International Journal of Aquatic Science
ISSN: 2008-8019
Vol 12, Issue 03, 2021

Comparative Evaluation Of Cyclic Fatigue Resistance Of Hyflex Cm With Newer Gold Treated Niti File Systems: An In Vitro Study

Running Title: Cyclic Fatigue Resistance Of Rotary Niti In Extreme Canal Curvature

[1]Sahithi Reddy, [2]Arunajatesan Subbiya, [3]Dhakshinamoorthy Malarvizhi, [4]Venkatachalam Prakash, [5]Arumugam Karthick, [6]Alagarsamy Venkatesh

[1]B.D.S., Third year Postgraduate student, Department of Conservative Dentistry and Endodontics, Sree Balaji Dental College and Hospital, Bharath Institute of Higher Education and Research, Narayanapuram, Pallikaranai, Chennai -600100. Tamilnadu, India.
[2]M.D.S., Professor & Head of the department, Department of Conservative Dentistry and Endodontics, Sree Balaji Dental College and Hospital, Bharath Institute of Higher Education and Research, Narayanapuram, Pallikaranai, Chennai -600100. Tamilnadu, India.
[3]M.D.S., Professor Department of Conservative Dentistry and Endodontics, Sree Balaji Dental College and Hospital, Bharath Institute of Higher Education and Research, Narayanapuram, Pallikaranai, Chennai -600100. Tamilnadu, India.
[4]M.D.S., Professor Department of Conservative Dentistry and Endodontics, Sree Balaji Dental College and Hospital, Bharath Institute of Higher Education and Research, Narayanapuram, Pallikaranai, Chennai -600100. Tamilnadu, India.
[5]M.D.S., Professor Department of Conservative Dentistry and Endodontics, Sree Balaji Dental College and Hospital, Bharath Institute of Higher Education and Research, Narayanapuram, Pallikaranai, Chennai -600100. Tamilnadu, India.
[6]M.D.S., Professor Department of Conservative Dentistry and Endodontics, Sree Balaji Dental College and Hospital, Bharath Institute of Higher Education and Research, Narayanapuram, Pallikaranai, Chennai -600100. Tamilnadu, India.

E-mail:[2]drsubbiya@gmail.com

Abstract:
Objective: The aim of this study was to evaluate cyclic fatigue resistance of three control memory wire based instruments namely, Hyflex CM NiTi files (Coltene/ Whaldent, Switzerland), M3 Pro Gold NiTi files (United Dental, Shanghai, China) and NeoEndo Flex NiTi files (Orikam health care, Gurgaon, India) in an extreme canal curvature.
Method: A total of 30 NiTi instruments of three different rotary systems weretested using a custom made jig that reproduces a curvature of 90° and 5mm radius. All of the files were used in the artificial canals until the fracture occurred. The time to fracture for each group was recorded using digital chronometer. Using the time data, the numbers of cycles to failure (NCF) were calculated. The mean, standard deviation and standard error of the

three groups were calculated and statistically analyzed using SPSS software 21.0 version. One-way analysis of variance (ANOVA) was done to determine significant differences among the systems, between groups and within groups. Post Hoc test of Tukey was performed to identify pair-wise significance.

Results: NeoEndo Flex had highest NCF followed by M3 Pro Gold and Hyflex CM with a mean of 425.310, 380.060 and 259.960 NCF respectively. On one way ANOVA the three groups had statistically significant difference (P value = 0.025) and on Post hoc Tukey HSD between all the three groups NeoEndo Flex vs. Hyflex CM was statistically significant (P value = 0.024).

Conclusion: Within the limitations of present study, NeoEndo Flex had significantly higher cyclic fatigue resistance than Hyflex CM in 90 degree canal curvature and among all the three NiTi systems.

