Original Article

Comparative Evaluation of Cyclic Fatigue Resistance of ProTaper Gold, Neo Endo Flex, and HyFlex CM Nickel–titanium Rotary Files – An *In vitro* Study

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Abstract

Background: Nickel–titanium (NiTi) files have drastically improved endodontic treatment. Cyclic fatigue occurs as a consequence of repeated cycles of tensile-compression stress. The study aimed to compare the Cyclic Fatigue Resistance of ProTaper Gold (PTG), Neo Endo Flex, and HyFlex CM, using a cyclic fatigue testing device. **Materials and Methods:** Three NiTi rotary systems, ProTaper Gold, Neo Endo Flex, and HyFlex CM, were selected and divided into three groups containing six files each of 4% taper, #25 size, and 21 mm. A custom-made model with brass was fabricated with a single curve of 5 mm radius and 60° curvature. Cyclic fatigue resistance was evaluated through a static model in a customized device specifically created for this purpose. **Results:** HyFlex CM and Neo Endo Flex both have greater cyclic fatigue resistance than PTG, which has the least cyclic fatigue resistance. **Conclusion:** Neo-Endo Flex and HyFlex CM NiTi files have higher cyclic fatigue resistance than PTG, and no significant difference between the cyclic fatigue resistance of Neo Endo Flex and HyFlex CM.

Keywords: Cyclic fatigue resistance, HyFlex CM, Neo Endo Flex, ProTaper Gold

Introduction

Since their introduction in 1988, nickel–titanium (NiTi) files have drastically improved endodontic treatment.[1] However, to minimize the risks of file separation, knowledge of the NiTi instruments' characteristics is crucial.[2] NiTi files can suddenly separate during root canal preparation due to torsional and cyclic fatigue.[3]

Cyclic fatigue occurs as a consequence of repeated cycles of tensile-compression stress to which the instruments are subjected when it rotate inside curved canals.[4] Many variables are involved in the fracture of rotary files, some of which depend on the instrument properties.[4]

Other parameters implicated in the file separation are related to the canal configuration, including root canal curvature, angle, radius, length of the curve, and its location.[5] In particular, the degree of curvature represents a critical factor mainly in S-shaped canals.[6]

Furthermore, environmental temperature affects the cyclic fatigue resistance of NiTi instruments.

Recent years to improve the thermomechanical characteristics of NiTi rotary endodontic files. These improvements aim to enhance the flexibility, metallurgy, design, kinematics, and fracture resistance of NiTi files. Attempts to achieve this goal include surface modification by electro-polishing and the enhancement of mechanical properties by adding new alloys and new designs, including cross-sectional modifications.[7,8]

Several studies have shown enhanced cyclic fatigue resistance (CFR) due to recent advancements in file technology. However, to the best of our knowledge, no study has yet compared the effects of different heat-treated file types together. Therefore, the present study aimed to compare the CFR of three different NiTi rotary file systems, namely ProTaper Gold (PTG), Neo Endo Flex, and HyFlex CM, using a cyclic fatigue testing device.

The aim of the study is to calculate the cyclic fatigue resistance of ProTaper Gold, Neo Endo Flex, and HyFlex CM NiTi rotary

Access this article online

Website: www.jrad.co.in

DOI: https://doi.org/10.53064/jrad.2024.16.5.729

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Received: Aug. 04, 2025; **Accepted:** Sep. 04,2025; **Published:** Sep. 24,2025

How to cite this article: Aparajita Rakesh, Pradeep K, Sandhya K, Sharma P, Patil TN, Kumar VA. Comparative Evaluation of Cyclic Fatigue Resistance of ProTaper Gold, Neo Endo Flex, and HyFlex CM Nickel–titanium Rotary Files – An *In vitro* Study. J Res Adv Dent 2025;16(5):1-4.

files. The objective of the study is to calculate the cyclic fatigue resistance of ProTaper Gold, Neo Endo Flex, and HyFlex CM in a single curvature canal in rotary motion utilizing a customized cyclic fatigue testing device.

