , following the instructions provided by the manufacturer, with a moderate back-and-forth movement within the mesiobuccal canal. The instruments were removed upon encountering resistance and replaced with the following instrument. The file sequence utilised was as follows : a Pre-RaCe 40/0.1 and then Pre-RaCe 35/0.8 were utilised to prepare the coronal as well as central sections of the canal. The remaining part of canals was enlarged using instruments sized 25/0.02, 25/0.04, and 25/0.06, up to the working length. A 2 ml of 2.5% sodium hypochlorite were used to flush debris after each instrument with an attached # 22 gauge stainless steel needle up to a total volume of 10 ml per tooth. The needle was placed passively inside the canal and reached 1mm shorter than working length.

Group II was instrumented by Fanta F1 blue file system as follows: Fanta F1 blue Orifice opener file 17\0.12 had been used so as to widen root canal orifices of the mesiobuccal canal using gentle in and out motion for 5 mm from the working length in crown-down manner. Then rotary file size 0.25 with taper 0.04% was used in pecking motion till it reach the working length and at last rotary file size 0.25 with taper 0.06 had been used , 2.5% sodium hypochlorite(2 ml) was used to irrigate canals using a needle of" 22 gauge" between instruments.

Group III was prepared by Fanta AF Blue S1 file system as follows: Fanta AF blue S1 Orifice opener file 17\0.12 was utilised to access the root canal opening. of the mesiobuccal canal, using gentle in and out motion for 5 mm from the working length in crown-down manner. Then file size 0.20 with taper 4% was utilised in pecking motion reaching full working length followed by size 0.25 with taper 6%, canals then were thoroughly irrigated with 2.5% of sodium hypochlorite(**2ml)** .

Methods of Evaluation: Following the instrumentation of the groups of all teeth in the groups, each tooth was bisected longitudinally. Subsequently, two longitudinal grooves were created in parallel direction using a slow speed-diamond disc. ***on the external surfaces of the roots without penetrating the root canal. In order to prevent contamination of the canals during the separation procedure, a light plastic instrument was employed as a small chisel to divide the roots into half. Subsequently, each half was positioned onto a square metal plate and secured using double-sided adhesive tape in order to facilitate examination under the scanning electron microscope.****.

For assessment of smear layer, one half of each root was examined after mechanical preparation in both main groups. Smear layer presence was qualitatively evaluated by a scanning electron microscope at three levels: apical , middle , and lastly coronal thirds of the mesiobuccal root canal . The evaluation was done under a magnification power of 1000x. This smear layer within each root canal wall were evaluated scored qualitatively according to the scoring system described by Hülsmann[7].

* NSK, Japan

** Endomate TC2 NSK, Japan

*** NTI® Diamond Discs incorporate.

**** SEM (JEOL JXA-840A JAPAN)

Indicators of the dispersion of smear layer:

Score 1: Absence of smear layer, with all dentinal tubules exposed.

Score 2: Minimal presence of smear layer, with a few exposed dentinal tubules.

Score 3: The smear layer is evenly distributed and covers the surface uniformly, with only a few dentinal tubules being exposed.

Score 4: uniform layer of smear covering with no obvious exposed dentinal tubules.

Score 5: The walls of the root canal are completely covered by thick and uneven layer of smear.

For debris evaluation, one half of each mesiobuccal root canal was examined after mechanical preparation in both main groups. A scanning electron microscope was utilised to qualitatively assess the presence of the smear layer at the three levels of root canals walls : apical, middle, and lastly coronal thirds. The evaluation was conducted under a magnification power of 500x. The debris within each root canal wall was evaluated and scored qualitatively according to the scoring system described by Hülsmann[7].

Indicators of the dispersion of debris :

Score 1: The walls of the root canal were free from any dirt or contaminants, with just a small number of debris particles present.

Score 2: Limited aggregations of wreckage

Score 3: Several clusters of debris covered less than half of the canal walls.

Score 4: The canal sides were more than 50% covered with debris.

Score 5: The canal walls were completely or almost completely covered with debris.

Statistical analysis

The numerical data were reported in terms of mean and standard deviation (SD) values. The data distribution was examined and the Shapiro-Wilk test was used to assess normality. The data exhibited a non-parametric distribution, so they were subjected to statistical analysis using the Kruskal-Wallis test, followed by the Dunn's post hoc test with Bonferroni correction for independent samples. Additionally, the Friedman's test was employed for repeated measurements, and subsequently, the Nemenyi post hoc test was applied. The significance level was established at a threshold of $p < 0.05$. The statistical investigation was performed using R statistical analysis software version 4.1.3 for the Windows operating system.

