

Comparative Evaluation of Cyclic Fatigue Resistance of Four Different Glide Path Files in S Shaped Artificial Canal

Anakha Santhosh¹, Bindiya S Kumar², Rajesh Pillai³, Afzal A⁴

¹Department of Conservative Dentistry and Endodontics, PMS College of Dental Science and Research
anakha66[at]gmail.com

²Department of Conservative Dentistry and Endodontics, PMS College of Dental Science and Research
bindiya.skumar22[at]gmail.com

³Department of Conservative Dentistry and Endodontics, PMS College of Dental Science and Research
rajpillai_21[at]rediffmail.com

⁴Department of Conservative Dentistry and Endodontics, PMS College of Dental Science and Research
afzalabdulsalim[at]gmail.com

Abstract: ***Aim:** The aim of our study was to determine the cyclic fatigue resistances of four different glide path files namely ProGlider, Hyflex EDM glide path file, NT Rainbow glide path file, NeoEndo Flex Glide in s shaped canals. **Materials and Methods:** Ten files from each group were tested. An artificial groove simulating s shape was machined in a stainless steel block. The groove measured 1.6mm in diameter at the top and decreasing towards the apical region having 0.4mm at the tip with 0.06 taper, 19 mm in length, and 1.5 in depth was used in this study. Cyclic fatigue resistance was determined by counting the number of cycles to fracture[NCF]. **Results:** Hyflex EDM glide path files showed significantly higher NCF values when compared to the other glide path files tested. **Conclusion:** Within the limitations of our study, Hyflex EDM has the highest cyclic fatigue resistance among the glide path files tested.*

Keywords: Cyclic fatigue resistance, number of cycles to fracture[NCF], glide path files, nickel titanium

1. Introduction

Nickel-titanium rotary (NTR) files have brought about a revolution in the cleaning and shaping of the root canal system. One of the main disadvantages of nickel titanium rotary files is instrument fracture.¹ Torsional fatigue and cyclic fatigue are the two main modes of instrument fracture.^{2,3} Among the two modes, cyclic fatigue has been involved in the majority of the fractured instruments.⁴

Glide path preparation is considered as the first phase of cleaning and shaping preparation and is considered as a critical stage for evaluating the root canal anatomy and ensuring the smooth entrance into apical portion of the root canal.⁵

Fracture of files because of cyclic fatigue occurs as a result of accumulation and continuous repetition of compression and tension stresses at maximum flexibility point in curved canals. However, failure due to torsional fatigue occurs as the coronal part of the file starts rotating when a portion or tip of the file is stuck within the canal.^{2,6}

ProGlider (Dentsply Maillefer, Ballaigues, Switzerland) is a NiTi rotary glide path files that is manufactured as single file system. ProGlider is made of M-wire alloy. M-wire is a special NiTi alloy that is manufactured by a special thermal method to increase the flexibility and cyclic fatigue resistance of NiTi files.⁸ ProGlider has 0.16-mm tip diameter and variable taper between 2% and 8% along the shaft. Variable taper design lets coronal pre-expansion for

the use of next larger files. The file is manufactured in lengths of 21, 25, and 31 mm and has square cross section.

The HyFlex EDM (HEDM; Coltene/Whaledent, Altstätten, Switzerland) rotary file system is a new-generation single-file system, which works in continuous rotation motion. HEDM (25/.08) files are made of electric discharge machining treatment. According to the manufacturer, this treatment has significantly improved the mechanical properties of the files.⁷

The Flex Glide system (Orikam) undergoes a proprietary heat treatment, and has a triangular cross-section with 2% taper and 0.16 mm tip size.

NT Rainbow S [NineTen] is an advanced heat treated and nano carbon coated file system with glide path file having 3% taper and 0.15 mm tip size.

