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Assessing the amount of apically extruded debris of one curve, edge file x7, AF™ R3 blue in curved canals: An *in vitro* study

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Abstract
Aim of the study: Assessing the relationship between one curve, edge x 7 and AF Fanta files use in curved canals and the quantity of apically extruded debris.
Materials and Methods: 60 curved mesial roots of lower molars with 20-30-degree curvature were selected for this study, Group I: AF™ R3 Blue
Group II: Edge file x7 Group III: one curve system
The analysis of variance (ANOVA) and the fairly significant difference (HSD) tests were used to assess the statistical significance of the variation in debris levels across the groups under investigation, using a significance level of 0.05.
Results: The results revealed that all tested groups had produced apical debris in different amounts.
Conclusions: Under the purview of the present investigation, apical debris was produced in all tested groups. The one curve produced less amount of debris than other tested groups. AF™ R3 Blue file produced the most amount of apical debris.

Keywords: Debris extrusion, one curve, edge file, AF™ R3 Blue

1. Introduction
Flare-up condition, which can result in the failure of an endodontic treatment, are often caused by the debris extruded from the root tip during the shaping and cleaning of root canals. (Yılmaz and Özyürek, 2017; Siqueira *et al*., 2019) [39, 28].
Pulp tissue fragments, dentinal chips, bacterial waste products, and irrigation solutions can all be forced through the apical foramen and into the periapical tissue during instrumentation (Yılmaz and Özbay, 2021) [38].
A number of tooth-related factors affect the prevalence of debris apical extrusion, including tooth type, root curvature, and apical foramen size (Arias *et al*., 2013) [2].
Other factors include the instruments used, which includes the instrumentation method, motion, the number of files being used, instrument alloy and design (Mustafa *et al*., 2021) [20].
New advances in endodontic instrumentation attempted to improve instrument properties (Arias & Peters, 2022) [3].
An important clinical pointer for calculating the efficacy of instrumentation methods and currently available instruments is the amount of debris that is extruded from the apex (Tanalp, 2022) [32]. AF™ R3 Blue (Fanta, china) were treated with H Wire technology, more over reciprocating movement Counterclockwise to 150 degrees, and clockwise by 30 degrees. Therefore, excellent debris discharge capability and Increase the file resistance to cyclical fatigue (AF™ R3 Blue brochure).
Edge File X7 system (EdgeEndo, Albuquerque, New Mexico, USA), were treated with proprietary heat process called FireWire alloy, it is requested to deliver high flexibility. One Curve system (Micro Méga, Besançon, France) is a heat-treated file made from C. wire that uses a single file to shape the root canal's full length, from top to the apex unswervingly (One curve brochure).

Finally, according to the best of author's know agent there are no studies considering the amount of extruded debris using AF™ R3 Blue, edge x 7 and one curve.
The present study pointed to associate and quantify and the debris extruded apically produced by multiple NiTi rotary systems.

