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# COMPARATIVE ASSESSMENT OF CLEANING EFFICIENCY OF DIFFERENT ROTARY INSTRUMENTS IN ROOT CANAL PREPARATION OF CURVED ROOT CANALS USING STEREOMICROSCOPE: AN IN VITRO STUDY

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## *ABSTRACT*

For endodontic therapy to be successful, the root canal space needs to be sufficiently biomechanically prepared. In this study, the three different rotary systems Fanta AF F One file, Neonitini rotary system, and 2Shape system had been employed to assess the cleanliness of root canals following root canal instrumentation using a stereomicroscope.

**Materials &Methods:** In all, 45 recently extracted lower mandibular first molars had been chosen. In accordance with the NiTi rotary system used in canal instrumentation, root canals were divided randomly to three groups (15 teeth each), ensuring that each group had an equal representation of the curvature range of 25º to 40º using Schneider's method: Fanta AF F One file is Group 1. The Neonitini file rotary system is group 2. Group 3: Rotating 2-shape system. Using a stereomicroscope (Leica MZ12.5) with a 10X magnification, the effectiveness of cleaning had been assessed regarding the quantity of remaining dentinal debris in the inside of canal wall.

**Results:** Fanta AF F One file system was significantly effective in eliminating debris in comparison to 2 shape and Neonitini file systems. The three file systems more easily cleaned the coronal and middle portions of the root canals but less easily cleaned apically.

**Conclusions:** When compared to 2 shape and Neonitini rotary systems, the Fanta AF F One had superior cleaning capabilities at all root canal levels.

**KEY WORDS:** Fanta AF F One file, NeoNiTi rotary system, 2shape system

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## INTRODUCTION

For endodontic therapy to be successful, the root canal space ought to be sufficiently biomechanically prepared. The objectives were to clean the root canal, remove the majority of the debris, and shape the canal [1]. To make root canal instrumentation more effective, a number of rotating tools had been created [2]. It was crucial to assess the instrument's cleaning ability because poor cleaning could result in endodontic failure [3]. No tool had been able to completely clean the root canal system effectively [4]. Despite numerous developments in the production of nickel-titanium rotary systems, further research was still needed to determine their cleaning efficacy [5]. Recently, numerous attempts had been made to modify the NiTi rotary instrument design and minimize the number of instruments employed in the preparation process [6].

Researchers asserted that the novel design offered more cutting efficiency by allowing debris to escape through the vertical blades of the flutes to the safe-side section and finally exit the canal, resulting in less debris building up around the file and more debris removal during instrumentation [7]. The Fanta AF F One file (Shanghai Fanta Dental Materials Co., LTD) was made from CM wire, which increased the flexibility. The manufacturer claimed that the cross-section design with S-shape could enhance debris removal [8].

A single-file rotary system that had been heat-treated and had rectangular cross section with a non-homothetic design and uninterrupted rotating action was the NeoNiTi file (Neolix sas, Evron, France). According to the manufacturer, it was made using a CM Electrical discharge machining method using wire-cut which produced sharp edges for cutting and increased flexibility [9]. Another file system, 2Shape (MicroMega, France), was made of T-wire that had been heat-treated with NiTi alloy to increase its flexibility. With the triple helix, the file's two primary cutting blades offer exceptional cutting efficiency. According to the company, it might remove more debris and increase the effectiveness of selective cleaning [10]. The cleaning capabilities of the NeoNiTi, 2Shape, and Fanta AF F One rotary file systems had not been investigated. In this study, the three different rotary systems had been utilized to evaluate the cleanliness of root canals following root canal instrumentation using a stereomicroscope. Null Hypothesis: The three rotary NiTi file systems did not significantly differ in their capacity to remove debris.

