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A Comparative Evaluation of Cyclic Fatigue Resistance of Hyflex EDM, Woodpecker Endo Plus and Flexicon Edge Files in Continuous Rotary Motion: An In-vitro Study

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***Abstract*: *Aim:* The purpose of this study was to evaluate the resistance to cyclic fatigue of Hyflex EDM, Woodpecker Endo Plus and Flexicon Edge Endo files in continuous motion. *Subjects and Methods:* A total of 5 new size 25.06 taper Hyflex EDM files, Woodpecker Endo Plus 25.06 taper files and Flexicon Edge Endo 25.06 taper files each were selected. A cyclic fatigue testing device with stainless steel canal with a 90°angle of curvature; curvature starting at 6 mm from the tip was used. All instruments were rotated till fracture occurred and time till fracture of each instrument was recorded in seconds. *Statistical Analysis Used:* Data were analysed using ANOVA. *Results:* In continuous motion, every file demonstrated superior resilience to cyclic fatigue. Hyflex EDM primary files displayed maximum resistance to cyclic fatigue both in continuous motion. Followed by Flexicon Edge Endo and Woodpecker Endo Plus files exhibiting least resistance. *Conclusion:* In comparison to other files, Hyflex EDM files demonstrated improved cyclic fatigue resistance at apical curvature.**

***Keywords*: Canal curvature, Continuous motion, Cyclic fatigue.**

1. Introduction

Nickel-titanium (NiTi) alloy endodontic instruments were introduced in the 1980s, improving mechanical root canal preparation while avoiding issues with stainless steel instruments such ledges, zipping, stripping, perforation, and root canal transportation. NiTi instrument research has drawn interest over time. In 1988, Walia and colleagues made nickel-titanium (NiTi) files available to endodontists for the first time. NiTi alloy was first suggested by Civjan et al. as a component for hand and rotary instruments.

Rotating NiTi instruments have the remarkable ability to negotiate curves during continuous rotation without incurring permanent plastic deformation, which allows them to clean and shape root canals more precisely than stainless steel hand files. Since the preparations are self-centred in the canal, the original root canal configuration is maintained. But these tools frequently break down suddenly.

Torsional fatigue and cyclic fatigue were found to be the two types of fracture for a rotating NiTi file by Ferreira et al. When the instrument's tip becomes stuck in the root canal while the file is still rotating, torsional fatigue develops. The separation happens as a result of slippage between the planes of its crystalline boundaries, primarily as a result of the excessive torsion pressures, and is accompanied by an apparent distortion of a file.

Without much to no visible distortion, another fracture could occur across the metal's grain. When an instrument is repeatedly subjected to cycles of compression and tension, a fracture of this type can be detected as the result of fatigue. A rotating file experiences compression on the inside of a canal's curvature and tension on the outside of the curvature. The root of cyclic fatigue is this.

NiTi rotary file systems were developed to increase flexibility and lessen iatrogenic errors. Special alloys, various cross-sectional patterns, cutting edges, and various tapers are employed by these systems.

The majority of file systems in use employ mechanical handpieces that rotate continuously. In addition to offering better taper in canal preparation, rotary instrumentation has the capacity to gather and remove material from the canal system in a coronal direction. The endodontist can prepare the complete root canal system with just one NiTi instrument, thanks to the lower stress created by reciprocating motion.

Woodpecker endo plus files are the heat-treated gold rotary files maintain the same guiding principles as the first generation of files (file sequence, file sizes, motor settings, and obturation methods) while offering significant additional advantages such as increased flexibility (24% on average) and greater resistance to cyclic fatigue (2.6 times greater on an F3 finishing file). Pre-curved functionality in gold heat activation files makes them safer for distinctive root canals. Files can back straight in hot water automatically after operation.

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Hyflex EDM instruments are produced by Coltene Whaledent in Alstatten, Switzerland, using electrodischarge machining. The material acquires a seemingly isotropic surface as a result, and this is said to increase the instrument's resistance to cycle fatigue and torsional stress. This instrument's special control memory system makes it easier to negotiate complex canal curvatures, resulting in less iatrogenic difficulties. It also shows reversion after heat sterilisation.

Rotary files manufactured by Flexicon Edge Endo (Johnson City, Tennessee, USA) are built with FireWire technology, which makes them incredibly flexible and torsional strain resistant. The Crown-Down Technique is used by the Flexicon NiTi Rotary File to prepare the root canal. Flexicon files are made with an additional safety feature that will unwind in the event of a break, helping to prevent further damage. Until the files unwind backward, they must be used. The manufacturer claims that the file's parabolic cross-section offers a high level of efficiency and flexibility while also being secure and resistant to fracture in curved canals.

