ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)

IJDSIR : Dental Publication Service

Available Online at:www.ijdsir.com

Volume – 6, Issue – 1, January - 2023, Page No. : 180 - 185

Comparative evaluation of cyclic Fatigue Resistance of three rotary systems one curve, Protaper next and Neo Endo flex files in simulated root canals

[1]Dr. Sial Shruti, MDS, Reader, Govt. Dental College, Raipur, Chhattisgarh, Pin: 492001.

[2]Dr. Kunhappan Sanjeev, MDS, Professor, Govt. Dental College, Raipur, Chhattisgarh, Pin: 492001.

[3]Dr. Jain Deepti, MDS, Lecturer, Govt. Dental College, Raipur, Chhattisgarh, Pin: 492001.

[4]Dr. Lakra Namita, Post Graduate student, Govt. Dental College, Raipur, Chhattisgarh, Pin: 492001.

[5]Dr. Beevi Sumayya, Post Graduate student, Govt. Dental College, Raipur, Chhattisgarh, Pin: 492001.

[6]Dr. Siddiqui Taha, Post Graduate student, Govt. Dental College, Raipur, Chhattisgarh, Pin: 492001.

Corresponding Author: Dr. Kunhappan Sanjeev, MDS, Professor, Govt. Dental College, Raipur, Chhattisgarh, Pin: 492001.

Citation of this Article: Dr. Sial Shruti, Dr. Kunhappan Sanjeev, Dr. Jain Deepti, Dr. Lakra Namita, Dr. Beevi Sumayya, Dr. Siddiqui Taha, "Comparative evaluation of cyclic Fatigue Resistance of three rotary systems one curve, Protaper next and Neo Endo flex files in simulated root canals", IJDSIR- January - 2023, Volume –6, Issue - 1, P. No.180– 185.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Aim: The introduction of NiTi files in endodontics is a boon to negotiate curved canal as they maintain centrality thus avoiding some procedural errors. However, instrument separation is one of main concerns for NiTi files. This is caused by cyclic fatigue of the instruments in curvature of the canal. Thus, the present study compared cyclic fatigue resistance of three different NiTi rotary file systems One curve, Protaper Next and Neo Endo Flex files in an artificial simulated canal system.

Materials and Method: Forty-five files, 15from each group were included in this study. They were tested in artificial custom-made groove which simulated a curve canal. The rotations of the file were kept as per manufacturers' instructions. The number of cycles needed for instrument fracture (NCF) was calculated as revolutions per minute multiplied by time for failure. The values obtained were subjected to one way ANOVA and post hoc Tukey.

Results: The NCF values were highest for One curve (2085±120.93) followed by Protaper Next (843±72.25). Least cyclic resistance was observed with Neo Endo Flex files (621±39.115). There was a statistically significant difference amongst each of the group.

Conclusion: The One curve showed superior cyclic fatigue resistance as compared to others. Further studies are warranted in this regard.

Keywords: Cyclic fatigue, Neo Endo Flex, NiTi files, one curve, Protaper Next, Simulated.

Introduction

The NiTi files provide the advantages of being flexible thus making them an ideal for use in curved canals. NiTi files have been reported to maintain satisfactory canal shape in a shorter time period. The preparation achieved are rounder and Centered, maintaining the original anatomy of the canal.[1] The disadvantage of NiTi instruments lies in the fact that there are higher incidences of instrument separation. The fracture of instrument is due to the cyclic fatigue of the instrument alloy.[2] Flexural fatigue results when there is excessive number of tension-compression strain cycles. These cycles are increased in case of severe curvature, reach a point of maximum flexure leading to fracture of the instrument. [3,4] to overcome this, manufacturers strived***I.*** to better these instruments by altering their design, using a single file protocol and modifying the temperatures to make it more resistant.[5] The heat treatment modifies the crystallographic structure of the alloy causing change in transformation behaviour. This results in increased austenite finish; which in turn cause the file to remain in a mixed martensitic state, R-phase and austenitic structure. Therefore, these files show increased flexibility and better flexural fatigue resistance.[6]

One-Curve NiTi files (OC, MicroMega, Besancon, France) are formed using heat treated alloy using a C-wire. This helps in memory control, curvature conservation and pre-bendability. There is a continuous taper of 6%, with ISO 25 tip size. It has a triangular cross section at the tip, while s-shape nears the shank. This provides a perfectly Centered trajectory with excellent cutting efficiency.[7] Protaper Next (Dentsply Sirona, Ballaigues, Switzerland) has a variable taper and an off Centered rectangular cross section. There are only two cutting points when the file is rotated within the canal; this is claimed to reduce strain on file while it is in use.[8] Apart from this it is known to create an enlarged space for debris removal. M-wire alloy is used in its manufacturing which improves its flexibility and have increased cyclic fatigue.[9] Neoendo flex files (Orikam Healthcare India Private limited) receives a proprietary heat treatment to make them flexible. They have a triangular cross- section; flutes do not open when stress level is reached. This results in increased cyclic resistance.[10]

These files are routinely used for endodontic treatment; hence, the aim of the current study is to compare the cyclic fatigue resistance of three different NiTi rotary file systems Onecurve, Protaper Next and Neoendo Flex files in an artificial simulated canal system.