RESULTS

I- Debris score

1- Effect of filing system:

The values for mean as well as for standard deviation (SD) of debris score for various filing methods were displayed in **Table 1 and Figure 2-4**. There was a significant difference between different groups (p<0.001). The highest value was found in F1 (3.29±0.75), followed by S1 (2.92±0.72), while the lowest value was found in Race (1.62±0.92). Post hoc pairwise assessments revealed that Race had a considerably lower value compared to the other categories (p<0.001).

Regardless of root section, race filing system showed the least debris score (1.62) after mechanical preparation while S1 and F1 system showed almost similar amount of remaining debris.

TABLE (1) The mean values as well as standard deviation (SD) values for debris score in different filing systems

Debris score (mean±SD)			p-value
S1	**F1**	**Race**	
$2.92{\pm}0.72^{A}$	$3.29{\pm}0.75^{A}$	$1.62{\pm}0.92^{B}$	**<0.001***

Distinct superscript letters denote a statistically significant disparity within the identical horizontal category
****; significant (p ≤ 0.05) ns; non - significant (p > 0.05).***

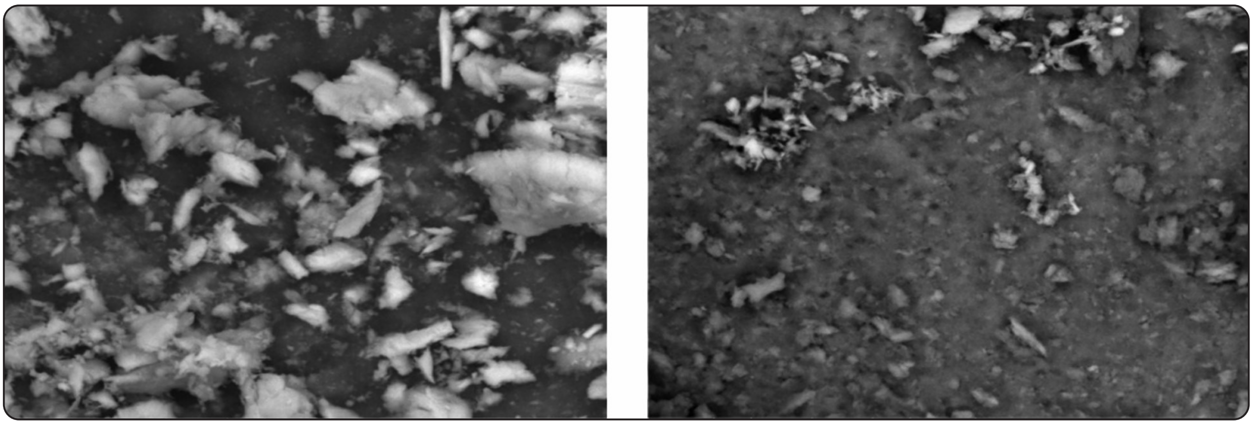

Fig. (2) Scanning electron micrographs showing debris in teeth sections prepared with race files (middle third).

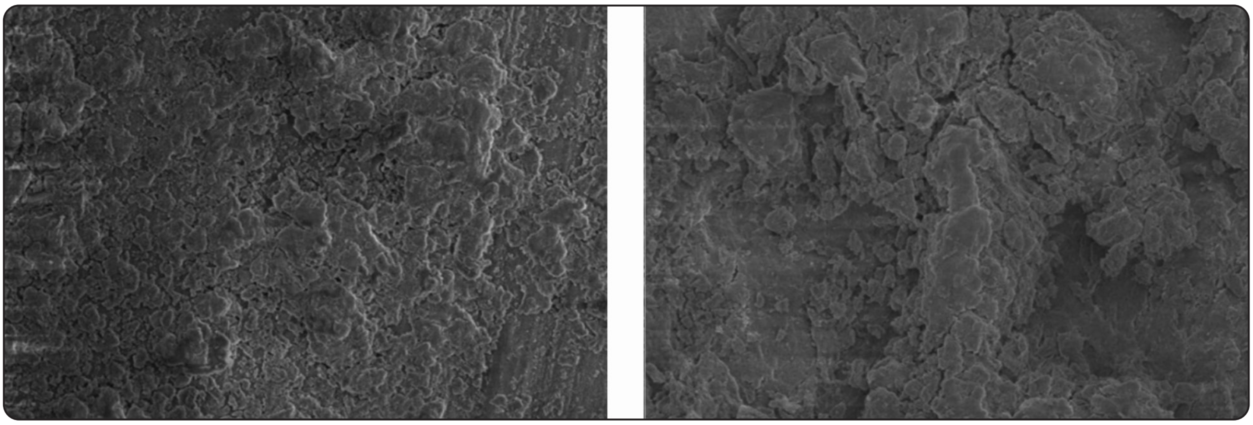

Fig. (3) Scanning electron micrographs showing debris in teeth sections prepared with Fanta F1 Blue files (middle third)