2. Materials and Methods

2.1 Sample Selection and preparation

Sixty freshly extracted mandibular molars with patient's age range from 30-40.
The mesial root of teeth had been selected for this study according to specific criteria which include mature root apex, curved root with 15-25 degree root curvature, Root devoid of any resorption, cracks, fracture or previous root canal treatment.
The root surfaces were then inspected with a light cure device (Eightteeth, china) and a magnifying eye lens (Zumax, china) for any visible fractures or cracks (Zarrabi *et al*, 2006a; Hamouda *et al*, 2011) [40, 12].
Until time of use, teeth were kept in distilled water (changed daily) (Boijink *et al*., 2018) [4].
Pre-operative X-rays were taken after the teeth were established in wax block, using portable x-ray device sensor (Wood picker, china) in standardized manner with constant position of the radiation source and the tooth and distance between the tooth and radiation source was 12 cm. This radiograph used for calculating root curvature by Schneider's method (Schneider, 1971) [27].
Samples with visible canals on pre-operative X-ray with curvatures between 20° and 30° were used. Measure program were used to measure the the angle effectively.
After that the crown of the tooth was sectioned to a length of 12 mm with a special disc bur under abundant water to create an unvarying length. Then, the mesial root was separated from distal root
The canals' apical patency was next verified by inserting a #10 hand K-file into the channel and working it forward until it's visible at the apical foramen.
After adjustment of the silicon stopper, the file was removed and the working length was obtained by subtracting 1mm from the length of the root which is to get the working length.
60 glass vial were used to collect the debris, each vial was weighed pre-operatively.
The roots, except the coronal section, were inserted into the hole cut in the rubber stopper and the vials were placed inside the glass container for ease of handling and to prevent environmental debris from accumulating during operation.
Subsequently the pre-weighed collecting glass vial was secured to the stopper/root complex, rubber dam sheet was utilized to cover the outside surface of the container, and ligatured ligature elastic was secured around the container.
The pressure on both the inner and outer sides of the vial were then brought to the same level by inserting a needle (Gauge-25) through the rubber dam and stopper next to the root Fig. 1.

Fig 1: Coating the vial with rubber dam and insertion of ventilating needle through stopper and the root inside the rubber stoper.

2.2 Instrumentation

All systems in this investigation were set up in accordance with their respective manufacturers' recommended sequences.
All canals prepared to MAF # 25/06 with endo motor (Woodpecker, china).
For all groups, irrigation protocol were 10- ml of distilled water as total volume which is divided with a 5-ml during instrumentation and 3-ml after instrumentation by using a disposable side vented 30-gauge navi tip needle which was inserted passively 2mm from the working length.
As soon as the instrumentation was finished, the root's external surface was irrigated with 2-ml of distilled water using 25-gauge tip vented needle to collect any adhering debris on the apical part of the root into the collecting glass vial.

2.2.1 Group I: AF™ R3 Blue
Instrumentation with reciprocation files system was done with the reciprocating motion (150 CCW-30 CW) (de Carvalho *et al*., 2022) [10].
Af fanta #25/06 was used to full working length while applying very light apical pressure through gentle 3 mm strokes and permitting the file to reach the working length passively.

2.2.2 Group II: edge file x7
Instrumentation with at a 300 rpm speed with a full-rotating motion and a 2.2 ncm torque.). R file #25/06 was used to full working length while applying very light apical pressure through gentle 3 mm strokes and permitting the file to reach the working length passively.

2.2.3 Group III: One curve
Instrumentation was done in crown-down technique at a 300 rpm speed with a full-rotating motion and a 2.2 NCM torque. #25 File was used with 1 Rhythm Motion to 5mm for removing of coronal and mid-root dentin then the #25 File were file #15 was used as a manual gliding path for all samples once canal patency was established with K-file #10. used with 2 rhythm motions until WL is achieved.

2.3 Collection and weighing of apically extruded debris
After the root canals were instrumented and irrigated, the needle and ligature elastic were removed, and the rubber-stopper/root assembly was detached from the collecting glass vials.
Then, 2.0 mL of distilled water was used to flush the root tip and gather any remaining material into the vial (Koçak *et al*., 2015) [19].
Subsequently, the vials with the collected samples were placed for 3 hours at 110 °C in a hot air oven and were inspected every 30 mintes up until they achieved dryness (Bürklein *et al*., 2016) [8].
Then, To ensure that the collecting vials were thoroughly dry and to absorb any lingering moisture, they were taken out of the oven and placed in a desiccator with calcium chloride for 24 hours (Hussein and Al-Zaka, 2014; Sowjanya *et al*., 2022) [5, 29].
After that, each vial was removed from the desiccator and re-weighed using the same electronic balance (Accuracy of 0.00001 g) to obtain the vial's total weight (Extruded debris weight included).
Weighing of each vial was repeated three times a day for three days and the mean value had been calculated, these 3 consecutive measurements showed difference only in the last digit by 1-2 (<0.00002 g.); the above-mentioned figure denotes the weight after the instrumentation process.
By deducting the pre-instrumentation weight from the post-instrumentation weight of each collecting vial, the weight of the extruded debris was then determined (Myers and Montgomery, 1991; Parirokh *et al*., 2012; Al-Saffar and Al-Gharrawi, 2023) [21, 23, 1].