Keywords: cyclic fatigue, extreme curvature, Hyflex CM, M3 Pro Gold, NeoEndo Flex

1. INTRODUCTION

Ameliorating rotary files to enhance proficiency, precision and endurance has always been the pursuit of a dentist. Nickel-titanium rotary files are proven to be efficient to shape root canals but, they undergo repetitive strain excursions during rotation in root canals [(1)]. Inside a curved canal, they tend to break due to cyclic fatigue, which has been majorly attributed to 50% to 90% of mechanical failure [(1–4)]. Thus, increasing the fatigue resistance to fracture has always been a focus with the advancement of rotary NiTi instruments [(2–5)]. Manufacturers have claimed to improve the resistance to fracture by altering the metallurgy, design, kinematics of the files and through the heat treatments applied to the files [(5)]. Recent techniques of modifying the mechanical properties of these materials include thermal treatment of NiTi alloys [(3, 6, 7)]. The thermo-mechanical treatment influences the mechanical properties of NiTi alloys by optimizing the microstructure and, in turn affecting the transformation behaviour of the alloys [(8)]. In addition to the mechanical properties of the file, various other factors such as angle of curvature [(4, 9)] and radius [(4, 9–11)] also influence the cyclic fatigue resistance.

Files with different metallurgical properties are being developed of which, Hyflex CM NiTi files (Coltene/ Whaldent, Switzerland), is made of CM wire and the files are flexible but without shape memory unlike conventional NiTi Files. These files have lower elastic modulus and therefore exhibit higher fracture resistance [(12)].The NeoEndo Flex NiTi files (Orikam health care, Gurgaon, India) is a newly introduced NiTi instrument. This file system as stated by the manufacturer is a gold thermal treated file with enhanced cutting efficiency and extreme flexibility. Similarly, M3 Pro Gold Rotary files (United Dental, Shanghai, China) are also gold treated CM wire, with greater flexibility and are more resistant to fracture than M3 rotary files [(3)].

Many in-vitro studies were performed on the cyclic fatigue resistance of rotary NiTi files [(2–4, 10, 11, 13–15)] including the newer generation files but, very few studies have tested them in severely curved canals [(16)]. Though there are comparative studies between CM wire and other systems, these three different commercially available CM wire file systems have not been compared, especially in severe curvature. Hence, the aim of this study was to evaluate cyclic fatigue resistance of three CM wire files in canal curvature of 90° and 5mm radius. Null hypothesis of the study is that there is no difference in cyclic fatigue resistance among the instruments being tested.

2. MATERIALS AND METHODS

A total of 30 NiTi instruments of 3 different rotary systems of same size and taper 25/.06(n=10) were used in the present study: Hyflex CM NiTi files (Coltene/ Whaldent, Switzerland), M3 Pro Gold NiTi files (United Dental, Shanghai, China) and NeoEndo Flex NiTi files (Orikam health care, Gurgaon, India). A static cyclic fatigue test was performed using a custom-made jig that allowed a reproducible simulation of an instrument confined in an artificial curved canal [17]. The artificial canal was made of stainless steel, with an inner diameter of 1.5 mm, total length of 20 mm and an arc with a curvature radius of 5 mm located just coronal to the apical end point. Base of the concavity is at a curvature of 90˚, which was calculated according to Schneider's method [4] to provide a suitable trajectory. The dental hand piece of 16: 1 reduction (X-Smart Endo Motor, Dentsply Sirona) was attached to the descending cross head of the Instron (8874) testing machine (Boston, Massachusetts, USA). In order, to reduce the friction of the instruments as it came into contact with the artificial canal walls, special high-flow synthetic oil (WD- 40 Company, Milton Keynes, U.K.) was applied. All three groups of files were rotated at a speed according to the manufacturer's instructions. All of the files were used in the artificial canals until the fracture occurred. The time to fracture for each group was recorded using digital chronometer and stopped as soon as the failure was detected. Using the time data, the numbers of cycles to failure (NCF) were calculated according to the following formula: NCF = revolutions per minute × time to fracture (seconds)/60.

3. STATISTICAL ANALYSIS

The mean, standard deviation and standard error of the three groups were calculated and their 95% confident intervals were calculated. The number of cycles to failure was statistically analyzed using SPSS software 21.0 version (SPSS Inc, Chicago, IL). One -way ANOVA was done to determine significant differences among the systems, between groups and within groups. When the overall F test indicated significant difference, Post Hoc test of Tukey was performed to identify pair-wise significance of the groups. The differences were considered statistically significant when P value < 0.05.