The retrieval of separated instruments from the root canal system is very difficult and sometimes impossible. Moreover, un-retrieved fractured files may have negative effect on the outcome of endodontic treatments. So to avoid or reduce the risk of instrument separation, cyclic fatigue resistance has got high clinical significance.⁸

2. Literature Background

- Uygun et al in their study concluded that Hyflex EDM has higher cyclic fatigue resistance compared to Vortex Blue, ProTaper Gold and OneCurve files.²⁴

- Mustafa et al in their study concluded that Hyflex EDM has got highest cyclic fatigue resistance when compared to WaveOne Gold , Reciproc Blue and Twisted File.²⁵
- Mohsen Aminsobhani in their study compared the cyclic fatigue resistances of five different glide path files in a double curved artificial canal and concluded that NeoNiti GPS and Scout RaCe glide path files had the highest cyclic fatigue resistance.²⁶

3. Materials and Methods

An artificial groove simulating s shaped canal was machined in a stainless steel block and was hardened with electric discharge machining. The groove measured 1.7mm in diameter at the top and 0.5mm diameter at the apex with 0.06 taper, 17 mm in length, and 1.5mm in depth was used in this study. The coronal curve had 65 degree angle of curvature and apical curve had 75 degree angle of curvature.[Figure 1]

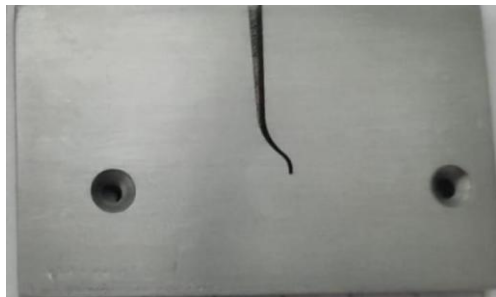


Figure 1: Stainless steel block with s shaped groove.

The following NiTi rotary glide path files were evaluated in this study:

- 1) ProGlider (Dentsply Sirona, Ballaigues, Switzerland) (tip size: 16, with a variable taper)
- 2) HyFlex EDM (HEDM; Coltene/Whaledent, Altstätten, Switzerland)
- 3) NeoEndo Flex Glide[Orikam]
- 4) NT Rainbow [NineTen]

A glass slab was put on the block and hand piece was fixed to the block with the file in it. The instruments were made to rotate freely in a “static” mode .To standardize the study a 250 rpm speed and 2 N/cm torque was set in endomotor and were applied for all glide path files.[Figure 2]The glide path files rotated until it fractured and the time taken to fracture was noted.



Figure 2: File rotated in the groove in static mode until fracture

NCF [number of cycles to fracture]=time (seconds) to fracture * rotational speed/60[10]

Statistical Analysis

Data was analyzed using the statistical package **SPSS 26.0** (SPSS Inc., Chicago, IL) and level of significance was set at **p<0.05**. **Descriptive statistics** was performed to assess the mean and standard deviation of the respective groups. Normality of the data was assessed using **Shapiro Wilkison test**. **Inferential statistics** to find out the difference between the group was done using **Kruskal wallis test** followed by **Bonferroni test**.

4. Results

Hyflex EDM Glide path file showed significantly higher NCF values compared to the other glidepath files tested. There was no significant difference between NeoEndo Flex and NT Rainbow glide path file. Hyflex EDM have significantly higher NCF values than ProGlider. Higher NCF values indicate that Hyflex EDM has got higher cyclic fatigue resistance compared to other files.

