Scholars Journal of Dental Sciences (SJDS) **ISSN 2394-4951 (Print)**
Abbreviated Key Title: Sch. J. Dent. Sci. **ISSN 2394-496X (Online)**

A Unit of Scholars Academic and Scientific Society, India
www.saspublishers.com DOI:10.36347/sjds.2018.v05i06.001

Torsional Resistance and Cyclic Fatigue Life of a New Single-File Reciprocating Instrument Wave One Gold

Howaida Abdulmuniem[1*], Esraa Khalifah[2]
[1]Head Department of Restorative Dentistry, Faculty of Dentistry, International University of Africa, Khartoum, Sudan
[2]Department of Restorative Dentistry, Faculty of Dentistry, International University of Africa, Khartoum, Sudan

Original Research Article

***Corresponding author**
Howaida Abdulmuniem

Article History
Received: 02.05.2018
Accepted: 16.05.2018
Published: 30.06.2018

DOI:
10.36347/sjds.2018.v05i06.001

Abstract: The present study aimed to evaluate the bending resistance and cyclic fatigue fracture resistance of a new single-file reciprocating instrument called WaveOne Gold. WaveOne instruments were used as references for comparison. 28files, 25-mm NiTi instruments (WaveOne Primary and WaveOne Gold Primary) were tested. Flexibility was determined by applying 45° bending tests using a universal testing machine (n=10.(A custom-made device was used during cyclic fatigue test (n=10), comprising a stainless steel artificial canal measuring 1.4 mm in diameter, 19 mm in total length with an 86° angle and 6 mm radius of curvature.Statistical analysis was performed using one-way analysis of variance. Post hoc pair-wise comparisons were performed using Tukey's test for multiple comparisons ($P<0.05$). Waveone gold resulted in significantly higher torsional resistance when compared with the corresponding Waveone primary file system ($P<0.05$) Waveone resulted in significantly higher cyclic fatigue resistance when compared with the corresponding Waveone gold primary file system ($P<0.05$)**.**The cyclic fatigue resistance of Waveone file system was better than of the Waveone gold file system. On other hand the torsional resistance of Waveone gold better than of the Waveone files system.
Keywords: Bending resistance; cyclic fatigue; NiTi alloy; WaveOne Gold.

INTRODUCTION

NiTi alloy has special characteristics of superelasticity and shape memory. Superelasticity is the ability of the material to deform reversibly to very high strains of ~ 8% and recover the original pre-deformed shape spontaneously upon unloading.

External stresses convert the austenitic crystalline form of NiTi into a martensitic crystalline structure that can accommodate greater stress without increasing the strain. On release of the stress, the structure returns back to austenite, recovering its original shape in the process. Therefore superelasticity occurs in association with reversible phase transformation between austenite and martensite [1].

Despite the numerous advantages of nickel–titanium (NiTi) rotary instruments, these instrumentspresent a risk of fracture when used in curved canals, which could compromise the prognosis of root canal treatment [2]. Different alloys and variations in cross-sectional designs have been suggested to increase the resistance to fatigue fracture and flexibility of these instruments [3, 4].

Additionally, reciprocating motion kinematics has also been demonstrated to extend the lifespan of a NiTi instrument and its resistance to cyclic fatigue in comparison with continuous rotation movement [3, 5, 6]. In this kinematics, the instruments travel a shorter angular distance compared to in conventional rotary kinematics, which are subject to lower stress values, thus rendering an extended fatigue fracture resistance [5, 6]. The thermal treatment of NiTi alloys has been successfully used to improve the mechanical properties of endodontic instruments [7-9] conventional NiTi files are in the austenite phase during clinical use, whereas CM files are mainly in the martensite phase.This phenomenon is termed shape memory. A sequence of thermomechanical processing procedures has been developed with the objective of producing superelastic NiTi wires. That contains the considerably stable martensite phase under clinical conditions. Improvements in these areas of material management have led to the development of the next-generation endodontic instruments. M-Wire (Dentsply Tulsa Dental Specialties) was introduced in 2007 and is produced by applying a series of heat treatments to NiTi wires. Whilst conventional superelastic NiTi has an austenite structure, M-wire is a mixture of nearly equal amounts of R-phase and austenite [10, 11]. M-wire NiTi contains considerable amounts of martensite that does not undergo phase transformation resulting in a

metallurgical microstructure that exhibits alloy strengthening [10] WaveOne (Dentsply Maillefer, Baillagues, Switzerland) are the main commercially available single-file systems forroot canal preparation using reciprocating motion

