Available online at **www.ijmrhs.com**

ISSN No: 2319-5886

International Journal of Medical Research & Health Sciences, 2018, 7(2): 69-74

In-vitro Assessing the Shaping Ability of Three Nickel-Titanium Rotary Single File Systems by Cone Beam Computed Tomography

Ali Imad Al-Asadi[1]* and Raghad Al-Hashimi[2]

[1] *Master Student, Department of Restorative and Esthetic Dentistry, College of Dentistry, University of Baghdad, Iraq*

[2] *Assistant Professor, Department of Restorative and Esthetic Dentistry, College of Dentistry, University of Baghdad, Iraq*

**Corresponding e-mail:* draliemad88@gmail.com

ABSTRACT

Aim of the study was to evaluate the canal transportation and centering ability of three nickel-titanium single file rotary systems by cone beam computed tomography (CBCT). ***Materials and methods:*** *Thirty permanent maxillary first molar with a range of mesiobuccal canals curvature from 20-30 degree were selected and assigned into three groups (n=10), according to the biomechanical preparation system used: Hyflex EDM (HF), Reciproc blue (RB) and OneShape (OS). The sampled were scanned by CBCT after being mounted on customized acrylic base and then rescanned after the instrumentation. Slices from the axial section were taken from both exposures at 3 mm, 6 mm and 9 mm from the root apex corresponding to the apical, middle, and coronal third respectively. Data were statistically analyzed using Kurskal-Wallis and Mann-Whitney U tests at the 5% confidence level.* ***Results:*** *The results showed that there were no significant differences at the apical and coronal third and a significant difference at the middle third regarding canal transportation. However, there was a significant difference at the apical third and no significant difference at the middle and coronal third regarding centering ratio.* ***Conclusion:*** *It was concluded that the three single rotary systems reported a degree in canal transportation and centric ratio but the Hyflex EDM reported the least one.*

Keywords: CBCT, Shaping ability, Canal transportation, Centering ability, Single file systems

INTRODUCTION

The endodontic treatment pass through three steps which include diagnosis, shaping and obturation phase to achieve the goal of symptoms free tooth and thus preserving it [1,2]. The shaping phase holds an important role as it may influence the success of the following phase, which may affect the whole prognosis of the endodontic treatment. Schilder [3] reported that root canal preparation should present a flare form starting apically to coronal portion, with no deformation of the apical foramen and no alteration of the original canal shape, however, achieving this goal in curved and narrow canal may go through different difficulties with a tendency of alteration the original canal shape [4-6].

The incorporation of nickel-titanium (Ni-Ti) rotary files has drastically enhanced the quality of canal shaping [7]. Recently proposed single-file shaping technique simplifies the instrumentation protocol while reducing the risk of instrument failure and cross contamination [8]. The two different concepts of single-file systems are continuous rotation and reciprocation [4].

HyFlex EDM (HF); (Coltene/Whaledent AG, Altst€atten, Switzerland) is manufactured using the technique of electrical discharge machining [9]. This manufacturing process uses spark erosion to stiffen the surface of the Ni-Ti file, giving rise to increase fracture resistance and superior cutting efficiency. HF Ni-Ti files are manufactured using Controlled Memory alloy technology like the HyFlex CM (Coltene/Whaledent AG) NiTi files. HF has the taper alternating throughout the file shaft and a 0.25-mm apical diameter. The kinematic movement of Hyflex EDM is based on full rotation concept. along the file shaft, HF utilize 3 different cross sections: quadratic in the apical third, trapezoidal in the middle third, and almost triangular in the coronal third [10,11].

Reciproc Blue (RB) manufactured by (VDW, Munich, Germany) is innovated by special heat treatment that changes the molecular structure of the alloy gaining the instrument a blue color. This heat treatment helps to increase both flexibility and cyclic fatigue resistance with less surface micro-hardness values compared with its predecessor [12,13].

One Shape (OS) is a new concept of single file instrumentation where a single instrument is used in a full clockwise rotation. The One Shape system has a tip size of (25, 30, 37) and a constant taper of 0.06, and is characterized by different cross-sectional designs over the entire length of the working part. At the apical part, there are three symmetrical cutting edges. In the middle the number decreases to two cutting edges; this part is asymmetrical. In the coronal part there are two S shaped cutting edges [14].