2.4 Statistical Analysis
The debris weight data was analyzed using IBM SPSS Statistics 25 (SPSS, Chicago, IL, USA). The software indicated before was used to determine the minimum, maximum, mean, standard deviation, and standard error.
The Shapiro-Wilk test indicated that there was a normal distribution among the groups. The ANOVA test was employed to see if there were any significant differences between the groups. In addition, the Turkey honestly significant difference (Turkey HSD) test was conducted to compare several groups.
A significance level of 0.05 was set as the threshold for statistical significance. P values over this threshold are deemed to indicate non-significant.
P values that were equal to or less than 0.05 were considered significant.

3. Results
Mean AED was lowest in the one curve group, followed by the edge file x 7 group, and highest in the AF™ R3 Blue file group (Table 1).
There was a statistically significant split in the test groups, as shown by the ANOVA test.
Further, the Turkey honestly significant difference (Turkey HSD) showed that the one curve system extruded significantly less AED than all tested groups. (Table2)

Table 1: Descriptive statistics of apically extruded debris for all groups

Groups	Mean	SD	SE	Max	Min
AF Fanta	0.0213120	0.00786682	0.00203121	0.01139	0.03404
Edge file x 7	0.0178633	0.00987065	0.00254859	0.03455	0.00455
One curve	0.0136307	0.00427167	0.00110294	0.0210	0.00677

Table 2: Tukey HSD test for multiple comparison between groups.

Multiple Comparisons Tukey HSD				
Groups		**Mean Difference (I-J)**	**P value**	**Sig.**
AF Fanta	Edge file x 7	0.00344855	0.022	Sig.
	One curve	0.01401933	0.000	Sig.
Edge file x 7	One curve	0.00633800	0.001	Sig.

4. Discussion
It's been speculated that post-operative discomfort following root canal instrumentation may be due to the presence of AED (Tanalp and Gung, 2014; Hadi and Hameed, 2017; Zawrzykraj *et al*., 2022) [31, 11, 41].
AED seems to be the most important etiological factor of post-operative pain (Zawrzykraj *et al*., 2022) [41].
Many factors, including the preparation technique, and the files' size, design, count, and kinematics determine the amount of AED occurring from canal preparation (Ustun *et al*., 2015) [34].
It has been observed that molar teeth are more likely to have post-endodontic discomfort (Arias *et al*., 2013) [2].
Therefore, the researchers chose the curved mesial roots of lower molars to establish a connection between the findings of this study and the occurrence of flare-ups in clinical scenarios (Mustafa *et al*., 2021) [20].
Moreover, the clinicians face many challenges during instrumentation of molar teeth with moderate to severely curved roots (Topcuoglu *et al*., 2016) [33].
Capar *et al*., in 2014 concluded that larger apical foramen tend to extrude more debri, Morover, since different sizes of apical foramen affect the amount of AED; thus, only canal with # 10 file patency was used.
An important factor in how much debris is extruded from a root canal is its curvature. (Karataslioglu *et al*., 2019) [15].
Sodium hypochlorite, when used as an irrigation solution in root canal therapy, has a more effective ability to dissolve tissue. However, the crystalline solution that forms after the drying process might hinder the accurate measurement of post-instrumentation weight (Tamilselvi *et al*., 2020; Tanalp, 2022) [30, 32].

For this reason distilled water was used as an irrigant with a side vented needle gauge 30. All samples had the same irrigation depth (2 mm short of the WL) while also avoiding binding.

