Cyclic Fatigue Fracture Resistance Evaluation of ThreeNiTi Rotary Multiple File Systems: An In-Vitro Comparative Study

Abstract

Background: This in-vitro study was aimed to comparatively evaluate the cyclic fatigue fracture resistance of three rotary multiple file system; Neoendo flex, Hanu Dent and Hero Gold utilizing cyclic fatigue testing device.

Place and Duration of Study: Department of Conservative Dentistry and Endodontics, Institute of Dental Sciences Sehora, Jammubetween November 2022 and January 2023.

Methodology: Three rotary nickel titanium systems Neoendo flex, Hanu Dent and Hero Gold; Micromega size #25,4% taper were used in this study. Ten files were used in each file system, which were 25 mm long 4% taper and tested with cyclic fatigue tester. Each experimental file was coated with EDTA gel and was placed in endodomotorhandpiece with rubber stopper. The dental hand piece was mounted on a mobile device that allowed for the simple placement of each instrument inside the artificial canal.The files were engaged in the artificial canal until the occurrence of fracture. The time was then converted into number of cycles to failure. NCF = Number of rotations per minute x Time to fracture.

Results: Hero Gold showed highest mean values of time in seconds to fracture followed by HanuDent .Neoendo Flex showed least resistance to cyclic fatigue fracture when used in curved canals.

Clinical Significance:

The selection of file systems in cleaning and shaping protocols is an enigma to the endodontics. This *in vitro* study explored the selection protocols for the execution of root canal preparation. Heat treatment of nickel–titanium (NiTi) endodontic files improved the cyclic fatigue résistance significantly enhancing the clinical life of file systems.

Keywords: Canal Curvature, Heat Treatment, Cyclic Fatigue, Neoendo Flex, Hanudent, Hero Gold.

Introduction

Nickel-titanium (NiTi) instruments have become important part of dentist's practice for preparation of the root canal biomechanically for the last two decades.[1,2] They maintain original canal anatomy better than preparation done manually even when obtaining glide path.[3,4]Because of the superelasticity of NiTi rotary files, they can create the desirable tapered root canal form with reduced tendency of canal transportation.Despite these advantages, NiTiinstruments appear to have a high risk of separation, mainly because of fatigue and torsional shear stresses. Clinical fracture of NiTi instruments incidence ranges between 0.26%-21%.[2,7,8] Torsional fatigue occurs

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when the tip of the instrument binds in the root canal while the file continues turning.[5] Cyclic fatigue failure is reported to occur unexpectedly without any sign of previous permanent deformation. This happens when the instrument rotates inside a curved root canal and issubjected to an excessive number of tension-compression strain cycles in the region of maximum root canal curvature. Many variables such as the rotational speed, the metal surface treatments, multiple autoclaving, and the metallurgic characterization of the NiTi alloys that could possibly influence the fatigue resistance of NiTi rotary files have been investigated.[6] Advances in technology and manufacturing process of NiTi alloy have resulted in a new generation of files with superior physical-mechanical properties, flexibility and resistance to cyclic fatigue. Different techniques, designs, alloys and manufacturing methods have been proposed in order to reduce fractures.[8,9] Today there are large number of file systems available in the market from different manufacturers. Every manufacturer claims that their NiTi rotary file system is superior than other brands and clinician gets confused in choosing the right brand, thus a comparative evaluation of these file systems was needed. In this study we have compared three multipleNiTi rotary file systems-Neoendo Flex (Orikam), Hanu Dent and Hero Gold (MicroMega).

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Neoendo Flex Rotary Files

Neoendo flex files (Orikam Healthcare India Private limited) are recently introduced files designed with a triangular cross section and a proprietary heat treatment rendering them highy flexible. The manufacturers also claim that the flutes do not open when the stress level is reached, which helps in increasing the cyclic fatigue resistance. It has a non cutting safety tip. It is used at speed of 350 RPM and torque 1.5 Ncm.

Hanu Dent Rotary Files

Hanu Dent NiTi rotary files are relatively newer files introduced in India. They are heat treated NiTi rotary files. Manufacturer claims in simple cases, they can prepare 20-25 canals without any risk of fracture. They have good cutting efficiency and are extremely flexible to go past curvatures. It is used at speed of 350RPM and torque 3.5Ncm.

