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Cyclic Fatigue Fracture Resistance Evaluation of Three NiTi Rotary Multiple File Systems: An *in-vitro* Comparative Study

Kartik Sharma [a++*], Aditi Goel [a#] and Khushnuma Shah [b]

[a] Department of Conservative Dentistry and Endodontics, Institute of Dental Sciences Sehora, Jammu (J&K), India.
[b] Consultant Apollo Aesthetics Jammu, (J&K), India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: This *in-vitro* study used cyclic fatigue testing device to compare the cyclic fatigue fracture resistance of three rotary multiple file system; Neoendo flex, Hanu Dent and Hero Gold.
Place and Duration of Study: Between November 2022 and January 2023 in Department of Conservative Dentistry and Endodontics at the Institute of Dental Sciences Sehora in Jammu, Union Territory of Jammu and Kashmir.
Methodology: In this research three rotary nickel titanium systems Neoendo flex, Hanu Dent and Hero Gold; Micromega of size #25 with 4% taper were subjected to cyclic fatigue testing. Each system contained ten files which were 25 mm long. Each experimental file had EDTA gel applied to

[++]Lecturer;
[#]Tutor;
**Corresponding author: E-mail: endokartik@gmail.com;*

it before being put into endodomotor handpiece with rubber stopper. The dental hand piece was attached to portable device making it easy to insert each instrument inside the artificial canal. The files were working in the artificial canal as long as fracture occurred. The number of cycles until fracture was then calculated using the time. NCF = Number of rotations per minute x Time to fracture.

Results: Hero Gold was followed by Hanu Dent in terms of mean values for the number of seconds to fracture. When utilized in curved canals, Neoendo Flex showed least resistance to cyclic fatigue fracture.

Clinical Significance: To endodontists, the choice of file systems in cleaning and shaping of root canal is a mystery. This *in vitro* study investigated the choice of rotary root canal preparation file systems. NiTi endodontic files that have undergone heat treatment have dramatically enhanced the cyclic fatigue résistance extending the average life of file systems.

Keywords: Canal curvature; heat treatment; cyclic fatigue; neoendo flex; hanudent; hero gold.

1. INTRODUCTION

Over the past 20 years, nickel-titanium (Ni-Ti) instruments have been a vital component of dentist's practise for biomechanically preparing root canals [1,2]. Even when obtaining glide route they preserve original canal anatomy better than manual preparation [3,4]. Ni-Ti rotary files extreme flexibility allows them to produce the desired tapered root canal morphology with a lower inclination for canal transportation. Despite these benefits, there seems to be a substantial risk of separation with Ni-Ti instruments mostly due to fatigue and torsional shear pressures. The incidence of clinical fracture in Ni-Ti instruments ranges from 0.26% to 21% [2,5,6]. When the instrument's tip becomes stuck in the root canal while the file is still spinning torsional fatigue develops [7]. According to reports, cyclic fatigue failure can happen suddenly and without any indication of prior permanent deformation. This occurs when the instrument rotates within a curved root canal and is repeatedly stretched and compressed in the area of greatest root canal curvature.

Numerous factors that may affect the fatigue resistance of Ni-Ti rotary files including rotational speed, metal surface treatments, multiple autoclaving and metallurgical characterization of the Ni-Ti alloys, have been researched [8]. Ni-Ti alloy files now come in this new generation with improved physical-mechanical qualities, flexibility and resistance to cyclic fatigue thanks to technological advancements in the manufacturing process. To decrease fractures several strategies, layouts, alloys and production processes have been suggested [6,9].

There are numerous file systems from various manufacturers in the market right now.

Every manufacturer believes that their Ni-Ti rotary file system is better than other brands, making it difficult for clinicians to select the best brand. As a result a comparison review of different file systems was required. Neoendo Flex (Orikam), Hanu Dent and Hero Gold (MicroMega) were the three multiple Ni-Ti rotary file systems that we compared in this study.

1.1 Neoendo Flex Rotary Files

Neoendo flex files manufactured by Orikam Healthcare India Private Limited are freshly developed files with a triangular cross section and an exclusive heat treatment that make them extremely flexible. The flutes do not open when the stress level is met according to the producers, helping to increase cycle fatigue resistance. It has a safety tip that isn't cutting. It operates at 350 RPM and 1.5 Ncm of torque.