Recently, a new reciprocating system was launched in the endodontic market, namely WaveOne Gold (Dentsply Maillefer). According to the manufacturer, WaveOne Gold offers the simplicity of the WaveOne system, but with additional advantages, specifically it is fabricated with NiTi and underwent repeated heat-treatment and cooling to improve the file's flexibility and strength, allowing a broader range of canal morphologies to be shaped more safely and efficiently. Moreover, the cross-section in WaveOne Gold has been improved from the triangular shape of its precursor to a parallelogram design that gives one or two cutting edges depending on the location along the file. According to the manufacturer, this new design minimizes the screwing effect and reduces the torque. However, up to now, no study has yet been done to evaluate the cyclic fatigue fracture resistance and the bending resistance of WaveOne Gold. Therefore, the aim of the present study was to evaluate and compare the cyclic fatigue fracture resistance and bending resistance of WaveOne Primary and WaveOne Gold Primary instruments. The null hypotheses tested were as follows:

- That there are no differences in the cyclic fatigue fracture resistance among the instruments;
- That there are no differences in the bending resistance among the instruments.

MATERIALS AND METHODS

A sample size of (28 files, 14 file for each group) NiTi instruments for use under reciprocationmovement [Reciproc (WaveOne (25/0.08) (Dentsply Maillefer) and WaveOne Gold (25/0.07) (Dentsply Maillefer, Ballaigues, Switzerland)] was tested. For reliability and standardization of the study, all the NiTi instruments were examined for defects and deformities under a dental operating microscope (Global Surgical, St. Louis, Missouri) for any signs of visible deformation.

Torsional resistance

The test was done by using an experimental design described by Park *et al*., [12] and Yum *et al*., [13]. Custom made metal block with a cubical hole (5 mm × 5 mm × 5 mm).

Five mm of the tip of each file was securely held in place by filling a thin layer of flowable composite (Filtek Z350XT; 3M ESPE, St. Paul, MN, USA)followed with increments of a hybrid resin composite (Filtek Z250XT; 3M ESPE, St. Paul, MN, USA) and cured with Curing Light (Welkang Ltd, London, UK) for 20 seconds. Uniform torsional stresses (300 rpm, 2.0 Ncm) were applied repetitively using an X-Smart plus Motor until the files submitted to torsional failure. This test was conducted until thetip of each specimen underwent an elastic displacement of 45°.The force values were acquired in the 45° position. (Figure.1). The time to failure was recorded in Seconds [14].

Cyclic Fatigue Resistance Test

Custom made cupper was used to test the cyclic fatigue resistance similar to that described by Gambarini [4] and Lee *et al*., [15]. The mold was constructed by using a wax duplication of K file size 70.The file was precurved using the method that introduced by Schneider. To determine the degree of file curvature a line was drew parallel to the long axis of the file and. a second line was drawn from tip of the file to intersect with the first line .The acute angle formed was the degree of file curvature (60°) [16]. Then, the file was heated and inserted in a wax block .When After the file was cooled the file was removed from the wax block keeping space with the same shape of the predetermined angled file. The wax duplicate was casted with a cupper to produce the final mold. Seven files from each system (n = 7). Each file was tested in the previously described artificial canal made of tempered Cupper. Using X-Smart Plus Motor (Dentsply Maillefer, Ballaigues, Switzerland), files were used in reciprocative mode. The artificial canal wall was flooded with synthetic oil (HAMA- Oil Spray; Topdental Ltd, UK) before each file insertion to reduce friction of file and artificial canal walls when it contacted [17]. The canals were covered with glass to avoid the files from slipping out the artificial canal [18]. The files were reciprocated until fracture occurred. The time to failure was recorded. Recording of time stopped as fracture detected visually and/or audibly. The number of cycles to failure (NCF) for each file calculated by multiplying the time (seconds) to failure by the rotational speed (Figure 1-6) [17].

