ISSN: 0976-3031

Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 9, Issue, 1(H), pp. 23404-23407, January, 2018

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Research Article

COMPARATIVE EVALUATION OF CYCLIC FATIGUE FRACTURE RESISTANCE OF NEWER NICKEL-TITANIUM ROTARY FILES IN SIMULATED CURVED CANALS: IN VITRO STUDY

Kumar Ujjwal., Anamika C.Borkar., Pradeep Shetty., Nikhil Borse and Nikhil Nighot

Department of Conservative Dentistry and Endodontics, DR. DY Patil Dental College and Hospital DR. DY Patil Vidyapeeth Pimpri, Pune

DOI: http://dx.doi.org/10.24327/ijrsr.2018.0901.1461

ARTICLE INFO

Article History:

Received 17th October, 2017
Received in revised form 21th October, 2017
Accepted 28th December, 2017
Published online 28th January, 2018

Key Words:

Nickel- titanium, neolix, one shape, t files, cyclic fatigue, fracture resistance

ABSTRACT

Introduction: Nickel-titanium (NiTi) rotary files were used widely in endodontics for preparing root canals. By using NiTi rotary files, the complications that are observed when using stainless steel files such as perforations, straightened root canals, ledges, zips, started to be seen less frequently. Nickle titanium files are flexible, have good elasticity and have more resistance to fracture. By the use of these files original canal anatomy was maintained.

Materials and Methods: The custom made device and Hand piece of rotary Endodontic motor with file were stabilized in Universal Testing Machine (Instron). The instruments were rotated at 300 rpm by using an electric motor (Sybron Endo, Endotouch TC2) at maximum Torque. The instruments were aligned to a specific mark (to allow for repositioning the same location), and then the file were set to rotate, synchronized with timing by a stopwatch. The instruments were allowed to rotate freely until fracture. Timer was stopped as soon as fracture was detected visually or audibly. The time was then converted into number of revolutions to failure.

Results: By applying Tukey-Kramer Multiple comparison test there is a significant difference between mean values of Time in seconds to Fracture and Number of rotations to failure in Neolix, One Shape and T Files compared together ($p<0.001$)

Conclusions: Among all the groups, the group with Neolix files showed the highest resistance to cyclic fatigue when used in artificial simulated curved canals.

INTRODUCTION

Nickel-titanium (NiTi) rotary files were used widely in endodontics for preparing root canals. By using NiTi rotary files, the complications that are observed when using stainless steel files such as perforations, straightened root canals, ledges, zips, started to be seen less frequently. Nickle titanium files are flexible, have good elasticity and have more resistance to fracture. By the use of these files original canal anatomy was maintained.[1]

The property of nickel titanium instruments such as super-elasticity and strength is the possible reason to manufacture rotary instruments with double, triple and quadruplet taper compared to the traditional standard. 02 taper of the stainless steel hand instruments. Earlier nickel titanium files were used as multiple file system which are still in use. But these files are time consuming as series of files are required for the proper cleaning and shaping of the canal. So, Single file is introduced which is made up of NiTi or M wire technology. This system is more efficient and takes less time for the bio-mechanical preparation. Despite the advantages of NiTi files, the fracture risk of NiTi rotary files, especially in curved canals, is significantly high. Fractured NiTi files might affect the success of endodontic treatment. The fractures of NiTi files might occur due to either torsional or cyclic fatigue.[2]

In order to prevent the fracture of NiTi rotary file systems many innovations were done. Fracture which is caused by flexure occurs due to fatigue of the metal. The instrument rotated freely in a curved canal produces tension and compression cycles at the point of maximum flexure until the fracture occurs. As an instrument is held in static position and continues to rotate, upper half of the instrument shaft is in tension, whereas the lower half of the shaft is compressed. Revolution in the curved canals leads to frequent compression and tension cycles which increases cyclic fatigue of the instrument over time and causes instrument separation.[3]

Corresponding author:* **Kumar Ujjwal
Department of Conservative Dentistry and Endodontics, DR. DY Patil Dental College and Hospital DR. DY Patil Vidyapeeth Pimpri, Pune

Hence this study was taken to evaluate and compare the Cyclic Fatigue fracture resistance of newer Nickel Titanium rotary files in simulated curved root canals.

MATERIALS AND METHODS

Three brands of Nickel Titanium instruments (single file system) were tested in this study. The nickel titanium endodontic file systems evaluated were Neolix, One shape and Twisted files of 25 mm length and 6%taper.Ten files from each group were tested.