Considering the clinical advantages of biomechanical preparation with rotary systems, it is necessary to investigate the shaping effectiveness of Ni-Ti file systems and understand how the respective design features impact performance. Different methods can be used to evaluate the root canal shaping, though more recently, the use of cone beam computed tomography (CBCT) has been suggested for this purpose because it is a nondestructive and very precise method that even allows measuring the amount of root dentin removed by endodontic instruments [15].

MATERIALS AND METHODS

Thirty extracted human maxillaries permanent first molars were collected on the basis of having a range of mesiobuccal canal curvature from (20°-30°) which is measured according to Schilder [3] with completely formed root and mature apices. The access opening was performed using an endo-access bur (Dentsply Maillefer, Switzerland) under air-water irrigation. Crowns were sectioned at the dentin enamel junction to standardize the root length at 15 mm. Working length was determined by inserting a size #10 k-file (Dentsply Maillefer, Switzerland) into the canal until it was visible through the apical foramen and then subtracting 1 mm from that measurement.

The samples then were coded and randomly divided into three groups (n=10) according to rotary system used: the HF group, the RB group and OS group.

The instrumentation of the root canal was carried out by a single operator with strict accordance to the manufacturer's instructions for each system. All systems were powered by an electric speed and torque-controlled endodontic micomotor (Wave One, Dentsply Maillefer). Each canal was instrumented to the working length and irrigated with 2 mL of 5.25% NaOCl using a 27-G needle. Each file was discarded after being used in three canals.

Image Analysis

The roots were positioned vertically on a metal base with the aid of sticky was and surrounded by L-shape metal mold and then poured with acrylic for easy handling of sample during instrumentation and scanning.

The specimens were scanned before and after instrumentation using CBCT (Planmeca, Promax 3D max, Helsinki, Finland) with the following parameters (90 kV, 7.1 mA and 0.1 × 0.1 × 0.1 mm voxel size and 0.100 mm axial thickness). The data were collected and analyzed by the (AutoCAD 2014 software program). Three cross sections at levels of 3 mm, 6 mm and 9 mm from the root apex were viewed by the Planmeca romexis viewer and the shortest distance from the canal periphery to the external root surface was calculated in the mesial and distal direction of the roots. Calculations were recorded before and after instrumentation to measure the followings:

1) The amount of canal transportation at each level using the following formula [16]:
   (m1 – m2) - (d1 – d2) and (b1-b2) – (l1-l2)
2) Centering ability at each level according to the following formula:
   (m1 – m2)/(d1 – d2) or (d1 – d2)/(m1 – m2) and (b1-b2)/(l1-l2) or (l1-l2) (b1-b2)

As m1 - the shortest distance from the mesial root wall to the mesial margin of the canal prior to preparation, d1 - the shortest distance from distal root wall to the distal margin of the canal prior to preparation, m2 - the shortest distance from the mesial root wall to the mesial margin of the canal after preparation, d2 - the shortest distance from distal root wall to the distal margin of the canal after preparation, b1 - the shortest distance from the buccal root wall to the buccal margin of the canal prior to preparation, l1 - the shortest distance from lingual root wall to the lingual margin of the canal prior to preparation, b2 - the shortest distance from the buccal root wall to the buccal margin of the canal after preparation and l2 - the shortest distance from lingual root wall to the distal margin of the canal after preparation.

Statistical Analysis

Statistical analysis of data obtained in this experimental study was performed using SPSS 21 (IBM SPSS Inc. Chicago, IL) software. Shapiro-wilk test was used to test the distribution of data, it was determined that the acquired data showed abnormal distribution. So, the Kruskal-Wallis test was used to compare among the group and Mann-Whitney U test was used for pair-wise comparison between the groups when the Kruskal-Wallis test

RESULTS

The mean and slandered deviation values of the canal transportation and the centering ratio at the three levels are reported in Table 1.

Table 1 Mean and standard deviation of canal transportation in (mm) and centering ratio values (mm) for the tested groups

