

Original article:

A comparative analysis of cyclic fatigue resistance of new rotary NiTi file systems (Hyflex CM and One Shape): An In-Vitro Study.

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ABSTRACT

Instrument in curved and narrow root canal still remains a challenge. Introduction of NiTi instruments have revolutionized endodontics with escalation in rotary techniques and innovations in instrument design. Despite the improvement in the design of these instruments, the unexpected instrument separation during their clinical use, still remains a major concern. The incidence of instrument separation was reported to vary from 1.7 to 14%. Among these, flexural fatigue is an important factor to be considered when using these in clinic. The present in-vitro study aimed to compare the cyclic fatigue fracture resistance of two different rotary NiTi instrument system (One Shape and Hyflex CM). The cyclic fatigue testing was conducted with the file rotating at an angle of curvature 60° with maximum radius of curvature at 5mm from the tip.

Ten endodontic rotary files were selected in each of the two groups to be tested. The files were rotated with standard parameters 350 rpm and 2.5 Nm torque using the Tri auto mini endomotor set until fracture occurred. The time until fracture was recorded in seconds by using a stopwatch, and the number of cycles till fracture was then calculated. The results were obtained and then statistically analyzed. The results showed Hyflex CM (Group 1) performed significantly better than One Shape rotary endodontic file system (Group 2) during cyclic fracture resistance evaluation. A statistically significant difference ($P < 0.05$) was noted. It is concluded that Hyflex CM had greater resistance to cyclic fatigue than One Shape endodontic file system.

Keywords: Cyclic Fatigue, Cyclic fatigue resistance, Endodontics, Flexural fracture resistance.

INTRODUCTION

Root canal preparation in narrow and curved canals is a great challenge. Rotary Ni-Ti files can be used to prepare curved canals as they are 2-3 times more elastic and flexible in bending & torsion and have Superior resistance to torsional fracture compared with similar size stainless steel files.¹

Despite the advantages of rotary Ni-Ti instruments, concern has been expressed by many authors and clinicians about the potential for rotary Ni-Ti instrument to fracture within the root canal system during endodontic treatment.²⁻⁴ Endodontic instrument fracture within canal is a complex event. Fracture occurs without warning and without any

visible defects of previous permanent deformation. Hence, visible inspection is not reliable test for testing NiTi instruments.

Two modes of fracture of rotary Ni-Ti endodontic instruments have been identified in the clinical situation: Torsional fracture and Flexural fracture.⁵ Among these, flexural fatigue is an important factor in a clinical point of view. An understanding of factors that contribute to instrument fracture is important in preventing its occurrence. These include the following: Root canal anatomy in terms of radius & degree of curvature, operator proficiency, operational speed and torque, previous use, sterilization procedures

and cross sectional area and design of the instrument.⁶

HyFlex™ CM NiTi Files respond to excessive resistance with straightening of the spirals, which avoids binding to the walls and therefore increases fracture resistance. This form adaptation can be reversed quickly by heat treatment (during autoclaving or with a glassbead sterilizer) returning the instruments back to their original shape. Furthermore it will strengthen the files making them a lot more resistant to cyclical fatigue. Also it provides a clear visual opportunity to verify safe continuation of file use.⁷

The OneShape file system consists of only one instrument made of a conventional austenite 55-NiTi alloy. It is characterized by different cross-sectional designs over the entire length of the working part. In the tip region, the cross section represents three cutting edges while in the middle of the cross-sectional design progressively changes from a three cutting edge design to two cutting edges. At the shank, the S-shaped cross section shows two cutting edges, resembling the cross-sectional design of Reciproc instruments. This design is alleged to eliminate threading and binding of the instrument in continuous rotation.

The aim of this study was to evaluate and compare the cyclic flexural fatigue resistance of HyflexCM and One Shape endodontic rotary file system.

METHOD

The endodontic rotary file system Hyflex CM (ColteneWhaldent, Germany) and One Shape (Micro Mega, Besancon, France) were chosen. The tip size ISO 25, 21 mm in length were selected for this study.

A simulated testing apparatus was used that allowed fatigue test to be conducted in a manner similar to that of Youssef et al.⁸ It comprises of three cylindrical steel blocks (one supporting block

and two shaping block) attached on a 6mm thick acrylic sheet/ wooden sheet which was held vertically with the help of a vise. The positions of the shaping blocks was adjusted in order to get the desired degree of curvature (60°) in the instrument in such a manner that maximum curvature was at 5mm from the tip.