Materials and Methods

Three NiTi rotary systems, ProTaper Gold, Neo Endo Flex, and HyFlex CM, were selected and divided into three groups, containing six files each of 4% taper, #25 size, and 21 mm. A custom-made model with brass was fabricated with a single curve of 5 mm radius and 60° curvature angle, with the center of the angle of curvature located 8 mm from the orifice [Figure 1].[9]

The files were examined using a stereomicroscope at ×20 magnification to detect any deformation before the cyclic fatigue test. No file was discarded. Cyclic fatigue resistance was evaluated through a static model in a customized device specifically created for this purpose [Figure 2].[9]

A continuous back-and-forth axial oscillation motion inside the artificial canal was performed with an amplitude of 3 mm/s to simulate clinical usage. A 6:1 reduction electrical handpiece has been maintained in a standardized tridimensional position through tests to confirm the exact fracture time. The time to fracture recorded with a digital chronometer was multiplied by the number of rotations per minute (number of rotations per second).[9]

A high-flow synthetic oil was applied to the artificial canal as a lubricant to reduce the friction. A digital camera was used during the number of cycles to fracture (NCF). A single expert operator performed all the experiments. A second blinded examiner was responsible for the surface examination.[9]

Data were subjected to the Shapiro–Wilk test to verify their normality and statistically analyzed using two-way analysis of variance and the Bonferroni multiple comparison *post hoc* test (Prism 8.0; GraphPad Software, Inc.) with $P < 0.05$.

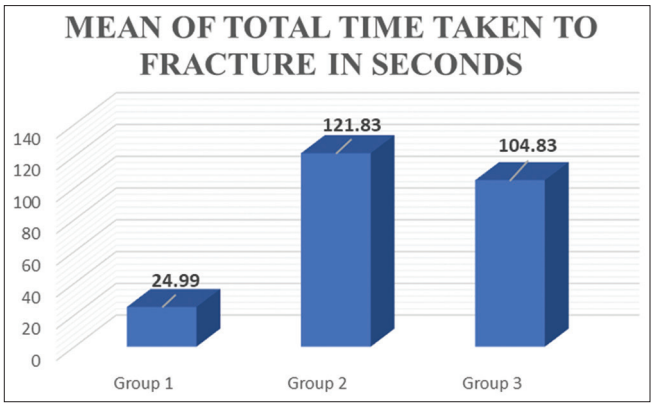
Results

Graph 1 shows the mean of total time to fracture (TTF), and Graph 2 shows NCF values for groups 1, 3, and 3 tested in laboratory conditions.

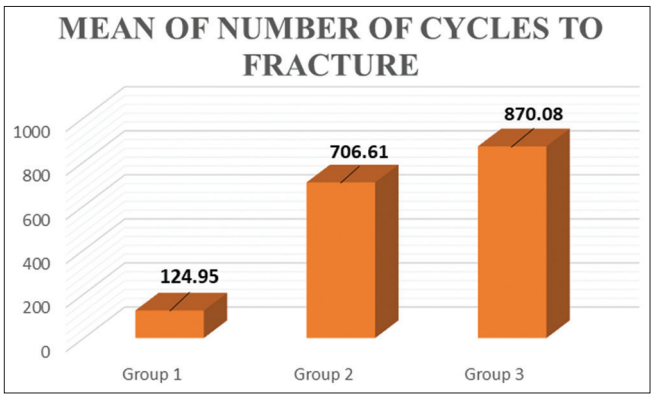
Comparing instruments with the same size, overall, HyFlex CM and Neo Endo Flex showed higher cyclic fatigue resistance than PTG among all the tested files ($P < 0.05$). Statistical differences were observed between PTG, having the least cyclic fatigue resistance, and HyFlex CM and Neo Endo Flex, having greater cyclic fatigue resistance. No statistical differences were observed between HyFlex CM and Neo Endo Flex in single curvatures.

Discussion

Cyclic fatigue can be defined as the stress, strain, and deformation induced in a material by cyclic loading. Cyclic



Graph 1: Group 1 – ProTaper Gold, Group 2 – Neo Endo Flex, Group 3 – HyFlex CM



Graph 2: Group 1 – Protaper gold, Group 2 – Neo Endo Flex, Group 3 – Hyflex CM

fatigue life is the number of loading cycles that produce a rupture or breakage in the material.[10] It determines the longevity of NiTi files to undergo tension and compression before fracture.

NiTi rotary files have shape memory, great flexibility, and preserve the original shape of the canal during preparation of the canal. Peculiarly, the elasticity of NiTi files is double or triple times higher than stainless-steel files because the modulus of elasticity of NiTi is low.[11]

Several factors are involved in NiTi instrument fracture, some of which are related to file design and others to root canal anatomy. NiTi files last longer before breaking within simpler root canal anatomies, such as single curved canals, while NCF decreases as the complexity of the intracanal anatomy increases.[9]

The NiTi file system chosen for this study includes PTG, Neo Endo Flex, and Hyflex CM.