## METHODS

### Study design

The study protocol was approved by the Research Ethics Committee (REC), Faculty of Dentistry, Sinai University, (approval no: SU.REC.2024 (21H) .All of the teeth were taken from individuals who had previously given their consent outlining their agreement for using their biologic samples prior to the start of the study. Every patient should be free of any systemic diseases, and their current health should be assessed using an appropriate medical index.

### Sample size calculation

G*Power version 3.1.9.7 had been used to calculate the sample size based on the findings of an earlier study [11–12]. Based on the findings of a prior study, an effect size (d) of 0.55925 and an alpha level of 0.05 and beta of 0.1 were determined, resulting in power = 90%. With 15 extracted mandibular molars per group, the expected sample size (n) was 45. to identify any differences in debris layer ratings across groups.

### Specimen selection

In all, 45 recently extracted lower mandibular first molars for orthodontic or periodontal treatment were chosen . They had been used within a month of extraction and kept at 4 C in saline supplemented

with 0.02% sodium azide. The crowns would be taken out, and the occlusal surface might be flattened to create a point of reference for standardizing the working length so that a measurable root length of 18 mm. The mesial root length was measured from the apical end in an average of 15 mm. The length and apical foramen size of the mesial roots should be standardized, and the mesiobuccal canal should have a curvature range of 25º to 40º using Schneider's method [13]. Regarding standardization, the canal diameter was fit to the initial apical file #15 K-file . The study was created to satisfy the following parameters, taking into account the inclusion and exclusion criteria: a length of fully formed roots with no visible fractures or cracks. Each molar's mesiobuccal canal was designated for instrumentation, and mesial canals featured two unique apical foramina at the end. The purpose of the exclusion criteria was to cancel teeth with calcified canals, internal resorption, undeveloped roots, and root canals without apical patency. To remove tissue that had adhered to the root surface, 5 ml of a 2.6% sodium hypochlorite solution (NaOCl) were used for 1 hour. After removing any leftover tissue or calculus, the teeth had been placed in a standard saline solution (0.9%) to be kept until they were needed. [14-15].

**Specimens' preparation**

After preparing a closed canal system, tray adhesive was applied to each root's cementum. Before inserting the root into a clear Plexiglas tube filled with polyvinyl silicone, the apex was coated with adhesive and left to harden [16]. After access to the root canal orifice was established, K-file ISO #10 was placed inside the canal for the mesiobuccal root to check for apical clearance. This was carried out until the apical foramen showed the root's tip. The file's length was reduced by 1 mm in order to calculate the working length [14–15]. The working length had been indicated to be 17 mm. In accordance with the NiTi rotary system used in canal instrumentation, root canals had been divided randomly to three groups (15 teeth each), ensuring that each group had an equal representation of curvature range: Fanta AF F One file is Group 1. The NeoNiTi file rotary system is group 2. Group 3: Rotating 2-shape system.

**Root Canal Instrumentation**

For all groups, each canal was instrumented in a crown-down approach accompanied with in out motion until reaching the entire working length, where the final preparation of apical part had been set to # 25/6%.Group 1:following the manufacturer instructions, root canals were made using the Fanta AF F One (#25, taper 6%). The device was rotated continuously at 500 rpm and 2.6 Ncm of torque. Group 2: root canals were done according to manufacturer instructions using the Neoniti single-file system (#25, taper 6%) adjusted at 300 rpm and 2 N.cm. Group 3: Following the recommendations of the manufacturer, root canals were performed using a 2-shape rotary file system in the following order: TS1 (25/0.04) & TS2 (25/0.06).

**Irrigation protocol for all groups**

Initially, 3 mL of 2.5% NaOCl (Golden Falcon, Dubai, UAE) was used to flush the root canals for 1 minute. Following #10 K-file and #15 K-file, 2 mL of the same solution was used for 1 minute in between instrumentations, and 5 mL of 2.5% NaOCl was used for canal irrigation .Each single file was used in three waves till the whole working length.