1.2 Hanu Dent Rotary Files

Hanu Dent NiTi rotary files are rather more recent additions to the Indian market. They are rotary files made of heat-treated NiTi. According to the manufacturer, they can prepare 20–25 canals in straightforward situations without any fracture danger. They are quite flexible to manoeuvre around curves and have outstanding cutting efficiency. It operates at 350 RPM and 3.5 Ncm of torque.

1.3 Hero Gold Micro Mega Rotary Files

Pronounced tapering: These files streamline and speed up the root canal procedure. The apical and coronal thirds are prepared using the 4% and 6% taper versions respectively. The files gradually free the root canal system of any

restrictions and flare the channel. The length of the cutting portion and helical pitch of the files varies. It operates at 350 RPM and 1.2 Ncm of torque.

2. METHODOLOGY

1. Custom made cyclic fatigue tester
2. Neoendo (Orikam) 25#, Hanu Dent, Hero Gold Multiple Ni-Ti Rotary File System (Micromega)
3. Stop watch

In this investigation, three Ni-Ti rotary systems—Neoendo Flex (Oricam), Hanu Dent, and Hero Gold (Micromega)—were employed. A total of 30 rotating instruments, each measuring 25 mm in length and 4% taper, were examined using a cyclic fatigue tester. Three groups of testing for fracture resistance were created. Before the experiment, each instrument was checked for flaws or deformities with Zumax TTL loupes with a 3.5x magnification and replaced with a new one if necessary.

Group 1- (n=10) multiple file system Neoendo Flex by Oricam.

Group 2- (n=10) multiple file system by Hanu Dent.

Group 3- (n=10) multiple file system Hero Gold by Micromega.

Haikel et al. provided the accepted guidelines for evaluating cycle fatigue resistance[9].In order to simulate root canals artificial grooves were created in stainless steel plate that were 2 mm wide, 20 mm long, and 2.5 mm deep with a 45 degree canal curvature and a U-shaped cross-section. 316 L standard stainless steel blocks were machined with computer assistance before being hardened with a chrome finish. The dental hand piece was attached to a portable device making it easy to insert each instrument into the artificial canal. Then both the timer and the motor were turned on. The manufacturer's suggested speed and torque were used to rotate each instrument.

Group 1- Neoendo Flex, 350 rpm/1.5 Ncm

Group 2- Hanu Dent, 350 rpm /3.5 Ncm

Group 3- Hero Gold, 350 rpm /1.2 Ncm

The instrument was observed and visualised throughout each test until fracture occurred and the time to fracture was measured in seconds using two techniques: (A) Direct visualisation with a Zumax loupe 3.5x TTL (B) Playback of recorded videos using Corel Video Studio ProX2 (Corel Corp., Ottawa, Canada).

The time was then converted into number of cycles to failure.

