M D J

Centering ability and canal transportation of : ProTper,Mtwo,WaveOne,Reciproc in simulated curved canals (A comparative study)

Dr. Jamal A. Mahdi B.D.S., M.Sc
Dr. Rafal M. Maruish B.D.S

Abstract

Background: this study was conducted to compare the centering ability and canal transportation of: Protaper, Mtwo, WaveOne, Reciproc in simulated curved canals.

Materials and methods: Eighty simulated curved canals of 40° curvature were divided into four groups and prepared to an apical size 25 using a crown-down technique for ProTaper instruments and single length technique for Mtwo instruments and single file technique for WaveOne and Reciproc instruments. The following parameters were evaluated: outer and inner canal transportation and the centering ability. The measurements were carried out at five different levels. Pre-and postoperative images of the canals were taken at 40X magnification by aid of stereomicroscope. An assessment of the canals shape was determined using Photoshop CS2 and AutoCAD software. The data were analyzed statistically using ANOVA and LSD test.

Results: Considering canal transportation, the direction of transportation of rotary NiTi instruments was usually toward the inner aspect at middle parts of the canal and toward the outer aspect of the curve at the apex of curve and the end of preparation. Waveone and Reciproc files were showed a better maintaining its original curvature with less straightening and transportation especially at the end of preparation of simulated canals. WaveOne and Reciproc instruments obtained better centering ability at all levels especially at the end point of preparation comparing with Protaper and Mtwo instruments.

Conclusions: WaveOne and Reciproc instruments maintained the original curvature significantly better than ProTaper and Mtwo.

Key words: Mtwo, ProTaper,WaveOne, Reciproc, single file technique.

Introduction

The objective of root canal preparation is to clean and shape the canal system to eliminate necrotic material, microorganisms, and canal irregularities, and to facilitate the placement of a permanent root filling [(1)]. The ideal preparation for the root canal is a contentiously tapered funnel shape with smallest diameter at the apex and the widest diameter at the canal orifice [(2)]. The shape can be achieved either by hand or by mechanical preparation and is readily produced in straight canals. However,

cleaning and shaping of narrow and sever curved canals with rotary nickel-titanium instruments can be difficult and may not provide the optimal shape [3]. Many reports have described the tendency of root canal preparation technique to cause canal transportation and other procedural problems. These complications may compromise the long –term success of treatment by failing to eliminate infection of the root canal system and making obturation more difficult [4,5,6]. Various instrumentation techniques and endodontic instruments have been introduced in attempt to reduce these problems aiming to provide the optimum shaped preparation. Various challenges during root canal preparation, especially straightening of curved root canals, were minimized by the introduction of Nitinol into endodontics [7]. The unique properties of nickel-titanium alloy, such as flexibility, have allowed the development of nickel-titanium endodontic instruments in order to overcome the limitations imposed by stainless steel alloy. Reciprocating nickel titanium instruments have been shown to prepare the root canal rapidly, and maintain the canal shape and working length with few irregularities during root canal preparation[3].

Materials and Methods

Simulated curved canals, made of clear polyester resin, were used; the diameter and the taper of all simulated canals were equivalent to an ISO standard size 10 root canal instrument. The curvature was defined mathematically with a radius of 5.5 mm, resulting in an angle of 40° according to the method of Pruett [8]. The simulated canals were prepared either with ProTaper, Mtwo, WaveOne, Reciproc instruments. Eighty resin blocks, divided into four groups, 20 each, were enlarged #25. The first penetration was done with #10 K-file hand instrument to the full working length (16 mm). Patency was checked with the same size after each sequence. Prior to their preparation, each simulated canal was filled with a drawing ink and photographs of the unprepared canals were taken by a stereomicroscope and a digital camera at magnification of 40 times. Each resin block was placed in a custom made epoxy mould, so that the process was carried out with purely tactile sensation. Glycerin was used to coated the instrument to act as a lubricant and copious irrigation with tap water was performed repeatedly before and after the use of each instrument; approximately 5 ml of water for each canal. Each instrument was used to enlarge five canals. The sequence of instruments was as follow:

Group A: The Protaper instruments will be completed in a crown-down manner according to the manufacturer's instructions using a gentle in-and-out motion. The preparation sequence will follow:

1. SX file (auxiliary shaping file) was used to (11 mm).
2. S1file (shaping file no.1) was used to (16 mm) the full working length.
3. S2 file (shaping file no. 2) was used to (16mm) the full working length.
4. F1file (finishing file no. 1) was used to (16mm) the full working length.
5. F2 file (finishing file no. 2) was used to (16mm) the full working length.

