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Comparison of canal transportation and centering ability of wave one and hyflex CM rotary endodontic system by using computed tomography an *in-vitro* study

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Abstract
Introduction: The purpose of this study was to evaluate and compare the canal transportation and centering ability of 'WaveOne' (WO) and 'HyFlex-CM' in moderately curved mesiobucal canals of mandibular first molars.
Methods: Forty extracted teeth with moderately curved mesiobuccal canals were selected for the study. Conventional access was performed and the samples were divided into two experimental groups of 20 teeth each. Group A and group B were prepared by using WaveOne and HyFlex CM respectively. Canal transportation and canal centering ability at coronal, middle and apical third were assessed using computed tomography (CT).The two groups were statistically analysed using One way analysis of variance (ANOVA) technique adjusted for multiple comparisons using Tukey's method in each group, followed by unpaired t test to evaluate inter-group comparison. The significance was set at $P<0.05$.
Results: Less canal transportation and better centering ability occurred with the Hyflex CM file system ($P>0.05$). The WaveOne file system remained centered but showed significant canal transportation in the coronal and middle third of the canal ($P<0.05$). In the inter-group comparison Hyflex CM group caused significantly less canal transportation at the middle third and superior canal centering ability at the middle and apical thirds ($P>0.05$).
Conclusion: The 'HyFlex-CM' rotary system demonstrated the best results for all the variables measured in this study.

Keywords: Wave one, Hyflesx CM, controlled memory wire, computed tomography, canal transportation, canal centering ability, M-wire

Introduction
Effective cleaning and shaping of the root canal without altering its original shape is essential to the clinical success of root canal therapy [1-2]. Weine observed that the original canal shape can change drastically in curved canals at the end of cleaning and shaping procedures [3].
Canal transportation is defined as "the removal of canal wall structure on the outside curve in the apical half of the canal due to the tendency of files to restore themselves to their original linear shape during canal preparation" [4]. Centering ability is the ability of the instrument to stay centered in the canal [5].
Deviation from the original canal axis can lead to inappropriate dentin removal, straightening of the canal, a biomechanical defect known as elbow and over shaping of the canal resulting in fracture of the tooth [6-8].
Ni-Ti rotary instruments have substantially reduced the incidence of procedural errors such as canal transportation [9]. However deviation from the original canal shape may be more pronounced in some systems than in others [10-12]. Two innovative NiTi systems were recently introduced, namely waveone ('Wave One' Dentsply Maillefer, Ballaigues, Switzerland) and Hyflex CM (Coltene-Whaledent, Allstetten, Switzerland). WaveOne files are reciprocating files, made of a special NiTi alloy called M-wire, created by an innovative thermal-treatment process [13]. M-wire NiTi instruments possess increased flexibility and improved resistance to cyclic fatigue [14]. This works on the principle of Roane's balanced Force technique [15].
'Hyflex CM' is a NiTi instrument made using the new "controlled memory" technology. Controlled memory wire (CM wire) is manufactured by a unique process that controls the

material's memory, making the files extremely flexible, but without the shape memory that is typical of other NiTi files [16].

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No studies have been published, to date, on comparison between WaveOne and HyFlex CM rotary endodontic systems on canal transportation and centering ability.

Computed tomography (CT), a non-invasive technology allows accurate comparison of endodontic instrumentation at different levels in the root canal [17].

In this *in-vitro* study, root canal transportation and centering ability were determined between 'WaveOne' and 'HyFlex CM' rotary endodontic instruments by using Computed Tomography.

Method: Extracted human mandibular first molars were collected and stored in 10% buffered formalin solution. A conventional access cavity was prepared in each tooth and a glide path was established with a size 10 K-file (Dentsply, Maillefer) in the mesiobucal canal. Periapical radiographs were taken with the same instrument in the canal. Pruett's method was employed to determine the angle and radius of canal curvature [18] (Fig 1).

Forty of these teeth with an intermediate radius of curvature between 4-8mm were selected for the study. Working length was determined by measuring the end of a size 10 K-file (Dentsply, Maillefer) placed inside the canal until it was visible at the apical foramen, and subtracting 0.5mm from the measured length. For more uniform samples, the crowns were flattened with diamond coated steel disks, and a final WL of 18mm was achieved for each tooth. All roots were embedded in Clear Acrylic (DPI cold cure).