Materials and Method

A total of forty-five files which comprised of fifteen files each of onecurve, Protaper next and neoendo flex files were used in the study; NeoEndo (NE) file (size 25 and taper 0.06), Protaper Next (PTN) X2 (size 25 and taper 0.06), One shape (size 25 and taper 0.06). All instruments were inspected using an optical stereomicroscope under 20 × magnifications for any signs of visible deformation. All defective instruments were discarded.

The cyclic fatigue test was performed in a custom-made groove in form of a curved canal. Using a computer-assisted milling, an artificial u-shaped cross section grooves were formed in 316L stainless steel blocks to simulate a root canal procedure. The diameter, angle and radius of the curvature of the simulated canal were kept at 1.4 mm, 60 degree and 5 mm respectively. Then the surface of the blocks was hardened with polished chrome plating. A 4 mm-thick glass was screwed in front of the simulated canal to make the instruments

visible in the canal and also to prevent slippage of the files.

The headpiece was fixed above the block to perform the cyclic fatigue test in a reproducible position. Synthetic oil was used to reduce friction between the two metal surfaces of the canal wall and moving instrument. Each instrument was inspected visually, and the time between initiating the test and its fracture was recorded with a 0.01-second precision chronometer. The number of cycles needed for instrument fracture (NCF) was calculated by multiplying the time recorded in seconds by the number of instrument rotations or cycles per second. Also, the length of the separated instrument was measured to ensure that the instrument was separated at the curvature of the simulated canal. The instruments were operated as per manufacturer's recommendations which were: Onecurve at 300rpm/2.5Ncm; Neoendo Flex at 350rpm/1.5Ncm; ProTaper Next at 300 rpm/2 Ncm. Mean values were then calculated. The formula to calculate number of cycles to failure (NCF) is NCF = revolutions per minute × time to failure (seconds)/60.[10] The values obtained were analysed using SPSS 21.0.The data was subjected to one way ANOVA. Post hoc Tukey was applied for assessing significant differences ($p \leq 0.05$) amongst the groups.

I.

II.

Result

The NCF values for all the three groups were expressed in terms of mean and standard deviation (Table 1). The highest value was obtained for Onecurve which was statistically significant ($p \leq 0.05$) (Table 2,3) when compared to Neoendo Flex (1464) and ProTaper Next (1242) (Table 3). This suggested that Onecurve file has highest cyclic fatigue resistance which was followed by Protaper Next. Neoendo Flex files have shown least cyclic fatigue resistance (621±39.11). The comparison of NCF value Protaper Next and Neoendo Flex have also shown statistically significance in favour of the former.

Discussion

The NiTi instruments during their use in the curved canals, experience compressive force on the inner aspect of the canal and tensile forces on the outer aspect of the canal. This result in breakage of these files in the canal due to a phenomenon called as cyclic fatigue failure.[11] This is affected by numerous factors including rotational speed of the file, metal treatment of the file, number of autoclaving done as well as the metallurgic characterization of the alloys.[12] Since the cyclic fatigue do not show any signs of failure of the metal alloy, it is difficult to assess the integrity of file before and while performing the clinical procedure. The manufacturers strive to continuously improve and avoid this aspect of NiTi files. The alteration in design, thermal treatments and changes in kinematics of the file will affect the cyclic fatigue resistance. Thus, the present study was aimed to compare the number of cycles leading to their separation in a simulated environment of three files: One curve, Neo Endo flex, Protaper next.