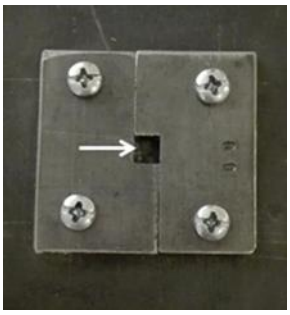

Fig-1: a custom made metal block with cubical hole

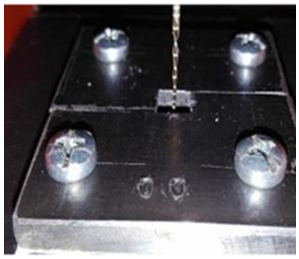

Fig-2: Fixing the file in the center of cubical hole

Fig3: Placing flowable composite in flutes of the file

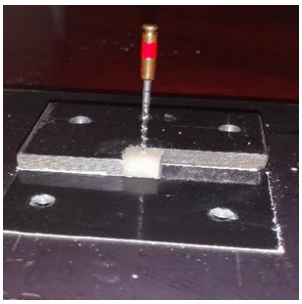

Fig-4: Side view of the file fixed in composite resin cube inside the custom made mold.

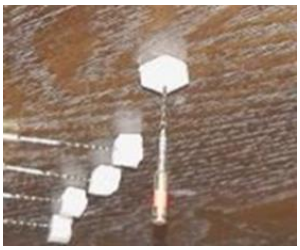

Fig-5: Composite cube after finishing with fixed file (attached)

Fig-6: Using X-Smart plus Motor (300 rpm, 2.0 Ncm) to rotate the file until failure occur

RESULTS

The data were analyzed by using independent samples test with the aid of the SPSS program in version 24 (Statistical Package for the Social Sciences, Chicago, USA). The normality of the data distribution and the homogeneity of variances were tested Levene's tests. The statistical significance level was established at $P < 0.05$.

The mean and standard deviations of the torsional for each system are presented in Table-1. Waveone gold resulted in significantly higher torsional resistance when compared with the corresponding Waveone primary file system.

Table-1: Mean time to Torsional Resistance Test of waveone and waveone gold systems.

Torsional Resistance Test	Mean ± SD (Time in Sec.)	P-value	Mean Difference	95% Confidence Interval of the Difference	
				Lower	Upper
WaveOne	1.09 ± 0.04	0.000*	-0.470	-0.554	-0.386
WaveOne gold	1.56 ± 0.08				

On the other hand Waveone resulted in significantly higher cyclic fatigue resistance when compared with the corresponding Waveone gold primary file system. The mean and standard deviations of the cyclic fatigue resistance for each system are presented in Table-2.

Table-2: Mean (NCF) to Cyclic fatigue Resistance Test of different types

Cyclic fatigue Resistance Test	Mean ± SD (NCF)	P-value	Mean Difference	95% Confidence Interval of the Difference	
				Lower	Upper
WaveOne	1051.8 ± 114.1	0.042*	169.4	3.6	335.2
WaveOne gold	882.4 ± 135.0				