Levels	Assessment	OS	RB	HEDM	P value
3 mm	MDT	0.090 ± 0.131	0.031 ± 0.122	0.013 ± 0.198	0.503
	BLT	0.056 ± 0.173	0.033 ± 0.113	0.030 ± 0.089	0.96
	MDC	0.402 ± 0.281	0.480 ± 0.453	0.769 ± 0.581	0.38
	BLC	0.369 ± 0.237	0.746 ± 0.426	0.980 ± 0.619	0.009*
6 mm	MDT	0.204 ± 0.131	0.061 ± 0.120	0.022 ± 0.124	0.008*
	BLT	0.143 ± 0.174	0.063 ± 0.105	0.006 ± 0.110	0.012*
	MDC	0.294 ± 0.437	0.490 ± 0.304	0.751 ± 0.515	0.101
	BLC	0.296 ± 0.316	0.690 ± 0.137	0.851 ± 0.724	0.109
9 mm	MDT	0.111 ± 0.234	0.069 ± 0.104	0.004 ± 0.107	0.353
	BLT	0.018 ± 0.037	0.017 ± 0.165	0.004 ± 0.153	0.96
	MDC	0.388 ± 0.175	0.396 ± 0.301	0.566 ± 0.281	0.368
	BLC	0.395 ± 0.333	0.406 ± 0.294	0.678 ± 0.256	0.17
MDT: mesiodistal transportation; BLT: buccolingual transportation; MDC: mesiodistal centering BLC: buccolingual centering; *significant (P < 0.05) by Kruskal-Wallis test					

Canal Transportation

At 3 mm level, there was no significant difference among the groups (P>0.05). However, there was significant difference among the groups at 6 mm with HF group showed the least transformation mean values in both direction (MDT 0.022 ± 0.124 mm) and (BLT 0.006 ± 0.110). On the other hand, there was no significant difference at 9 mm (P>0.05).

Further analysis of all data was needed to examine the difference between each two groups; so, Mann-Whitney U test was performed for multiple comparisons between groups as shown in Table 2.

Table 2 Mann-Whitney U test for canal transportation at 6 mm

Groups	Test	MDT	BLT
A-B	Mann-Whitney U	40	30
	p-value	0.449	0.13
B-C	Mann-Whitney U	16	12
	p-value	0.010*	0.004*
A-C	Mann-Whitney U	12	26
	p-value	0.004*	0.069
*significant (P<0.05) by Mann-Whitney U test			

Centering Ability

At 3 mm there was a significant difference among the group in the buccolingual direction and the HF group show the highest centering ratio values (0.980 ± 0.619) and the data revealed no significant difference at the other levels (P>0.05).

Further analysis of all data was needed to examine the difference between each two groups; so, Mann-Whitney U test was performed for multiple comparisons between groups as shown in Table 3.

Table 3 Mann-Whitney U test for centering ratio at 6 mm

Group	Test	BLC
A-B	Mann-Whitney U	33
	p-value	0.198
B-C	Mann-Whitney U	32
	p-value	0.173
A-C	Mann-Whitney U	18
	p-value	0.016*
*significant (P < 0.05) by Mann-Whitney U test		

DISCUSSION

Studying the canal transportation and centering ability of different file systems is extremely important because it helps the dentists with valuable information about endodontic instruments available so that they can make good decisions regarding the most effective and safe instruments to complete root canal preparation objectives [17-19]. On the basis of the results of present study, it can be stated that the null hypothesis was accepted as both canal transportation and centering ratio were affected by using different instrumentation systems.

In this study, natural teeth were chosen to perform the research to simulate the clinical situation. In addition, selection of natural teeth could help to perform the study under more realistic circumstances in natural canals, as it will be more profitable than in standardized resin artificial canals [20,21].

Shaping ability of the instrumentation systems can be studied on natural teeth through various methods. In the present study, the CBCT tool was used to evaluate the shaping performance of the tested systems, as CBCT imaging method is a noninvasive, accurate, reproducible and a relevant process for the analysis of canal geometry and feasible to take different sections of the teeth before and after instrumentation without sectioning and destruction of the samples [22-24].

It is noteworthy that there was no available experimental research to compare the shaping ability of Hyflex EDM, Reciproc blue and OneShape, so it's not possible to directly compare the result of present study with others.

At 3 mm, the results showed that there were no significant differences among the tested groups regarding the canal transportation. This could be attributed to the fact that all the tested systems have a non-cutting tip; which functionalize solely as a guide to allow easy penetration with minimal apical pressure, and the standardized master apical file size. In this sense Wu, et al. [25] reported that apical transportation of more than 0.3 mm could negatively affect the salability of filling materials. In this study, no system exhibited this amount of transportation.