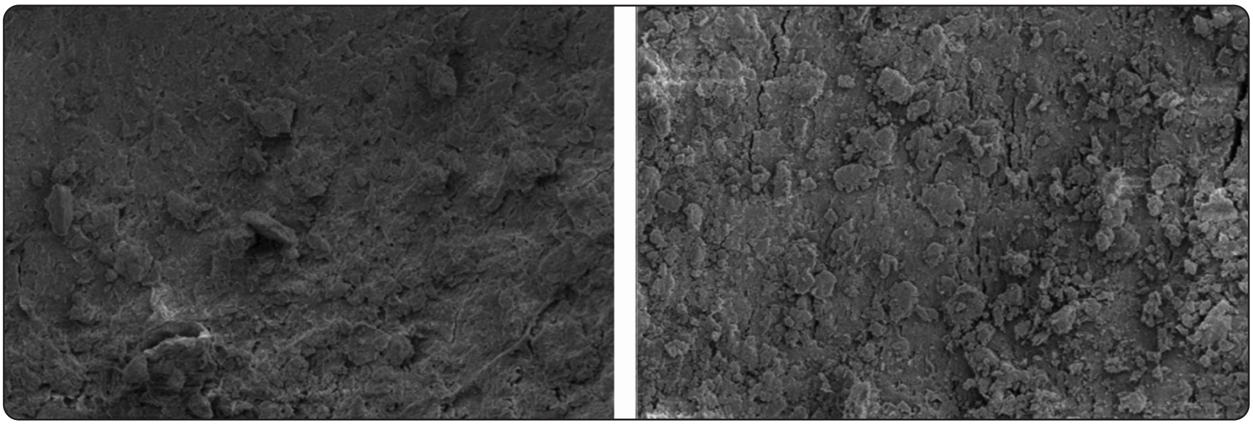

Fig. (4) Scanning electron micrographs showing debris in teeth sections prepared with Fanta AF Blue S1 files (middle third)

TABLE (2) Mean values as well as standard deviation (SD) values of debris score for the different filing systems within each root section

Root section	Debris score (mean ± SD)			p-value
	S1	F1	Race	
Coronal	2.88 ± 0.64^{A}	3.12 ± 0.64^{A}	2.25 ± 1.28^{A}	**0.246ns**
Middle	2.75 ± 0.71^{A}	3.62 ± 0.74^{A}	1.38 ± 0.52^{B}	**<0.001***
Apical	3.12 ± 0.83^{A}	3.12 ± 0.83^{A}	1.25 ± 0.46^{B}	**<0.001***

Distinct superscript letters denote a statistically meaningful distinction within identical horizontal category
****; significant (p≤0.05) ns; non - significant (p > 0.05)***

2- Effect of different file systems on root canals section:

The mean as well as standard deviation (SD) values of debris score for various filing systems within each root section were presented in Table 2.

In coronal section: There was no significant difference between Race, S1 and F1 systems' scores in removing debris.

In middle section: Race also showed least remaining. Debris followed by S1 system and then F1. System.

In apical section: Race showed least remaining debris followed by S1 and F1 system which have nearly similar scores in removing debris.

3- Effect of root section within other variables:

The mean as well as standard deviation (SD) values of various score seen in different root sections within other variables were shown in Table 3.

- **S1:** There was not any apparent disparity between the values obtained at various sections. (p=0.554). The highest value was found at the apical part (3.12±0.83), followed by the coronal part (2.88±0.64) and lastly the middle section (2.75±0.71).
- **F1:** There was not any apparent disparity between its values obtained at various sections. (p=0.449). The highest value was found at the middle section (3.62±0.74), followed by the coronal section (3.12±0.64), while the lowest values was shown at the apical section (3.12±0.83).
- **Race:** There was not any apparent disparity between the values obtained at various sections. (p=0.066). The highest values was found at the coronal section (2.25±1.28), followed by the middle section (1.38±0.52), while the lowest values was found in the apical section (1.25±0.46).