2. Materials and Method

In this study, three NiTi rotary file systems—Woodpecker Endo Plus, Hyflex EDM, and Flexicon Edge Endo of size #25, 0.6%—were employed.

Before usage, any flaws in the instruments were checked for.

Following a three-group experimental division of the files, the further steps were carried out.

- Group 1- Woodpecker Endo Plus files, 300rpm, 2Ncm
- Group 2- Hyflex EDM files, 300rpm, 2Nc
- Group 3- Flexicon Edge, 300rpm, 2Ncm

The rotary files were used in accordance with the manufacturer's instructions with an endodontic X SMART PLUS (DENTSPLY) hand piece.

Five new size 25.06 taper Hyflex EDM files, 25.06 taper Flexicon Edge files, and 25.06 taper Woodpecker Endo Plus files total were chosen. The chosen files were all 25 mm long.

3. Cyclic Fatigue Testing

Using a specially made instrument, the results of cyclic fatigue testing were assessed. An iron framework supported the artificial canal system, which was constructed of tempered steel. The dental hand piece was attached to a portable device, making it easy to insert each instrument into the artificial canal.

Stainless steel blocks with a 90° angle and a 3 mm width make up the canal system. 6 mm from the tip, there is a curvature.

Dentsply X-Smart Plus Motor was employed to rotate the files (300 rpm speed, 2 Ncm torque). The artificial canals were enclosed with glass to prevent the instruments from slipping out and to allow observation of the instruments.

Then, two operators each activated the timer and motor simultaneously. To assess their resistance to cycle fatigue, all of the instruments were rotated, and the time to fracture in seconds was noted. Each test involved watching the instrument through the glass until a fracture occurred, at which point the time to fracture was recorded in seconds.

The formula used to determine the number of cycles to fracture (NCF) is as follows:

No. of cycles to fracture (NCF) = Number of rotations per minute(rpm) x Time to fracture(sec).

4. Statistical Analysis

The SPSS statistical programme 23.0 Version was used to evaluate the data for the current study, which was entered into Microsoft Excel 2007. The descriptive statistics included mean, standard deviation. The level of the significance for the present study was fixed at 5%.

The intergroup comparison for the difference of mean scores between independent groups was done using the unpaired /independent t test

The Shapiro–Wilk test was used to investigate the distribution of the data and Levene's test to explore the homogeneity of the variables. The information was discovered to be uniform and normally dispersed. For each variable, the mean and standard deviation (SD) were calculated.

The mean time taken in the Woodpecker Endo Plus files (Group I) was 143,20±18.130, in the Hyflex EDM (Group II) it was 317,20 ±11.562 and in the Flexicon Edge (Group III) it was 264.60 ± 6.107. The intergroup comparison between the three groups was statistically significant (p=0.001) when analyzed using One way ANOVA. When the post hoc analysis was done

Table 1

(a) Comparison of Time taken of files using different files

	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
Wood pecker Endo Plus	143.20	18.13009	8.10802	120.6885	165.7115	130.00	175.00
Hyflex EDM	317.20	11.56287	5.17107	302.8428	331.5572	297.00	326.00
Flexicon Edge	264.60	6.10737	2.73130	257.0167	272.1833	257.00	270.00

(b)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	79634.533	2	39817.267	239.047	0.001 (Sig)
Within Groups	1998.800	12	166.567		
Total	81633.333	14			

(c) Post Hoc analysis for intergroup comparison

Group	Mean Difference	Std. Error	P value	Significance
Wood pecker Endo Plus vs. Hyflex EDM	174.00	8.162	0.001	Significant
Wood pecker Endo Plus vs. Flexicon Edge	121.400	8.162	0.001	Significant
Hyflex EDM vs. Flexicon Edge	52.600	8.162	0.001	Significant

the intergroup comparison between Group I and Group II, Group I and Group III, Group II and Group III was statistically significant when analyzed using the post hoc LSD analysis and paired t test.

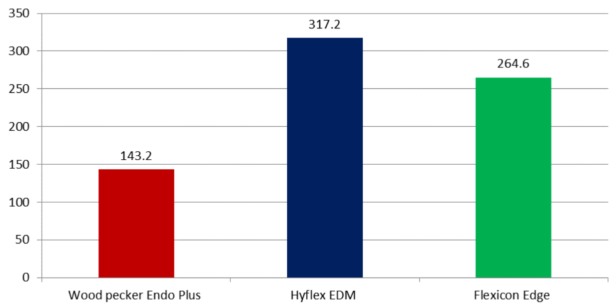

Fig. 1.

