

COMPARISON OF CANAL TRANSPORTATION AND CENTERING ABILITY OF XP SHAPER, WAVEONE AND ONESHAPE: A CONE BEAM COMPUTED TOMOGRAPHY STUDY OF CURVED ROOT CANALS

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ABSTRACT

This study investigated the shaping abilities of XP Shaper and compared it with other single file NiTi systems using full rotation and reciprocation motion by cone beam computed tomography. Mesio Buccal canal of forty-five mandibular first molars, were divided into three equal groups, using WaveOne, OneShape and XP shaper. Pre-and post instrumentation images were obtained at 3mm, 5mm and 7mm from the apex and were assessed to determine canal transportation and centering ability. Data were analyzed using Kruskal-Wallis test for comparing the three systems, while Friedman's test was used to compare between the root levels. WaveOne and OneShape showed the highest mean amount of transportation with no statistically significant difference between them. XP Shaper showed the lowest statistically significantly mean amount of transportation. There was a statistically significant difference in the canal centring ability among the three instruments used. It was concluded that XP shaper preserved the original canal shape better than WaveOne and OneShape.

KEYWORDS: Canal transportation, Centering ability, Cone beam computed tomography, OneShape, WaveOne, XP Shaper.

INTRODUCTION

The ultimate root canal treatment goal is the removal of infected pulpal remnants, elimination of microorganisms, shaping of the root canal system through optimum biomechanical preparation⁽¹⁾. Root canals should be uniformly enlarged in all dimensions to permit thorough disinfection while maintaining the original curvature

without introducing iatrogenic errors⁽²⁾.

However, endodontic preparation in narrow and curved root canals has always been a challenge, due to the tendency of the prepared canal to deviate from its natural axis⁽³⁾. Continuous innovations and techniques are being established aiming to reduce the difficulties encountered during endodontic therapy. The use of nickel-titanium instruments allowed for a

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favorable treatment of curved canals in shorter time through their enhanced properties of shape memory, super elasticity and cutting efficiency (4).

Various single-file systems with different metallurgy and designs have been promoted to prepare root canals with one instrument using either continuous rotation or reciprocation motion. WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) and OneShape (Micro Mega, Besancon, France) are representatives for these single file systems. Where, Waveone works in reciprocation motion and are made of a special NiTi-alloy called M-Wire which is created by an innovative thermal treatment process. The benefits of this M-Wire NiTi are based on increased flexibility of the instruments and on improvement of resistance to cyclic fatigue, The Primary WaveOne file have a fixed tapers of 8% from D1-D3, whereas from D4-D16, they have a unique progressively decreasing percentage tapered design. This design serves to improve flexibility and conserve remaining dentin in the coronal two-thirds of the finished preparation.

While, OneShape is made of a conventional austenite 55- NiTi alloy with a tip size of 25 and a constant taper of 0.06 with various cross-sectional designs and variable pitch over the entire length, and is used in continuous rotation, the design is claimed to eliminate threading and binding of the instrument when working in continuous rotation.

Recently, XP Shaper instrument (FKG, LaChaux-de-faund, Switzerland) has been introduced to the market, based on the MaxWire's adaptive core technology. The MaxWire alloy allows the instrument to shift its shape from a relatively malleable and straight shape at room temperature, to a more robust shape at body temperature. The transformation cause the instrument to be flexible and straight at room temperature with high cutting efficiency at body temperature (5).

Hence, the purpose of the study was to compare the effect of the new NiTi rotary instrument (XP

Shaper instrument) on the canal transportation and the canal centering ability with other single file NiTi instruments utilizing reciprocation motion (WaveOne) and full rotation (One shape) using cone beam computed tomography. The null hypothesis was that there is no difference among the 3 rotary NiTi file systems regarding the analyzed parameters.

MATERIALS AND METHODS

Selection of the samples

A total of forty-five human permanent mandibular first molars extracted due to periodontal or prosthodontics reasons from the Department of Oral Surgery, Cairo University were selected. Preoperative periapical radiographs were taken to inspect the mesial roots and to determine the angle of root curvature. The inclusion criteria included the presence of two canals in the mesial root with independent apical foramina, complete root formation, no internal root calcification, no internal or external root resorption, mesiobuccal canal curvatures between 20° and 35° according to Schneider's method (6).

