International Journal of Dental Research
Online ISSN: 2664-9055, Print ISSN: 2664-9047
Received: 27-02-2020; Accepted: 14-03-2020; Published: 23-03-2020
www.dentaljournal.net
Volume 2; Issue 1; 2020; Page No. 32-34

A comparative analysis of cyclic fatigue resistance of recent NiTi rotary endodontic file systems: An *In-Vitro* study

Akanksha Bhatt[1*], Dharmveer Singh[2]
[1] Associate Professor, M.D.S, Ph. D (Dental Sciences) Department of Conservative Dentistry & Endodontics, Babu Banarasi Das College of Dental Sciences, BBD University, Lucknow, India
[2] Dental Surgeon, Lucknow, India

Abstract
This study aimed to compare the cyclic fatigue fracture resistance of two rotary Ni Ti instrument systems. The instruments compared were a new rotary system Protaper Next rotary endodontic file system and One Shape rotary file system. The cyclic fatigue testing was conducted with the instrument rotating freely at an angle of curvature 60º 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 at 375 rpm using the Tri auto mini endomotor set at 2.5 Torque, until fracture occurred. The time until fracture was recorded in seconds by using a stopwatch, and the number of rotations to fracture was then calculated and results were then statistically analyzed. The results showed One Shape (Group 2) performed significantly better than Protaper Next rotary endodontic file system (Group1) in cyclic fatigue testing.

Keywords: curvature, cyclic fatigue, endodontics, flexural fracture, torsional fracture, flexible, resistance, root canal

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 fatigues 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].
Many different rotary systems are available with difference in cross sectional shape and design, Taper and total number of instruments within system. But it is quite difficult to determine the best one. ProTaper Next, which is manufactured by M-Wire, has been introduced recently. This system has an off-centered rectangular cross-section design. Files manufactured with this M-wire method showed more flexible and fatigue resistance than did conventionally manufactured files. This design of the cross section is found to enhance the resistance to stress and increases the efficiency of shaping due to its unique asymmetric rotary motion [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 Protaper Next and recently introduced rotary Ni-Ti system One Shape.

Materials and Method
The endodontic rotary file system Protaper Next (Dentsply Maillefer, Ballaigues, Switzerland) 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 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 (60º) 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 60^0 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 than calculated using the simple formula: No. of rotation to fracture= 375/ 60 x 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 One Shape (Group 2) was significantly greater than that of ProTaper Next (Group 1) at angles of curvature 60° .

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

Sample	Protaper Next (Group 1)	One Shape (Group 2)
1	145	152
2	151	152
3	144	150
4	143	152
5	147	152
6	150	148
7	145	152
8	151	156
9	145	150
10	140	144

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

	Protaper Next (Group 1)	One Shape (Group 2)
Mean	145.89	150.07
Standard Deviation	4.25	3.83

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 obturation [11].

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 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, 19]. It is advocated that clockwise and counter clockwise movements reduces the incidence of torsional fracture caused by taper lock [18, 19].

The cross cut design incorporated in the One Shape system might results in less cyclic fatigue than other instruments of similar taper as some of the values of Protaper Next. As this was an in-vitro study more clinical trials should be carried out for reaching out to reach to a definite conclusion.

Conclusion

Within the limitations of this study, One shape file system showed significantly higher resistance to cyclic fatigue fracture compared with the Protaper Next file system at 60° of curvature. Instrumentation with files with reciprocal motion increases significantly instrument life and makes them safer during shaping of root canals.

References

1. Walia H, Brantley WA, Gerstein H. An initial investigation of the bending and torsional properties of nitinol root canal files. JOE, 1988; 14:346-51.
2. Huismann M, Peters OA, Dummer PMH. Mechenical preparation of root canals: shaping goals, techniques and means. Endod Topics, 2005; 10:30-76.
3. Spili P, Parashos P, Messer HH. The impact of instrument fracture on outcome of endodontic treatment. J Endod, 2005; 31:845-50.
4. Souter NJ, Messer HH. Complications associated with fractured file removal using an ultrasonic technique. J Endod, 2005; 31:450-2.
5. Sattapan B, Nervo GJ, Palmara JEA, Messer HH. Defects in rotary nickel-titanium files after clinical use. J Endod, 2000; 26:161-5.
6. Margot E Anderson, John WH, Peter Parashos. Fracture resistance of electropolished rotary nickel titanium endodontic instruments. J Endod, 2007; 33:1212-16.
7. Burklein S, Hiller C, Huda M, Schafer E. Shaping ability and cleaning effectiveness of M two versus coated and uncoated Easy Shape instruments in severely curved root canals of extracted teeth. Int Endod J, 2011; 44:447-457.
8. Youssef Haikel, Rene Serfaty, Geoff Bateman, Bernard Senger, Claud Allemann. Dynamic and cyclic fatigue of engine driven rotary Nickel-Titanium endodontic instruments. J Endod, 1999; 25:434-440.
9. Schneider SW. A comparison of canal preparation in straight and curved root canals. Oral Surg, 1971; 32:271-5.

10. Zelada G, Varela P, Martin B, Jose G, Magan F, Ahn S, *et al*. The effect of rotational speed and the curvature of root canals on the breakage of rotary endodontic instruments. J Endod, 2002; 28(7).
11. Anderson ME, Price JWH, Parashos P. Fracture resistance of electropolished rotary Nickel-Titanium endodontic instruments. JOE. 2007; 33(10):1212-1216.
12. Galvao Barbosa FO, Ponciano Gomes JA, Pimenta de Araujo MC. Influence of previous angular deformation on flexural fatigue resistance of K3 nickel-titanium rotary instruments. J Endod. 2007; 33(12):1477-80.
13. Bahia MG, Melo MC, Buono VT. Influence of simulated clinical use on the torsional behaviour of nickel-titanium rotary endodontic instruments. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2006; 101(5):675.
14. Roland DD, Andelin WE, Browning DF, Hsu G-HR, Torabinejad M. The effect of preflaring on the rates of separation for 0.04 taper nickel titanium rotary instruments. J Endod. 2002; 28(7):543-545.
15. A Comparative evaluation of three different Ni-Ti rotary files using Crown Down technique." An Exvivostudy using C T scan. Bangladesh Journal of Medical Science. 2017; 16(2):212-218.
16. Berruti E, Negro AR, Lendini M, Pasqualini D. Influence of manual preflaring and torque on the failure rate of ProTaper rotary instruments. J Endod. 2004; 30(4):228-30.
17. Berutti E, Chiandussi G, Gaviglio I, Ibba A. Comparative analysis of torsional and bending stresses in two mathematical models of nickel titanium rotary instruments: Pro Taper versus ProFile. J Endod. 2003; 29(1):15-19.
18. Yared G. Canal preparation using only one NiTi rotary instrument: Preliminary observations. Int Endod J. 2008; 41(4):339-44.
19. Bhatt A, Rajkumar B. A comparative evaluation of cyclic fatigue resistance for different endodontic NiTi rotary files: An *in-vitro* study. J Oral Bio Craniofac Res. 2019; 9(2):119-121.