Teeth were divided into two experimental groups consisting of 20 teeth each. All teeth were scanned by Computed Tomography (CT) to determine the root canal shape before instrumentation. 1mm thick slices at 3mm, 9mm and 15mm were selected from the apex to the canal orifice, representing the apical, middle and coronal third. This was archived onto a magnetic optical disk. Group-A samples were prepared by using WO instruments according to the manufacturer's recommendations. If a size 10 K-file was very resistant to movement, WO small file (S; 0.06/20) was used till the WL. If a 10k-file moved to length easily or was very loose, WO primary file (P; 0.08/25) was used till the WL.

Group B samples were prepared by using the HyFlex CM (Coltene whaledent) system according to the manufacturer's recommendations. The sequence of instruments used were as follows: Starting with an orifice shaper 0.08/25, files 0.04/20, 0.04/25, 0.06/20, 0.04/30 were used sequentially. Each instrument was changed after 4 canals.

For both groups RC-Prep (Premier Dental Products, Plymouth Meeting, PA) was used as a lubricant during instrumentation. After the use of each file, canals were irrigated with 3ml of a 5.25% NaOCl solution. 1ml of 17% EDTA was used for 1 minute as a final flush. The post instrumentation scan was taken under the same criteria as the initial scans taking three sections into consideration. The data was stored on a magnetic optical disk.

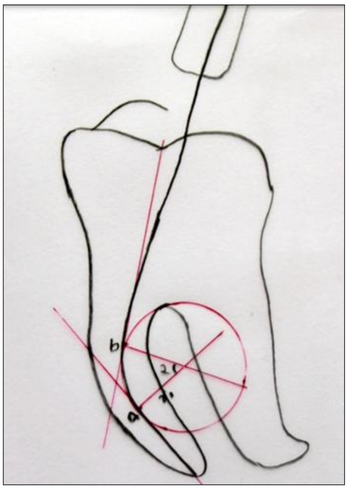

Fig 1: Determination of the angle and radius of curvature of the root canal. Method of John Pruett *et al*. points represents the start (point b) and the end(point a) of the canal curvature. The curved part of the canal is represented by a circle with tangents at points *a* and *b*. The length of these lines is the radius of the circle and defines the radius of the curvature of the canal (16).

Evaluation of canal transportation

The amount of canal transportation was determined by measuring the shortest distance from the edge of the uninstrumented canal to the periphery of the root (mesial and distal) in the initial scan. This was then compared with the measurements obtained from the instrumented images.

As shown in (Fig 2) a_1 represents the shortest distance from the outside of the curved root to the periphery of the uninstrumented canal; b_1 represents the shortest distance from the inside of the curved root to the periphery of the uninstrumented canal; a_2 represents the shortest distance from the outside of the curved root to the periphery of the instrumented canal; b_2 represents the shortest distance from the inside of the curved root to the periphery of the instrumented canal [19].

The formula used for the calculation of canal transportation was: $(a_1 - a_2) - (b_1 - b_2)$ According to this formula, a result other than zero (0) indicates that transportation has occurred in the canal.

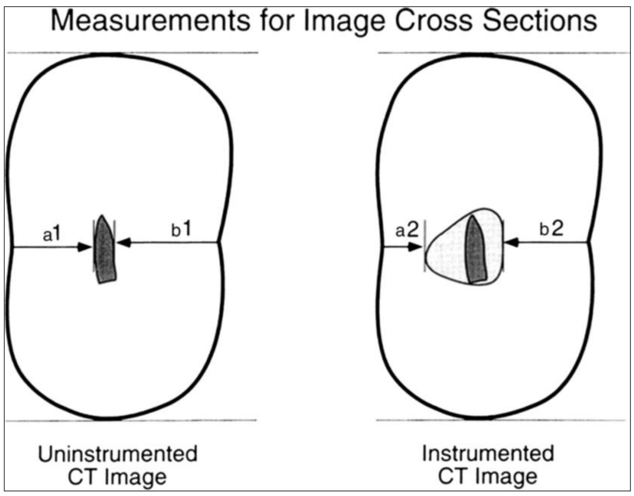

Fig 2: Representation drawing of tooth sections showing how transportation and centering ratios were derived. Uninstrumented image (left): original canal space represented by dark shaded area. Instrumented image (right): light shaded area represents canal's shape after instrumentation.

