Original Article

IN-VITRO RESEARCH TO COMPARE THE CYCLIC FATIGUE RESISTANCE OF THREE ROTARY NITI GLIDEPATH FILES IN EXTREMELY CURVED SIMULATED ROOT CANAL

Mona Somani[1], Jadawala Kruti M[2*], Joshi Chintan[3], Aashray Patel[4], Sweety Thumar[5], Neelam Desai[6], Parmar Anisha D[7]

[1] Associate Professor, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India.
[2] Post Graduate Student, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India
[3] Professor and Head of the Department, fellow PhD,Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India.
[4] Assistant professor, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India.
[5] Associate Professor, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India.
[6] Senior Lecturer, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India.
[7] Post Graduate Student, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India.
Corresponding Author: Jadawala Kruti M, Post Graduate Student, Department of Conservative Dentistry and Endodontics, Karnavati School of Dentistry, Karnavati University, Gandhinagar, Gujarat, India.
E-mail: kmj9896@yahoo.com

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Abstract

Aim: In-Vitro research to compare the cyclic fatigue resistance of three rotary NiTi glidepath files in extremely curved simulated root canal.

Methodology: Thirty heat treated rotary nickel titanium (NiTi) files were used for analysis in this study. Ten NiTi files were distributed to each group: Group A: ProGlider. Size – 25mm, 15.02, Group B: TruNatomy. Size –25mm, 17.02, Group C: HyFlex GPF. Size –25mm, 15.02. The cyclic fatigue of the NiTi instruments was evaluated using a custom-made experimental setup. NiTi files were tested within simulated 90-degree curvature canal in a metal block until the files were fractured. The shaping block was set-up and consisted of concave tempered steel radius with a specific radius of curvature, i.e 5 mm with a constant degree of curvature of 90o.Number of cycles to failure (NCF) was then measured for each instrument. The one way-ANOVA test and post hoc Tukey’s test was performed as statistical analysis to compare the cyclic fatigue of different rotary file.

Results: Group C (HyFlex GPF) group has the highest cyclic fatigue value of 13.4 and Group A (ProGlider) had the least value of 5 which was statistically significant with $p < 0.01$.

Conclusions: HyFlex GPFperformed better amongst the other path finding files in simulated extreme canal curvature.

Keywords: Glidepath files, curved simulated root canal, cyclic fatigue resistance.

Introduction

Simple straight root canal is more of an exception than a rule in human teeth. Root canals frequently have different curves in multiple planes.[1]Nickel-titanium (NiTi) files' mechanical qualities allow them to be more flexible and better conform to the canal's curve than stainless steel instruments, which helps them withstand fracture with less wear. [2] The risk of breakage is still higher for NiTi rotary (NTR) equipment despite the alloy's increased flexibility and strength. Variations in the canal anatomy, such as degree and angle of curvature, merging, recurving, dilacerating, or dividing canals, might cause NTR instruments to fracture.[3]

Creating a glide path using rotary NiTi files may be more predictable, especially in curved canals. It can lead to less deviation from the original root canal anatomy in comparison to manual files. Recently, many glide path NiTirotary files have been introduced to the market for glide path enlargement. [4]

Before cleaning and shaping the curved root canals, creating a glide path is recommended. Glide path is described as a smooth and centered radicular tunnel from the orifice to the apical foramen or physiologic terminus of the root canal. [5] Negotiation and glide path preparation is a vital step for the assessment of the root canal anatomy and the establishment of a repeatable patent access to the apical portion of the root canal. Creating a glide path in extremely 90º curved canal can be difficult.

The NiTi rotary glide path files known as ProGlider (Dentsply Maillefer, Ballaigues, Switzerland) are produced as singlefile systems. M-wire alloy is used to make ProGlider. To boost the flexibility and cyclic fatigue resistance of NiTi files, a unique thermal process is used to create M-wire, a particular NiTi alloy. Its tip diameter is 0.16 mm, and its shaft taper varies from 2% to 8%. Coronal pre-expansion for the usage of upcoming larger files is possible with variable taper design. The file has a square cross section and is produced in lengths of 21, 25, and 31 mm. [6]

A multiple-rotary pathfinding system using three instruments—size 0.15,.01 taper, size 0.15,.02 taper, and size 0.20,.02 taper—is the Hyflex GPF (Coltene-Whaledent, Altstätten, Switzerland). The 0.15 and.01 taper size instruments are built of standard NiTi Wire and have a triangular cross section; the other instruments are made of controlled memory wire (CM-Wire) and have a square cross section (Apar et al. 2015). [7]

TruNatomy Glider files (Dentsply Maillefer, Ballaigues, Switzerland) is a heat-treated wire: of size #17.02, Progressive taper and length of 25mmand a cross section of centered parallelogram. [8]

Due to the fact that no other study has assessed the cyclic wear of rotary route finder files in extreme 90º canal curvature. The current study's objective was to investigate the cyclic fatigue resistances of single-file NiTi rotary glide route files under dynamic model conditions in a simulated model with a 90° extreme canal curvature. Our study's null hypothesis was that the cycle fatigue resistances of NiTi rotary glide path files would be similar.