Once the instrument has negotiated to the end of the canal and has rotated freely, it was freely remove. The Endo-mate motor that used with Protaper rotary instruments was set into a

permanent rotation at 300 rpm with a 16:1 reduction and torque at 1.4 Ncm. This was within the range suggested by the manufactures.

Group B: Mtwo Endodontic Instruments the Mtwo instruments were used to the full working length of the canals (single-length technique). The preparation sequence was as follow:

1. A 0.04 taper size 10 instrument.
2. A 0.05 taper size 15 instrument.
3. A 0.06 taper size 20 instrument.
4. A 0.06 taper size 25 instrument.

Once the instrument has negotiated to the end of the canal and has rotated freely, it was removed. The Endo-mate motor that used with Mtwo rotary instruments was set into a permanent rotation at 280 rpm and with a 4:1as a reduction gear and torque at 1.4 Ncm. This will within the range suggested by the manufactures.

Group C: WaveOne Endodontic Instruments

Twenty canals were instrumented with WaveOne Primary reciprocating files. A primary reciprocating WaveOne file having a size 25 and a taper of 0.08 was used in reciprocating, slow in-and-out pecking motion according to the manufacturer's instructions. The flutes of the instrument were cleaned after three pecks. No glide path was created prior to instrumentation with the WaveOne file. The dedicated reciprocating motor (Dentsply, Maillefer) of the WaveOne file was used with the manufacturer configuration setup [(9)].

Group D: Riceproc Endodontic Instruments

Twenty canals were instrumented with Reciproc (R25) file that was used in a reciprocating working motion generated by the motor. A Reciproc (R25) file having a size 25 at the tip and a taper of 0.08 over the first three millimeters was used in a reciprocating, slow in-and-out pecking motion according to the manufacturer's instructions. The flutes of the instrument were cleaned after three in-and-out motions [(10)].

Then canals were injected again with the drawing ink and the image procedure is repeated. Pre- and postoperative digital photographs were stored in a Pentium 4 computer and measurements were accomplished using Adobe Photoshop CS2 and AutoCAD software program. The difference between the canal configuration before and after instrumentation was determined for both the inner and the outer side of the curvature at five reference points [(11)].

- Point 1 (O): the canal orifice.
- Point 2 (HO): the point half-way from the beginning of the curve to the orifice.
- Point 3 (BC): the point where the canal deviates from the long axis of its coronal portion and is called the beginning of the curvature.
- Point 4 (AC): the point where the long axes of the coronal and the apical portions of the canal intersect and is called the apex of the curve.
- Point 5 (EP): the end point of preparation.

Outer and inner transportations and centering ratio were measured. The mean centering ratio is a measure of the ability of the instrument to stay centered in the canal and the following mathematical formula was used to obtain a parameter:

$$\beta = [(D1 - D2)/ D] \times 100$$

Where; parameter β represent centering propensity of the filed canal.

D1(X2-X1): being the distance between the edge of the original (pre-operative) canal and the edge of the filed canal (post-operative) on concave side.

D2 (Y2-Y1): being the distance between the edge of the original (pre-operative) canal and the edge of the filled (post-operative) canal on the convex side.

D (X2 + Y2): being the width of the filed canal.

The smaller the ratio, the better the instrument remained centered in the canal. The data were analyzed statistically using ANOVA and LSD test.