Fig-7: WaveOne apical cross section, modified convex triangular

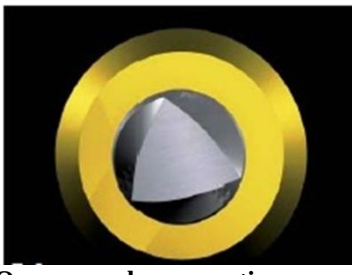

Fig-8: WaveOne coronal cross section, convex triangular

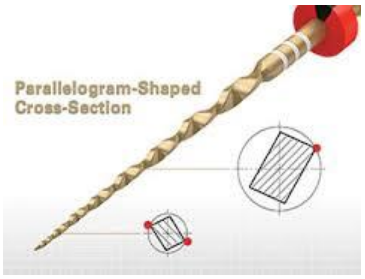

Fig-9: WaveOne gold cross section, parallelogram

DISCUSSION

Although shaping root canal with single file exposing the file to high level of stress therefore cyclic and torsional fatigues can happen [19]. It was suggested that the files, which fractured during clinical use, mainly fracture because of cyclic fatigue and\or torsional stress [8]. Manufacturers aim to improve the cyclic fatigue resistance and torsional stress of NiTi rotary files by changing its metallurgy, design, heat treatment, cross-sectional shape, helical angle, and dimensions [20]. The aim of present study was to compare the torsional stress of WaveOne Gold with WaveOne systems, in addition to their cyclic fatigue resistances. Many important factors can influence laboratory studies on comparing the cyclic and torsional fatigue resistance of files which are material characteristics and designs that might have effect on the results [21]. Yao *et al*., have reported that the disadvantage of using the extracted teeth is the difficulty for replicating the clinical conditions of ensuring the standardization that may affect the results [22]. For this reason, standard artificial canals made of cupper were laboring in the present study. According to the results of the present study, WaveOne Gold endodontic file was found to be statistically significantly more resistant to torsional stress than WaveOne file. While as this result was vice versa when compared to their cyclic fatigue. For this reason, the null hypothesis of the present study was rejected, since WaveOne file was significantly better than WaveOne Gold in relation to cyclic fatigue (Table-1 & 2). WaveOne Gold has been introduced by the manufacturer company as an update to WaveOne (WO, Dentsply Maillefer) file. The reciprocation movement of the file was maintained, while the cross section, dimensions, and geometry were different. The cross section of the file was changed to the parallelogram design containing 2 cutting edges while Waveone files have a modified convex triangular crosssectional design. The Waveone gold files are manufactured with the heat-treatment procedure for gold alloy. On the contrary to M-Wire technology, the heat-treatment for gold alloy uses the method of heating and then slowly cooling the file. Some previous studies decided that the cross section had effect on the cyclic fatigue resistance [23, 24]. It is possible that the design and cross-sectional and taper difference between file systems, might result in increased cyclic fatigue resistance of Waveone files (Figure 7-9) [25].

There are number of studies investigating the cyclic fatigue resistance of Waveone gold files in the literature [26-30, 20]. According to the results of the present study, the fatigue life of Waveone gold was found to be shorter than waveone, On the contrary with these results [26], have determined the cyclic fatigue resistance of the WaveOne Gold Primary single-file system was higher than the WaveOne Primary single-file instruments [26, 20]. This me be due to diffierence in the material and diameter of artificial canal.

There was no study that compares the torsional resistance of Waveone and waveone gold systems in the literature. For this reason, the results of the present study cannot be directly compared to those of other studies.

CONCLUSION

Within limitation of this study the cyclic fatigue resistance of Waveone file system was better than of the Waveone gold file system. On other hand the torsional resistance of Waveone gold better than of the Waveone files system.

REFERENCES

1. Shen Y, Zhou HM, Zheng YF, Peng B, Haapasalo M. Current challenges and concepts of the thermomechanical treatment of nickel-titanium instruments. Journal of endodontics. 2013 Feb 1;39(2):163-72.
2. Ankrum MT, Hartwell GR, Truitt JE. K3 Endo, ProTaper, and ProFile systems: breakage and distortion in severely curved roots of molars. Journal of endodontics. 2004 Apr 1;30(4):234-7.
3. Plotino G, Grande NM, Testarelli L, Gambarini G. Cyclic fatigue of Reciproc and WaveOne reciprocating instruments. International endodontic journal. 2012 Jul 1;45(7):614-8.
4. Gambarini G, Rubini AG, Al Sudani D, Gergi R, Culla A, De Angelis F, Di Carlo S, Pompa G, Osta N, Testarelli L. Influence of different angles of reciprocation on the cyclic fatigue of nickel-titanium endodontic instruments. Journal of endodontics. 2012 Oct 1;38(10):1408-11.