4. RESULTS

The results showed that NeoEndo Flex had highest NCF followed by M3 Pro Gold and Hyflex CM with a mean of 425.310, 380.060 and 259.960 NCF respectively (Table 1). On one way analysis of variance (ANOVA) the three groups had statistically significant difference (P value of 0.025) (Table 2) and on post hoc Tukey HSD of all the three groups, NeoEndo Flex vs. Hyflex CM was statistically significant (P value is 0.024) whereas, Hyflex CM vs M3Pro Gold (P value is 0.121) and M3Pro Gold vs NeoEndo Flex (P value is 0.725) had no significant difference (Table 3). Since cyclic fatigue resistance of NeoEndo Flex file system was found to be statistically higher than Hyflex CM and M3 Pro Gold files, the null hypothesis of the present study was partly rejected.

5. DISCUSSION

Cyclic fatigue resistance refers to the number of cycles to failure that an instrument is able to resist under a specific loading condition [14]. Currently, there are no standardised testing

devices in existence for cyclic fatigue. Though the extracted tooth model resembles the clinical condition, it is not ideal to test the physical properties of NiTi files as, no two root canals are perfectly identical [15]. Thus, in this study a non-tooth model was selected to rule out the confounding factors and to ensure standardization. A static model was preferred though it does not simulate the advised pecking motion of the file, because the instrument being tested could be constrained in precise trajectory [18, 19]. In previous studies it has been proved that canal curvature majorly influences the NCF and an instrument can behave comparably different in different curvatures [20]. It was also observed that more micro fissures occurred in severely curved canals [16]. Hence, in the present study 90° canal curvature was used. Though a very few NiTi systems were studied at this curvature Hyflex CM to our knowledge has not been subjected to cyclic fatigue testing in a 90° curvature. Studies on Hyflex CM have been done only at 60° and 45° curvature [2]. An identical size and taper of 25/.06 were selected because it is the master apical file in many operative sequences and safe to use in curved canals [21]. Hyflex CM was the first to be introduced in CM wire rotary files category which can be considered as a conventional CM wire file system. CM instruments, in addition to the austenite, also contained martensite and R-phase [6] .Whereas, NeoEndo Flex and M3Pro Gold are CM wire systems subjected to gold thermal treatment unlike Hyflex CM.

According to the results of the present study, cyclic fatigue resistance of NeoEndo Flex file system was found to be significantly higher followed by M3 Pro Gold and Hyflex CM (P value of 0.025) with mean NCF of 425.31 (graph 1). Hyflex CM has shown to perform well in cyclic fatigue resistance in comparison to many other file systems in previous studies [2]. But the compared file systems in those studies were conventional NiTi files that did not undergo thermo-mechanical treatment. The higher NCF of Hyflex CM was also observed in previous studies in comparison with Protaper next and other heat treated file systems [7]. The cross-sectional design, surface conditioning and thermo-mechanical process applied during manufacturing also determines cyclic fatigue resistance of rotary instruments [22]. In this study all the three files have a similar triangular cross section but mainly vary in the post-machining thermo mechanical processing without any surface conditioning such as electropolishing.

The higher cyclic fatigue resistance of NeoEndo Flex and M3 Pro Gold in comparison to Hyflex CM could be due to the gold heat treatment. The possible reason for increased cyclic fatigue resistance is damping characteristics of the martensitic phase transformation. Where, on heat treatment the energy absorption of twinned phase structure results in internal movement of lattices without breaking the atomic bonds resulting in formation of a complex array of secondary cracks due to its multiple interfaces, which dissipates the energy required for crack propagation. They also have high Af temperature around 50°C [23]. Another possible reason could be due to the relatively harder surface layer of the Gold heat-treated instruments that may resist crack initiation and also might compensate for the decreased micro hardness [24].

The post machining heat treatment reduces the surface defects formed while manufacturing the file which also increases the longevity [23]. All Gold and Blue heat-treated files showed increased flexibility and fatigue resistance than conventional NiTi and M-Wire instruments which might be attributed to their martensitic state [25]. In a study done by Pedullà et al, it was observed that the M3 Pro Gold files showed greater cyclic fatigue resistance than the M3 Rotary files, which was attributed to significant R-phase and martensite [3]. The results of present study are in accordance with both these studies, where gold heat treated files had higher cyclic fatigue resistance. A limitation of the study is that the files were tested only in

90 degree curvature, and further studies are required to test the cyclic fatigue resistance of these files at different canal curvatures.

