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Evaluation of Canal Transportation and Centering Ability of Curved Canal Prepared by Two Rotary Systems

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ABSTRACT

Purpose: The aim of this study was to evaluate canal transportation and centering ability ratio of 2 single Ni-Ti instruments; one shape and wave one gold using Cone Beam Computed Tomography scanning (CBCTs). **Materials and Methods:** Forty mesiobuccal canals of human mandibular first molars with a curvature angle that ranges from 15° to 35° were divided into 2 groups based on the type of instrument used to prepare the canal. Group I: instrumented with one shape and Group II: instrumented with Wave One Gold. Pre and post preparation, canals were scanned using CBCT scanner to evaluate the amount of canal transportation and centering ability ratio at coronal, middle, and apical parts of root canal system. **Results:** There was no statistical significance difference between the two tested groups ($P<0.05$) in canal transportation and centering ability. C**onclusion:** Both one shape and wave one gold systems preserving the canal's original form.

KEYWORDS

Canal transportation, centering ability, one shape, wave one gold

INTRODUCTION

Achieved root canal (RC) treatment success is contingent upon the use of chemo-mechanical approaches to shape the RC structure into a constantly tapering preparation and to completely decontaminate the canal of both organic and inorganic substrates [(1)].

- Paper extracted from master thesis titled " Evaluation of Canal Transportation and Centering Ability of Curved Canal Prepared by Two Rotary Systems."

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The evaluation of the RC curvature is important for the clinical purposes [2]. Indeed, curvature of the root canal to an extreme degree has been identified as a possible risk factor that may impair treatment results and result in complications such as RC transportation, forming of ledges, and instrument separation [3].

Transportation is described in the AAE as "the elimination of canal wall structure in the apical half of the canal on the outside curve because of files tendency to revert to their initial linear form during intra-canal instrumentation" [4]. While, centering ability is defined as the ability of the instrument to remain centered in the root canal system during intra-canal instrumentation [5].

Using of rotary NiTi instruments with super-elastic properties has considerably simplified endodontic treatment. Due to the super-elasticity of Ni-Ti instruments, they are suitable for the preparation of curved root canals with minimal stress and bend to follow the canal's anatomical curvature, resulting in less canal transportation [6].

Advances in endodontic RC treatment was based on the principle that "less is better". Following that, a single file technique has developed for the purpose of shaping canals, regardless of the diameter, length, or curvature of their bodies. Nickel-Titanium single file systems has been implemented into endodontics because they increase the efficiency of root canal preparation, provide predictable treatment outcomes, and cause less iatrogenic harm, including in severely curved canals [7].

Numerous single file system has been promoted to be used in preparation of root canal with a single instrument using continuous rotation or reciprocation motion. One Shape is a single instrument that rotates fully clockwise (CW). It is constructed of a traditional austenite 55-Ni-Ti alloy and features a variety of cross-sectional designs and variable pitch along its length [8]. While, Wave One Gold is another single-file instrumentation term that is used reciprocally. It is constructed of gold-plated wire, parallelogram-shaped cross section with two cutting edges and an off-center design [9].

Cone Beam Computed Tomography (CBCT) is a non-invasive procedure that enables proper representation of various canal segments with increased precision and accuracy, thus providing tool for evaluating action of various endodontic instruments in various sections of the RC system and suitable for in vitro studies [10].

The aim of this study was to evaluate canal transportation and centering ability ratio of 2 single Ni-Ti instruments one shape which used in continuous rotation movement and Wave one gold which used in reciprocation movement using CBCT.

MATERIALS AND METHODS

Forty anonymous permanent mandibular first molars which were extracted for periodontal or prosthodontic reasons were collected from the clinic of oral and maxillofacial surgery at Faculty of Dental Medicine for Girls, Al-Azhar University. The use of extracted human teeth was ethically approved in accordance with the guidelines of the Research Ethics Committee (REC), Faculty of Dental Medicine for Girls, Al-Azhar University (Code:REC-EN-21-05). Periapical radiographs were taken prior to treatment to evaluate the mesial roots and to determine the angle of root curvature according to Schneider's method [11].