The angle of curvature was calculated by Schneider's method, which defined the angle of curvature by drawing a line parallel to the long axis of the canal and the outer line from the apical foramen to intersect with first line at a point wherein the canal began to leave the long axis of the canal.¹⁰

Ten instruments were tested in each of the two experimental groups and 60° angle of curvature to give a total of 20 instruments tested. The instruments were rotated at 375 rpm using the Tri auto mini (J Morita, Australia) Endomotor. The time until fracture was recorded in seconds by using a stopwatch, and the number of rotations to fracture was then calculated using the simple formula: No. of rotation to fracture = $375 / 60 \times$ Time taken to fracture (in seconds). Because the study was a direct comparison of fatigue resistance among groups, a separate control group was not required. Results of cyclic fatigue test were analysed by using Paired t test using SPSS Software with level of significance at $p < 0.05$.

RESULTS

Observations were laid down regarding the number of rotations to fracture, when the instruments were rotated at a 60° angle of curvature (Table1). The statistical tools like mean & standard deviation were employed (Table2). The results showed that the number of rotations until fracture for Hyflex CM (Group1) was significantly greater than that of One Shape (Group2) at angles of curvature 60°.

Table 1: Table of number of rotations at fracture at 60° angle of curvature.

Sample	HyflexCM (Group 1)	One Shape (Group 2)
1	325	154
2	312.5	150
3	362.5	148
4	337.5	154
5	350	152
6	362.5	146
7	356.25	153
8	362.5	158
9	343.75	151
10	325	143

Table 2: Table of means and standard deviations of number of rotations to fracture.

	Hyflex CM (Group 1)	One Shape (Group 2)
Mean	312.5	151.07
Standard Deviation		3.84

DISCUSSION

The present study confirmed that the number of rotation to fracture an instrument largely depends on the degree of curvature with more incidence of breakage at greater degree of curvature. This result is in accordance to other studies.^{9,10} In endodontic treatment, Biomechanical preparation is very important as the outcome is largely depends on proper cleaning and shaping. A more tapered preparation results in enhanced cleaning as there is more removal of infected dentin and also endodontic irrigants can reach more apically and results in better microbial control and better debridement and also good quality obturation¹¹.

Fracture of NiTi files occurs in one of two ways, flexural or torsional failure. Flexural fracture is a result of repeated compression and tension in curved canals. Torsional fracture occurs when the tip or any other part of the instrument binds to the canal walls whereas the hand piece keeps turning. In fact, NiTi files exposed to torsional stress are

prone to fracture at a lower cyclic fatigue and torsional resistance decreases in used files^{12,13}.

One possible method for preventing file fracture in clinic is to reduce torsional stress in the process of canal preparation. For this purpose preflaring and the crown-down preparation have been suggested.¹⁴ Preliminary creation of a glide path has been shown to be fundamental for safer use of NiTi rotary instrumentation.^{15, 16} The root canal diameter becomes bigger than or at least the same size as the tip of the first rotary instrument used, reducing the stress the instruments suffer.

The lifespan of an instrument is directly proportional to the stress accumulated during work in the root canal.¹⁷ It is advocated that clockwise and counter clockwise movements reduces the incidence of torsional fracture caused by taper lock¹⁸.

The cross cut design incorporated in the Hyflex CM system might results in less cyclic fatigue than

other instruments of similar taper as some of the values of One Shape.

It is believed that the material property had a substantial impact on the fatigue lifetime. The composition of Hyflex CM files has low % weight of nickel (50% wt. Ni) . It was also found that superior cyclic fatigue resistance of hyflex CM file is due to greater A_f temperature (more than 37° C), which has both mixture of Austenite and Martensitic structures at room temperature.^{19,20}

The results of present study was in accordance to the study conducted by Shen Y & Zhou H M et al, Shen Y & Qian W et al and Santos L de A that showed CM wire manufactured files have more flexibility and more resistance to cyclic fatigue

then M wire manufactured wire.²¹⁻²³ As this was an in-vitro study more clinical trials should be carried out for reaching out to a definite conclusion.

CONCLUSION

Within the limitations of this study, Hyflex CM file system showed significantly higher resistance to cyclic fatigue fracture compared with the One shape file system at 60° of curvature.

KEY NOTE

- In this era of NiTi rotary files, it is recommended that Hyflex CM files manufactured from proprietary process found superior in cyclic fatigue resistance can be used in severely curved root canals without fracture several times.

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