Evaluation of centering ability: Centering ability was calculated for each section by using the following ratio: $(a_1 - a_2)/(b_1 - b_2)$ or $(b_1 - b_2)/(a_1 - a_2)$. According to this formula, a result of one (1) indicates perfect centering.

Statistical Analysis: The results were evaluated statistically by using one-way analysis of variance followed by the post hoc Tukey honestly significant difference (HSD) test to explore canal transportation and canal centering ability in each group. The unpaired t test was applied for the inter-group comparison. A P value less than 0.05 was considered significant.

Results

Mean Values for Canal Transportation (mm) and the Canal Centering Ratio for the Tested Groups by using ANOVA are shown in Table 1. Comparing the mean values of transportation (mm) among the tested levels in each group, the WaveOne group recorded significant transportation at the coronal and middle level of the canal, while transportation at the apical third was statistically insignificant. The Hyflex CM group showed statistically insignificant difference in the mean of transportation (*P*>0.05). The results also revealed no significant difference in the pre and post instrumentation difference ratio of canal centering in each group when evaluated separately.

Table 2 represents the inter-group comparison at Coronal, Middle and Apical area with respect to Mean Values for canal transportation and canal centering ratio. Wave One recorded significantly higher mean of canal transportation in the middle third of the canal (*P*<0.05) than compared to Hyflex CM (Fig 3). Hy Flex CM files were shown significantly better canal centering ability than Wave One at the middle and apical thirds (*P*>0.05).

Table 1: Statistical Analysis of the Mean Values for Canal Transportation (mm) and the Canal Centering Ratio for the Tested Groups

	N	Level	Mean ±standard deviation	P value
Canal transportation				
Wave One	20	Coronal	0.035±0.05	0.003[a]
	20	Coronal	1.35±0.49	
	20	Coronal	1.1±0.380.	
	20	Middle	14±0.15	
Hyflex CM	20	Apical	0.06±0.07	0.398[b]
	20	Coronal	0.035±0.06	
	20	Middle	0.05±0.07	
	20	Apical	0.025±0.04	
Canal centering ratio				
WaveOne	20	Middle	1.76±0.72	0.132[b]
	20	Apical	1.6±0.68	
Hyflex CM	20	Middle	1.3±0.64	0.427[b]
	20	Apical	1.2±0.38	

A *P*<0.05 was considered significant. Different superscript letters indicate statistical significant differences.

Table 2: Comparison of two groups (WaveOne and Hyflex CM) at Coronal, Middle and Apical area with respect to Mean Values for canal transportation and canal centering ratio by unpaired t-test

	Groups	Mean ±standard deviation	t-value	P value
Canal transportation				
Coronal	WaveOne	0.035±0.05	0.00	1[d]
	Hyflex CM	0.035±0.06		
Middle	WaveOne	0.14±0.15	2.48	0.019[a]
	Hyflex CM	0.05±0.07		
Apical	WaveOne	0.06±0.07	1.97	0.063[d]
	Hyflex CM	0.025±0.04		
Canal centering ratio				
Coronal	WaveOne	1.4±0.49	1.8	0.08[d]
	Hyflex CM	1.1±0.38		
Middle	WaveOne	1.8±0.72	2.14	0.0.4[b]
	Hyflex CM	1.3±0.64		
Apical	WaveOne	1.6±0.68	2.3	0.03[c]
	Hyflex CM	1.2±0.38		