The fatigue testing was conducted in a custom made device with simulated root canals with 60^0 angulation in an attempt to eliminate variations of canal anatomy as a source for torque and force differences. (Fig 1)

The custom made device and Hand piece of rotary Endodontic motor with file were stabilized in Universal Testing Machine (Instron) (Fig 2). The instruments were rotated at 300 rpm by using an electric motor (SYBRON ENDO, ENDOTOUCH TC2) at maximum Torque. The instruments were aligned to a specific mark (to allow for repositioning the same location), and then the file was set to rotate, synchronized with timing by a stopwatch. The instruments were allowd to rotate freely until fracture. Timer was stopped as soon as fracture was detected visually or audibly. The time was then converted into number of revolutions to failure.

NCF = Number of rotations per minute × Time to fracture.

Fig 1 Materials used for the study

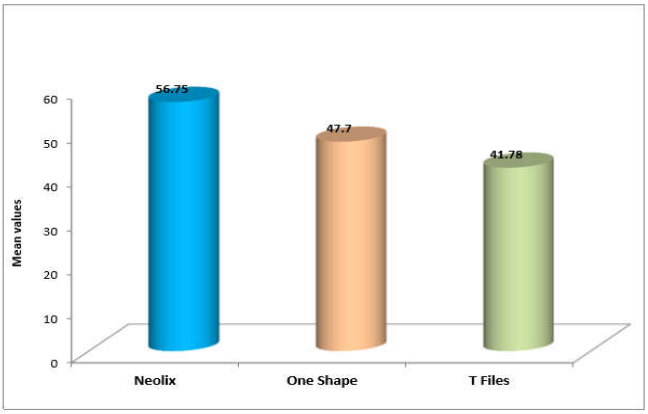
Fig 2 Rotary file rotating in simulated model in universal testing machine

RESULTS

Table No.1: Distribution of mean and SD values of Time in seconds to Fracture in Neolix, One Shape and T Files groups under study:

Neolix	One Shape	T Files
Mean ± SD	**Mean ± SD**	**Mean ± SD**
56.75±4.86	47.70±4.31	41.78±3.86

GRAPH NO. 1



Distribution of mean values of Time in seconds to Fracture in Neolix, One Shape and T Files groups under study.

Statistical Analysis

Statistical analysis was done by descriptive statistics as mean, SD and percentage etc. Comparison of groups was done by applying Student's Unpaired't' test at 5% and 1% level of significance. One way ANOVA test was applied at 5% and 1% level of significance. Statistical analysis software namely SYSTAT (Version 12) by Crane's Software, Bangalore was used to analyse the data. By applying Student's Unpaired 't' test there is a significant difference between mean values of Time in seconds to fracture and Number of rotations to failure in Neolix and One shape group ($p<0.01$)

DISCUSSION

Nickel-titanium (NiTi) alloys were used to manufacture root canal instruments in 1988 to overcome the high modulus of elasticity of stainless steel material. Stainless steel hand files have many disadvantages as it is time consuming, there is increased incidence of canal transportation and instrumentation in narrow canals can be very frustrating in difficult access cavities. The super elastic property of the NiTi rotary instruments facilitates its use in continuous rotation, even in curved root canals, to produce a continuous tapered root canal form, with reduced chances of transportation. As NiTi rotary instruments does not show any visible signs of permanent deformation during clinical uses, instrument fracture occurs suddenly. Clinically, there is increased chances of rotary NiTi instruments to separate in the canal; even new instruments separate unexpectedly on first use. The main reason of fracture is excess torsion and cyclic fatigue, the latter is probably the more prevalent cause of ''unexpected'' breakages. Fatigue cracks usually gets initiated at the surface of a working part. It gets increased if the area with the highest stress coincide with the machining marks or miniature grooves. Nowadays the main

goal in the design of new NiTi rotary systems is to enhance the fracture resistance[4].