Specimen preparation

Two K-files #10 were used in the mesiobuccal and mesiolingual canals to confirm the presence of the two distinct mesial canals. Instrumentation was limited to the mesiobuccal canals. The apical foramen was checked for patency, and by subtracting 1mm from the apex, the working length was determined. Roots were vertically mounted in Zetaflow rubber base impression inside lower plastic arch. To ensure uniformity pre and post scanning, the long axis of the plastic arch must be parallel to long axis of the mold.

All roots have been scanned using CBCTs system at 75kV and 15 mA to determine the canal shape before instrumentation. For each specimen, according to the distance from the root apex three tomographs were selected as follow; 3 mm corresponding to the apical third, 5mm corresponding to the middle third and 7mm corresponding to the coronal third.

A #15 K- file was used to establish a glide path. The samples were divided into 2 equal groups randomly (n = 20 each) as follow;

Group I (One Shape): RCs were shaped with One Shape rotary file (0.06/25) with the motor set to 400 rpm / 4-N/cm torque.

Group II (Wave One Gold): RCs were shaped with the Wave One Gold (0.07/25) group reciprocating files in 150 degree CCW and 30 degree CW direction.

Root canal preparation was performed using MARATHON™ endo-motor with apex locator was used. During the instrumentation procedure, irrigation of 5 ml of 2.6% sodium hypochlorite using conventional syringe and 30G needle placed 1 mm from the WL.

After root canal preparation of all samples, it was scanned using CBCT in the same pre-instrumentation scanning protocol. The shortest distance between the root's periphery (mesial and distal) and the mesiobuccal canal's edge was determined using length tool on reconstructed cross-sectional images of the pre- and post-instrumentation scanning. Where, **M1 and M2**: are the shortest distance between the root's mesial edge and the un-instrumented and instrumented canal's mesial edge respectively. While, **D1 and D2:** is the shortest distance between the distal edge of the root and the un-instrumented and instrumented canal's distal edge respectively. To determine the degree of canal transportation, this formula was used;

Canal transportation = (M1 - M2) - (D1 - D2)

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

Statistical analysis

The mean values and standard deviation were determined for each group in each test. The Kolmogorov-Smirnov and Shapiro-Wilk tests were used to check for normality, and the results revealed a non-parametric (not-normal) distribution. To compare two groups of unrelated samples the Mann Whitney test was used. To equate more than two groups in similar samples, the Friedman test was used. To compare between two groups in related samples, Wilcoxon test was used. The significance level was set at $P \leq 0.05$.

RESULTS

Canal transportation

Comparing the two tested groups within each canal level revealed no statistical significant difference in canal transportation mesiodistally or buccolingually between the two tested groups ($P < 0.05$).

Regarding the results of both groups I (One Shape) and II (Wave One Gold) at MD direction; statistical significant difference was found between (coronal) and each of (middle) and (apical) levels. However, there was no statistical significant difference was found between (middle) and (apical) levels ($P < 0.05$).

On the other hand, at BL direction in group I (One Shape); statistical significant difference was found between (apical) and each of (coronal) and (middle) levels. While, there was no statistical significant difference was found (coronal) and (middle) levels ($P < 0.05$). While, in group II (Wave One Gold); there was no statistical significant difference between coronal, middle and apical levels. (Table 1, Fig. (1-3)

Table (1): *The mean values and standard deviation (SD) for canal transportation mesiodistally and buccolingually of the two groups.*

Canal transportation	Variables	Group I One Shape		Group II Wave one gold		*P*-value
		Mean	SD	Mean	SD	
MD	Coronal	0.17	0.19	0.19	0.11	0.686
	Middle	0.34	0.17	0.31	0.15	0.558
	Apical	0.35	0.25	0.33	0.18	0.773
	P-value	0.014*		0.012*		--------
BL	Coronal	0.27	0.21	0.19	0.21	0.236
	Middle	0.22	0.22	0.24	0.31	0.815
	Apical	0.11	0.10	0.15	0.15	0.207
	P-value	0.028*		0.271		--------

(*) = significance difference (P<0.05)