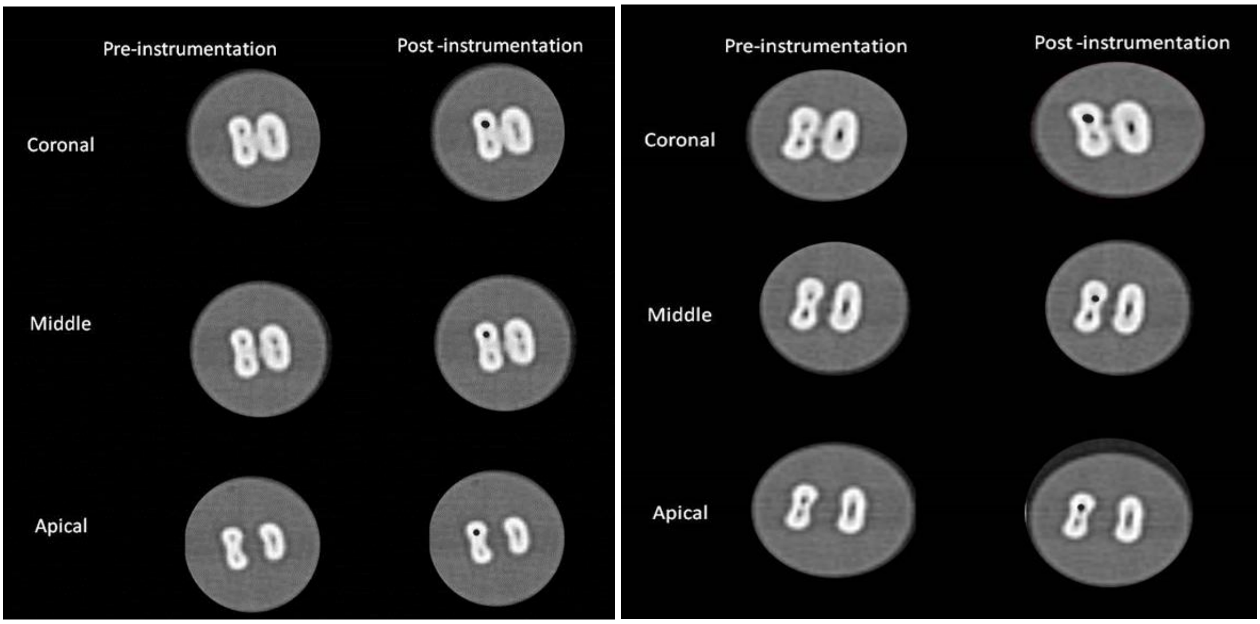

Fig 3: CT scan images before and after instrumentation with Hyflex CM (left) and WaveOne (right).

Discussion

A new generation of NiTi endodontic instruments has evolved to potentially allow shaping of narrow curved root canals without causing aberrations, by virtue of their increased flexibility and shape memory [20]. Patterns of motions such as rotational and reciprocating have been advocated to shape the canal. The present study aimed to compare the shaping ability of two recently developed rotary file systems: Wave One and Hyflex CM. Mesiobuccal canals of moderately curved mandibular first molars were standardized to radii ranging from 4mm to 8mm and root canal curvatures ranging from 25° to 30° as suggested by Pruett *et al.* [18] Pruett's method overcomes the limitations of other methods such as Schneider and Weine techniques by measuring both angle and radius of curvature. The methodology used in this study to evaluate the canal transportation and centering ability of the two rotary systems was modeled on the studies conducted by Richard Gergi *et al.* [19] and Gambill *et al.* [5]. Computed tomography, is a non-destructive technology, advocated for pre and post instrumentation evaluation of canal. It can render highly accurate and quantifiable cross-sectional (cut plane) and 3D images [21, 22].

In the present study, after instrumentation, WaveOne caused significant transportation at the coronal and middle level of the canal. However, transportation at the apical third was statistically insignificant. On comparing Hyflex CM and WaveOne, WaveOne showed significantly higher canal transportation in the middle third of the canal. The non-cutting tip design, acts as a guide to allow easy penetration [23] and the modified convex triangular cross section with radial land, in the apical part of the file, distributes pressure evenly, allowing more uniform circumferential cutting at the apical third of the canal [24]. This change to a neutral rake angle, with a sharper triangular cross section in the middle part of the file leading to more uneven cutting and greater canal transportation at the middle third [13]. Marzouk and Ghoneim *et al.* stated multiple tapers along the cutting length of waveOne file could be the reason for increased canal transportation when compared to continuous rotation motion [25]. Testarelli *et al.* contradicted this, claiming that the thermo mechanical procedure used for the manufacture of single reciprocating files, makes these instruments more flexible and Superelastic leading, in fact, to less aberrations throughout the canal [26].