Materials and method:

Methodology:

Thirty selected nickel titanium files were used for analysis in this study of which, ten TruNatomy, ten ProGlider, ten HyFlexGPFNiTi rotary files were used.

1. Group A: ProGlider. Size – 25mm, 15.02

2. Group B: TruNatomy. Size –25mm, 17.02

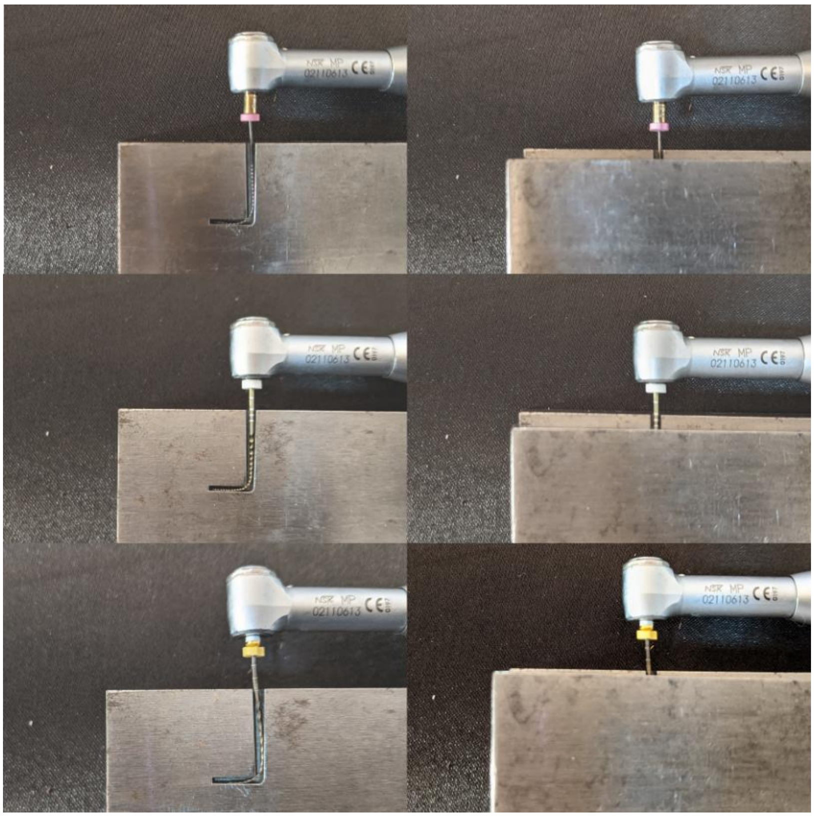
3. Group C: HyFlex GPF. Size –25mm, 15.02

Simulated canal in steel block:

300 series stainless steel block (70 mm length 10 mm width) were used to simulate the artificial canal. Canal was milled by using diode laser (GIDC, Ahmedabad, Gujarat) with the aid of computer SOLID EDGE programme retained the instrument trajectory and replicated the instrument size and taper according to the settings chosen. The radius of curvature was set at 5 mm, with the angle of curvature remaining at 90^o.

A custom-made experimental set up was made. The fixed shaping block had a radius of curvature of 5 mm and a constant degree of curvature of 90° and was made of concave, tempered steel.A 4-mm-thick steel block was screwed in front of the simulated canal to prevent the instrument from slipping out.

Figure 1: Experimental set-up with glidepath files: (Image A)ProGlider, (Image B) TruNatomy, (Image C) HyFlex GPF, Curvatures covered with metal block- Image D, E, F



The instruments rotated freely in the simulated canal after placing a steel slab on the block and attaching the hand piece to the block with the file in it. In (Figure 1) All glide path files were given a 300-rpm speed and a 2 N/cm torque to standardise the research. During the rotation of the file, liquid paraffin (KimiagarToos, Mashhad, Iran) was applied to the canalwalls and utilised as a lubricant. The instruments were used up until a fracture developed, and the time to fracture was captured in high definition video and measured in seconds.

Number of cycles to failure (NCF) was then measured for each instrument with the following formula:

NCF Time taken for file to fracture (seconds) x Speed of Endomotor (rpm). Mean values were then calculated for each group and statistically analysed by usingone way-ANOVA and post hoc Tukey’s test.