Hero Gold Micro Mega Rotary Files

Pronounced tapers. These files make root canal treatment quicker and simpler. The 4% and 6% variants in taper are used to prepare the apical and coronal thirds respectively. The files progressively remove any constraints present in the root canal system and flare the canal.The files have a varying helical pitch and length of the cutting portion.It is used at speed of 350RPM and torque 1.2Ncm.

Methodology

1. Custom made cyclic fatigue tester
2. MultipleNiTi rotary File System: Neoendo (Orikam) 25#, Hanu Dent; Hero Gold (Micromega)

3. Stop watch

Three NiTi rotary systems Neoendo Flex; (Oricam), Hanu Dent; Hero Gold (Micromega) were used in this study. Ten rotary instruments of each type with the total of 30 instruments of 25 mm in length and 4% taper tested with cyclic fatigue tester. Fracture resistance tests were divided into 3 groups. Every instrument was inspected for defects or deformities before the experiment using Zumax TTL loupes of magnification3.5x and replaced with a new one if found defective.
Group 1- (n=10) Neoendo Flex; Oricam- multiple file system
Group 2- (n=10) Hanu Dent – multiple file system
Group 3- (n=10) Hero Gold; Micromega- multiple file system

The standard guideline for the assessment of cyclic fatigue resistance was given by Haikel et al.[9]Artificial grooves were depicted in stainless steel plate resembling the root canals measuring 2 mm in width, 20 mm in length, and 2.5 mm in depth with 45 degree canal curvature with U-shaped cross-section, and 316 L standard stainless steel blocks were subjected to computer-aided milling followed by hardening procedures employing chrome finish.The dental hand piece was mounted on a mobile device that allowed for the simple placement of each instrument inside the artificial canal. The motor and timer were then simultaneously activated. All of the instruments were rotated at the speed and torque recommended by the manufacturer.
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

During each test, the instrument was monitored and visualized until fracture occurred and the time to fracture was recorded in seconds by two methods: (A) Direct visualization with 3.5x TTL Zumax loupe (B) playing captured videos by Corel Video Studio ProX2 software (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