6. CONCLUSION

Within the limitations of present study, NeoEndo Flex and M3 Pro Gold has better cyclic fatigue resistance than Hyflex CM in 90 degree canal curvature and of all the three NiTi systems NeoEndo Flex had significantly higher cyclic fatigue resistance than Hyflex CM. The impetus of this study is to present an assessment of incidence of fracture and support prudent use of instruments in root canal preparation thereby, giving an idea to the clinician on adequate time for fracture so that instrument can be used more cautiously in severely curved canals.

Source Of Funding: Nil
Ethical Clearance: This article does not contain any studies with human participants and does not require ethics committee approval.
*Conflict Of Interest***:** Nil

7. REFERENCES

[1]. Parashos P, Gordon I, Messer HH. Factors influencing defects of rotary nickel-titanium endodontic instruments after clinical use. J Endod. 2004; 30(10):722-5.
[2]. Vivekanandhan P, Subbiya A, Mitthra S, Karthick A. Comparison of apical debris extrusion of two rotary systems and one reciprocating system. Journal of conservative dentistry 2016 May;19(3):245.
[3]. Pedullà E, Lo Savio F, La Rosa GR, Miccoli G, Bruno E, Rapisarda S, et al. Cyclic fatigue resistance, torsional resistance, and metallurgical characteristics of M3 Rotary and M3 Pro Gold NiTi files. Restor Dent Endod2018;43(2):e25.
[4]. Manojkumar T, Vivekanandhan P, Dhakshinamoorthy M, Tamilselvi R, Subbiya A. Evaluation of Cyclic Fatigue Resistance of Three Different Niti Rotary Systems-An Invitro Study. Indian Journal of Public Health. 2020 Jan;11(01):689.
[5]. Gutmann JL, Gao Y. Alteration in the inherent metallic and surface properties of nickel–titanium root canal instruments to enhance performance, durability and safety: a focused review. Int Endod J 2012;45(2):113-28.
[6]. Pereira ÉS, Viana AC, Buono VT, Peters OA, de Azevedo Bahia MG. Behavior of nickel-titanium instruments manufactured with different thermal treatments. J Endod 2015;41(1):67-71.
[7]. Pedullà E, Benites A, La Rosa GM, Plotino G, Grande NM, Rapisarda E, Generali L. Cyclic fatigue resistance of heat-treated nickel-titanium instruments after immersion in sodium hypochlorite and/or sterilization. J Endod 2018;44(4):648-53.
[8]. Bardsley S, Peters CI, Peters OA. The effect of three rotational speed settings on torque and apical force with vortex rotary instruments in vitro. J Endod 2011;37(6):860-4.
[9]. Zelada G, Varela P, Martín B, Bahíllo JG, Magán F, Ahn S. The effect of rotational speed and the curvature of root canals on the breakage of rotary endodontic instruments. J Endod 2002;28(7):540-2.
[10]. Inan U, Aydin C, Tunca YM. Cyclic fatigue of ProTaper rotary nickel-titanium instruments in artificial canals with 2 different radii of curvature. Oral Surg Oral Med Oral Pathol Oral RadiolEndod2007;104(6):837-40.