Results

1. WaveOne files showed the lowest mean of outer transportation (20.45) followed by Reciproc files (24.9) and Mtwo files (128.8) respectively while the highest mean of outer transportation showed by ProTaper files (255.25). At level 2 and 3, the sequence of the instrumentation was the same as the level 1 and the value for level 2 were : WaveOne (28.95) ,Reciproc (37.15), Mtwo (172.9), and Protaper (184.45) and for the level 3 were : WaveOne (59), Reciproc (59.8), Mtwo (116.95) and ProTaper (240.55). At level 4 the highest mean value of outer transportation was with ProTaper (291.95) and the lowest mean value was with (89.3). Finally at level 5, the lowest mean value was with WveOne (133.85) followed by Reciproc (164.95) while the higher mean value was with Mtwo (209) and the highest mean valve was with ProTaper (349).
2. The ProTaper showed the highest mean valve of inner canal transportation (214) followed by Mtwo (204) and Reciproc (55) while WaveOne showed the least mean value (46). At level 2, the lowest mean value shown by WaveOne files (67) followed by Reciproc files (96) while the highest value found with ProTaper (307) and Mtwo (225) respectively. At level 3 and 4 , the sequence of the instruments was the same at level 1and the values at level 2:PrpTaper (159), Mtwo(287),WaveOne (144), Reciproc (189).finally at level 5, WaveOne showed the least mean valve (199) while the highest mean value (522) showed by ProTaper**.**
3. At first level, Wave One showed the best centering ability among the other instruments (0.010) followed by Reciproc (0.012), Mtwo (0.037) respectively. While ProTaper exhibited the worst ability to center in the canal (0.045). Next to the second measuring point the sequence of the instruments was the same as the first one and the values were as follow: WaveOne (0.017), Reciproc (0.019), Mtwo (0.064) and finally ProTaper (0.078). The performance of WaveOne at the third level was the best among the other three instruments (0.025) and Reciproc file came in second order and scored (0.026). Mtwo moved towards the third rank with the value of (0.119); while ProTaper came on the last order (0.127).At the forth plane the least centering ability was again recorded for ProTaper (0.187); while WaveOne achieved the most centering ability (0.033) then Reciproc (0.036) and Mtwo (0.106). On the last level, another time ProTaper displayed the worst ability to stay centered in the

canal (0.258) followed by Mtwo (0.142); while WaveOne scored the best value of centering ability (0.040) and Reciproc file came in second order after WaveOne (0.033).

Discussion

Canal Transportation (Inner and Outer): The direction of transportation of rotary NiTi instruments observed in this study was generally toward the inner aspect at middle parts of the canal and toward the outer aspect of the curve at the apex of curve and the end of preparation .Other studies confirmed this trend rotary endodontic instruments Sonntag et al., 2007[12]; Al-Nuaimi and Al- Hashimi, 2008[13]; Versiani, 2008[14]; Alia and Al-Hashimi, 2010[15].This is mainly due to the restoring forces of the metal where the forces in straight file in a curved canal attempt to return the file to its original shape and straighten it toward the outer curvature thereby preferentially removing material in this area during preparation and thus lessens its cutting along the inner wall. If this effect is pronounced a significant portion of the canal wall remains untouched. [16]

In comparison with Protaper and Mtwo, canals prepared by Waveone files was showed a better maintaining its original curvature with less straightening and transportation especially at the end of preparation of simulated canals This observations are in accordance with published studies Berutti et al., 2004[9]; Franco et al., 2011[17]; Boutsioukis et al., 2010[18]; Karbucak et al., 2010[19]. This may be due to the following reasons: First; the Waveone system has a unique design characterics; they have a reverse helix and 2 distinct cross section along the length of their active portions. From D1-D8, the waveOne files have a modified convex triangular cross section, whereas from D9-D16, these files have a convex triangular cross section. The design of the two waveOne cross section is further enhanced by a changing pitch and helical angle along their active portions. This design is thought to reduce the core diameter and increase the flexibility, which may eliminate threading, and bending during preparation [20].

Second: the reciprocating motion has been significantly correlated to a more centered preparation compare with continuous rotating motion by evidence by an increase the enlargement at the external side of the canal especially at the end of preparation [17]. The advantages of reciprocating motion is based on physical law of action and reaction applied on the root canal instrumentation which result in a balanced force as theorized by Roane et al. 1985[21]. Moreover, the reciprocating movement minimizes the torsional and flexural stress, increases the canal centering ability and reduced the taper lock within the number of the instrument cycles within the root canal [22, 23].

Third: the Waveone files are manufacture with the M-wire NiTi alloy which is more flexibility than the conventional NiTi alloy and maintained the comparable tortional properties and enhance the centering ability with less transportation.