To reduce the potential impact of volume on apically extruded debris, each sample was irrigated with 10 ml of distilled water (Kharouf *et al*., 2022) [16].

All procedures in the current investigation were performed by a single operator in an effort to reduce operator variance (Koçak *et al*., 2016) [17]. High-precision electronic balance, as well as because of the flexibility with which it can be modified to mimic real-world clinical settings (Tanalp, 2022) [32].

In the current investigation, care was taken with the delicate electronic balance to prevent interference with the weight conduction process from outside sources (Tanalap. 2022) [32]. So the weighting was done at a temperature of 25 °C and a range of humidity between (58%-65%), (Kharouf *et al*., 2022) [16]. However, all rotary file systems extruded debris apically in different quantities.

The results of this investigation indicated that the one curve method generated much lower levels of AED compared to the other groups that were evaluated.

This can be attributable to several factors, such as the rotating movement of the file. Previous studies have shown that rotational motion generates the least amount of AED compared to other types of motion (Bürklein *et al*, 2014; Toyoğlu & Altunbaş, 2017; Predin *et al*., 2021) [18, 41, 25].

The file possessed a varied cross-section along the blade, which enhanced its capacity to center itself in the apical third and effectively remove debris in the medium and coronal sections (Yalniz *et al*., 2021) [38].

Moreover The Myers Methodology was used because of its ability to precisely measure extruded debris with a and Montgomery, prevents self-threading "screw in" to canal and enhances debris removal (Sanghvi and Mistry, 2011) [26].

Although edge file x7 has the same rotational movement of one curve, it showed significantly more AED than it.

They have Parabolic asymmetric triangular cross section (Khalil *et al*., 2018) [42]. Hence, altering the shape of the root canal wall using three cutting sites has an impact on the file's centric ability, according to Bürklein *et al*., 2020 [43] who studied the impact of different designs of file cross-section on transportation in S-shaped canals and concluded that cross-sections that have only one cutting-edge less aggressive mode of action when enlarging canals (Bürklein *et al*., 2020) [43].

Finally the great amount of apical debris were produced by AF™ R3 Blue file system, the contributing factors of such results may be the square cross section, reversed cutting edge and smaller chip space.

All these features make it have piston like action and push debris apically (Vivekanandhan *et al*., 2016; Sowjanya, 2022) [36, 29].

Moreover, the utilization of a sequare cross-sectional form in the file design offers increased contact surface area with the root canal wall during the preparation process.

This design also minimizes the available space for accumulation and clearance of debris towards the coronal region (Sowjanya, 2022) [29].

Moreover the reciprocating motion of this file may tend to produce more debris as supported with previous studies (Toyoğlu & Altunbaş, 2017; Predin *et al*., 2021) [41, 25].

Generally, in this study the rotary files (one curve and edge file x 7) extrude less debris from reciprocating files (AF™ R3 Blue) when comparing the mean values of tested groups.

During the process of rotation at the release angle, it is seen that the flutes exert a force that causes the debris to be displaced in an apical direction (Sowjanya *et al*., 2022) [29].

The continual rotation of the crown facilitates the coronal transportation of dentin, and a number of authors have speculated that the reciprocal rotation may operate as a mechanical piston, enhancing the transport of debris towards the apex (Bürklein *et al*., 2014; Uzunoglu *et al*., 2015) [8, 35].

Unfortunately, to the best of author's knowledge, there are no studies in this field regarding these files. For this reason, we cannot compare with agreement or disagreement with other studies.

5. Conclusions

Within the limitation of the present *in vitro* study, the following can be concluded

1. The one curve system rotational system generated a less quantity of trash compared to other utilized methods.
2. 2. Edge file x7 resulted in a similar amount of AED.
3. The AF fanta file produced the most amount of AED.

6. Conflict of Interest

The authors reported that they have no conflicts of interest.

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