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

Fig. 1. Materials used in the study

Fig. 2. Zumax 3.5x TTL Loupes

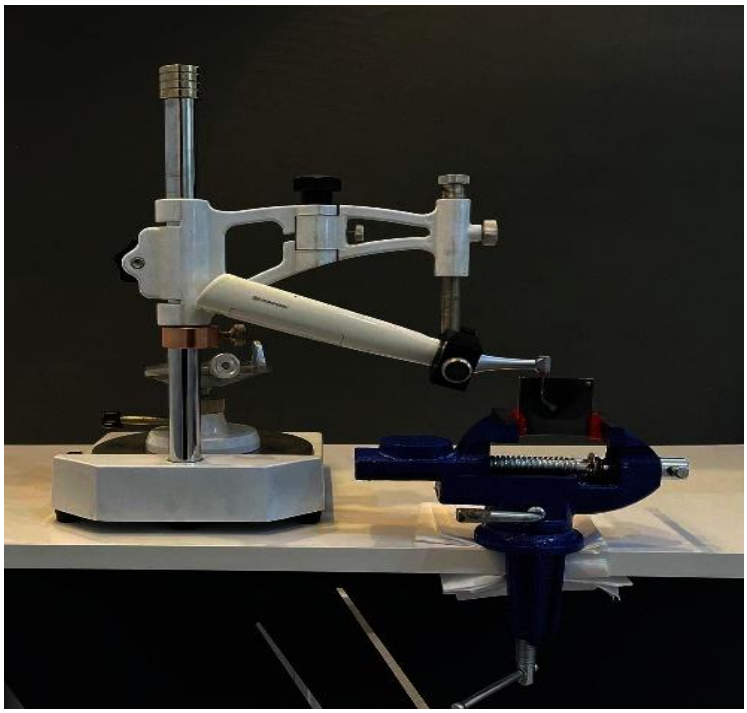


Fig. 3. Cyclic fatigue fracture resistance testing apparatus

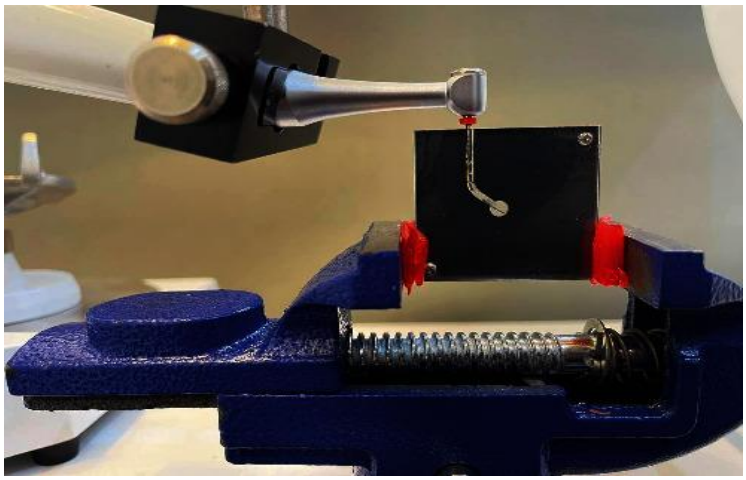


Fig. 4. Fractured file during testing

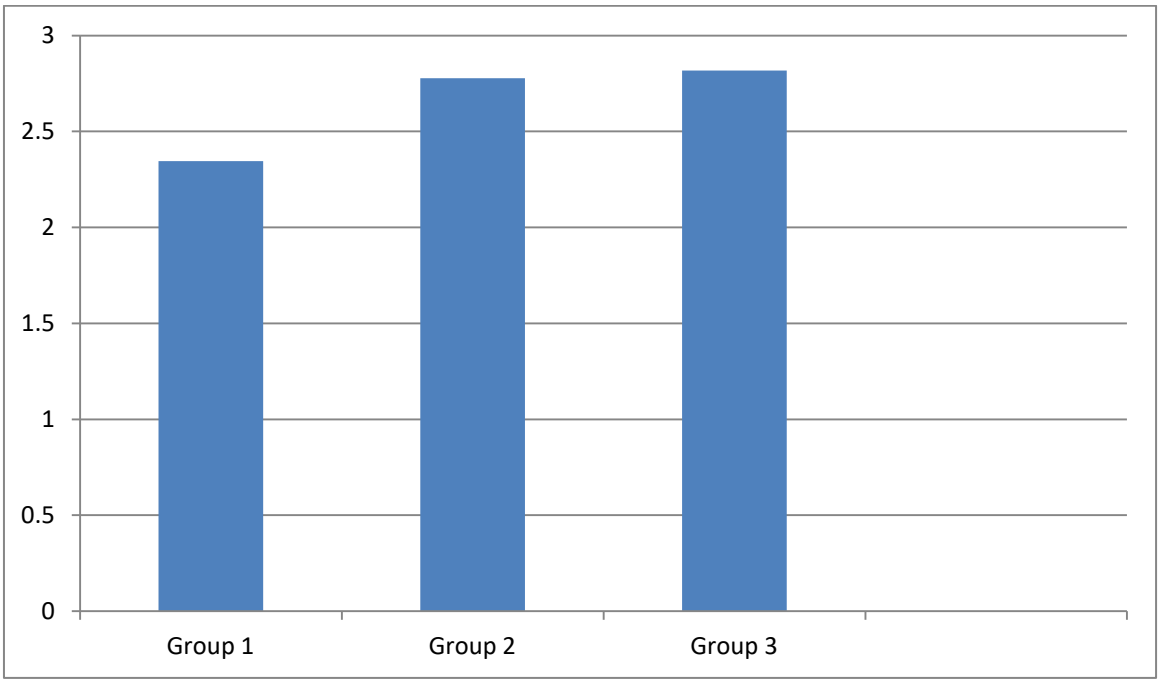
3. RESULTS

Hero Gold - Group 3 has the greatest mean and standard deviation (2.817 ± 0.669), followed by Hanu Dent - Group 2 (2.778 ± 0.602), and Neoendo Flex - Group 1 (2.346 ± 0.509).