TABLE (3) The mean as well as standard deviation (SD) values of debris score for various filing systems and root thirds

Root section	Debris score (mean±SD)			p-value
	S1	F1	Race	
Coronal	2.88 ± 0.64^{Aa}	3.12 ± 0.64^{Aa}	2.25 ± 1.28^{Aa}	**0.246ns**
Middle	2.75 ± 0.71^{Aa}	3.62 ± 0.74^{Aa}	1.38 ± 0.52^{Ba}	**<0.001***
Apical	3.12 ± 0.83^{Aa}	3.12 ± 0.83^{Aa}	1.25 ± 0.46^{Ba}	**<0.001***
p-value	**0.554ns**	**0.449ns**	**0.066ns**	

Different upper and lowercase superscript letters indicate a statistically significant difference within the same horizontal row and vertical column respectively *; significant (p ≤ 0.05) ns; non-significant (p>0.05)

II- Smear layer score

Effect of filing system:

The mean and standard deviation (SD) values of the smear layer score for various file systems were displayed in Table 4 and Figures 5-7. There was a notable disparity among various groupings. The maximum value was observed in S1 (3.42±0.83), with F1 (3.17±0.76) having the second highest value, while Race had the lowest value (1.50±0.59). Post hoc pairwise comparisons revealed that the Race group had a considerably lower value compared to the other groups (p<0.001). Race filing system showed the least amount of smear layer formation after mechanical preparation (1.50±0.59), while F1 system and S1 Showed nearly similar smear layer formation values.

TABLE (4) Mean and standard deviation (SD) values of smear layer score for different filing systems

Smear layer score (mean±SD)			p-value
S1	F1	Race	
3.42 ± 0.83^{A}	3.17 ± 0.76^{A}	1.50 ± 0.59^{B}	**<0.001***

Distinct superscript letters denote vstatistically significant disparity within the identical horizontal category *; significant (p ≤ 0.05) ns; non - significant (p > 0.05)

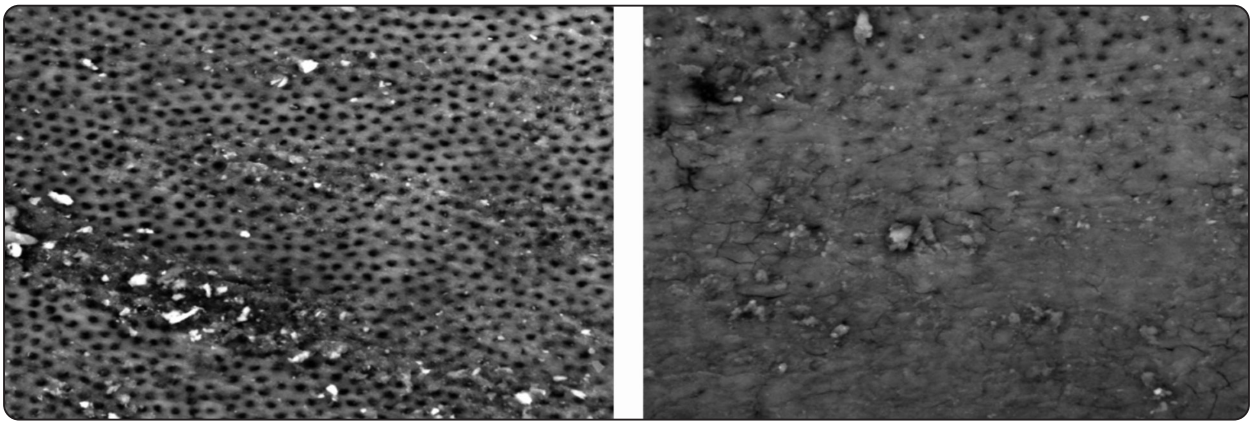

Fig. (5): Scanning electron micrographs showing smear layer in teeth sections prepared with race files (almost patent dentinal tubules) (middle third).