Figure 1: Materials used in the study

Figure 2:Zumax 3.5x TTL Loupes

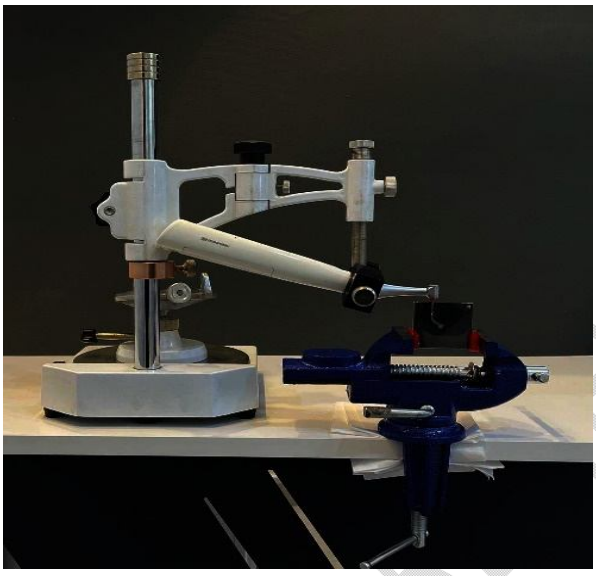


Figure 3: Cyclic Fatigue Fracture Resistance Testing Apparatus

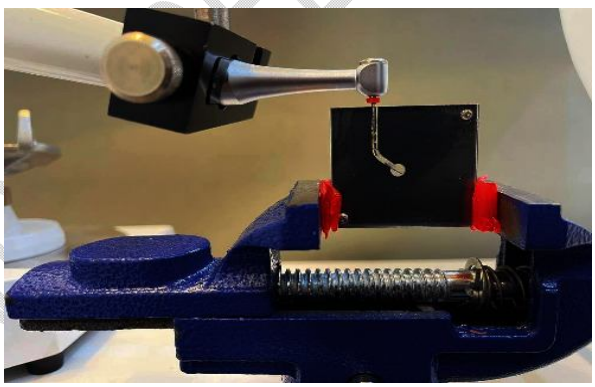


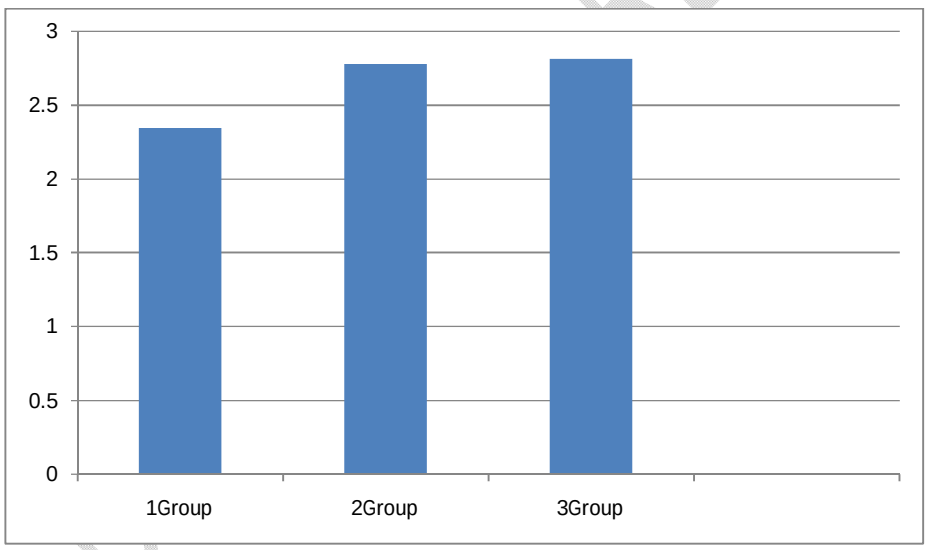
Figure 4: Fractured file during testing

Results

Group 3: Hero Gold has highest mean and standard deviation of (2.817 ± 0.669), followed by Group 2; Hanu Dent (2.778 ± 0.602) and Group 1; Neoendo Flex (2.346 ± 0.509). Intergroup comparison showed statistically significant results.

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, Group3: Hero Goldunder study.

Discussion

One of the most important decision for a dentist is selection of rotary file with high flexibility and fracture resistance during cleaning and shaping of the root canal to minimize the incidence

of file separation. There are many factors that determine the fracture resistance of the instrument such as their manufacturing process, structural characteristics and geometric designs, surface texture, canal curvature and method used for fatigue failure calculation. This study used two methods for calculating time of file fracture – direct visualization and and watching a captured video clip in comparison to other studies that used on direct visualization. No significant difference was seen between the fracture time estimated by two methods. Manufacturers are aiming at developing instruments with high fracture resistance in all clinical conditions irrespective of canal curvature by improving the design, metallurgy, surface treatments and kinematics. Three ways for improving the longevity of endodontic files have been suggested which include the following: (I) Thermal treatments before machining; (II) Choosing machining conditions adapted to the NiTi alloy and (III) electro-polishing.

This study compared the cyclic fatigue resistance of three different types of NiTi rotary files-Neoendo Flex, Hanu Dent and Hero Gold with different manufacturing techniques and different improvement strategies. Artificial canal was depicted from a stainless steel plate resembling the root canals measuring 2 mm in width, 20 mm in length, and 2.5 mm in depth with 45 degree canal curvature with U-shaped cross-section, and 316 L standard stainless steel blocks were subjected to computer-aided milling followed by hardening procedures employing chrome finish. Each experimental file was coated with EDTA gel and was placed in endodomotorhandpiece with rubber stopper. Other lubricants such as glycerine[10] and RC‑prep[11] can also be used. All the instruments were rotated or reciprocated until fracture occurred. According to the results of the present study, the cyclic fatigue fracture resistance of Group 3 Hero Gold was higher compared with the other file systems used i.e. Group 1 and Group 2 [Table 1].Hero Gold files progressively remove any constraints present in the root canal system and flare the canal.The files have a varying helical pitch and length of the cutting portion.

Limitations of the study

Although artificial canal system with 45 degree canal curvature was milled to replicate the original root canal, this invitro study does not depict real clinical scenario because sometimes root canal curvature ranges from 45 degree to 60 degree or greater. Clinically, the axial movement of the endomotorhandpiece is controlled manually by the dentist and these variables were not replicated in this invitro study and hence futherin-vivo studies are required to confirm the results of the present study.

Conclusion

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Hero Gold exhibited the highest and Neoendo Flex exhibited the lowest fracture resistance compared to other evaluated file. However further long-term studies with longer follow-ups are required to access the best file in this group**.**

COMPETING INTERESTS DISCLAIMER:

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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Comment [DS28]: Update the references

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