Results of the intergroup comparison were statistically significant.

Table 1. Mean time to fracture of different types of file systems

	N	Mean	Std. Dev	Minimum	Maximum	P value
Group 1	10	2.346	0.509	1.09	3.32	
Group 2	10	2.778	0.602	1.99	3.65	0.1153 (S)
Group 3	10	2.817	0.669	2.00	4.08	
Total	30	2.647	0.616	1.09	4.08	



Graph 1. Distribution of mean values of time in seconds to fracture in Group 1: Neoendo flex, Group 2: Hanu Dent, Group 3: Hero Gold under study

4. DISCUSSION

One of the most crucial choices a dentist must make while cleaning and contouring a root canal is choosing a rotary file with high flexibility and fracture resistance to reduce the likelihood of file separation. The manufacturing process, structural properties, geometrical designs, surface texture, canal curvature and method for calculating fatigue failure are the variables that affect an instrument's fracture resistance. This study employed two approaches for measuring time of file fracture - direct visualisation and also watching a filmed video clip in comparison to other studies that used on direct visualisation. No significant difference was detected between the fracture time calculated by two approaches. By enhancing the design, metallurgy, surface treatments and kinematics of their products, manufacturers hope to create instruments that are highly fracture resistant in all clinical situations regardless of canal curvature. The following three suggestions have been made to lengthen the life of endodontic files: Prior to machining, there are three steps: (I) thermal treatments; (II) selecting machining conditions appropriate for the Ni-Ti alloy; and (III) electropolishing. Various scholars have proposed various techniques for evaluating cyclic fatigue resistance. There is currently no equipment or method available for fatigue testing that has been incorporated into international standards for endodontic instruments despite the fact that variations in testing devices utilised for the evaluation can result in varied results [10]. Regarding how electro-polishing affects rotary file fatigue failure, debate rages on. While Herold et al. inferred that electro-polishing did not prevent the development of microfractures and Barbosa et al. concluded that electrochemical polishing had no influence on the resistance to fracture of the rotary instruments, some studies have shown that electro-polishing improves the instrument's working properties such as resistance to failure by producing a smooth and homogeneous protective surface oxide layer with less defects and residual surface stress [11].

In this study, three different types of Ni-Ti rotary files—Neoendo Flex, Hanu Dent, and Hero Gold—with various production processes and different improvement methodologies were examined for their cyclic fatigue resistance. Because it is challenging to standardise root canal length, degree and radius of curvature as well as dentin hardness, the use of actual teeth was avoided [12]. A stainless steel plate was used to create an artificial canal that had dimensions similar to those of root canals: 2 mm wide, 20 mm long, and 2.5 mm deep with a 45 degree canal curvature and a U-shaped cross-section. 316 L standard stainless steel blocks were then subjected to computer-aided milling followed by hardening procedures using a chrome finish. Each experimental file was coated with EDTA gel and was inserted in endodomotor handpiece with rubber stopper. Additionally, RC-prep [13] and glycerine [14] can be utilised as lubricants. Until fracture occurred, all instruments were rotated or reciprocated. According to the findings of this investigation, Group 3 Hero Gold's cycle fatigue fracture resistance was stronger than that of the other file systems employed, namely Group 1 and Group 2 [Table 1]. The root canal system's restrictions are gradually removed and the canal is flared using Hero Gold files. The length of the cutting portion and helical pitch of the files varies. Hero Gold files, according to its manufacturers operate better due to heat treatment, an electropolished surface, a large inner core, and anti-breakage control technology.

5. CONCLUSION

Hero Gold demonstrated much greater cyclic fatigue fracture resistance than Hanu Dent under the constraints of the current study. Of all files examined in the group, Neoendo Flex had the lowest cycle fatigue fracture resistance. The current study's findings however are liable to vary depending on the environment and testing procedures. Therefore, additional study is required to support the conclusions of the current study.

6. LIMITATIONS OF THE STUDY

This *in vitro* study does not accurately represent a genuine clinical setting even though an artificial canal system with a 45 degree canal curvature was created to duplicate the actual root canal. This is because root canal curvature can occasionally range from 45 degree to 60 degree or more. In practise, the dentist controls the axial movement of the endomotor handpiece manually. Because these variables were not repeated in this in vitro study, additional in vivo studies are necessary to verify the findings of the current study.

CONSENT AND ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that they have no known competing financial interests or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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