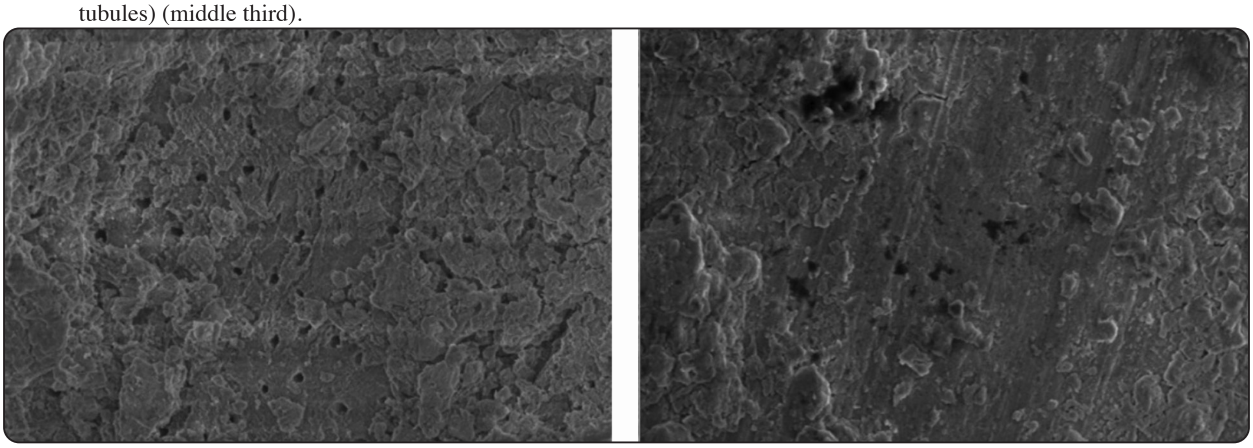

Fig. (6): Scanning electron micrographs showing smear layer in teeth sections prepared with Fanta F1 Blue files (middle third)

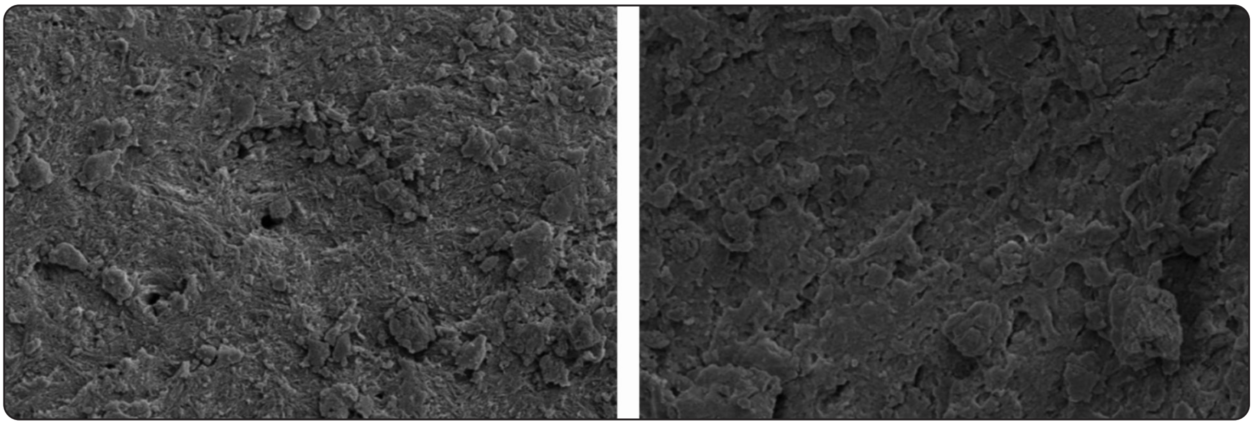

Fig. (7): Scanning electron micrographs showing smear layer in teeth sections prepared with Fanta AF Blue S1 files (middle third)

2- Effect on root section:

The Mean as well as standard deviation (SD) values of smear layer score for various filing systems within each root section were presented in Table **5.**

In coronal section: Race showed least smear layer formation (1.38) followed by F1 and S1 which had nearly similar results.

In middle section: Race have also showed least smear layer formation (1.5) in comparison to F1 system (3.12) and S1 system (3.75) which. Have nearly similar results.

In apical section: Race have also showed greater decrease in smear layer formation (1.62) in comparison to S1 system (3.38) and F1 system (3.50) which showed almost same results

3- Effect of root section within other variables:

The Mean as well as standard deviation (SD) values of smear layer score for various root sections within the remaining variables were shown in Table 6.

- **S1:** There was no significant difference between values measured at different sections (p=0.165). The highest value was measured at the middle section (3.75±0.71), followed by the apical section (3.38±0.74), The coronal section had the lowest value, measuring 3.12±0.99.
- **F1:** There was no significant difference between values measured at different sections (p=0.368). The highest value was measured at the apical section (3.50±0.76), followed by the middle section (3.12±0.64), The coronal section had the lowest value, measuring 2.88±0.83.