In term of outer transportation, more cutting effectiveness of PT at first four levels than WaveOne and Reciproc with highly significant difference and more than Mtwo with significant difference. This may come in agreement with the findings of other studies Webber et al., 2011; Berutti et al., 2012; This was as a result of: (a) absence of radial land area in PT combination with, (b) the increased

taper of ProTaper files of up to 0.19 whereas just 0.08 for Wave One and Reciproc and just 0.06 for Mtwo.

In this study, Mtwo was removed more resin from the outer side at the coronal part (orifice and half – way orifice levels) and at the apical portion of canal; while it was more efficient on the inner wall at the beginning and the apex of the curve. These observations are in accordance with recently published studies with Mtwo instruments have the ability to cut inner wall of the curvature and the end of preparation and from the outer wall of the canal at the coronal and middle parts of the canal more than Waveone and Reciproc and this agree recent studies Berutti et al., 2012[24]; Franco et al., 2011[17]; Boutsioukis et al., 2010[18]; Karbucak et al., 2010[19].

In regard of inner transportation, there was no difference from the results of outer transportation at all five levels. This may agreement with the findings of similar studies Versiani, 2008[14]; Aliaa and Al- Hashimi, 2010[15]. At end of preparation, again superiority of PT instrumentation, this could be probably attributed to combination of its cross-section and its flute design that facilitated more canal removal.

Centering Ability:

The main parameters used to evaluate shaping are to protect the curvature of the canal and to maintain good centering ability. By comparing the mean absolute values for centering ability of the four NiTi systems, WaveOne instruments obtained better centering ability at all levels especially at the end point of preparation comparing with Protaper and Mtwo instruments. These outcomes have been noted by other recent studies Berutti et al., 2012 [24]; Franco et al., 2011[17]; Boutsioukis et al., 2010[18]; Khabbaz et al., 2011[25]. Low values indicated that the preparation was better centered in the canal, and this occurred at the end point, apex of curve and half –way orifice and the beginning of curve this was probably attributed to the reciprocating motion, the variable section design, the M-wire , the reverse cutting blades, or combination of these variables [24]. Reciproc instruments came in the second order after Waveone files at all the five measuring levels and this result was agreed with a recent studies Berutti et al., 2012[24]; Franco et al., 2011[17]; Boutsioukis et al., 2010[18]; Khabbaz et al., 2011[25]. this was probably due to the transverse section of the Reciproc which is an italic 'S' with two blade cutting surfaces with non cutting tip and its manufacture with the M-wire NiTi alloy which is more flexibility than the conventional NiTi alloy and maintained the comparable tortional properties and enhance the centering ability with less transportation. Mtwo instruments was showed better centering ability than the PT instrument and the difference between them was significant at the end point, apex of the curve and the half-way orifice, this result was agreed with Veltri et al., 2005[25]; Bürklen and Schäfer, 2006[27]; Schäfer et al., 2006[28]; Al-Nuaimi and Al-Hashimi[13] 2008; Aliaa and Al-Hashimi, 2010[15], and it was probably due to the original flexibility of Mtwo as its specific design .Furthermore , the increasing pitch from the tip to the handle should allow a more delicate cutting action at the apex and more aggressive one in the coronal portion and the difference between them was no significant at the orifice and the beginning of the curve ,this was probably because of the elimination of the coronal interference with brushing action against the outer canal walls so that the Mtwo and PT instruments result in excessive resin removal especially at the coronal parts of the canal. These findings were

agreed with Elayouti et al., 2008 [29]; Martin- Mico et al., 2009[30]. ProTaper files have excessive tapering this may increase the rigidity of the consequently more resin will be removed from the one side of the canal than the other. Additionally the brushing action which is recommended with this system may cause unevenly resin removal, these factors may explain relatively low centering ability of this system compare with other NiTi instruments at five measuring levels and this agree with Bergman et al., 2003(32); Mohammed and Al-Azzawi, 2008[33];

Versaini et al., 2008[14].Finally, in this study the single file technique used with reciprocating motion enhance the canal centering ability, leading to less invasive root canal preparation.