Nickel-titanium alloy have the unique properties of shape memory and pseudoelasticity.1In addition, NiTi alloy has high modulus of elasticity (MOE), increased range of elastic deformation and higher strength. However, because of pseudoelasticity of this alloy, manufacturing of the NiTi instruments should be done by machining rather than twisting a NiTi wire. During manufacturing of NiTi files, machining of the flutes cause work hardening of the surface. The grinding process produces selected areas that are work hardened and more brittle. Machining also produces micro cracks and tool marks that are thought to be crystalline dislocation centers. These causes fracture propagation and contribute to the reduction of the mechanical properties of NiTi. Thus, surface defects occur more rapidly which causes instrument wear. This combination of surface wear and lower microhardness decrease the cutting efficiency of NiTi files. To enhance the cutting efficiency and properties of NiTi instruments various surface treatments are done which are plasma immersion ion implantation, cryogenic treatment, thermal nitridation, electropolishing etc[5].

Nickel titanium files are used as multiple file system which are still in use. But these systems takes more time as series of files have to be used for proper chemo mechanical preparation of the root canal. So, single file system were introduced which are made up of nickel titanium or m wire technology .These systems are more efficient and takes less time for the bio mechanical preparation Lowers cross contamination, Faster preparation and has added advantage of reducing the instrument fatigue i.e. minimizes separation within canal without compromising the cutting efficiency, There is no need for disinfecting, cleaning, sterilizing and organizing the files[6,7]. Hence research was done to assess the metal fatigue fracture resistance of Neolix , One shape and T files.

Neolix is a single and universal rotary NiTi system which is manufactured by electric discharge machining (EDM) process. This process consists of sparks produced by high energy and high frequency electric discharges between the metal work-piece and an electrode, leading to melting and evaporation of the work-piece material locally resulting in the finished product of desired geometry[8].

Twisted Files are produced with Kerr Endodontics proprietary R-Phase Technology. This patented technology was used to modify the molecular phase and property of nickel titanium (NiTi). Cyclic fatigue resistance and flexibility of the file is improved by the R-Phase[9].

One shape single file system has innovative instrument design characterized by 3 dissimilar cross section zones over the total length of the working component. Asymmetrical cross section, longer pitch-increase the available volume for upward debris elimination and high quality shaping[10].

The perfect study design to evaluate cyclic fatigue is the use of natural teeth with curved canals. However, this is not possible because shape of the canal would change during instrumentation hence natural tooth can be used only once and therefore standardization is not possible. In order to avoid this problem, several devices are designed. Several researchers have used artificial canals that were constructed by bending glass or metal cylindrical tubes with different inner diameters and point of maximum curvature and using various radii and angles of curvature. Larsen et al. evaluated cyclic fatigue of NiTi files with a simulated canal in a metal block having 1.5-mm width, 60^0 angle and 3-mm radius of curvature. An acrylic top face cover over the metal block was used for revelation of the files[3].

In the current study an artificial metal jig was used with 60^0 angle and 3 mm radius of curvature to the centre of the 1.5 millimeters canal width was used. In the previous studies, it has been reported that when a dynamic test was performed without consideration for the brand and manufacture type of the files, the number of cycles until fracture of the files increased significantly compared to the static test. Because the file does not move axially (back and forth) in the static test model, the pressure and tensile stresses concentrate in just an area along the file. These cumulative stresses induce micro structural changes. In the dynamic test model, the file moves axially, causing the stress to be distributed along the shaft of the file. Researchers state that with stress accumulation being prevented in this way, the resistance of the file against fracturing increases. For this reason, in several studies, cyclic fatigue tests have been performed with the dynamic test model [11].

Earlier studies have been done using a custom made experimental set up which consists of dental hand-piece attached to the downward cross head of Universal Testing Machine (Lloyds Instruments, UK) and a shaping block for endodontic files. The files were then guided into the simulated canal and rotated till fracture. Synthetic oil was used to decrease the resistance between the canal wall and the instrument. The instruments were rotated according to the manufacturer's instructions which were synchronized with time using a chronometer (stopwatch). Number of rotations per minute was multiplied by the time required for the instrument to fracture to obtain the number of cycles to fracture (NCF) for each instrument.[4].

In our study the custom made device and hand piece of rotary Endodontic motor with file were stabilized in Universal Testing Machine. The instruments were rotated at 300 rpm by using an electric motor at maximum torque. The file were rotated , synchronized with timing by a stopwatch until fracture . Time was noted as soon as fracture was detected visually or audibly. The time recorded was then converted into number of revolutions to failure.

The results were statistically analysed. By applying Tukey–Kramer Multiple comparison test there is a significant difference between mean values of Time in seconds to Fracture and Number of rotations to failure in Neolix, One Shapeand T Files compared together ($p<0.001$).