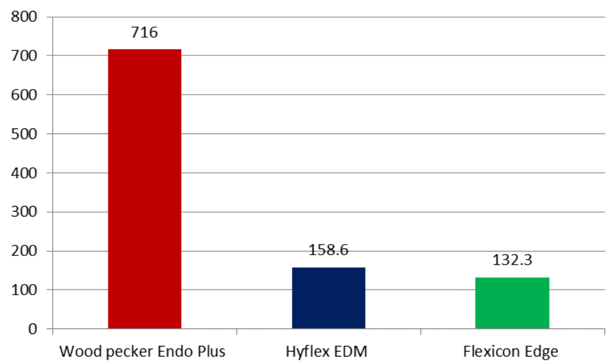

Fig. 2.

The mean cyclic fatigue in the Woodpecker Endo Plus files (Group I) was 716.00±90.650, in the Hyflex EDM (Group II) it was 158,60 ±57.814 and in the Flexicon Edge (Group III) it was 132.30 ± 30.536. The intergroup comparison between the three groups was statistically significant (p=0.001) when analyzed using One way ANOVA. When the post hoc analysis was done the intergroup comparison between Group I and Group II, Group I and Group III, Group II and Group III was statistically significant when analyzed using the post hoc LSD analysis and paired t test.

5. Results

- In comparison to the NCF values of the Woodpecker Endo Plus and Flexicon Edge Endo groups, the No of Cyclic Fatigue value of the HEDM group was much greater. Compared to Groups 1 and 3, Group 2 demonstrated greater cyclic fatigue resistance.
- GROUP 2>GROUP 3>GROUP 1
- Group 2 showed more cyclic fatigue resistance as compared to Group 3 and Group 1.

6. Discussion

Electro discharge machining is used to create Hyflex EDM equipment. This creates a seemingly isotropic surface on the material, which is supposed to boost the instrument's resistance to cyclic fatigue and torsional stress. This instrument's special control memory system makes it easier to navigate complex canal curvatures, leading to less iatrogenic difficulties. It also demonstrates reversion after heat sterilisation.

According to Pedulla et al. [1], HyFlex EDM files have stronger cycle fatigue resistance and angle of rotation to fracture than the other file. However, they found that Hyflex EDM instruments (controlled memory wire) have lower torque to failure than the other two files (M-wire for both files).

It has already been stated that the cross-sectional area and flexibility of the file have a major impact on the cyclic fatigue resistance. The current findings could be explained by variations in the cross-sectional designs of these instruments. Additionally, a file's helical angle and number of threads both influence its resistance to cyclic fatigue. It is possible that instruments' variable pitch designs may have boosted cyclic fatigue resistance.

HyFlex EDM files have stronger cycle fatigue resistance than other files, according to research by Gundogar M. and Ozyurek T [2]. This is due to their extraordinary fracture resistance, regulated memory, increased cutting efficacy, and ability to keep the canal's original shape.

7. Conclusion

HyFlex EDM demonstrated superior cycle fatigue resistance within the parameters of this investigation compared to the

Table 2

(a) Comparison of cyclic fatigue resistance using different files

	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
				Lower Bound	Upper Bound		
Wood pecker Endo Plus	716.00	90.650	40.540	603.442	828.557	650.00	875.00
Hyflex EDM	158.60	57.814	25.855	1514.210	1657.786	1485.00	1630.00
Flexicon Edge	132.30	30.536	13.656	1285.085	1360.916	1285.00	1350.00

(b)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1990863.333	2	995431.667	239.047	0.001 (Sig)
Within Groups	49970.000	12	4164.167		
Total	2040833.333	14			

(c) Post Hoc analysis for intergroup comparison

Group	Mean Difference	Std. Error	P value	Significance
Wood pecker Endo Plus vs. Hyflex EDM	-870.00000*	40.81258	0.001	Significant
Wood pecker Endo Plus vs. Flexicon Edge	-607.00000*	40.81258	0.001	Significant
Hyflex EDM vs. Flexicon Edge	263.00000*	40.81258	0.001	Significant

other two rotary file systems. When compared to the traditional grinding procedure, EDM technology offered superior NiTi file surface preservation during clinical usage in strongly curved canals. Better cycle fatigue resistance is provided by Hyflex EDM files.

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