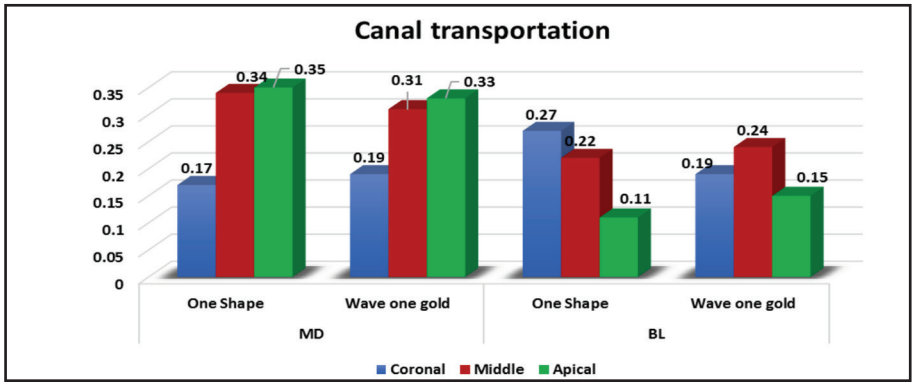
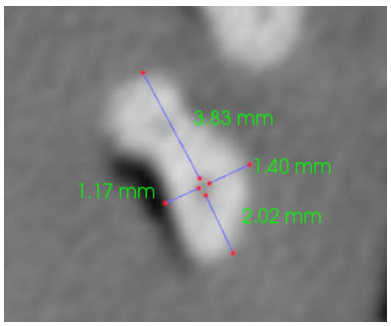
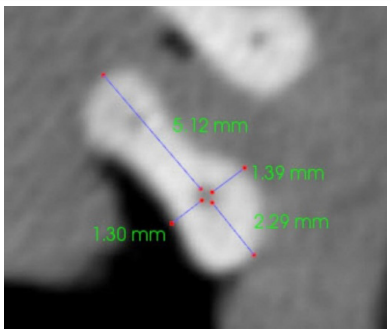
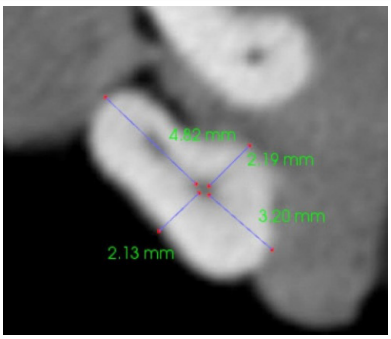


Figure (1): A bar chart representing canal transportation in the two groups at the three canal levels mesiodistally and buccolingually.

Pre instrumentation		
a- Apical (3mm)	b- Middle (5 mm)	c- Coronal (7 mm)
		