The following was the final irrigation protocol; in order to counteract the NaOCl's carryover effect, 5 ml of distilled water were introduced into the canals for a duration of 1 minute. The smear layer was then removed by passively injecting 5 mL of a 17% ethylenediaminetetraacetic acid (EDTA) solution (Dent Wash, Dental, New York, NY) into each root canal in each group for a duration of 1 minute [20]. Finally, 5 ml of distilled water were injected into the root canals for a duration of 1 minute. A 30-gauge

needle (NaviTip, Ultradent, UT, USA) and a plastic disposable syringe (S-S disposable syringe, Ptterson Dental Supply) were used to provide the irrigation. The irrigant was then injected away from working length by 2mm and introduced passively. 20 ml of NaOCl, 5 ml of EDTA, and distilled water of about 5mm had been utilized. A size #10 K-file had been employed to keep the canal patent [17–18].

**Methods of evaluating cleaning ability**

In accordance with Caron et al., every tooth was sectioned longitudinally [19]. By utilizing a diamond cutting disc to create buccal and lingual grooves. The prepared canal was filled with the size 25/0.06 taper as rotary master apical file. After that, the root had been crushed till the file showed up. To prevent dentinal debris intrusion during cutting of disc, the roots were divided in half using dental chisels after buccal and lingual grooves had been created with the disc. Using a stereomicroscope (Leica MZ12.5) with a 10X magnification, the effectiveness of cleaning had been assessed regarding the quantity of entire canal remaining debris . Using photographic editing software (Adobe Photoshop 7.0, Adobe Systems Inc., San Jose, California, USA), stereomicroscope images were analyzed. Three photographs (coronal, middle, and apical) were obtained for each segment to give a through perspective of the segment and assess canal cleanliness. To determine the quantity of debris in each section, the photos were examined using Image J (National Institutes of Health, v1.39a), an image processing program. For every third of the canal, the proportion of debris was computed. Debris percentage is measured as the total surface area of the debris divided by the canal's total surface area [20]

**Statistical analysis**

The recorded data had been evaluated employing the statistical software for social sciences, version 26.0 (SPSS Inc., Chicago, Illinois, USA). The non-parametric quantitative data had been displayed as mean, standard deviation, and median with interquartile range. Using the Shapiro-Wilk and Kolmogorov-Smirnov tests, the data had been examined for normality. The tests listed below were conducted: Kruskal-Wallis test; Post Hoc test (Dunn's test for multiple comparisons in non-parametric data) was used to compare each of the two groups pairwise. A 95% confidence interval and a 5% acceptable margin of error had been established. Thus, P-value of less than 0.05 had been considered as significant.

**RESULTS**

At every canal level, there had been a statistically significant difference between the tested parameters (P=0.001). The Fanta AF F One had the lowest median value for the quantity of leftover debris, while 2 Shape had the greatest median value, followed by Neonitini. While there had been a statistically significant difference at the canal levels in the Neonitini, rotational system, there had been no statistically marketable difference between the canal levels regarding the residual debris in the 2Shape and AF Fanta one, ($p > 0.05$). According to Table 1, the apical region had the highest median value for the amount of debris that remained, followed by the middle portion, and the coronal portion had the lowest median value.

According to Table 2, 2- shape had the greatest median value for the total amount of debris left followed by Neonitini, while, AF Fanta One was the lowest.

TABLE (1) Mean ± SD data for the residual debris indicate how each region's canal cleanliness is affected by the type of file.