The results of pre and post instrumentation difference ratio of canal centering, in the present study were insignificant in both the groups, when each group was evaluated separately. The WaveOne file has a reverse helical design and a counterclockwise engaging angle that is five times the clockwise disengaging angle. Berutti claimed that this enhances canal centering ability leading to less invasive root canal preparation throughout the canal [27]. Burklein *et al.* compared the shaping ability of a reciprocating file system with other rotary instruments and concluded that all instruments maintained canal curvature well [13] Elio Berutti *et al.* concluded that the WaveOne file respected original canal curvature compared with the ProTaper system [27].

Hyflex CM files showed insignificant post instrumentation difference in canal transportation and canal centering ability. Hyflex CM files maintained original canal anatomy uniformly throughout the canal. On comparing Hyflex CM and WaveOne, HyFlex CM caused significantly less canal transportation in the middle third than WaveOne. It has been proved that the multiple-file continuous rotary system resulted in significantly lower canal transportation when compared to single reciprocating files [25]. HyFlex CM files are manufactured with a unique thermo mechanical process that controls the material's memory, making the files extremely flexible [28]. This increases the ability of the file to follow the anatomy of the canal very closely and reduces the risk of transportation, ledges and perforation [29].

Hyflex CM files demonstrated centering ability superior to that of the WaveOne file system. Zhao *et al.* showed Controlled Memory files (Hyflex CM files) resulted in adequate canal shape throughout the length of the canal with no major shaping errors [16]. Testarelli L *et al.* reasoned that this could be because controlled memory files (Hyflex CM files) were bendable and more flexible than conventional superelastic NiTi files [26]. The alloy is more ductile, thus keeping the instrument centered in the canal [30]. In addition, the critical stress for martensite reorientation of CM wires is in the range of 128-251Mpa at room temperature and the ultimate tensile strength CM wires is about 1094Mpa. These indicate superior flexibility of CM wire compared to conventional NiTi wire [28].

In contrast to the results of the present study, Franco V *et al.* found that reciprocating files were more centered than continuous motion files [31].

Within the parameters of this study, it can be concluded that the 'HyFlex-CM' rotary system demonstrated the best results for all the variables measured in this study. HyFlex CM showed superior canal centering ability and performed better than the WaveOne file system in the middle third, with regard to canal transportation. However, in the apical third of the canal both the file system performed equally well.

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The authors deny any conflicts of interest related to this study.

References

1. Schilder H. Cleaning and shaping the root canal. Dent Clin North Am. 1974; 18:269-96
2. Weine F, Kelly R, Lio P. The effect of preparation procedures on the original canal shape and on apical foramen shape. J Endod. 1975; 1:255-62.
3. Weine book
4. American Association of Endodontics Glossary of Endodontics Terms. 7th ed. Chicago:AAE, 2003.
5. Gambill JM, Alder M, del Rio CE. Comparison of nickel-titanium and stainless steel hand-file instrumentation using computed tomography. J Endod. 1996; 22(7):369-75.
6. Endodontics Ingle, Elsevier BC.5th ed2002, 775.
7. Gutmann JL. Problem solving in endodontics.3rd ed. Mosby Inc, 1997, 96.
8. Gutmann JL. Problem solving in endodontics.3rd ed. Mosby Inc, 1997, 105.
9. Cohen10th edn
10. Thompson SA, Dummer PM. Shaping ability of Quantec Series rotary nickel-titanium instruments in simulated root canals: Part 2. Int Endod J. 1998-2000; 31(4):268-74.
11. Bergmans L, Van Cleynenbreugel J, Wevers M, Lambrechts P. Mechanical root canal preparation with NiTi rotary instruments: rationale, performance and safety. Status report for the American Journal of Dentistry. Am J Dent. 2001; 14(5):324-33.
12. Hülsmann M, Herbst U, Schäfers F. Comparative study of root-canal preparation using Lightspeed and Quantec SC rotary NiTi instruments. Int Endod J. 2003; 36(11):748-56.
13. Burklein S, Hinschitza1 K, Dammaschke T, Schafer E. Shaping ability and cleaning effectiveness of two single-file systems in severely curved root canals of extracted teeth: Reciproc and WaveOne versus Mtwo and ProTaper. Int Endod J. 2012; 45(5):449-61.
14. Alapati SB, Brantley WA, Iijima M, Clark WA, Kovarik L, Buie C, Liu J, Ben Johnson W. Metallurgical characterization of a new nickel-titanium wire for rotary endodontic instruments. J Endod. 2009; 35(11):1589-93.