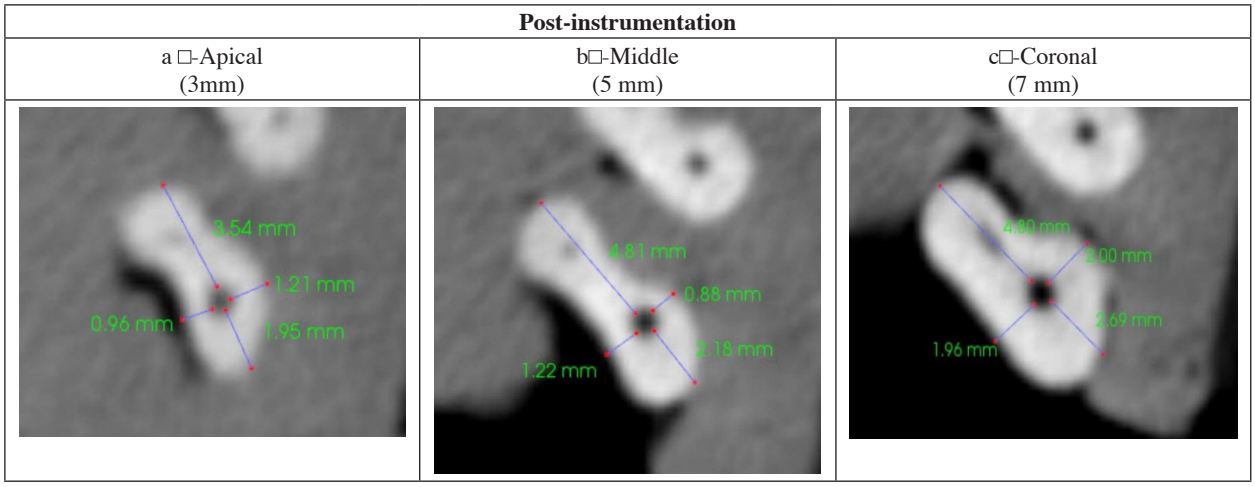


Figure (2): CBCT pre-and post-instrumentation images of a specimen prepared with One shape instrument; a, a□)At 3mm; b, b□) at 5mm and c, c□)at 7mm from the anatomic apex.

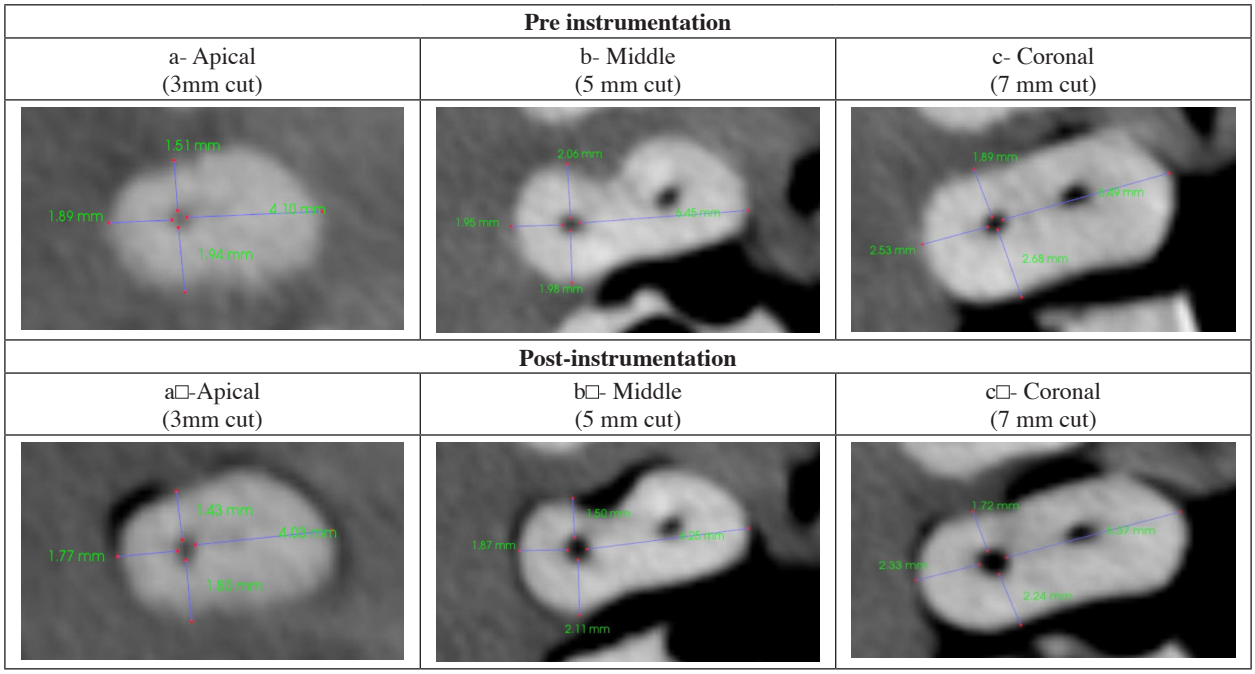


Figure (3): CBCT pre-and post-instrumentation images of a specimen prepared with Wave One gold instrument; a, a□)At 3mm; b, b□) at 5mm and c, c□)at 7mm from the anatomic apex.

Centering ability

When the two tested groups were compared within each level, no statistical significant difference in their ability to center themselves mesiodistally or buccolingually was observed (P <0.05).

