

COMPARISON OF CYCLIC FATIGUE RESISTANCE OF FOUR DIFFERENT ROTARY
NI-TI INSTRUMENTS(IN-VITRO STUDY)Amira Alsherbini^{*1}, Medhat Taha El Faramawy² and Tariq Yehia Abdelrahman³¹MSc Student, Endodontic Department, Faculty of Dentistry, Ainshams University.²Associate Professor, Endodontic Department., Faculty of Dentistry, Ainshams University.³Professor, Endodontic Department, Faculty of Dentistry, Ain Shams University, Cairo, Egypt.

*Corresponding Author: Dr. Amira Alsherbini

MSc Student, Endodontic Department, Faculty of Dentistry, Ainshams University.

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ABSTRACT

Introduction: The aim of this study was to evaluate the cyclic fatigue resistance of Plex V, M Pro, Woodpecker W3-Pro, and Fanta AF Blue rotary files in a custom-made simulated canals with different radii and curvatures at body temperature. **Methods:** A total of 80 files(Plex V,M Pro, Woodpecker W3-Pro,and Fanta AF Blue) Size 25/.06 were assessed inside two simulated canals [(60 curvature, 3 mm radius) and (45 curvature, 5 mm radius)]at 37 ± 0.5 degrees Celsius. Number of cycles to fracture (NCF) was recorded. **Results:** Plex V had the highest cyclic fatigue resistance in severe canal curvature, followed by Woodpecker W3 Pro and the least cyclic fatigue resistance was for Fanta AF Blue. While in moderate canal curvature there was no significant difference between four groups. **Conclusion:** Plex V files had the highest cyclic fatigue resistance in severe canal curvature among the fourtypes evaluated. With no difference between four groups in moderate canal curvature.

KEYWORDS: Cyclic fatigue, Plex V, M Pro, Woodpecker W3-Pro, Fanta AF Blue.

INTRODUCTION

Nevertheless, there is an increased chance of apical transportaion and ledge formation in curved canals. Consequently, rotary instruments made of nickel-titanium (NiTi) were created. A NiTi file experiences compressive stress on the inside of the curved canal. The file experiences tensile stress on the outside of the curve at the same time.

Both compressive and tensile stresses affect the file through its rotation. The file metal matrix experiences microfractures as a result of this ongoing cycle of stress. We call this cyclic fatigue. This kind of failure is notorious for happening suddenly and without any indication of prior irreversible deformity. To increase the resistance to cyclic fatigue, many strategies have been used, such as novel alloys, altered file designs, and altered kinematics. It's critical to evaluate the fatigue resistance of recently developed niti rotary instruments since instrument fracture could compromise endodontic treatment.

The mechanical characteristics of Chinese rotary NiTi files manufactured of CM alloy are still not well enough understood. The dynamic cycle fatigue resistance of Plex V, Woodpecker W3- Pro, Fanta AF Blue, and M Pro rotary files in mild and severe canal curvatures at body temperature were judged to be worth comparing.

MATERIALS AND METHODS

For this study, a total of 80 Size #25.06 taper of the following file types were used: Plex V (Orodeka, Jining, China), Woodpecker W3-Pro (Woodpecker Medical Instrument Co, Guilin, China), Fanta AF Blue (Fanta Dental Material Co, Shanghai, China), and M Pro (Innovative Material and Devices Shanghai, China). They were sorted into four categories based on the file type (n=20). According to canal curvature, each group was subdivided into two subgroups: Subgroup A (10 files): samples were tested in artificial canal of 60° curvature and radius 3mm. Subgroup B (10 files): samples were tested in artificial canal of 45° curvature and radius 5mm.

For every subgroup, 10 samples were selected. This was in compliance with ASTM International's standards, which state that six to twelve samples should be used for statistical analysis of fatigue data.^[1]

Every instrument was examined for any obvious deformation using a digital microscope^[2] setto the proper magnification, and any that showed evidence of damage were thrown away.

A E-cube Endodontic motor (Saeshin Precision Co., Gwanju, Korea) was used to mount the files, Motor settings were modified in accordance with the manufacturer's recommendations for each file. In order

to simulate body temperature, files were rotated while submerged in distilled water at $37 \pm 0.5^\circ$.^[3] The water temperature was regulated by modified heater connected to temperature controller and calibrated using digital thermometer. As soon as a file fracture was visually confirmed, the time to fracture was stopped and recorded. The number of cycles to failure, or NCF, was determined using the equation^[4]:

$$\text{NCF} = \text{rpm} \times \text{time taken to fracture (in sec.)}$$

RESULTS

The one-way ANOVA test was used to evaluate the normally distributed data, and Tukey's post hoc test was used to compare groups. For every test, the significance level was set at $p \leq 0.05$.

Severely curved canal (curvature 60) showed statistically significant NCF less than moderately curved canal (Curvature 45). (Table 1)

Table 1: Mean and Standard Deviation Of All Groups In Curvature 60°, 45°.

	Curvature 60° Mean±SD	Curvature 45° Mean±SD	P value
Plex V Group	60513.00 ± 6147.29 ^a	No file fracture up to 10 minutes of rotation	<0.0001*
W3 Pro Group	38147.55 ± 4773.48 ^b	No file fracture up to 10 minutes of rotation	<0.0001*
Fanta AF Blue Group	12325.20 ± 1555.07 ^c	No file fracture up to 10 minutes of rotation	<0.0001*
M Pro Group	16782.50 ± 3719.62 ^c	No file fracture up to 10 minutes of rotation	<0.0001*

Mean with the same superscript letters were insignificantly different as $P > 0.05$.