[11]. Pruett JP, Clement DJ, Carnes Jr DL. Cyclic fatigue testing of nickel-titanium endodontic instruments. J Endod 1997;23(2):77-85.
[12]. Shim KS, Oh S, Kum K, Kim YC, Jee KK, Chang SW. Mechanical and metallurgical properties of various nickel-titanium rotary instruments. BioMed Res Int 2017; 2017:1-13.
[13]. Braga LC, Silva AC, Buono VT, de Azevedo Bahia MG. Impact of heat treatments on the fatigue resistance of different rotary nickel-titanium instruments. JEndod 2014;40(9):1494-7.
[14]. Ullmann CJ, Peters OA. Effect of cyclic fatigue on static fracture loads in ProTaper nickel-titanium rotary instruments. J Endod 2005;31(3):183-6.
[15]. Yao JH, Schwartz SA, Beeson TJ. Cyclic fatigue of three types of rotary nickel-titanium files in a dynamic model. J Endod 2006;32(1):55-7.
[16]. Peng C, Hui WU, Wang L, Xin HU, Deng S, Li C, Zhang L. Cyclic fatigue resistance of two nickel-titanium instruments in different curving angles: a comparative study. Braz oral res 2015;29(1):1-7
[17]. Plotino G, Grande NM, Testarelli L, Gambarini G, Castagnola R, Rossetti A, et al. Cyclic Fatigue of Reciproc and Reciproc Blue Nickel-titanium Reciprocating Files at Different Environmental Temperatures. J Endod 2018;44(10):1549-52.
[18]. Pedullà E, Grande NM, Plotino G, Gambarini G, Rapisarda E. Influence of continuous or reciprocating motion on cyclic fatigue resistance of 4 different nickel-titanium rotary instruments. J Endod 2013;39(2):258-61.
[19]. Silva EJ, Tinoco JM, Tinoco EM, Vieira VT, Sassone LM, Lopes HP. Bending resistance and cyclic fatigue life of a new single-file reciprocating instrument WaveOne Gold. EurEndod J 2016;1(1):4-4.
[20]. Wu H, Peng C, Bai Y, Hu X, Wang L, Li C. Shaping ability of ProTaper Universal, WaveOne and ProTaper Next in simulated L-shaped and S-shaped root canals. BMC Oral Health 2015;15(1):27.
[21]. Hartmann MS, Barletta FB, Fontanella VR, Vanni JR. Canal transportation after root canal instrumentation: a comparative study with computed tomography. J Endod 2007; 33(8):962-5.
[22]. Adigüzel M, Turgay B, Ong Tk, WesselinkPr, Crielaard W, Garcez As, et al. Comparison of the cyclic fatigue resistance of Reciproc and Reciproc Blue nickel-titanium instruments in artificial canals with single and double (S-shaped) curvatures. EurEndod J 2017;2(1):32-32.
[23]. Shen Y, Zhou HM, Zheng YF, Peng B, Haapasalo M. Current challenges and concepts of the thermomechanical treatment of nickel-titanium instruments. JEndod 2013;39(2):163-72.
[24]. Gao Y, Shotton V, Wilkinson K, Phillips G, Johnson WB. Effects of raw material and rotational speed on the cyclic fatigue of ProFile Vortex rotary instruments. J Endod 2010;36(7):1205-9.
[25]. Nguyen HH, Fong H, Paranjpe A, Flake NM, Johnson JD, Peters OA. Evaluation of the resistance to cyclic fatigue among ProTaper Next, ProTaper Universal, and Vortex Blue rotary instruments. J Endod 2014;40(8):1190-3.

Tables And Figures

Table 1: Descriptive statistics of NCF (number of cycles to failure) of three groups. (HCM-Hyflex CM, NEF- NeoEndo Flex, MPG-M3 ProGold, Std- standard)

CYCLIC FATIGUE FREQUENCY - DESCRIPTIVE STATISTICS						
Groups	Sample size	Mean	Std. Deviation	Std. Error	Minimum	Maximum
HCM	10	259.960	149.6777	47.3323	91.6	508.3
NEF	10	425.310	126.9103	40.1326	291.6	647.5
MPG	10	380.060	115.5564	36.5421	248.3	577.5

Table 2: A one-way analysis of variance (ANOVA) was calculated for NCF between the three groups. (*p Value Significant at the level <0.05)

ANALYSIS OF VARIANCE (ANOVA)					
	Sum of Squares	df	Mean Square	F	p VALUE
Between Groups	146040.650	2	73020.325	4.224	0.025*
Within Groups	466766.337	27	17287.642		
Total	612806.987	29			

Table 3: Post hoc comparisons using the Tukey HSD test among three comparison groups. (HCM-Hyflex CM, NEF- NeoEndo Flex, MPG-M3 ProGold, Std- standard)

Post hoc comparisons using the Tukey HSD test				
I	J	Mean Difference (I-J)	Std. Error	p VALUE
HCM	NEF	-165.3500*	58.8008	0.024*
HCM	MPG	-120.1000	58.8008	.121

MPG	NEF	-45.2500	58.8008	.725

Graph 1: Mean NCF of Hyflex CM, NeoEndoFlex& M3 Pro Gold