TABLE (5) Mean and standard deviation (SD) values of smear layer score for different filing systems within each root section

Root section	Smear layer score (mean±SD)			p-value
	S1	F1	Race	
Coronal	$3.12{\pm}0.99^{A}$	$2.88{\pm}0.83^{A}$	$1.38{\pm}0.52^{B}$	**0.001***
Middle	$3.75{\pm}0.71^{A}$	$3.12{\pm}0.64^{A}$	$1.50{\pm}0.53^{B}$	**<0.001***
Apical	$3.38{\pm}0.74^{A}$	$3.50{\pm}0.76^{A}$	$1.62{\pm}0.74^{B}$	**0.001***

Distinct superscript letters denote statistically significant disparity within identical horizontal category
****; significant (p ≤ 0.05) ns; non - significant (p > 0.05)***

TABLE (6) The mean as well as the standard deviation for smear layer values score within different filing systems and root sections

Root section	Smear layer score (mean±SD)			p-value
	S1	F1	Race	
Coronal	3.12±0.99^{Aa}	2.88±0.83^{Aa}	1.38±0.52^{B}	**0.001***
Middle	3.75±0.71^{Aa}	3.12±0.64^{Aa}	1.50±0.53^{B}	**<0.001***
Apical	3.38±0.74^{Aa}	3.50±0.76^{Aa}	1.62±0.74^{B}	**0.001***
p-value	**0.165ns**	**0.368ns**	**0.670ns**	

are used to denote a statistically significant difference within the same horizontal row and vertical column, respectively. The symbol * represents significance (p ≤ 0.05), whereas abbreviation " ns " indicates non-significance (p > 0.05).

- **Race:** There was no statistically significant differences observed in values recorded at different parts (p=0.670). The apical part had the greatest measured value (1.62±0.74), followed by the intermediate section (1.50±0.53), while the coronal section had the lowest value (1.38±0.52).

DISCUSSION

Over the past years root canal treatment was done using different systems that uses multiple filing systems and this was a long procedure causing discomfort to both patient and dentist but lately single filing systems introduced to the market to provide comfort and saves time[8].

To accomplish adequate root canal treatment, root canals should be clean before filling, this can be accomplished through adequate chemo-mechanical preparation. During the mechanical preparation of root canals, the endodontic tools cut into the dentinal walls of root canals, resulting in the creation of debris and a smear layer. [9], This could potentially host germs and degrade the integrity of the sealant used for the root canal filling materials [10].

Debris have mixture of dentin chips, remains of pulp, and particles that are loosely connected to the wall of the root canal. It is important to note that this debris is typically infectious, and can consist of both vital (living) or necrotic (dead) pulp tissue [7].

The smear layer is a disordered and uneven thin film that develops on the walls of root canals following instrumentation[11]. Presence of the microorganisms inside the smear layer can withstand chemo-mechanical preparation and lead to prolonged infection, so compromising the effectiveness of our root canal therapy. [10]. According to reports, the presence of the smear layer obstructs the capacity of root canal irrigants to effectively reach the dentinal tubules, which impairs the disinfection of the root canal and prevents sealers from diffusing into the tubules. As a result, the sealing ability of the root canal filling is diminished.[12].

The present study assessed and compared the efficacy of Race, Fanta F1 blue, and Fanta AF blue S1 endodontic rotary files in terms of their ability to remove debris and smear layer. Several studies have examined the efficacy of various file systems in terms of their capacity to clean debris as well as removing smear layer during root canal therapy. A previous study has indicated that the rotation of a single file system results in a reduced amount of trash and smear layer.[13]. Another prior investigation found that the utilisation of Race files led to a notable increase in remaining debris in the apical part of the canals. 14, Furthermore Schafer et al. also found that Race files generated a greater amount of debris in comparison to Mtwo files. [15].

In the present investigation, as part of the chemo-mechanical preparation process, all the root canals were meticulously flushed with a solution of 2.5% sodium hypochlorite (NaOCl) owing to its bactericidal properties. 16, It was utilised independently because it does not impact smear layer. Additionally, it is used to prevent the interference of other elements in the removal of debris and smear layer. 14 A final rinse with a 2.5% NaOCl solution was performed to remove any remaining debris. This step is necessary because NaOCl is capable of reaching areas that were previously covered by the smear layer, which has been eliminated. [17].

Randomization of samples produces comparable groups, in terms of general characteristics as the degree of canal cleanliness after instrumentation, the smear layer as well as amount of debris before evaluation. Randomization minimizes bias and allows for a just comparison between groups[18].

For smear layer and debris analysis, The scanning electron microscope is a suitable technique for examining the impact of endodontic instruments over the structure of dentine surfaces. Previous studies have utilised magnifications ranging from ×500 to ×1000.[13].

In the current study, under low magnification Significant quantities of debris are readily visible, but, more detailed observations like remnants of the smear layer or identification of dentinal tubules require higher magnifications.[13,]18One drawback of employing higher magnification is that it reduces the size of the region being examined, which might potentially result in misinterpretation. Therefore, for the purpose of evaluating debris, a magnification of x500 was utilised, whereas a magnification of x1000 was used for evaluating smear layer. [19].