Means with different superscript letters were significantly different as $P < 0.05$.

For SEM results: the fracture planes revealed fibrous center sections and areas of elevation at the periphery. Additionally, there were visible black dimplings and crack propagation areas, all signs of a ductile mode of

fracture. (Fig 1)

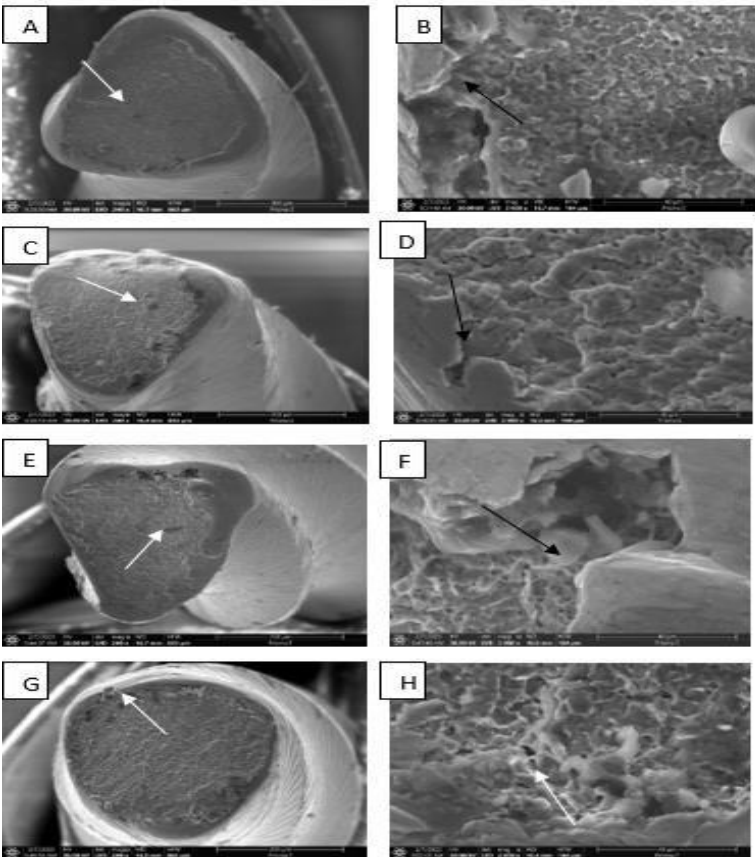


Fig. 1: General view of (A) Plex V; (C) Fanta AF blue; (E) W3-Pro; (G) M-Pro and high-magnification view of (B) Plex V; (D) Fanta AF blue; (F) W3-Pro; (H) M-Pro instruments showing areas of elevations at the peripheries (Black arrows), Cracks and microstructure voids (White arrows).

DISCUSSION

Understanding a file's resistance to cyclic fatigue is crucial because research has shown that the majority of files that broke during clinical use did so primarily due to cyclic fatigue. According to earlier research, the root canal's radius and angle of curvature have a significant impact on cyclic fatigue resistance.^[5,6] Consequently, cyclic fatigue resistance was evaluated in this study in a variety of root canal curvatures with varying radii.

To mimic clinical situations, two artificial canals were used. The first canal, which represented the severe curvature, had a radius of 3 mm and a curvature angle of 60°.^[7,8,9,10] The second canal, which represented the moderate curvature, had a radius of 5 mm and a curvature of 45°.^[11,12] Files tested in the severely curved canal demonstrated significantly less NCF than files tested in the moderately curved canal, regardless of the type of file. This is consistent with Ounsi et al.^[13], Pruett et al.^[14] As well as Kwak et al.^[15]

In severe canal curvature, Plex V files showed the highest cyclic fatigue resistance, while Fanta AF Blue files showed the least cyclic fatigue resistance. The findings dispute the null hypothesis (H0), which proposed that the resistance of NiTi endodontic rotary files to dynamic cyclic fatigue would not be impacted by the cross-section design's geometry. Based on previous studies, the S-shaped cross sectional design has lower blade engagement than the triangular cross section, which may have an impact on the instrument's ability to withstand cyclic fatigue.^[16]

Other than the geometry of the cross-section design, speed of rotation plays another role. The speed of rotation according to the manufacturers' recommendations in Plex V files is (500 rpm), while in Fanta AF Blue is (400 rpm). Therefore, Plex V showed higher NCF than Fanta AF Blue. This was disagreed with Lopes et al.^[17] revealed that the increase in rotational speed significantly reduce the number of cycles to fracture.

Although W3-Pro and Fanta AF Blue have the same cross-section, there was statistically significant difference between them. This demonstrates that not only the cross-section factor but also the manufacturing technique, heat treatment, and alloy type affect the cyclic fatigue resistance of the instrument.^[18,19,20] Fanta AF Blue produced with AF-R wire technology which is a special heat-treated wire. According to the manufacturer's claims^[21], it should improve flexibility and increase cyclic fatigue resistance of the file. However, this was not evident in our study.

CONCLUSION

Plex V files had the highest cyclic fatigue resistance in severe canal curvature among the four types evaluated. With no difference between four groups in moderate canal curvature.

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