Medico Research Chronicles

ISSN No. 2394-3971

Original Research Article

EVALUATION OF CYCLIC FATIGUE RESISTANCE OF ROTARY NITI VS CONTROLLED MEMORY ENDODONTIC FILE SYSTEMS: AN *IN-VITRO* STUDY

Dr. Akanksha Bhatt*, Dr. B. Rajkumar, Dr. Vishesh Gupta*****

**Assistant Professor, Department of Conservative Dentistry &Endodontics, BBDCODS, BBD University, Lucknow , India.*

***HOD & Professor, Department of Conservative Dentistry &Endodontics, BBDCODS, BBD University, Lucknow , India.*

****Associate Professor, Department of Conservative Dentistry &Endodontics, BBDCODS, BBD University, Lucknow , India.*

Submitted on: May 2016
Accepted on: May 2016
For Correspondence
Email ID:
dr.abhatt@gmail.com

Abstract

The purpose of this study was to compare fracture resistance of Hyflex CM, Hero Shapers and Vortex NiTi file systems due to cyclic fatigue in curved canals. The methodology in this study involved testing the cyclic fatigue of endodontic root canal file rotating at 375 rpm. A simulated model was created such that, the instrument will bend at 60 degrees during function, maximum curvature being 5 mm from the tip of the file. The number of rotations till the instrument fractured was recorded by mathematical formula. The results were statistically analyzed. Hyflex CM performed significantly better than Vortex & Hero Shapers file system. However there was no statistically significant difference observed between Vortex & Hero Shapers file system in terms of cyclic fatigue.

Introduction

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. The superelasticity of NiTi allows fully recoverable deformation upto 8% strain as compared to 1% in stainless steel.[1]Moreover, these NiTi instruments have shown to provide more predictable, centered and faster canal preparation than stainless steel instruments.[2]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%.[3]Sattapan et al.classified the separation of NiTi rotary instruments due to "torsional failure" and "flexular fatigue". [4] Torsional failures occurs when the tip or any part of the instrument locks into the canal and the rotary motion still continues; while the flexural failure occurs due to work hardening and metal fatigue. Among these, flexural fatigue is an important factor to be considered when using these in clinic. An understanding of factors that contribute to instrument fracture

is important in preventing its occurrence. These include the following: Root canal anatomy, both in terms of radius and degree of curvature, operator proficiency, operational speed and torque, previous use, sterilization procedures and cross sectional area and design of the instrument.[5]

The purpose of the present study was to investigate the effect of change in manufacturing process on cyclic fatigue resistance. This was evaluated by comparing Hyflex CM endodontic file system with two NiTi endodontic file systems Vortex and Hero Shapers produced by a traditional grinding process.

Materials and Method

The endodontic files systems evaluated were Vortex (Tulsa Dental, U.S.A.), Hero Shapers (Micromega, France) and Hyflex CM files (Coltene Whaldent, Germany). All files with tip size ISO 25 and taper 6% were selected for this study.Total 30 endodontic files were taken (10 for each group) with the stopper adjusted to obtain the desired length of 21.0 mm for each instrument.

A simulated working model (Figure 1) was created similar to that used in study done by Youssef et al (1999). Three cylindrical steel blocks were taken; one supporting block and two shaping blocks were attached on a 6 mm thick acrylic sheet which was held vertically with the help of a vise. The position of shaping block was adjusted so as to get the desired angle of 60 degrees.[6]

The angle of curvature was calculated by Schneider's method, which defined the angle of curvature by drawing a line parallel to the longaxis of the canal and the outer line from the apical foramen to intersect with first line at a point wherein the root canal began to leave the long axis of the canal.[7]

10 instruments from each experimental group were tested with the angle of curvature being 60 degrees. The instruments were rotated at 350 RPM using reduction gear handpiece (Endomate, J Morita).

The time taken to fracture the endodontic instrument was recorded using a stopwatch. The numbers of revolutions taken by each tested endodontic file was calculated using the simple formula: No. of rotation until fractured = 350/60 xTime taken till fracture (in second). The results of the study were analyzed using multiple comparison tests i.e. Holmes test, for evaluating cyclic fatigue of various tested NiTi endodontic instruments, with a level of significance (p)<0.05.

Figure 1: **Simulated Working Model**

Results

The time taken until file fracture and the number of revolutions for each instrument until got separated has been summarized in table: 1 and table: 2 respectively. A statistically significant difference (P<0.05) was noted between Hyflex CM Files (Colten Waldent) and theVortex Files (Tulsa Dental) and Hero Shapers (Micromega) NiTi instruments. Hyflex CM Files (Colten Waldent) instruments showed the maximum number of rotations of instrument before

separation. No statistically significant difference (P>0.05) was noted between Vortex and Hero Shaper instruments.

Table 1: Comparison of time taken forseparation of various NiTi instruments.

S. No	Hyflex CM (Time in sec)	Hero Shaper (Time in sec)	Vortex (Time in sec)
1.	52	12	6
2.	50	8	8
3.	58	10	8
4.	54	8	9
5.	56	12	7
6.	58	10	6
7.	57	10	8
8.	58	9	7
9.	55	8	6
10.	56	7	8
Mean	**55.4**	**9.4**	**7.3**

Table 2: Comparison of number ofrevolutions of NiTi instruments beforeseparation

S. No	Hyflex CM (No. of revolutions until seperated)	Vortex (No. of revolutions until seperated)	Hero Shaper (No. of revolutions until seperated)
1	325	37.5	75
2	312.5	50	50
3	362.5	50	62.5
4	337.5	56.25	50
5	350	43.75	75
6	362.5	37.5	62.5
7	356.25	50	62.5
8	362.5	43.75	56.25
9	343.75	37.5	43.75
10	325	50	50
Mean	**312.5**	**46.625**	**58.75**

Mathematically, it can be shown that **Hyflex CM>Hero Shaper>Vortex**. This implies that, Hyflex CM rotary file system have more fracture resistance in comparison with Hero Shaper and Vortex rotary file instruments. A higher number of cycles to failure indicate greater resistance to cyclic fatigue of the tested instruments.