References

1- Schilder H. Cleaning and shaping the root canal. Dent. Clin. North Am. 1974; 18(2): 269-96.
2- Schilder H., Yee F. Canal debridement and disinfection. In: Cohen S, Burns RC, eds. Pathways of the pulp,11 ed. St Louis, MO 1984: CV Mosby , pp. 175- 204.
3- Castellucci A. Endodontics vol. 1. China, Mosby; 2005.
4- Weine FS, Kelly RF, Lio PJ. The effect of preparation procedures on original canal shape and on apical foramen shape. J Endod1975; 1: 255-262.
5- El Deeb N, Broas J. The effect of different files on the shape of curved canal. International Endodontic Journal 1985, 18 (1), 1-7.
6- Al-Omari MA, Dummer PM. Canal blockage and debris extrusion with eight preparation techniques. J Endod1995: 21: 154–158
7- Jodway B, Hülsmann M. A comparative study of root canal preparation with NiTi-TEE and K3 rotary Ni-Ti instruments. Int Endod J 2006; 39:71-80.
8- Pruett J, Clement D, Garnes D. Cyclic fatigue testing of nickel-titanium endodontic instruments. J Endod 1997; 23: 77-85.
9- Berutti E., Negro AR, Lendini M, Pasqualini D. Influence of manual preflaring and torque on the failure rate of ProTaper rotary instruments. J endod 30:4, pp. 228-230, 2004.
10- Yared G. The RECIPROC system. Roots 2010; 6(4):40.
11- Calberson FLG, Deroose CAJG, Hommez GMG, Raes H, DeMoor RJG. Shaping ability of GT rotary files in simulated resin root canals. lntEndod J 2002; 35: 607-14.
12- Sonntag D, Ott M, Kook k, Stachniss V. Root canal preparation with the NiTi systems K3, Mtwo and ProTaper. Aust Endod J 2007; 33:73-81.
13- Al-Nuaimi NE, Al-Hashimi WN. Comparative study on the shaping ability of rotary nickel-titanium systems K3 and HERO shaper instruments compared with stainless steel hand instruments in simulated root canals [Master's thesis].Department of Conservative Dentistry, University of Baghdad; 2008.
14- Versiani MA, Pascon EA, Alves de Sousa CJ, Gagliardi Borges MA, Sousa-Neto MD. Influence of shaft design on the shaping ability of 3 nickel-titanium rotary systems by means of spiral computerized tomography. Oral SurgOral Med Oral Pathol Oral Radiol Endod.2008; 105: 807-13.
15- Aliaa MJ, Al-Hashimi MK. Shaping ability of three rotary NiTi system in simulated curved root canal(A Comparative study) [Master's thesis] .Department of Conservative Dentistry; 2010.
16- Ayar LR, Love RM. Shaping ability of ProFile and K3 rotary NiTi instruments when used in a variable tip sequence in simulated curved root canals. Int Endod J 2004; 37: 593-601.
17- Franco Paque, Mattbiias Zebnder, Gustavo De-Deus J Endod 2011; 37(10):1394-1397.
18- Bonaccorso A, Cantatore G, Guido Condorelli G, Schäfer E, Roberta Tripi T: Shaping ability of four nickel-titanium rotary instruments in simulated S-shaped canals. J Endod 2009; 35: 883-886.
19- Karbucak B, GatanAJ, Hsiao C, Iqbal MK: A comparison of apical transportation and length control between EndoSequence and Guidance rotary instruments. J Endod 2010; 36: 123-125.
20- Webber J., Machtou P., Pertot W., Kuttler S., Ruddle CJ, West JD. The WaveOne single-file reciprocating system. Roots J 2011; 1:28-33.
21- Roane JB, Sabala C, Duncanson M. The balanced force concept for instrumentation of curved canals. J Endod 1985; 11 (5): 203-11.