The PTG (2014) was fabricated using gold heat treatment technology. It has a convex triangular cross-section and progressive taper, which enhances cutting action while decreasing rotational friction between the blade of the file and dentin. PTG instruments produced less transportation; maintained more dentin than ProTaper Universal (PTU). During the manufacturing phase, the files are subjected

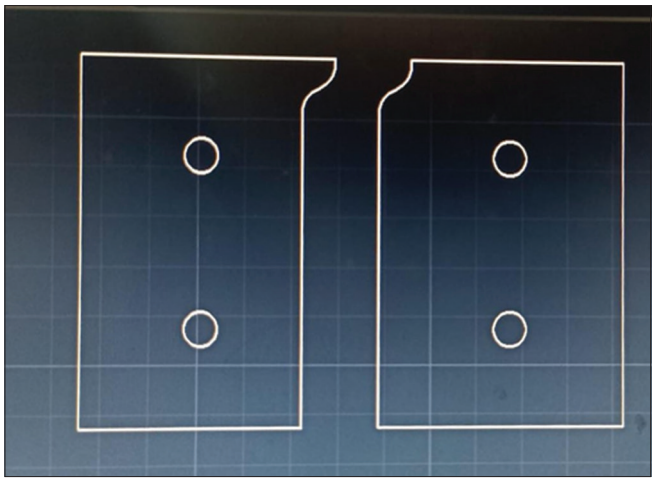


Figure 1: The accuracy of the calibration was standardized using graphical software before fabrication

Figure 2: Custom-made model with a file simulating a root canal

to a unique heat treatment process, ultimately exhibiting different phase transformation behaviour, higher flexibility, and higher cyclic fatigue resistance. The physical properties mentioned above are most suited for preparing root canals with challenging, abrupt curvatures.[12]

Neoendo Flex files (Orikam Healthcare India Private Limited, 2013) are recently designed files with a triangular cross-section and gold thermal treatment, making them exceptionally flexible. In addition, according to the producers, the flutes do not open when the stress level is met, increasing cyclic fatigue resistance.[13]

HyFlex® CM NiTi files have been manufactured utilizing a unique process that controls the material's memory, making the files extremely flexible but without the shape memory of other NiTi files. This gives the file the ability to follow the anatomy of the canal very closely, reducing the risk of ledging, transportation, or perforation compared to other instruments with a rebound effect.[14]

No previous studies have examined the cyclic fatigue resistance of PTG, Neoendo Flex, and HyFlex CM NiTi files.

Cyclic fatigue resistance can be calculated by evaluating the time to fracture (TTF) in seconds and then multiplying by rotation per minute (RPM)/60) to obtain the NCF.

In this study, the time to fracture (TTF) was recorded for each rotary file, recorded with a digital chronometer in seconds, and then multiplied by RPM/60 to obtain the NCF.

An automated Endo motor was used for checking the cycling fatigue resistance. RPM and torque were set for each file system according to the manufacturer's instructions.

The customized device was prepared with brass to mimic the hardness of dentin. Curvature of 60° is given with a 5 mm radius, and the distance is kept 8 mm from the centre of curvature to the orifice. Accuracy of the calibration was standardized using graphical software before fabrication. The curvature of the model was kept following Schnieder's principle, and the radius was kept according to Pratt's technique.[9]

The back-and-forth movement was performed inside the artificial canal to mimic the pecking motion. This permits the distribution of the stresses along the entire surface of the files, increasing their fatigue life.[9]

Neo Endo Flex and HyFlex CM NiTi files have higher cyclic fatigue resistance than PTG, and there is no significant difference between the cyclic fatigue resistance of Neo Endo Flex and HyFlex CM.[9]

A study conducted by Hamargo *et al*. compared the cyclic fatigue resistance, torsional failure, and flexural resistance of NiTi endodontic files: HyFlex CM (HYF), Genius files (GEN), Waveone Gold (WOG), and PTU, and concluded HYF and GEN showed the best results for cyclic fatigue, torsional failure, and flexural resistance, followed by WOG and PTU.[9] AQ11

A study conducted by Kocak *et al*.[15] compared the cyclic fatigue resistance between ProTaper Next, HyFlex CM, 2shape, and tf-adaptive file systems and concluded that HyFlex CM demonstrated better cyclic fatigue resistance than tf adaptive, ProTaper Next, and 2shape file systems. These studies support the result of our present study.[9]