The result of the present study exhibited least NCF with Neo Endo flex files and maximum with One curve. Protaper next showed better performance ($p \leq 0.05$) than Neo Endo flex, however when PTN and One curve was compared, the latter was highly significantly better. One curve file is a single file system which prepares and shapes the full length of canal. The c wire provides a superior flexibility of the file and a shape memory which is proposed to be 2.4 times more resistant as compared to existing generations of files. [13] The cross section of the files is variable giving a superior cutting efficiency. The heat-treated C wire possesses a controlled memory of NiTi alloy and has a better reach in curved canals along with adequate tapered preparation.[13] The

resultobtained in this study justifies these characteristics of One curve. M-wire alloy is component of Protaper Next. It has a fixed taper from D1 to D3 portion which decreases to the tip of the file. The martensitic microstructure comprises of the nanocrystalline structure which is provides the files an increased flexibility, better resistance and high strength then conventional NiTi files. The cross-section of the file is off Centered rectangular.[14]

The NCF values obtained for this group fell in the mid-range off the three groups compared. The least NCF values were found with NeoEndo flex files which has a triangular cross section. It is subjected to gold surface treatment.

The literature presents conflicting result when various NiTi files were compared on basis of their cyclic fatigue resistance. Kumar et al [14] has shown better result with NeoEndo flex files which was contrary to the present study while Ismail etal [15] showed similar result with Protaper Next files which was inferior in performance. Topcuoglu et al have shown similar result as the present study where PTN was found inferior to Onecarve files. they attributed this result to better cyclic fatigue resistance of controlled memory wire, cross section of the files and metal mass of the files.[16] Mahajan et al studied three different files in terms of their cyclic fatigue resistance and found Onecurve was better than Neoendo flex files.[17] Though there are numerous studies in comparing the cyclic fatigue of the various NiTi files, the present study is one of its kinds, to the best of authors' knowledge as it compares NiTi files which are routinely used in the clinics with comparable size and taper but different cross section. The present aimed to establish the effect of file design and proved that a variable cross section was better than the triangular cross section. One curvefiles had the highest NCF before their fracture followed by PTN and Neo Endo flex files were fractured with minimum NCF. Limitation of the study included small sample size. The temperature which causes change in the two phases of NiTi alloy could be a confounding factor. Although a uniform temperature was maintained throughout the test but effect of human body temperatures can be confounding factor in the result.

III. Conclusion

The three NiTi system were compared in this study for estimation of their cyclic fatigue resistance. Within the limitation of the study, it was concluded that One curve could be better than the other files in curved canals. The NCF values obtained for Protaper Next was statistically significant then Neo Endo Flex which had the least resistance.

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Table Legends

Table 1: Table showing descriptive statistics of NCF (Cyclic fatigue resistance) values content obtained from various groups.

No of Cycles								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Neo Endo flex	15	621.00	39.115	17.493	572.43	669.57	570	675
Protaper next	15	843.00	72.250	32.311	753.29	932.71	720	900
One curve	15	2085.00	120.934	54.083	1934.84	2235.16	1905	2220

Table 2: Table showing mean NCF values of various groups using one-way Anova.

ANOVA					
No of Cycles					
	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	6225240.000	2	3112620.000	436.859	.001*
Within Groups	85500.000	12	7125.000		
Total	6310740.000	14			

Table 3: Table showing comparison of mean.

Multiple Comparisons Tukey HSD						
No of Cycles						
(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Neo Endo flex	Protaper next	-222.000*	53.385	.004*	-364.42	-79.58
	One curve	-1464.000*	53.385	.001*	-1606.42	-1321.58
Protaper next	Neo Endo flex	222.000*	53.385	.004*	79.58	364.42
	One curve	-1242.000*	53.385	.001*	-1384.42	-1099.58
One curve	Neo Endo flex	1464.000*	53.385	.001*	1321.58	1606.42
	Protaper next	1242.000*	53.385	.001*	1099.58	1384.42
*. The mean difference is significant at the 0.05 level.						

Graph 1: Graph showing mean NCF content obtained from various groups.

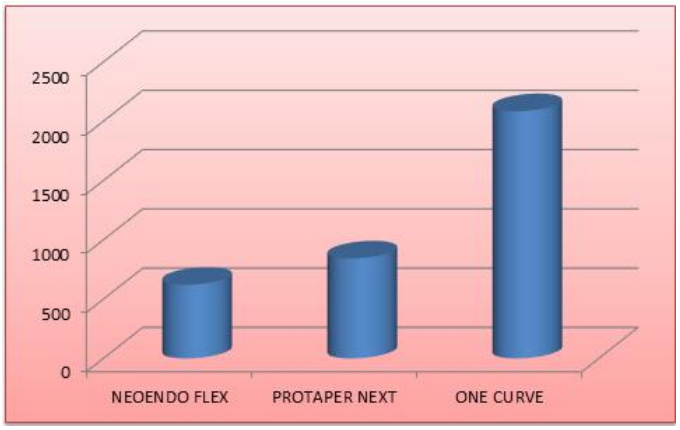

Figure 1: Use of test files in simulated artificial canal