5. De-Deus G, Moreira EJ, Lopes HP, Elias CN. Extended cyclic fatigue life of F2 ProTaper instruments used in reciprocating movement. International Endodontic Journal. 2010 Dec 1;43(12):1063-8.
6. Kiefner P, Ban M, De-Deus G. Is the reciprocating movement per se able to improve the cyclic fatigue resistance of instruments?. International endodontic journal. 2014 May 1;47(5):430-6.
7. Bardsley S, Peters CI, Peters OA. The effect of three rotational speed settings on torque and apical force with vortex rotary instruments in vitro. Journal of endodontics. 2011 Jun 1;37(6):860-4.
8. Gao Y, Gutmann JL, Wilkinson K, Maxwell R, Ammon D. Evaluation of the impact of raw materials on the fatigue and mechanical properties of ProFile Vortex rotary instruments. Journal of endodontics. 2012 Mar 1;38(3):398-401.
9. Shen Y, Coil JM, Zhou HM, Tam E, Zheng YF, Haapasalo M. ProFile Vortex instruments after clinical use: a metallurgical properties study. Journal of endodontics. 2012 Dec 1;38(12):1613-7.
10. Alapati SB, Brantley WA, Iijima M, Clark WA, Kovarik L, Buie C, Liu J, Johnson WB. Metallurgical characterization of a new nickel-titanium wire for rotary endodontic instruments. Journal of Endodontics. 2009 Nov 1;35(11):1589-93.
11. 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. International endodontic journal. 2012 Feb 1;45(2):113-28.
12. Ma LJ, Van Der Does HC, Borkovich KA, Coleman JJ, Daboussi MJ, Di Pietro A, Dufresne M, Freitag M, Grabherr M, Henrissat B, Houterman PM. Comparative genomics reveals mobile pathogenicity chromosomes in Fusarium. Nature. 2010 Mar;464(7287):367.
13. Yum S, An TK, Wang X, Lee W, Uddin MA, Kim YJ, Nguyen TL, Xu S, Hwang S, Park CE, Woo HY. Benzotriazole-containing planar conjugated polymers with noncovalent conformational locks for thermally stable and efficient polymer field-effect transistors. Chemistry of Materials. 2011 Mar 3;26(6):2147-54.
14. Varghese NO, Pillai R, Sujathen UN, Sainudeen S, Antony A, Paul S. Resistance to torsional failure and cyclic fatigue resistance of ProTaper Next, WaveOne, and Mtwo files in continuous and reciprocating motion: An in vitro study. Journal of conservative dentistry: JCD. 2016 May;19(3):225.
15. Lee MH, Versluis A, Kim BM, Lee CJ, Hur B, Kim HC. Correlation between experimental cyclic fatigue resistance and numerical stress analysis for nickel-titanium rotary files. Journal of endodontics. 2011 Aug 1;37(8):1152-7.
16. Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology. 1971 Aug 1;32(2):271-5.
17. 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. Journal of Endodontics. 2013 Feb 1;39(2):258-61.
18. Plotino G, Grande NM, Sorci E, Malagnino VA, Somma F. A comparison of cyclic fatigue between used and new Mtwo Ni–Ti rotary instruments. International Endodontic Journal. 2006 Sep 1;39(9):716-23.
19. Yared G. Canal preparation using only one Ni-Ti rotary instrument: preliminary observations. International endodontic journal. 2008 Apr 1;41(4):339-44.
20. Adıgüzel M, Capar ID. Comparison of cyclic fatigue resistance of WaveOne and WaveOne Gold small, primary, and large instruments. Journal of endodontics. 2017 Apr 1;43(4):623-7.
21. Cheung GS, Zhang EW, Zheng YF. A numerical method for predicting the bending fatigue life of NiTi and stainless steel root canal instruments. International endodontic journal. 2011 Apr 1;44(4):357-61.
22. Yao JH, Schwartz SA, Beeson TJ. Cyclic fatigue of three types of rotary nickel-titanium files in a dynamic model. Journal of endodontics. 2006 Jan 1;32(1):55-7.
23. Grande NM, Plotino G, Pecci R, Bedini R, Malagnino VA, Somma F. Cyclic fatigue resistance and three-dimensional analysis of instruments from two nickel–titanium rotary systems. International Endodontic Journal. 2006 Oct 1;39(10):755-63.
24. Ray JJ, Kirkpatrick TC, Rutledge RE. Cyclic fatigue of EndoSequence and K3 rotary files in a dynamic model. Journal of endodontics. 2007 Dec 1;33(12):1469-72.
25. Capar ID, Ertas H, Arslan H. Comparison of cyclic fatigue resistance of nickel-titanium coronal flaring instruments. Journal of endodontics. 2014 Aug 1;40(8):1182-5.

26. Özyürek, T. (2016). Cyclic fatigue resistance of Reciproc, WaveOne, and WaveOne Gold nickel-titanium instruments. *Journal of endodontics*, *42*(10), 1536-1539.
27. Elnaghy AM, Elsaka SE. Effect of sodium hypochlorite and saline on cyclic fatigue resistance of WaveOne Gold and Reciproc reciprocating instruments. International endodontic journal. 2017 Oct 1;50(10):991-8.
28. Yılmaz K, Özyürek T. Cyclic fatigue life of Tango-Endo, WaveOne GOLD, and Reciproc NiTi instruments. Restorative dentistry & endodontics. 2017 May 1;42(2):134-9.
29. Topçuoğlu HS, Düzgün S, Aktı A, Topçuoğlu G. Laboratory comparison of cyclic fatigue resistance of WaveOne Gold, Reciproc and WaveOne files in canals with a double curvature. International endodontic journal. 2017 Jul 1;50(7):713-7.
30. Keskin C, Inan U, Demiral M, Keleş A. Cyclic Fatigue Resistance of Reciproc Blue, Reciproc, and WaveOne Gold Reciprocating Instruments. Journal of endodontics. 2017 Aug 1;43(8):1360-3.