Regarding the results of both groups I (One Shape) and II (Wave One Gold) at MD direction; statistical significant difference was found between (coronal) and each of (middle) and (apical) levels. However, there was no statistical significant difference was found (middle) and (apical) levels, where (P <0.05).

On the other hand, at BL direction in group I (One Shape); statistical significant difference was found between (apical) and each of (coronal) and (middle)

levels. While, there was no statistical significant difference was found coronal and middle levels (P <0.05). While, in group II (Wave One Gold); there was no statistical significant difference between coronal, middle and apical levels (P <0.05). (Table 2, Fig. (4)

Table (2): *The mean values and standard deviation (SD) of the centering ratios mesiodistally and buccolingually of the two groups.*

Centering ability	Variables	One Shape		Wave one gold		P-value
		Mean	SD	Mean	SD	
MD	Coronal	0.41	0.19	0.48	0.25	0.499
	Middle	0.13	0.11	0.08	0.05	0.091
	Apical	0.13	0.13	0.15	0.09	0.297
	P-value	<0.001*		<0.001*		--------
BL	Coronal	0.27	0.25	0.39	0.29	0.169
	Middle	0.31	0.17	0.41	0.23	0.126
	Apical	0.49	0.29	0.46	0.24	0.720
	P-value	0.017*		0.680		--------

(*) = significance difference (p<0.05)

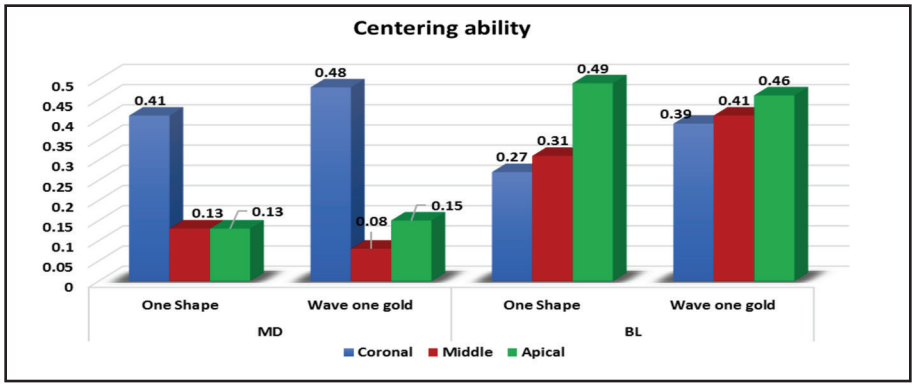


Figure (4): Bar chart representing centering ability in the two groups at all three canal levels mesiodistally and buccolingually.

DISCUSSION

One of the most important principles of shaping of the root canal system to maintain the original canal anatomy while striving for continuous tapering preparation. The ability of endodontics file to respect the anatomy of the canal is vital to prevent the procedural errors that may occur in various part of the root canal [12].

Over the years, a diverse variety of Ni-Ti instruments for RC shaping has been introduced. Ni-Ti instruments have provided for safer, faster canal preparation and improved preservation of the original canal since their introduction into endodontics [13]. Instead of continuous rotation motion, a modern instrumentation technique was used, which used a single file in reciprocation motion [14]. While some research documented the reciprocating motion's superior efficiency, others demonstrated that rotary files resulted in more centralized preparations and fewer transportation [15, 16].

One shape (OS) and Wave One Gold (WOG) are newly implemented single files that vary significantly in terms of geometric architecture, manufacturing processes, and kinematic. As such the aim of this study was to see if endodontic file design and motion affect canal transportation and centering ability [17].

The mesiobuccal canal of the mandibular first molar was selected because it is one of the most complex curved RCs of human teeth [18]. Crowns at the cementoenamel junction is resected to eliminate coronal intrusion that could impair the instrumentation operator's file power.Samples were flattened to a length of 16 mm to ensure uniformity [19].

Three ranges were selected for this study: 3, 5, and 7 mm from the apex. These dimensions correspond to the apical, middle, and coronal thirds of RCs, which usually have curvatures that are highly susceptible to iatrogenic mishaps [20]. Since the amount of canal transportation increases as the size of the apical preparation reaches 25 the apical preparation was limited to a register of size 25 [21].