Preparation of the samples

The crowns were sectioned using a water-cooled safe sided diamond disc leaving 3 mm above the cemento-enamel junction. The distal roots were separated from the mesial ones using diamond discs. The presence of two separate mesial canals was confirmed by simultaneous application of two K-files #10 (Maillefer, Ballaigus, Switzerland) in the canals. Only the mesiobuccal canals were used in instrumentation. Patency was checked and the working length was determined by subtracting 1 mm from the apical foramen.

The roots were vertically mounted halfway in transparent auto polymerizing acrylic resin (Acrostone, Dental & Medical Supplies, Cairo, Egypt) mixed according to the manufacturer's instructions inside a silicon mold (10 cm x 10 cm) to fix them before scanning. To prevent the resin from enter-

ing the apical foramen, the apices of the roots were sealed with wax (Wilson, Sao Paulo, Brazil). Each sample was inserted into the unset acrylic resin so that its long axis was parallel to the long axis of the mold to ensure standardization of the specimens for tomographic imaging. To facilitate the orientation of canal during the scanning, an amalgam filling was inserted into the resin at the bucco-distal line angle of the roots.

Pre-instrumentation scanning:

All roots were scanned using cone beam computed tomography (CBCT) system (Scanora 3D, Soredex, Palodex group, Finland) at 85 kVp and 15 mA to determine the canal shape before instrumentation. For each specimen, three tomograms were selected according to the distance from the root apex as follow: 3 mm corresponding to the apical third, 5 mm corresponding to the middle third and 7 mm corresponding to the cervical third. All images were assessed using Software program (OnDemand 3D, Cybermed, South Korea).

Root Canal Preparation

A #15 K- file (Maillefer, Ballaigus, Switzerland) was used to establish a glide path. The samples were randomly divided into 3 equal groups (n = 15 canals per group) as follow:

- Group I: The WaveOne group, root canals were shaped with WaveOne Primary reciprocating files using a slow in-and out pecking motion with amplitude of about 3 mm. The flutes of the instruments were cleaned after three in-and out movements (pecks)
- Group II: The OneShape group, root canals were shaped with OneShape rotary file with the motor set to 350 rpm / 5-Ncm torque, The instrument was used in slow pecking motion with an amplitude of less than 3 mm. The flutes of the instrument were cleaned after three in and out movements (pecks) till reaching the working length.

- Group III: The XP- Shaper group, root canals were shaped with XP-shaper file with the motor set at 900 rpm/ 1-Ncm torque. The file was inserted into the canal and 5 strokes were applied till reaching the working length.

Root canal preparation was performed using X-smart plus endodontic motor (Dentsply, Tulsa Dental, Tulsa, OK). Freshly prepared 2.6% sodium hypochlorite solution was used as an irrigant during instrumentation procedure with a 30-gauge needle tips (NaviTip, Ultradent, South Jordan, UT, USA) 1mm short from the working length.

Post-instrumentation scanning:

The root canals were scanned after the mechanical preparation using CBCT in the same pre-instrumentation scanning protocol.

The shortest distance from the periphery of the root (mesial and distal) to the edge of the mesiobuccal canal was measured by using the measure length tool on the reconstructed cross-sectional images of the pre and post-instrumentation scans

Where, M1: is the shortest distance from the mesial edge of the root to the mesial edge of the un-instrumented canal.

M2: is the shortest distance from the mesial edge of the root to the mesial edge of the instrumented canal.

D1: is the shortest distance from the distal edge of the root to the distal edge of the un-instrumented canal.

D2: is the shortest distance from the distal edge of the root to the distal edge of the instrumented canal

The degree of canal transportation was calculated according to the formula given by *Gambill et al.*⁽⁷⁾:

$$\text{Canal transportation} = (M1 - M2) - (D1 - D2)$$

Regarding transportation direction, CT equal to 0 (zero) meant lack of transportation, a negative

value represented transportation to the distal direction, and a positive value represented transportation toward the mesial direction.

Centering ability ratio was calculated using the values obtained during the measurement of transportation using the following equation:

Centralization ability ratio = $(M1 - M2) / (D1 - D2)$ or $(D1 - D2) / (M1 - M2)$

The formula was chosen in such a manner that the lowest of the results obtained through the difference should always be the numerator. A result equal to 1.0 indicated perfect centralization. When value was closer to zero, it implied that the instrument had a lower capacity to maintain itself in the central axis of the canal.