Neolix had superior cyclic fracture resistance as compared to one shape and twisted files which could be due to manufacturing process using electric discharge machining (EDM) process. This process consists of sparks produced by high energy and high frequency electric discharges between the metal work-piece and an electrode. This exclusive process allows sharp cutting edges, built in abrasive properties, variable changing profiles and a progressive flexibility[12].

According to our study One shape has superior fracture resistance as compared to twisted files. This could be because of the innovative instrument design characterized by 3 dissimilar cross section zones over the total length of the working component. In the study the new generation One Shape NiTi file has been found resistant to cyclic fatigue when compared with the old generation One Shape NiTi file[12].

In our study least cyclic fatigue resistance was observed by T files which is manufactured with a twisting method of a heat-treated wire (R- phase).

CONCLUSION

Among all the groups, the group with Neolix files showed the highest resistance to cyclic fatigue when used in artificial simulated curved canals.

Limitations

In this study static model was used to evaluate the cyclic fatigue fracture resistance of newer nickel titanium rotary files in simulated curved canals as compared to the dynamic model which replicate the clinical scenario.

Acknowledgements

It is my privilege to thank my teacher and guide, Dr. Anamika C. Borkar (Professor and Guide) for her inspiration and encouragement extended during the tenure of my thesis.

Sincere thanks to Dr.Sanjyot Mulay (Professor and Head of Department) and the staff members for their constant support, knowledge and enthusiasm .

I would like to give special thanks to department of mechanical engeneering, Dy Patil Engeering College, Pimpri, Pune. I would like to give special thanks to Dr. Nitika Tiwari and Dr. Nikhil Nighot for always being a part of this study.

Finally, I would like to acknowledge how highly indebted I am to my parents: Mr. Ranjeet Prasad and Mrs. Sova Devi.

…..Dr. Kumar Ujjwal

References

1. Zhao D, Shen Y, Peng B, Haapasalo M. Effect of autoclave sterilization on the cyclic fatigue resistance of thermally treated Nickel-Titanium instruments. *Int Endod J*. 2016 Oct; 49(10):990-5.
2. Martín B, Zelada G, Varela P, Bahillo JG, Magán F, Ahn S, Rodríguez C. (2003). Factors influencing the fracture of nickel-titanium rotary instruments. I*nt Endod J,* 36(4), 262-266.
3. Plotino G, Grande NM, Cordaro M, Testarelli L, Gambarini G. A review of cyclicfatigue testing of nickel-titanium rotary instruments. *J Endod*. 2009 Nov; 35(11):1469-76.
4. Kim HC, Yum J, Hur B, Cheung GS. Cyclic fatigue and fracture characteristics of ground and twisted nickel-titanium rotary files. *J Endod*. 2010 Jan; 36(1):147-52.
5. George GK, Sanjeev K, Sekar M. An in vitro evaluation of the effect of deep dry cryotreatment on the cutting efficiency of three rotary nickel titanium instruments. *J Conserv Dent.* 2011 Apr; 14(2):169-72.
6. Martín B, Zelada G, Varela P, Bahillo JG, Magán F, Ahn S, Rodríguez C. (2003). Factors influencing the fracture of nickel-titanium rotary instruments. *Int Endod J*, 36(4), 262-266.
7. Shruti JS (2016). Apical extrusion of debris and irrigant using neolix and one-shape rotary systems: A comparative study. *IJRSR*, 7(5), 11325-11327.
8. Dr.Amoud Stanurski 2014, Neolex ORIKAM,Pamphlet.
9. Twisted Files 2015, Pamphlet.
10. One Shape 2015, Pamphlet.
11. Reddy Y P, S K, Subbarao CV. Cyclic fatigue testing of three different rotary nickel titanium endodontic instruments in simulated curved canals - an in vitro sem analysis. *J Clin Diagn Res*. 2014 Feb; 8(2):211-3.
12. Haapasalo M, Shen Y. Evolution of nickel–titanium instruments: from past to future. *Endod Top* 2013; 29:3-17.

How to cite this article:

Kumar Ujjwal *et al*.2018, Comparative Evaluation of Cyclic Fatigue Fracture Resistance of Newer Nickel-Titanium Rotary Files In Simulated Curved Canals: In Vitro Study. *Int J Recent Sci Res.* 9(1), pp. 23404-23407.
DOI: http://dx.doi.org/10.24327/ijrsr.2018.0901.1461

****