The results of this study showed that there was no statistical difference between the tested instruments. These results are in agreement with several previous studies [22,23]. Santa-Rosa et al[24] when comparing WaveOne and OneShape single-file systems in the preparation of mesiobuccal root canals of maxillary molars with severe curvatures found similar canal transportation between groups and minor changes in the canal curvature, corroborating with the results of the present study.

In contrast, Saber et al.[25] when using X-ray analysis compared the preparation of severe curved root canals, using WaveOne, Reciproc and OneShape, and observed a greater apical transportation when using the OneShape system. Similarly, Dhingra et al.[22] showed that WaveOne preserved canal shape better than OneShape file, however the authors used Endo Training Blocks and pre and post-digital images as a method. The difference found between Saber et al.[25] and Dhingra et al.[22] results and the results of the present study may be related to the employed methods.

Regarding the result of One shape group, it could be related to its design, where it has crosssection with three regions; the first zone includes a variable three-cutting edge configuration, while the second zone moves from three to two cutting edges[26] and the final area contains two cutting edges. This asymmetrical cutting profile strengthens the instrument's snake-like flow through the canal while maintaining the canal's original shape. In addition to electro polishing and flexibility, this design can result in improved apical advancement with less transportation [27].

For Wave One Gold; this result is possible for a variety of reasons, one of which is the reciprocation motion which allows for the preservation of the canal's original form in curved roots during instrumentation[28]. Another explanation is that the metallurgy of the wire, which is commercially known as Gold wire, produces a more clinically ideal metal than Ni-Ti does directly, from a phase

transition point between martensite and austenite that generates the Primary Wave One Gold file which is more flexible [29]. Additionally, the new cross-section (parallelogram with two 85-degree cutting edges), which alternates with the new metal of Wave One Gold in one or two touch points with the canal wall, improves shaping by preserving apical curved canals while reducing the capacity for canal transportation [30].

Regarding One Shape rotary file canal transportation and centering ratios at MD direction; the results showed a statistically significant difference between (Coronal) and each of (Middle) and (Apical) levels with low mean value of canal transportation coronally and high mean value of canal transportation apically. Subsequently high mean value of centering ratios coronally and low mean value of centering ratios apically. This impact can be demonstrated by the asymmetrical cutting edges of One Shape file. When combined with a continuous rotating speed of 350 rpm allowing the instrument to advance through the curved canals, producing stress and perhaps leading to the observed apical transportation [25].

However, concerning BL direction; canals prepared with One Shape rotary file showed a statistically significant difference between (Apical) and each of (Coronal) and (Middle) levels with low mean value of canal transportation apically and high mean value of canal transportation coronally. Subsequently high mean value of centering ratios apically and low mean value of centering ratios coronally. This may be due to the cross-sectional configuration of the mesiobuccal canal which tends to be oval in the coronal third rather than circular in the apical third which tends to give a less uniform canal preparation because more round RC section is associated with better adaptation to the file motion within the canal with more centered preparation [31].

Regarding Wave One Gold reciprocating file canal transportation and centering ability at MD direction; there was a statistically significant difference between (Coronal) and each of (Middle) and (Apical) levels with low mean value of canal transportation coronally and high mean value of canal transportation apically. Subsequently high mean value of centering ratios coronally and low mean value of centering ratios apically. This may be explained by the fact that Wave One Gold features a constant taper from D1 to D3, followed by regressive taper from D4 to D16. According to various studies [32,33], instruments with a constant taper demonstrated superior centering ability ratio when compared to a progressively tapered instrument. Moreover, it may be due to greater taper of Wave One Gold (0.08 taper), increased taper results in the accumulation of greater magnitudes of internal stress, diminishing the file's stability and increasing the probability of canal transportation [34].

CONCLUSION

Both One Shape and Wave One Gold preserving the canal's original form.

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RECOMMENDATION

Further studies are recommended to evaluate whether endodontic cavity access influences the mechanical preparation of curved root canal system.

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None declared.

CONFLICT OF INTEREST

There are no conflicts of interest declared by the authors.

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