Assessment of root canal preparation

Root canal preparations were completed by one operator, while the assessment of the canal curvatures prior to and after instrumentation was carried out by a second examiner who was blind about all experimental groups.

Statistical analysis

Data were presented as mean and standard deviation (SD) values. Kruskal-Wallis test was used to compare the three systems. Friedman's test was used to compare the different root levels. Dunn's

test was used for pair-wise comparisons. Fisher's Exact test was used to compare the three systems. The significance level was set at $P \leq 0.05$.

RESULTS

Canal Transportation

At 3 as well as 5 mm level from the apex; results showed WaveOne and OneShape had highest mean amount of transportation with no statistically significant difference between them. However, Xp Shaper showed the statistically significantly lowest mean amount of transportation (Table 1).

At 7 mm from the apex: There was a statistically significant difference between the three groups. WaveOne showed the highest mean amount of transportation (0.22 ± 0.09) followed by OneShape (0.14 ± 0.11) followed by Xp Shaper, which had the lowest mean amount of transportation (0.08 ± 0.06).

Results showed that on using the WaveOne instrument, there was a statistically significant difference between root levels (P -value = 0.035). The highest distal transportation was found at 3 mm from the apex. While, the highest mesial transportation was observed at 7mm level. However, OneShape and XP Shaper instruments showed no statistically significant difference among the different root levels (P -value = 0.061, P -value = 0.175) (table 2).

TABLE (1): The mean, standard deviation (SD) values and results of Kruskal-Wallis test for comparison between canal transportation values (mm) after using the three systems

Root level	WaveOne		One Shape		XP Shaper		P-value
	Mean	SD	Mean	SD	Mean	SD	
3 mm	0.14 ^A	0.10	0.12 ^A	0.16	0.07 ^B	0.06	0.023*
5 mm	0.19 ^A	0.13	0.21 ^A	0.15	0.05 ^B	0.04	0.001*
7 mm	0.22 ^A	0.09	0.14 ^B	0.11	0.08 ^C	0.06	0.001*
Total	0.18 ^A	0.07	0.16 ^A	0.11	0.07 ^B	0.04	<0.001*

*: Significant at $P \leq 0.05$, Different superscripts in the same row are statistically significantly different

TABLE (2): The frequencies (n), percentages (%) and results of Friedman’s test for comparison between direction of transportation among different root levels

System	Direction	3 mm		5 mm		7 mm		P-value
		n	%	n	%	n	%	
WaveOne	Distal	10	66.7	6	40	2	13.3	0.035*
	Mesial	5	33.3	7	46.7	13	86.7	
	No transportation	0	0	2	13.3	0	0	
One Shape	Distal	13	86.7	9	60	7	46.7	0.061
	Mesial	2	13.3	6	40	8	53.3	
	No transportation	0	0	0	0	0	0	
XP Shaper	Distal	8	53.3	11	73.3	6	40	0.175
	Mesial	5	33.3	4	26.7	9	60	
	No transportation	2	13.3	0	0	0	0	

*: Significant at $P \leq 0.05$

Centering Ability

The maintenance of canal curvature was better with One Shape (0.54 ± 0.11) and Xp Shaper (0.41 ± 0.15) as compared to WaveOne, which showed the statistically significantly lowest mean centering ratio (0.31 ± 0.12) (Fig 1)

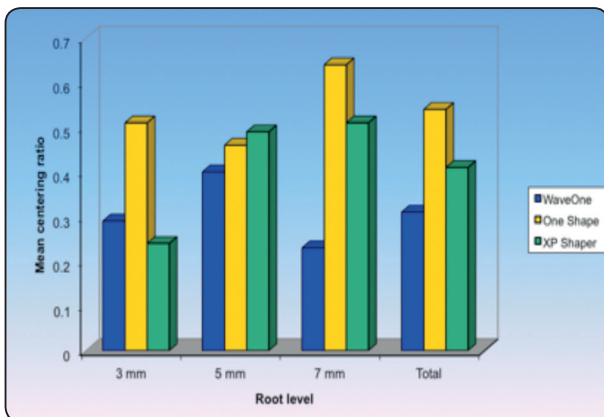


Fig. (1) Bar chart representing mean centering ratios after using the three systems

At the level of 3 mm from the apex; One Shape showed the highest mean statistically significant centering ratio (0.51 ± 0.32) and there was no statistically significant difference between WaveOne and XP Shaper instruments. At 5 mm level; there was no statistically significant difference among the three systems. Where, at 7 mm level; OneShape showed the statistically significantly highest mean centering ratio followed by XP Shaper followed by WaveOne.