At the apical third there was a significant difference in centering ability in buccolingual direction and this could be attributed to the presence of curve coronal to the apical third and due to difference in flexibility of the Ni-Ti files used in the study. As the Hyflex EDM file is the only available file that use electrical discharge machining technology that yield a high flexibility of the file promoting it to remain well centered during instrumentation and show better centering ratio than Reciproc blue which utilize the m-wire technology. While the OneShape file show less centering ratio values, and this could be attributed to the reason that it is made from conventional Ni-Ti which is less flexible that the M-wire or EDM technology [26-28].

At 6 mm there was a significant difference among the groups regarding canal transportation and this may be due to two factors; first, the tooth related factors as this region represents the beginning of curvature where the file flexes and bends. Second factor is the file related factors, which includes to the design of the file such as cross section, taper, and metallurgy.

Hyflex EDM has variable cross sections with an almost triangular cross section, whichs provide better management of curved canal than the S-shaped cross section of Reciproc blue and this could explain the difference in canal transportation values among the groups at this section.

The alternating taper of Hyflex EDM could be attributed to less transportation taken place during instrumentation as compared with 0.08 taper of Reciproc blue and 0.06 of OneShape. This difference in taper may lead to remove more dentine and the effect of increased taper on the flexibility of the file that tends to regain the original file shape and consequently altering the original canal shape.

This result is in favor of Venino, et al. [27] who did evaluate the shaping ability of Hyflex EDM and Protaper next and concluded that the Hyflex EDM produce less transportation at specific level due to alternating taper.

Different heat treatment processes of the files that produce different alloys with different mechanical properties resulting in increased phase transformation temperature and increased flexibility, this could be the reason of difference in canal transportation values among the groups [20,29].

CONCLUSION

Within the limitation of this experimental study, it could be concluded that the three tested systems produce transportation of the canal at the middle region, and different centering ability at the apical third. The innovated manufacturing method of the HF system leads to superior shaping ability that produce less transportation and better centering ability than that of other systems. On the other hand, RB system revealed better clinical performance than the OS system regarding both transportation and centering ratio

DECLARATIONS

Acknowledgment

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interest

The authors and planners have disclosed no potential conflicts of interest, financial or otherwise.

REFERENCES

[1] Franklin S. Weine, editor. *Endodontic Therapy*. 6th ed., University of Michigan, 2004.

[2] Torabinejad, Mahmoud, Ashraf Fouad, and Richard E. Walton. *Endodontics-e-book: Principles and practice*. Elsevier Health Sciences, 2014.

[3] Schilder, Herbert. "Cleaning and shaping the root canal." *Dental Clinics of North America,* Vol. 18, 1974, pp. 269-96.

[4] Thompson, S.A. "An overview of nickel-titanium alloys used in dentistry." *International Endodontic Journal,* Vol. 33, No. 4, 2000, pp. 297-310.

[5] Bergmans, Lars, et al. "Mechanical root canal preparation with NiTi rotary instruments: rationale, performance and safety." *American Journal of Dentistry,* Vol. 14, No. 5, 2001, pp. 324-33.

[6] Schäfer, E., and M. Vlassis. "Comparative investigation of two rotary nickel–titanium instruments: ProTaper versus RaCe. Part 2. Cleaning effectiveness and shaping ability in severely curved root canals of extracted teeth." *International Endodontic Journal,* Vol. 37, No. 4, 2004, pp. 239-48.

[7] Schäfer, E., and M. Vlassis. "Comparative investigation of two rotary nickel-titanium instruments: ProTaper versus RaCe. Part 1. Shaping ability in simulated curved canals." *International Endodontic Journal,* Vol. 37, No. 4, 2004, pp. 229-38.

[8] De-Deus, Gustavo, et al. "Extended cyclic fatigue life of F2 ProTaper instruments used in reciprocating movement." *International Endodontic Journal,* Vol. 43, No. 12, 2010, pp. 1063-68.

[9] Payal, H.S., Rajesh Choudhary, and Sarabjeet Singh. "Analysis of electro discharge machined surfaces of EN-31 tool steel." 2008.

[10] Özyürek, Taha, Koray Yılmaz, and Gülşah Uslu. "Shaping ability of Reciproc, WaveOne GOLD, and HyFlex EDM single-file systems in simulated S-shaped canals." *Journal of Endodontics,* Vol. 43, No. 5, 2017, pp. 805-809.

[11] Iacono, F., et al. "Structural analysis of HyFlex EDM instruments." *International Endodontic Journal,* Vol. 50, No. 3, 2017, pp. 303-13.