| Section | | 2Shape | Neonitini | Fanta AF F One | p-value |
|---|---|---|---|---|---|
| Apical | Mean±SD | 0.2980±0.2811 | 0.2273±0.1982 | 0.0553±0.2056 | **0.001*** |
| | Median(IQR) | 0.2450(0.0610-0.5760)$^{aA}$ | 0.2100(0.0208-0.3300)$^{aA}$ | 0.0007(0.0001-0.0033)$^{bA}$ | |
| Middle | Mean±SD | 0.2333±0.3363 | 0.1913±0.1595 | 0.0387±0.1276 | **0.001*** |
| | Median(IQR) | 0.0208(0.0012-0.3350)$^{aA}$ | 0.1327(0.0200-0.3267)$^{aA}$ | 0.0007(0.0001-0.0162)$^{bA}$ | |
| Coronal | Mean±SD | 0.1827±0.1989 | 0.0680±0.1224 | 0.0213±0.0521 | **0.013*** |
| | Median(IQR) | 0.2010(0.0040-0.3300)$^{aA}$ | 0.0030(0.0001-0.1600)$^{bB}$ | 0.0014(0.0001-0.0200)$^{bA}$ | |
| **p-value** | | **0.271** | **0.005*** | **0.499** | |

***SD: Standard deviation; IQR: Interquartile range*** ***Significance level p≤0.05, *significant***

***Dunn's test:***

*Different capital letters indicate significant difference at (p<0.05) among means in the same column*

*Different small letters indicate significant difference at (p<0.05) among means in the same row*

TABLE (2) Mean ± SD figures for the total amount of debris left, illustrating how file type affects canal cleanliness.

| Section | | 2 shape | Neonitini | Fanta | p-value |
|---|---|---|---|---|---|
| Overall | Mean±SD | 0.2380±0.2757 | 0.1622±0.1736 | 0.0384±0.1403 | 0.001* |
| | Median(IQR) | 0.2100(0.0045-0.3350)a | 0.1300(0.0040-0.2940)a | 0.0012(0.0001-0.0110)b | |