DISCUSSION

Ever since *Schilder* advocates the concept of preparing the root canal in a funnel shape, while maintaining its original curve⁽⁸⁾; ideal cleaning and shaping of the root canal systems remains a very challenging procedure.

The American Association of Endodontists defined transportation as ‘Removal of the canal wall structure on the outside curve in the apical half of the canal due to the tendency of the files to

restore their original shape during canal preparation⁽⁹⁾. The treatment prognosis is adversely affected by the inappropriate pattern of dentin removal as it causes high risk of straightening the original canal curvature, increase the rate of debris extrusion and postoperative discomfort⁽¹⁰⁾.

In the present study, mesiobuccal canals of extracted first mandibular molars were chosen to provide conditions similar to the clinical situation and to allow realistic evaluation of the instruments performance⁽¹¹⁾.

It has been documented that increasing the size of the apical preparation may improve the irrigation and cleaning efficiency but lead to unnecessary dentin removal and increase the risk of canal transportation⁽¹²⁾. Thus, single file instruments were selected for this study.

CBCT was used as it allows detailed three-dimensional (3D) observation of the root canal forms with high-resolution images, faster acquisition and reconstruction scheme. CBCT is effective in measuring dentin thickness, apical transportation and canal centering⁽¹³⁾.

Two parameters were assessed in the study: Apical transportation which can jeopardize efficient sealing of the root canal subsequently, reducing the treatment outcome and maintenance of the canal centering which is a primary requisite on preparing curved root canals⁽¹¹⁾.

Results showed that at the levels of 3 and 5 mm from the apex; there was no statistically significant difference between WaveOne and OneShape; both showed the highest mean amount of transportation, compared to XP Shaper. This could be attributed to the tip diameter corresponding to a size 25 for both WaveOne and the primary OneShape instrument comparable to size 17 which XP Shaper initially started with.

At the level of 7 mm from the apex; WaveOne showed the highest statistically significantly mean

amount of transportation followed by OneShape, while the XP Shaper showed the statistically significantly lowest mean amount of transportation. There is an inverse relationship between instrument tapering and canal transportation⁽¹⁴⁾. WaveOne instrument has an 8% taper over the first 3 millimeters that decreases to 4.3% and 5.5%, respectively and the primary OneShape instrument has a constant 6% taper. While, XP shaper possesses initial 1% taper through its whole length which expands to a final 4% taper^(15,5).

As regards the overall canal transportation; the results of this study showed that XP Shaper showed the lowest statistically significantly mean amount of transportation, while both WaveOne and OneShape instruments showed highest mean amount of transportation with no statistically significant difference between them.

The excellent results of XP Shaper can be attributed to its Adaptive Core, where it can expand while maintaining the original canal curvature⁽⁵⁾. XP applies minimal stress to the dentin walls, thereby can adapt easily to the canal irregularities⁽¹⁶⁾.

On the other hand, the attitude of OneShape instrument in the canal could be explained by its asymmetrical cutting edges. This design feature when combined with continuous rotation at a relatively high speed (350 rpm) cause the instrument to progress into the curved canals, creating some stress that might result in the observed apical transportation⁽¹⁵⁾.

While The results of our investigation cannot be compared directly with those of *Azim et al*⁽⁵⁾ because of the different file systems used, both results are consistent, they revealed that XP Shaper was superior to Vortex Blue in terms of shaping ability, where the file created nonuniform preparation adapting to the complex canal anatomy

Our results came in agreement with *Agarwal et al*⁽¹⁷⁾ and *Alrahabi and Alkady*⁽¹⁸⁾, who showed no

statistically significant difference between WaveOne and OneShape instruments in canal transportation. *You et al.*⁽¹⁹⁾ reported similar transportation for reciprocation motion and conventional continuous rotation technique. Also, *Capar et al.*⁽²⁰⁾ investigated six rotary file systems (ProTaper Next, ProTaper Universal, classical OneShape, Reciproc, Twisted File Adaptive, SM2, and WaveOne) and reported no significant difference among them in terms of transportation and canal curvature.