Statistical analysis:

The one-way ANOVA test and Post hoc Tukey test was performed to compare the cyclic fatigue of different glidepath rotary files in simulated 90^o curvature canal in steel block by using the SPSS version 20.0(SPSS Inc., Chicago, IL, USA).For numerical data, one-way analysis of variance (one-way ANOVA) was used to compare the means of three groups of samples (using the F distribution). To determine which of the three groups is responsible for the significant difference, a post hoc Tukey's test was utilized. Statistics were deemed significant at p< 0.001.

Result:

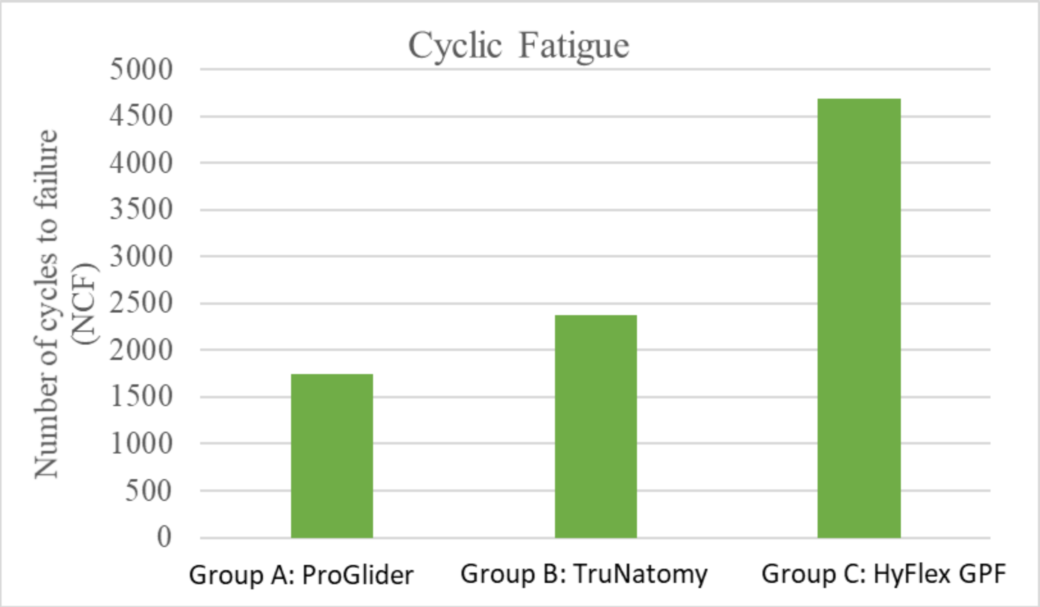
Within the limitation of this study, comparison of time taken to fracture between the three groups shows that Group C (HyFlex GPF) group has the highest value of 13.4 and Group A (ProGlider) had the least value of 5. This difference is statistically significant with a test value of 528.12 and p<0.001. Posthoc Tukey tests comparing Group C (HyFlex GPF) and Group B (TruNatomy) groups shows a mean difference of 6.6 and is statistically significant with a P <0.001. Comparing Group C (HyFlex GPF) and Group A (ProGlider) groups shows a mean difference of 8.4 and is statistically significant with a p<0.001.

Comparison of cyclic Fatigue between the three groups shows that Group C (HyFlex GPF) group has the highest value of 4685 and Group A (ProGlider) has the least value of 1750. This difference is statistically Significant with a test value of 519.305 and p<0.001.Posthoc Tukey tests comparing Group C (HyFlex GPF) and Group B (TruNatomy) groups shows a mean difference of 2305 and is statistically significant with p<0.001. Comparing Group C (HyFlex GPF) and Group A (ProGlider) groups shows a mean difference of 2935 and is statistically significant with p<0.001.