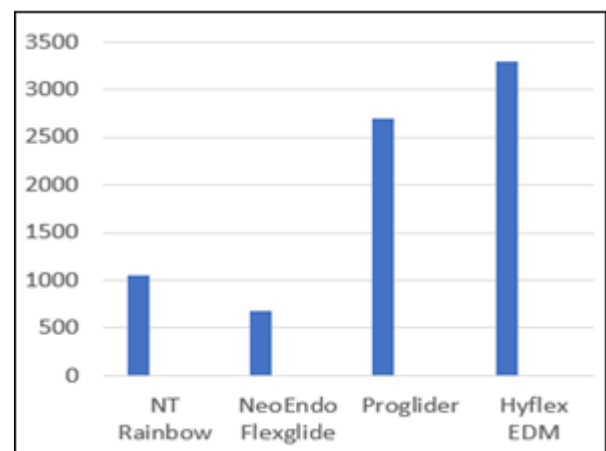


Figure 3: Mean NCF values of each group

5. Discussion

Glide path preparation reduces the chances of procedural errors during root canal preparation. Although both torsional fatigue and cyclic fatigue are the main causes of file failure, cyclic fatigue is the most common cause. Cyclic fatigue occurs when an instrument rotates in a curved canal by repetitive compressive and tensile stresses, and torsional failure occurs when the instruments' tip is locked or jammed in the canal, but the shank of the file keeps rotating.⁹ So we evaluated the cyclic fatigue resistance of four different glide path files manufactured differently.

ProGlider is made of M wire alloy. It is developed via thermo-mechanical processing and has three crystalline phases: deformed and micro-twinned martensite, R-phase, and austenite.¹⁰ The presence of the martensite phase enhances the fatigue resistance of the file, but at the expense of hardness, which necessitates the need for different surface treatments.¹¹

Hyflex EDM is manufactured by electrical discharge machining. NeoEndo Flex Glide is manufactured by gold thermal treatment. NT Rainbow S is an advanced heat treated and nano carbon coated file.

Artificial canal was used in the study to avoid the variability of the natural teeth. Hyflex EDM made by electrical discharge machining exhibited higher number of cycles to fracture when compared to other glide path files. ProGlider made of M wire alloy exhibited cyclic fatigue resistance higher than the other two glide path files.

Hyflex EDM (Coltene/Whaledent, Switzerland) instruments are manufactured by means of electrical discharge machining (EDM) process, wherein work pieces are made by generating a potential between the workpiece and the tool. The novelty of the HyFlex EDM owes its unique properties to a technology called “Electrical Discharge Machining.” This innovative manufacturing process uses spark erosion to harden the surface of the NiTi file, resulting in increased fracture resistance and improved cutting efficiency. EDM is a standard noncontact machining process that allows a precise quantity of material removed via pulsed electric discharge.¹¹ Just like HyFlex CM files, HyFlex EDM files offer trusted controlled memory effect and regenerative properties.¹²

The high cyclic fatigue resistance with Hyflex EDM (Group A) could be attributed to its EDM process, unique cross-section design, and greater austenite finish temperature (more than 370°C), which has both mixtures of austenite and martensitic structure at room temperature.¹⁵ Martensitic structure is less rigid compared to austenite and files produced by means of CM wires have more martensite at the cost of austenite, and consequently, this influences their fatigue properties and exhibits the flexibility and fracture resistance up to 700%.¹⁴ Hyflex EDM exhibits a significantly improved cyclic fatigue resistance in comparison to Hyflex CM, M-wire based instruments, and conventional NiTi systems.^{16,17,18,19}

In this study, files made by different manufacturing methods were selected to determine the influence of mode of manufacture on cyclic fatigue resistance of the files. S shaped artificial groove simulator was made as root canal system is complex with curvatures and ramifications. The coronal curve and the apical curve was made at 65 degree angle and 75 degree angle respectively to determine the efficiency of the files in establishing glide path in such curvatures. Moreover, the stainless steel block was machined using EDM technology. This might have affected the findings of the study. Hyflex EDM had significantly higher cyclic fatigue resistance compared to other glide path files tested. This can be attributed to the manufacturing process. EDM technology and the unique cross sectional design of the file might have influenced the cyclic fatigue resistance of the file. ProGlider, manufactured by M wire technology had cyclic fatigue resistance higher than the other two glide path files tested. M wire technology might have contributed to the increased cyclic fatigue resistance compared to other two glide path files. However, many studies show no difference in cyclic fatigue of M-wire and conventional NiTi files.^{20,21,22,23} There was no statistically significant difference in the cyclic fatigue resistance of NT Rainbow glide path file and NeoEndo Flex Glide. The alloy characteristics might have affected the findings of the study.

6. Conclusion

Within the limitations of the present study, Hyflex EDM glide path file exhibited the highest cyclic fatigue resistance compared to the other glide path files tested.

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