There have been contradictory results with *Saber et al.*⁽¹⁵⁾ who compared WaveOne, Reciproc, and OneShape. In that study, the use of OneShape files resulted in significantly greater apical transportation than WaveOne. Also, other studies declared that WaveOne system preserved the original canal curvature better than the OneShape system^(21,22).

However, it has to be declared that *Wu et al.*⁽²³⁾ reported that apical transportation of more than 0.3 mm can negatively affect the sealability of filling material. In the present study none of the rotary systems used caused more than 0.2 mm apical transportation.

Results showed that on using the WaveOne instrument, more distal canal transportation was apparent at 3 mm from the apex while at 7 mm level, results showed higher tendency toward mesial transportation.

These results confirm that as the diameter of the files increases, there is an increased tendency for canal transportation⁽¹⁰⁾. While OneShape and XP Shaper instruments showed no statistically significant difference among the different root levels. So, it can be postulated to avoid apical enlargement of curved canals with instruments of taper greater than 0.06.

Sinai documented that aggressive instrumentation in the cervical third of the root canal may lead to strip perforations and subsequently inflammatory complications⁽²⁴⁾. Less transportation towards this

area can be considered a favorable feature for the Wave One and XP Shaper instruments.

Agarwal et al.⁽¹⁷⁾ showed that at 3-mm above the apex ProTaper and WaveOne groups showed transportation towards the lateral side of the canal curvature while the OneShape group remained centred, which collaborate with the results of this study.

This result differs from previous studies that indicate that the apical segment usually has more canal transportation toward the outside of the curve⁽²⁵⁾.

Our results demonstrated that at the level of 3 mm from the apex; OneShape showed the highest mean statistically significant centering ratio and there was no statistically significant difference between WaveOne and XP Shaper instruments. Ni-Ti instruments are non-aggressive by nature and exert less force on the canal walls as they need less stress to bend causing less cutting on either side⁽²⁶⁾.

At 5 mm level; there was no statistically significant difference among the three systems. Where at 7 mm level; OneShape showed the statistically significantly highest mean centering ratio followed by XP Shaper followed by WaveOne. These findings can be related to that instruments with constant taper in the apical section produce good centering ability compared to instruments with progressive tapers along the cutting surface⁽²⁷⁾.

As regards total centering ratio; OneShape showed the statistically significantly highest mean centering ratio (0.54 ± 0.11) followed by XP Shaper (0.41 ± 0.15) followed by WaveOne (0.31 ± 0.12), which showed the statistically significantly lowest mean centering ratio. The superiority of OneShape instrument may be attributed to its design that progressively changes from variable 3-cutting edges at the tip to an S-shaped 2 cutting edges near the shaft⁽²⁸⁾. The snake-like motion aid to preserve the original canal shape due to the offset rotation center

causing the file to engage and disengage along the canal wall, thus reducing the stresses between the file and the canal wall⁽¹⁸⁾.

Whereas, WaveOne instrument showed low centering ability as it is considered a relatively large rigid single file with more taper that moves apically till reaching the working length creating a piston effect⁽²⁹⁾.

The finding of this research is consistent with previous results obtained by different authors, *Saleh et al*⁽³⁰⁾ who showed that canals prepared with the F360 and OneShape systems were better centered than those prepared with Reciproc and WaveOne systems. *Agarwal et al*⁽¹⁷⁾ showed that OneShape group had less transportation and remained more centered than WaveOne group, however the differences were not statistically significant, whereas its contradicted by those of *Dhingra et al*⁽²²⁾, and *Tambe et al*⁽²¹⁾ who showed the superiority of WaveOne system over OnesShape in terms of centering ability.

CONCLUSIONS

According to the results of the present investigation, the null hypothesis was rejected because significant differences were obtained between the 3 single-file systems regarding their shaping ability, the Xp shaper represents a new generation of rotary files that can be classified as an adaptive core instrument which can expand beyond its nominal size, its small mass and expanding properties appear to better preserve the original shape of the canal than OneShape and WaveOne NiTi systems.

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