Discussion

Nickel-titanium (NiTi) was developed by Buehler et al in the Naval Ordnance Laboratory (NOL) in Silver Springs, Maryland in early 1960's.[8] Using about 55 wt% Ni and 45 wt% Ti and substituting some Ni with less than 2 wt% Cobalt; nearly the same number of Ni and Ti atoms are combined, being reflected in the term equiatomic. This alloy is very popular among Endodontists, especially for negotiating curved canals and is commonly referred to as 55 NiTi NOL.

NiTi alloys are softer than stainless steel, not heat treatable and have a low modulus of elasticity. However they have more strength, are tougher, more resilient and have two important properties i.e. the *shape memory*

and *superelasticity.* These two extraordinary properties are the main reason why NiTi alloys are popular in the field of endodontics and other dental disciplines. These material properties are due to a change in the crystal structure. The low temperature phase is called 'martensitic' or daughter phase and the high temperature phase is called the 'austensitic' or parent phase. These lattice organizations can be altered by temperature or stress. During endodontic treatment, stress can be induced into the instrument, especially during instrumentation of curved canals. The austensitic phase transforms into the martensitic phase on stressing and in this form it requires only a light force to bend the instrument. After release of stresses, the metal returns to the austensitic phase and the instrument regains its original shape.[9] The improved flexibility and unique properties of NiTi have undoubtably provided better control while preparing curved canals and has made it possible to engineer greater taper instruments, thereby allowing better control in shaping the root canal.

A New files system Hyflex CM with controlled memory (CM), a metal alloy of nickel and titanium, have been introduced and manufactured by Coltene. The company reports that this file is more resistant to cyclical fatigue compared to other NiTi files, which reduces the incidence of file fracture. The purpose of this new rotary file is to simplify root canal treatment and to optimize cleaning and shaping of the canal. The cutting profile of each HyFlex® CM file facilitates penetration in the canal, and presents a root canal shape corresponding with the original anatomy. This system also offers precise apical finishing, leaving the structural integrity of the root intact after endodontic therapy. It works with an active cutting motion with variable helical angle and balanced pitch in the instrument.

Another rotary instrument which has become quite popular is Hero Shapers. It also has variable helical angle and adapted pitch; i.e. the more tapered an instrument is, the longer is itspitch. It has a positive rake angle and the blade shows a triple helix cutting edge. The tip is inactivein order to follow canal anatomy.

The principle of grain structure during manufacturing process is a key element in with standing stress. Maintaining the grain structure of NiTi during file manufacture, results in a stronger and more flexible rotary instrument. With the introduction of the Hyflex CM File having proprietary R-phase technology, mechanical rootcanal preparation may become safer and more predictable.

The other experimental two groups i.e. Hero Shapers and Vortex have a relatively narrow range of elasticity due to alteration in grain structure caused by grinding process. Moreover, grinding across the grain structure creates microfracture points and defects along the length of the instrument. These defects cause stress concentration points that weaken the instruments and can lead to separation of the instrument & hence intracanal failure. Cracks can propagate at a stress level much lower than the stress usually encountered during canal instrumentation, leading to sudden unexpected root canal file breakage.

The preliminary findings of the present study must be confirmed by more research, which should evaluate other clinically relevant mechanical properties of the Hyflex CM instruments *In- vivo*.

Conclusion

Under the limitations of the present study, itis concluded that Hyflex CM had greater resistance to cyclic fatigue than Hero Shapers and Vortex endodontic file system.

References

1. Thompson SA. An overview of nickel-titanium alloys usedin dentistry. IEJ 2000;33:297-310.
2. Guelzow A, Stamn O. Comparative study of six rotary nickeltitanium systems and hand instrumentation for root canal preparation. IEJ 2005;38:743-752.

3. Ankrum MT, Hartwell GR. Protaper and Profile systems: breakage and distortion in severly curved roots of molars. JEndod 2004; 30:234-237.
4. Sattapan B, Nervo GJ, Palamara JE. Defects in rotary nickeltitanium files after clinical use. J Endod 2000; 26:161-165.
5. Margot E Anderson, John WH, Peter Parashos. Fracture resistance of electropolished rotary nickel titanium endodontic instruments. J Endod 2007; 33:1212-1216.
6. Youssef Haikel, Rene Serfaty, Geoff Bateman. Dynamicand cyclic fatigue of engine driven rotary nickel titanium endodontic instruments. J Endod 1999; 25:434-440.
7. Schneider SW. A comparison of canal preparation in straightand curved root canals. Oral Surg 1971; 32:271-275.
8. Buehler WJ, Cross WB.55 Nitinol unique wire alloy memory. Wire J 1969; 2:41-49.
9. Michael A Baumann. Nickel- titanium: Options and challenges. DCNA 2004; 48:55-67.
10. Ruddle CJ. The Protaper technique. Endod Prac 2002; 5:22-30.