The roots were separated longitudinally to examine the root canal inner wall20. The outer surface of the roots were cut using a slow-speed diamond disc, creating two parallel longitudinal grooves. The root canal was not invaded during this procedure. To minimise contamination of the canals and the entry of debris from the outside, a plastic device was employed as a small chisel to break the roots into two halves during the separating process.[2].

The residual debris and smear layer were assessed using the scoring system outlined by Hülsmann. et al.[7].

The study found a substantial difference (p<0.001) in the creation of the smear layer across the different file systems used. Race got lesser scores in all thirds compared to Fanta AF blue S1 and Fanta F1 blue rotary file systems.

Over all, the better mean and standard deviation for all file systems occurred at coronal third followed by middle and finally the apical third. The poor efficacy of all examined instruments regarding cleaning the apical portion of the root canal may be the reason behind this [21] as well as the limited potential of the irrigant to the access apical areas.

The Fanta AF Blue S1 system exhibited the most significant production of smear layer and this may be due to the more efficient cutting action in comparison to F1 blue file which increases the smear layer formation. However, the variable pitch related to the file design enabled better debris transport towards the coronal direction in comparison to the flat sided F1 file which lead to less remaining debris in canals prepared with this file.

Regarding Fanta F1 Blue, it showed highest values of remaining debris this may be attributed to the patented flat side design which causes less file surface contact with canal walls which interfered with adequate removel of debris towards the coronal part, however, it showed less smear layer formation than AF blue s1 and this may be due to the S shape cross sectional design which lead to less surface in contact with canal walls therefore it formed less smear layer than AF blue s1.

The Race file system outperformed all other file systems in terms of smear layer formation. This can be due to the design created by the manufacturer, which features a triangular cross section as well as the alternation in cutting edges of the race files. The race file system demonstrates superior efficacy in removing debris, possibly attributed to the broader furrows and the active cutting blades of the race files, which effectively enable the movement of debris in a coronal direction[22].

Utilisation of a race rotary file system may be advantageous since it allows for the use of many files to maintain cleanliness in the canal. This, in turn, enables more effective delivery of the irrigant, particularly to the apical one third of the canal.[21]

The current study has indicated that the best results in canal cleanliness is found in the coronal portions of the root canal, including debris removal as well as smear layer creation.[23], Several investigations have observed an increasing accumulation of debris and smear layer towards the apical region following the use of the race files system for preparation.[24].

The current study was limited by the small sample size; Hence, it was found that using of multiple endodontic rotary file system confirmed better cleaning ability regarding smear layer disruption and debris removal.

CONCLUSION

Fanta F1 Blue showed highest values of remaining debris during chemo-mechanical preparation. The Fanta AF Blue S1 rotary file system exhibited the highest levels of smear layer development during chemo-mechanical preparation. Race file system resulted in lesser amounts of smear layer formation as well as debris generation than did the Fanta AF Blue S1 and Fanta Blue F1 during chemo-mechanical preparation along the three tooth horizontal thirds.

REFERENCES

1. Raut, A. W.; Mantri, V.; Palekar, A.; Gadodia, R.; Kala, S.; Raut, R. A., Comparative Analysis of Cleaning Ability of Three Nickel-Titanium Rotary Systems: ProTaper Universal, K3 and Mtwo: An: In vitro: Scanning Electron Microscopic Study. Nigerian Postgrad Med J 2016, 23 (4), 221-226.

2. Elnaghy, A. M.; Mandorah, A.; Elsaka, S. E., Effectiveness of XP-endo Finisher, EndoActivator, and File agitation on debris and smear layer removal in curved root canals: a comparative study. Odontol 2017, 105, 178-183.

3. Bighetti Trevisan, R. L.; Scatolin, R. S.; Castro Raucci, L. M. S. d.; Raucci Neto, W.; Froner, I. C., Effects of EDTA gel and chlorhexidine gel on root dentin permeability. Microsc Res Techniq 2018, 81 (2), 191-197.

4. Lopes, R. M. V.; Marins, F. C.; Belladonna, F. G.; Souza, E. M.; De-Deus, G.; Lopes, R. T.; Silva, E. J. N. L., Untouched canal areas and debris accumulation after root canal preparation with rotary and adaptive systems. Australian Endodont J 2018, 44 (3), 260-266.

5. Feghali, M.; Jabbour, E.; Koyess, E.; Sabbagh, J., Scanning electron microscopy evaluation of debris and smear layer generated by two instruments used in reciprocating motion WaveOne Gold® and Reciproc Blue®. Australian Endodont J 2019, 45 (3), 388-393.