15. Roane JB, Sabala CL, Duncanson MG. The balanced force concept for instrumentation of curved canals. J Endod. 1985; 11(5):203-11.
16. Zhao D, Shen Y, Peng B, Haapasalo M. Micro-computed tomography evaluation of the preparation of mesiobuccal root canals in maxillary first molars with Hyflex CM, Twisted Files, and K3 instruments. J Endod. 2013; 39(3):385-8.
17. Maitin N, Arunagiri D, Brave D, Maitin SN, Kaushik S, Roy S. An ex vivo comparative analysis on shaping ability of four NiTi rotary endodontic instruments using spiral computed tomography. J Conserv Dent. 2013; 16(3):219-23.
18. Pruett JP, Clement DJ, Carnes DL Jr. Cyclic fatigue testing of nickeltitanium endodontic instruments. J Endodon. 1997; 23:77-85.
19. Gergi R, Rjeily JA, Sader J, Naaman A. Comparison of Canal Transportation and Centering Ability of Twisted files, Pathfile-Protaper system, and Stainless steel Hand K-files by using Computed Tomography. J Endod. 2010; 36:904-907.
20. Thompson SA, Dummer PM. Shaping ability of Hero 642 rotary nickel-titanium instruments in simulated root canals: Part 1. Int Endod J. 2000; 33(3):248-54.
21. Nielsen RB, Alyassin AM, Peters DD, Carnes DL, Lancaster J. Microcomputed tomography: an advanced system for detailed endodontic research. J Endod. 1995; 21(11):561-8.
22. Rhodes JS, Ford TR, Lynch JA, Liepins PJ, Curtis RV. Micro-computed tomography: a new tool for experimental endodontology. Int Endod J. 1999; 32(3):165-70.
23. Saber Sel D, Abu El Sadat SM. Effect of altering the reciprocation range on the fatigue life and the shaping ability of WaveOne nickel-titanium instruments. J Endod. 2013; 39(5):685-8.
24. Mcspadden JT. Mastering endodontics instruments. chattanooga, tn: cloudland institute, 2007.
25. Marzouk AM, Ghoneim AG. Computed tomographic evaluation of canal shape instrumented by different kinematics rotary nickel-titanium systems. J Endod. 2013; 39(7):906-9.
26. Testarelli L, Plotino G, Al-Sudani D, Vincenzi V, Giansiracusa A, Grande NM, *et al.*. Bending properties of a new nickel-titanium alloy with a lower percent by weight of nickel. J Endod. 2011; 37(9):1293-5.
27. Berutti E, Chiandussi G, Paolino DS, Scotti N, Cantatore G, Castellucci A, *et al.*. Canal shaping with WaveOne Primary reciprocating files and ProTaper system: a comparative study. J Endod. 2012; 38(4):505-9.
28. Shen Y, Zhou HM, Zheng YF, Peng B, Haapasalo M. Current challenges and concepts of the thermomechanical treatment of nickel-titanium instruments. J Endod. 2013; 39(2):163-72.
29. Kumar SB, Pattanshetty S, Prasad P, Soni S, Pattanshetty K, Prasad S. An *in-vitro* evaluation of canal transportation and centering ability of two rotary Nickel Titanium systems (Twisted Files and Hyflex files) with conventional stainless steel hand K-flexofiles by using Spiral Computed Tomography. Journal of International Oral Health. 2013; 5(5):107-14.
30. Pongione G, Giansircusa A, Lisotti F, Milana V, Testarelli L. Mechanical properties of endodontic instruments made with different nickel titanium alloys: a stiffness test. Endo (Lond Engl). 2012; 6(1):41-44.
31. Franco V, Fabiani C, Taschieri S, Malentacca A, Bortolin M, Del Fabbro M. Investigation on the shaping ability of nickel-titanium files when used with a reciprocating motion. J Endod. 2011; 37(10):1398-401.