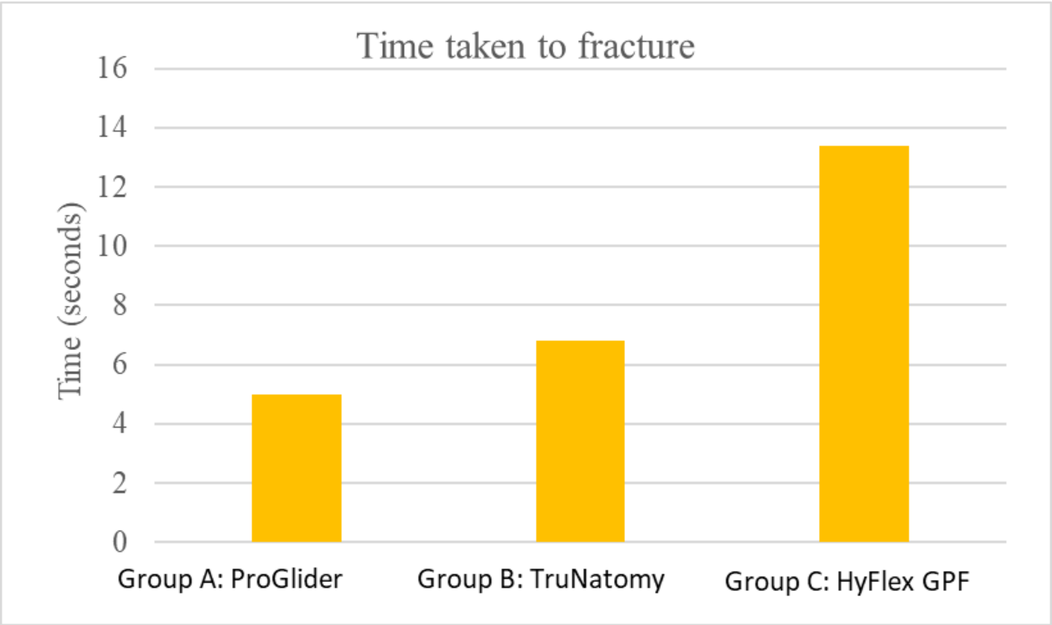
Table 1: Comparison of the mean and standard deviations of the time to fracture in seconds and the number of cycles to failure (NCF) of the different glidepath files tested in the present study at 90^{o} curvature

						ONE WAY ANOVA		
	Group A (ProGlider) (n=10)	Group B (TruNatomy) (n=10)	Group C (HyFlexGPF) (n=10)	F value *	P value	GroupB (TruNatomy) vs Group C (HyFlexGPF) difference (p value)	Group A (ProGlider) vs Group C (HyFlexGPF) difference (p value)	Group A (ProGlider) vs Group B (TruNatomy) difference (p value)
Time taken to fracture	5±0.67	6.8±0.42	13.4±0.7	528.12	<0.001	6.6 (<0.001)	8.4 (<0.001)	1.8 (<0.001)
Cyclic Fatigue	1750± 233.33	2380±147.57	4685± 248.38	519.305	<0.001	2305 (<0.001)	2935 (<0.001)	630 (<0.001)

Graph 1: Graph showing the cyclic fatigue for the file to fracture for each file



Graph 2: Graph showing cyclic fatigue of the file



Discussion:

Glide path preparation decreases the possible operational failures during root canal preparation.[6]The probability of instrument failure can be decreased[9]by reducing the overall torque generated by NiTi rotary files later employed in the root canal and the torsional stress on them by establishing a glide path as the initial phase of root canal preparation. However, when used, glide path files, themselves experience cyclic fatigue. Extremely curved canals can cause lower cyclic fatigue of glide path files and to fracture more quickly than single-curved canals.[10]

Extreme canal curvature of 90º was used in this study because curved canals were found in 59 percent of the teeth, with the posterior teeth having a higher frequency than the anterior teeth. The most frequent root canal curvature was seen in the apical third section (53.9 percent), followed by the cervical (33.3 percent) and middle (12.8 percent) third sections.[11]

According to the current research , files made of CM and MWire alloy had higher fatigue resistances than files produced of traditional NiTi alloy (Shen et al. 2011, Ye et al. 2012). Apar et al. (2015) used artificial canals to test the cycle fatigue resistances of the following NiTi rotary glide path files: PathFile, ScoutRaCe, ProGlider, HyFlex GPF (ColteneWhaledent), G Files (Micro-Mega, Besançon, France), ProGlider (Dentsply Sirona), and G Files. According to the authors, CM alloy-based HyFlex GPF exhibited the highest level of cycle fatigue resistance which was also observed in the cyclic fatigue values of the present study.

Instead of using extracted human teeth as in earlier research [10, 12], a stainless-steel artificial groove resembling 90º curved canals was used in the current study. This change was made to improve the standardisation of the experimental setup. Cycle fatigue testing in steel canals has the drawback that instruments may fit snugly in the groove.[13] Small glide path files might not frequently experience these conditions in clinical settings since in these settings, the files experience simultaneous torsional pressures along their length.

In the current study, the highest NCF values were seen in HyFlex GPFfollowed by TruNatomy and least was seen by ProGlider. These values were significantly higher than other evaluated files thus, the null hypothesis was rejected. The kind of alloy, the helical angle, [14][15] the cross-sectional form, and the dimension all have an effect on the flexibility and cyclic fatigue resistance of instruments. Heat-treated CM alloy used to create HyFlex GPF files has a high degree of flexibility and shape memory.[16] [17]This is also the case for TruNatomy, thus the value for cyclic fatigue is higher than ProGlider because TruNatomy being heat treated possessing greater flexibility and elasticity.

Conclusion:

HyFlex GPF had the highest cyclic fatigue resistance among the evaluated path finding files Therefore, it seems that they can be used efficiently in endodontic treatment of extreme canal curvatures clinically.

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