6. Vashisht, R.; Kumar, U.; Jhamb, S.; Singla, R., Comparative evaluation of cleaning efficiency of single file NiTi rotary system during root canal treatment procedure-A scanning electron microscope study. J Conserv Dent Endodont 2023, 26 (3), 316-320.

7. Hülsmann, M.; Rümmelin, C.; Schäfers, F., Root canal cleanliness after preparation with different endodontic handpieces and hand instruments: a comparative SEM investigation. J Endodont 1997, 23 (5), 301-306.

8. Bartols, A.; Laux, G.; Walther, W., Multiple-file vs. single-file endodontics in dental practice: a study in routine care. Peer J 2016, 4, e2765.

9. Sharma, G.; Kakkar, P.; Vats, A., A comparative SEM investigation of smear layer remaining on dentinal walls by three rotary NiTi files with different cross sectional designs in moderately curved canals. JCDR 2015, 9 (3), ZC43.

10. Endodontology, E. S. o., Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology. Int Endodont J 2006, 39 (12), 921-930.

11. Grandini, S.; Balleri, P.; Ferrari, M., Evaluation of Glyde File Prep in combination with sodium hypochlorite as a root canal irrigant. J Endodont 2002, 28 (4), 300-303.

12. Şen, B.; Wesselink, P.; Türkün, M., The smear layer: a phenomenon in root canal therapy. Int Endodont J 1995, 28 (3), 141-148.

13. Dagna, A.; Gastaldo, G.; Beltrami, R.; Poggio, C., Debris evaluation after root canal shaping with rotating and reciprocating single-file systems. J Functional Biomat 2016, 7 (4), 28.

14. Bidar, M.; Moradi, S.; Forghani, M.; Bidad, S.; Azghadi, M.; Rezvani, S.; Khoynezhad, S., Microscopic evaluation of cleaning efficiency of three different Nickel-titanium rotary instruments. Iranian Endodont J 2010, 5 (4), 174.

15. Schäfer, E.; Erler, M.; Dammaschke, T., Comparative study on the shaping ability and cleaning efficiency of rotary Mtwo instruments. Part 2. Cleaning effectiveness and shaping ability in severely curved root canals of extracted teeth. Int Endodont J 2006, 39 (3), 203-212.

16. Siqueira Jr, J. F.; Batista, M. M.; Fraga, R. C.; de Uzeda, M., Antibacterial effects of endodontic irrigants on black-pigmented gram-negative anaerobes and facultative bacteria. J Endodont 1998, 24 (6), 414-416.

17. Ferrer-Luque, C. M.; González-Castillo, S.; Ruiz-Linares, M.; Arias-Moliz, M. T.; Rodríguez-Archilla, A.; Baca, P., Antimicrobial residual effects of irrigation regimens with maleic acid in infected root canals. J Biol Res Thessaloniki 2015, 22 (1), 1-5.

18. Elamin, M. B.; Montori, V. M., The hierarchy of evidence: from unsystematic clinical observations to systematic reviews. Neurol: An evidence-based approach 2012, 11-24.

19. Hema, B.; Chandu, G.; SHiraGuppi, V. L., Scanning Electron Microscopic Evaluation of Root Canal Surfaces Prepared with LightSpeed & Endowave Rotary System. JCDR 2014, 8 (12), ZC35.

20. Drukteinis, S.; Balciuniene, I., A scanning electron microscopic study of debris and smear layer remaining following use of AET instruments and K-flexofiles. Stomatologija 2006, 8 (3), 70-5.

21. Paqué, F.; Musch, U.; Hülsmann, M., Comparison of root canal preparation using RaCe and ProTaper rotary Ni-Ti instruments. Int Endodont J 2005, 38 (1), 8-16.

22. Shahi, S.; Yavari, H. R.; Rahimi, S.; Reyhani, M. F.; Kamarroosta, Z.; Abdolrahimi, M., A comparative scanning electron microscopic study of the effect of three different rotary instruments on smear layer formation. J Oral Sci 2009, 51 (1), 55-60.

23. Schäfer, E.; Vlassis, M., Comparative investigation of two rotary nickel–titanium instruments: ProTaper versus RaCe. Part 1. Shaping ability in simulated curved canals. Int Endodont J 2004, 37 (4), 229-238.

24. Prati, C.; Foschi, F.; Nucci, C.; Montebugnoli, L.; Marchionni, S., Appearance of the root canal walls after preparation with NiTi rotary instruments: a comparative SEM investigation. Clin Oral Invest 2004, 8, 102-110.