[12] De-Deus, Gustavo, et al. "Blue thermomechanical treatment optimizes fatigue resistance and flexibility of the Reciproc files." *Journal of Endodontics,* Vol. 43, No. 3, 2017, pp. 462-66.

[13] Keskin, Cangül, et al. "Cyclic Fatigue Resistance of Reciproc Blue, Reciproc, and WaveOne Gold Reciprocating Instruments." *Journal of Endodontics,* Vol. 43, No. 8, 2017, pp. 1360-63.

[14] Gernhardt, Christian R. "One Shape-a single file NiTi system for root canal instrumentation used in continuous rotation." *Endodontic Practice Today,* Vol. 7, No. 3, 2013.

[15] Elsherief, Samia M., Mohamed K. Zayet, and Ibrahim M. Hamouda. "Cone-beam computed tomography analysis of curved root canals after mechanical preparation with three nickel-titanium rotary instruments." *Journal of Biomedical Research,* Vol. 27, No. 4, 2013, p. 326.

[16] Gambill, James M., Marden Alder, and E. Carlos. "Comparison of nickel-titanium and stainless-steel hand-file instrumentation using computed tomography." *Journal of Endodontics,* Vol. 22, No. 7, 1996, pp. 369-75.

[17] Zhao, Dan, et al. "Micro-computed tomography evaluation of the preparation of mesiobuccal root canals in maxillary first molars with Hyflex CM, Twisted Files, and K3 instruments." *Journal of Endodontics,* Vol. 39, No. 3, 2013, pp. 385-88.

[18] Shen, Ya, and Gary SP Cheung. "Methods and models to study nickel–titanium instruments." *Endodontic Topics,* Vol. 29, No. 1, 2013, pp. 18-41.

[19] De Melo Ribeiro, Marcus Vinícius, et al. "Comparison of the cleaning efficacy of self-adjusting file and rotary systems in the apical third of oval-shaped canals." *Journal of Endodontics,* Vol. 39, No. 3, 2013, pp. 398-401.

[20] Hashem, Ahmed Abdel Rahman, et al. "Geometric analysis of root canals prepared by four rotary NiTi shaping systems." *Journal of Endodontics,* Vol. 38, No. 7, 2012, pp. 996-1000.

[21] Setzer, Frank C., Tae-Kyung Kwon, and Bekir Karabucak. "Comparison of apical transportation between two rotary file systems and two hybrid rotary instrumentation sequences." *Journal of Endodontics,* Vol. 36, No. 7, 2010, pp. 1226-29.

[22] Hartmann, Mateus Silveira Martins, et al. "Canal transportation after root canal instrumentation: a comparative study with computed tomography." *Journal of Endodontics,* Vol. 33, No. 8, 2007, pp. 962-65.

[23] Zanette, Fabiane, et al. "Apical root canal transportation and remaining dentin thickness associated with ProTaper Universal with and without PathFile." *Journal of Endodontics,* Vol. 40, No. 5, 2014, pp. 688-93.

[24] De Carvalho, Guilherme Moreira, et al. "Apical transportation, centering ability, and cleaning effectiveness of reciprocating single-file system associated with different glide path techniques." *Journal of Endodontics,* Vol. 41, No. 12, 2015, pp. 2045-49.

[25] Wu, Min-Kai, et al. "Prevalence and extent of long oval canals in the apical third." *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology,* Vol. 89, No. 6, 2000, pp. 739-43.

[26] Jaber, Sura A., and Zainab M. Abdul-Ameer. "A Comparative Evaluation of the Centering Ability and Canal Transportation of Simulated S-Shaped Canals Instrumented with Different Nickel–Titanium Rotary Systems." *Journal of Baghdad College of Dentistry,* Vol. 28, No. 1, 2016, pp. 48-56.

[27] Venino, Pier Matteo, et al. "A Micro–computed Tomography Evaluation of the Shaping Ability of Two Nickel-titanium Instruments, HyFlex EDM and ProTaper Next." *Journal of Endodontics,* Vol. 43, No. 4, 2017, pp. 628-32.

[28] Wu, Hui, et al. "Shaping ability of ProTaper Universal, WaveOne and ProTaper Next in simulated L-shaped and S-shaped root canals." *BMC Oral health,* Vol. 15, No. 1, 2015, p. 27.

[29] Capar, Ismail Davut, et al. "Comparative study of different novel nickel-titanium rotary systems for root canal preparation in severely curved root canals." *Journal of Endodontics,* Vol. 40, No. 6, 2014, pp. 852-56.