***SD: Standard deviation; IQR: Interquartile range*** ***Significance level p≤0.05, *significant***

***Dunn's test:*** *Different small letters indicate significant difference at (p<0.05) among means in the same row*

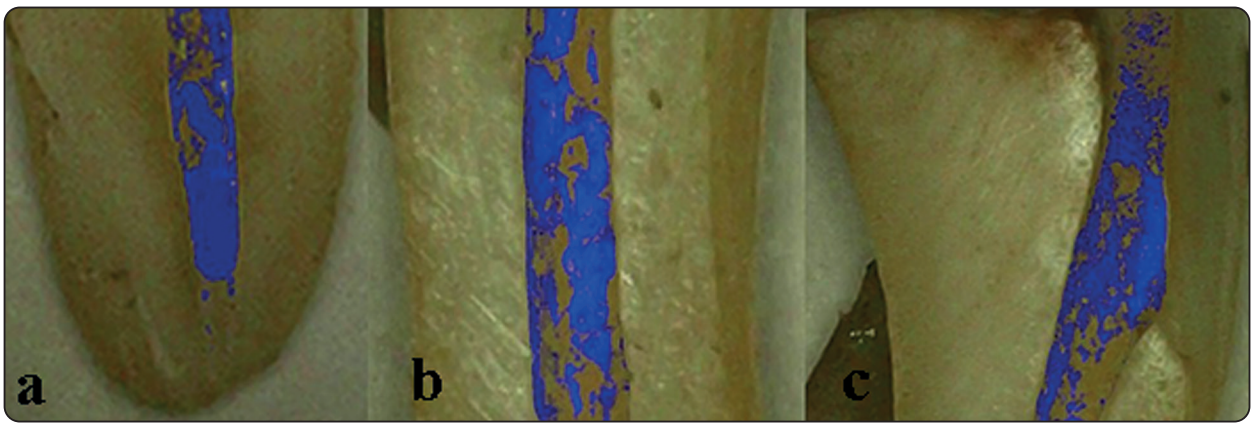


Fig. (1) **2 shape**

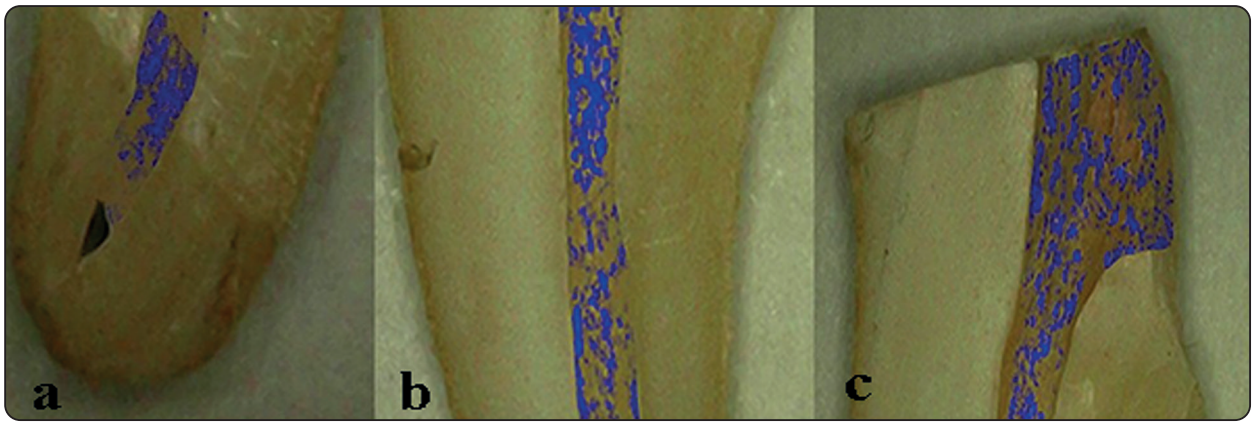


Fig. (2) **Neonitini**

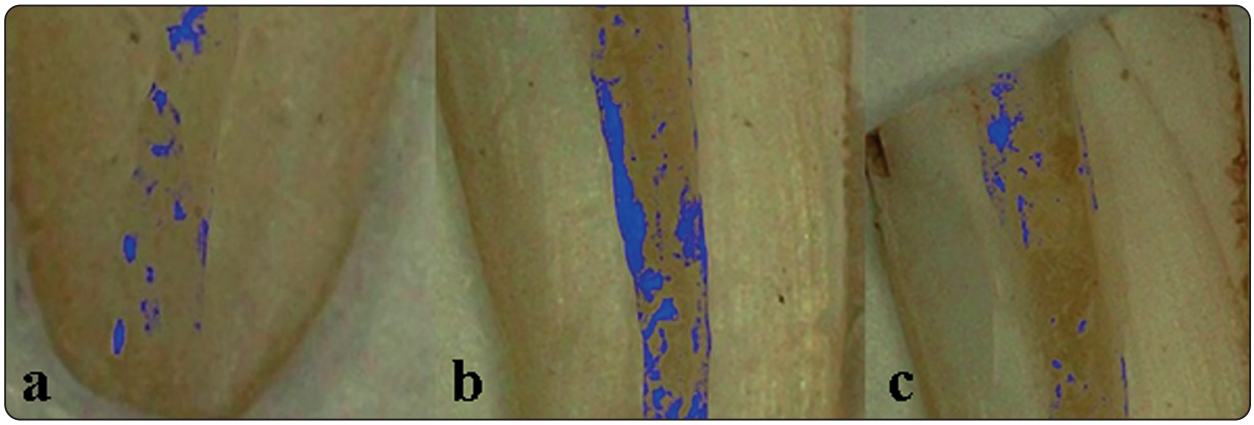


Fig. (3) **Fanta**

## DISCUSSION

During root canal instrumentation, it was crucial to leave the root canal system devoid of both necrotic and vital pulp tissue, dentinal debris, and bacteria [21]. Niti files undergo a variety of variations, including different heat treatment conditions, modifications to the instrument's metallurgical properties, and geometric adjustments to modify their mechanical properties [22]. The three rotary systems were chosen for the study because they were heat treated with various cross-sectional designs that facilitate the removal of debris upward and lessen the stresses on the rotating files. The goal of the current research was to assess the remaining debris on the canal walls by three different rotating systems (Fanta AF F One file, NeoNiTi, and 2Shape) because there was inadequate data on their behaviors regarding root canal cleaning ability. Natural extracted teeth had been chosen to replicate the clinical situation [23]. The selected teeth had similar lengths, angles, and diameters. In the present investigation, mesiobuccal root canals with two separate canals were utilized on extracted human permanent mandibular molar teeth because of their narrowness and two-planar curvature, which made instrumentation more difficult [24].