The study has some limitations since cyclic fatigue is a complex phenomenon to which several factors contribute simultaneously, and the study was conducted *in vitro,* which differs from the oral environment. Other factors include operator experience, anatomical complexities, and NiTi instruments tested.[9]

Under these laboratory limitations, the findings are clinically relevant because they confirm that different NiTi files can respond differently to anatomical and environmental variations. The clinician should be aware of this and select the best instrument for each clinical condition. Further investigations are needed to confirm these results and investigate the

metallurgical characterisation and other mechanical properties, including torsional resistance and cutting efficiency.[9]

Conclusion

Under the limitations of this study, Neo Endo Flex and HyFlex CM NiTi files have higher cyclic fatigue resistance than PTG, and there is no significant difference between the cyclic fatigue resistance of Neo Endo Flex and HyFlex CM.

Ethical Clearance Number

EC/NEW/INST/2023/3485.

References

1. Neelakantan P, Reddy P, Gutmann JL. Cyclic fatigue of two different single files with varying kinematics in a simulated double-curved canal. J Investig Clin Dent 2016;7:272-7.
2. Al-Obaida MI, Merdad K, Alanazi MS, Altwaijry H, AlFaraj M, Alkhamis AA, *et al*. Comparison of cyclic fatigue resistance of 5 heat-treated nickel-titanium reciprocating systems in canals with single and double curvatures. J Endod 2019;45:1237-41.
3. Ribeiro Camargo CH, Bittencourt TS, Hasna AA, Palo RM, Talge Carvalho CA, Valera MC. Cyclic fatigue, torsional failure, and flexural resistance of rotary and reciprocating instruments. J Conserv Dent 2020;23:364-9.
4. Pedullà E, La Rosa GR, Virgillito C, Rapisarda E, Kim HC, Generali L. Cyclic fatigue resistance of nickel-titanium rotary instruments according to the angle of file access and radius of root canal. J Endod 2020;46:431-6.
5. Alghamdi S, Huang X, Haapasalo M, Mobuchon C, Hieawy A, Hu J, *et al*. Effect of curvature location on fatigue resistance of five nickel-titanium files determined at body temperature. J Endod 2020;46:1682-8.
6. Elnaghy AM, Elsaka SE. Cyclic fatigue resistance of one curve, 2Shape, ProFile vortex, vortex blue, and RaCe nickel-titanium rotary instruments in single and double curvature canals. J Endod 2018;44:1725-30.
7. de Vasconcelos RA, Murphy S, Carvalho CA, Govindjee RG, Govindjee S, Peters OA. Evidence for reduced fatigue resistance of contemporary rotary instruments exposed to body temperature. J Endod 2016;42:782-7.
8. La Rosa GR, Palermo C, Ferlito S, Isola G, Indelicato F, Pedullà E. Influence of surrounding temperature and angle of file access on cyclic fatigue resistance of two single file nickel-titanium instruments. Aust Endod J 2021;47:260-4.
9. La Rosa GR, Leotta ML, Canova FS, Romeo VR, Cervino G, Generali L, *et al*. Cyclic fatigue resistance of different nickel-titanium instruments in single and double curvature at room and body temperatures: A laboratory study. Aust Endod J 2023;49:592-8.
10. Plastic Pipe Systems. Cyclic fatigue can be defined as the stress, strain, and deformation induced in a material by cyclic loading. In: Qureshi LA, editor. Plastic Pipe Systems. Oxford: Elsevier; 2006.
11. Abu Naila AS, Al-Huwaizi HF. Cyclic fatigue resistance of three different rotary endodontic instruments with design modification. J Res Med Dent Sci 2022;10:25-30.
12. Matea M, Nicola A, Turcu A, Bunget A, Bătăiosu M, Diaconu C, *et al*. Clinical and theoretical aspects of the use of ProTaper Gold and ProTaper Next needle systems in endodontic treatment. Rom J Med Dent Educ 2021;10:50-7.
13. Chhabra A, Ramya KP, Prathap BS, Yadav P. Life span of Neoendo Flex and ProTaper Next rotary files with reciprocating motion in single-rooted teeth. J Conserv Dent Endod 2023;26:420-3.
14. Caicedo R, Clark SJ. HyFlex CM rotary files: An excellent innovation for endodontic treatment. Endod Pract 2012;4:10-7.
15. Koçak S, Şahin FF, Özdemir O, Koçak MM, Sağlam BC. A comparative investigation between protaper next, hyflex CM, 2shape, and tf-adaptive file systems concerning cyclic fatigue resistance. J Dent Res Dent Clin Dent Prospects. 2021;15:172-7.

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