22- Southard D, Oswald R, Natkin E. Instrumentation of curved molar root canals with the Roane technique. Journal of Endodontics 1987, 13 (10), 479-89.
23- Kuttler S, McLean A, Dorn S, Fischzang A. The impact of post space preparation with Gates-Glidden drills on residual dentin thickness in distal roots of mandibular molars. J Am Dent Assoc 2009; 135: 903–911.
24- Berutti E., Negro AR, Lendini M, Pasqualini D. Influence of manual preflaring and torque on the failure rate of ProTaper rotary instruments. J Endod 2004; 30(4): 228-230.
25- Kock K, Brave D. The Ultimate Rotary File. Oral Health 2002; 3. P.59- 64.
26- Veltri M, Mollo A, Pini PP, Ghelli LF, Balleri P. In vitro comparison of shaping abilities of ProTaper and GT rotary files. J Endod 2004; 30:163-6.
27- Bürklein S, Schäfer E. The influence of various automated devices on the shaping ability of Mtwo rotary nickel-titanium instruments. Int Endod J. 2006; 39: 945-951.
28- Schäfer E, Erler M, Dammaschke T. Comparative study on the shaping ability and cleaning efficiency of rotary Mtwo instruments. Part2. Cleaning effectiveness and shaping ability in severely curved root canals of extracted teeth. IntEndod J 2006; 39:203-12.
29- Elayouti A, Chu A.-L, Kimionis I, Klein C, Weiger R, Löst C. Efficacy of rotary instruments with greater taper in preparing oval root canals. Int Endod J 2008; 41: 1088-1092.
30- Martín-Micó M, Forner-Navarro L, Almenar-García A. Modification of the working length after rotary instrumentation. A comparative study of four systems. Med Oral Patol Oral Cir Bucal. 2009 Mar 1; 14(3):E153-7.
31- Bergmans L, VanCleyn J, Beullens M, Wevers M, VanMeerbeek B, Lambrechts P. Progressive versus constant tapered shaft design using NiTi rotary instruments. Int Endod J, 2003; 36: 288-95.
32- Mohammed HK, Al-Azzawi AJ. Comparative study on the shaping ability of the three rotary nickel-titanium in simulated curved canals [Master's thesis]. Department of conservative Dentistry, University of Baghdad; 2008.

Table 1: Descriptive statistical results of the outer canals transportation (mm) after instrumentation

Level	Tested group	Mean	SD
O	PT	149	38.512
	Mtwo	145.9	31.313
	WaveOne	21.85	9.708
	Reciproc	44.3	19.537
HO	PT	223.55	38.310
	Mtwo	175.2	30.727
	WaveOne	36	15.563
	Reciproc	88.65	31.003
BC	PT	253.75	40.584
	Mtwo	223.65	33.848
	WaveOne	66.7	26.014
	Reciproc	139.1	26.228
AC	PT	286.2	50.490
	Mtwo	261.7	49.639
	WaveOne	101.3	28.879
	Reciproc	189.3	41.968
EP	PT	366.7	68.38
	Mtwo	306.25	63.67
	WaveOne	142.35	35.58
	Reciproc	222.5	35.80

Table 2: Descriptive statistical results of the inner canals transportation (mm) after instrumentation

Level	Tested group	Mean	SD
O	PT	255.25	30.420
	Mtwo	128.8	17.937
	WaveOne	20.45	6.794
	Reciproc	24.9	7.656
HO	PT	184.45	32.468
	Mtwo	172.9	33.501
	WaveOne	28.95	9.139
	Reciproc	37.15	10.703
BC	PT	240.55	51.122
	Mtwo	116.95	38.981
	WaveOne	59	10.945
	Reciproc	59.8	15.853
AC	PT	291.95	53.606
	Mtwo	151.15	39.223
	WaveOne	89.3	17.113
	Reciproc	92	16.721
EP	PT	349	67.365
	Mtwo	209	35.871
	WaveOne	133.85	43.732
	Reciproc	164.95	52.065

Table 3:Descriptive statistical results of the centering ratio (mm) after instrumentation

Level	Tested group	Mean	SD
O	PT	0.045	0.021
	Mtwo	0.037	0.020
	WaveOne	0.010	0.005
	Reciproc	0.012	0.005
HO	PT	0.078	0.034
	Mtwo	0.064	0.035
	WaveOne	0.017	0.007
	Reciproc	0.019	0.005
BC	PT	0.127	0.045
	Mtwo	0.119	0.057
	WaveOne	0.025	0.008
	Reciproc	0.026	0.007
AC	PT	0.187	0.056
	Mtwo	0.106	0.057
	WaveOne	0.033	0.009
	Reciproc	0.036	0.009
EP	PT	0.258	0.066
	Mtwo	0.142	0.068
	WaveOne	0.040	0.009
	Reciproc	0.047	0.010