The curvature angles of the mesiobuccal canals varied from 25˚ to 40˚ because it was based on a largely simulated clinical scenario [25].The preparation of root canals was finished at 25/0.06 for standardization, and it was most frequently employed [26]. During mechanical procedures,

2.5% sodium hypochlorite was preferred due to its low toxicity to tissues and antibacterial properties [27]. The samples were prepared using the same irrigation methodology, which used the same volume and concentration. A precise vertical tooth splitting technique was used in this work to improve image uniformity at 10X magnification. Compared to the conventional scoring system, the quantification process employing computerized software offered superior precision, dependability, and non-subjective judgment [28].

For more accuracy, images were examined using Image J software [26]. The cleaning capabilities of the three rotary NiTi systems differed significantly; the null hypothesis was rejected. Of all the canals evaluated, the coronal thirds had the best cleaning ability results, followed by the middle, while the lowest cleaning ability was presented in apical portion. The difficult anatomy in the apical area, narrow diameter, and the irrigant's difficulty to reach apically due to the apical vapor lock could be the cause [28-29]. In terms of the outcomes, there had been a significant difference between the tested rotating systems, The Fanta AF One had the highest cleaning ability followed by Neonitini and 2Shape system had the lowest cleaning impact. These results aligned with previous studies [30]. This outcome might be explained by the fact that the 2Shape system included two files made of T-wire technology, which revealed a lower cyclic fatigue resistance than the other systems [31].

Better adaptability to the root canal walls was also made possible by a triple-helix and asymmetrical cross-sectional design with a short secondary cutting edge that could result in a tighter contact and less space for the generated debris from being extracted through the root canal [32]. Furthermore, there was a correlation between increased instrument use and increased debris production [33].

Nevertheless, compared to NeoNiTi rotary systems, the Fanta AF F One rotary system showed somewhat less debris after the root canal treatment. It could be because the flat, side-cut form reduced the strain on the file and minimized surface area contact with canal walls, consequently increasing space for better penetration of irrigating solutions during instrumentation. It also could be correlated to its inability to touch every canal wall simultaneously. The Fanta AF F One File featured a flat-sided cross-section with S-shaped and two active cutting points; however, each point's portion changed. The file's flexibility was increased without sacrificing its strength thanks to the flat side-cut design, which was not deeply cut through the instrument. By using vertical blades to move away the debris to the safe-side relief region and subsequently beyond the canal, this increases the file's cutting efficiency [8]. These results were consistent with published research [20] while, contradicted with previous research [34]. The dispute might arise from variations in the tooth type, rotational mechanisms, and canal curvature. In contrast, NeoNiTi instruments had a non-homothetic rectangular cross-sectional design , which had resulted in aggressive cutting, less flexibility, and less stress distribution along its length [35]. The file's contact with the canal wall was also lessened, but there was still not enough room for the debris to escape. These results disagreed with those of earlier studies [36]. According to the study's limitations, because it was conducted on extracted teeth, it did not accurately reflect the clinical circumstances. Future research should examine the effects of different irrigation procedures in combination with different rotary files.

## CONCLUSIONS

Fanta AF F One file system was significantly effective in curved mesiobuccal canals for debris removal at all levels of root canals. In comparison, the cleaning efficacy between the tested rotary systems in apical portion was markedly less than other canal portions.

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