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Comparative analysis of canal transportation using reciproc blue and wavo one gold in simulated root canals using different kinematics

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A B S T R A C T

Objective: The purpose of the current study was to assess and compare the shaping ability of WaveOne Gold and Reciproc Blue in reciprocation and counter clock wise rotation using standardized resin blocks and to assess time required to reach full working length.

Methodology: A total of 52 curved canals in clear resin blocks with 30° angle of curvature and 16 mm canal length were used in this study. The blocks were divided into 4 groups according to the instrument and motion utilized into: Reciproc Blue/Reciprocation (RB/R) group, Reciproc Blue/counter clock wise rotation (RB/CCW) group, WaveOne gold/Reciprocation (WG/R) and WaveOne gold/Counter clock wise rotation (WO/RCR). Standardized digital images were taken prior and post instrumentation. Then, Adobe Photoshop was used to superimpose post and pre-instrumentation images to evaluate the degree of canal transportation. Digital chronometer was used to record the time required for canal preparation. One-way ANOVA followed by Tukey post hoc test was used to compare between more than two groups in non-related samples.

Results: No statistically significant difference was noted among all groups at the apical and middle thirds levels. As for the preparation time, both groups; RB/R and RB/CCW recorded significantly longer time than groups; WG/R and WG/CCW ($P < 0.001$).

Conclusions: The use of single-file in counter clock wise rotation showed favourable results in terms of avoiding canal transportation and preparation time.

1. Introduction

Shaping of the root canal is a critical step in endodontic treatment as it affects the subsequent (see Fig. 3).

Phases of irrigation, obturation and the long-term success of the treatment [1]. Mechanical preparation of the root canal should retain the shape and direction of the initial canal anatomy. However, creating such an ideal preparation in curved canal is challenging [2]. Aggressive instrumentation exereted on the root canal walls results in dentin loss which may weaken the tooth structure [3] (see Fig. 2).

Since the introduction of NiTi instruments in1992, many advantages have been granted over stainless steel files such as: maintenance of the initial canal architecture and prevention of zipping, ledge creation and perforation [4]. Yared in 2008 [5], was the first to implement the use of NiTi instruments in reciprocating motion. The alternating changes in the direction of rotation (reciprocation) provide the following advantages over the continuous rotation: Less frequent binding of the instruments into the root canal dentine walls, reduction of the torsional and flexural stresses on the instrument and faster preparation time [6–8].

Recently, different single-file systems have been introduced to the market with the capacity of simplifying the instrumentation procedure while decreasing the risk of instrument fracture and cross-contamination [9] The single-file reciprocating systems can prepare the root canals with different working motions using only one instrument, thereby they reduce the shaping time while sustaining the original canal curvature when compared to conventional rotary systems [10]. The recently introduced WaveOne Gold (Dentsply Maillefer, Ballaigues, Switzerland) and Reciproc Blue (VDW, Munich, Germany) systems are manufactured from special NiTi alloy called M-wire, which is fabricated by a new thermal treatment procedure. M-wire alloy is characterized by an enhanced flexibility and cyclic fatigue resistance in comparison with the martensitic NiTi. Waveone Gold is available in sizes: 20.07, 25.07, 35.06, 45.05, while Reciproc Blue is available in sizes 25.08, 40.06,

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50.05. These instruments are utilized in a reciprocating motion, where the values of clockwise/counter clockwise rotations are set by the manufacturer. The angle of counter-clockwise (allows the instrument to progress towards the apex) is greater than that of the clockwise (allows file disengagement and eliminates the binding of the instrument [11].

To our knowledge, none of these systems were tested to work in continuous counter clock wise rotation, Thus, the purpose of the present study was to compare the shaping ability of WaveOne gold and Reciproc Blue in reciprocation and the newly introduced counter clock wise rotation using standardized resin blocks. The null hypothesis tested was that there is no difference between the selected single-file systems regarding canal transportation or preparation time when using different rotary motions, in simulated curved canals.

2. Materials and methods

2.1. Sample size calculation

Sample size calculation was done using IBM® SPSS® Sample Power® Release 3.0.1. Based upon the results of Saber et al. (2015) [12], the minimum estimated sample size was 13 specimens per group.

2.2. Selection of the samples

A total of 52 curved canals in clear resin blocks (Dentsply, Maillefer) were employed in this study. The angle of curvature was set as 30° and was of 16 mm canal length. All simulated canals has diameter and the taper equivalent to an ISO standard size 15 with a 2% taper root canal instrument. The blocks were numbered from one to fifty-two (B1-B52) and then assembled into four groups. Each group consisted of thirteen blocks. For all the canals, a #15 hand K-file (Dentsply Maillefer, Ballaigues, Switzerland) was used to set the working length at the level of the apical foramen.

2.3. Pre-operative images

Prior to instrumentation, standardized digital images were obtained by placing a size 15 K-file in the canal. To establish a fixed camera-object position, each block was inserted in fixation mount made of silicone-based impression material (Optosil P Plus; Heraeus Kulzer, Hanau, Germany).

2.4. Canal instrumentation

The blocks were divided into four groups: Reciproc Blue/Reciprocation (RB/R) group, Reciproc Blue/counter clock wise rotation (RB/CCW) group, WaveOne gold/Reciprocation (WG/R) and WaveOne gold/Counter clock wise rotation (WO/RCR).

Primary WaveOne gold (25/07) and Reciproc Blue25(25/08) files worked in a reciprocating motion using a torque-limited electric motor (Silver Reciproc, VDW) using pre-set adjustments, while the counter clock wise rotation was performed using an electric motor (Endoest motor mini) adjusted at 300RPM/3N.

All the files worked in a slow in and out pecking motion with an amplitude of about 3 mm. The flutes of the instruments were cleaned after three in and out motions. The canals were irrigated with 2 mL of a 2.5% NaOCl solution (Clorox, Cairo, Egypt) using a 27- gauge needle (NaviTip; Ultradent, South Jordan, UT, USA) that was inserted without binding into the canal. Once the file had reached the end of the canal and freely rotate, it was removed.

As recommended by the manufacturer, single-file systems are used for a single patient, thereby, each instrument prepared only four canals, Then, post-operative images were taken in the same way as described before.

A digital chronometer (Timex, Middlebury, CT, USA) recorded the time taken for canal preparation. The recorded time included: active instrumentation, cleaning of the file flutes as well as the irrigation and excluded the time taken for working length adjustment.

Canal instrumentation was carried out by a single operator, while a second examiner who was blinded from the experimental groups, performed the assessment of the canal transportation.

The acquired digital images were transferred to a digital imaging software (Adobe Photoshop Version 7, Adobe System Inc., San Jose, CA, USA). The program superimposed the pre-and post-instrumentation images, where the amount of resin removed was measured at the mesial and the distal sides of the canal. Measurements were taken one-dimensionally at three measuring points 1,5,10 mm from the apical terminal of the canal using the NIH ImageJ software(National Institutes of Health, Bethesda, MD, USA). All the measurements were taken at right angle to the surface of the canal. Canal transportation was assessed by comparing the difference between the mesial and distal recorded measures. Any change in the working length, the number of deformed and fractured and instruments were documented.

2.5. Statistical analysis

One-way ANOVA followed by Tukey post hoc test was used to compare between more than two groups in non-related samples. Repeated measure ANOVA was used to compare between more than two groups in the related samples. Paired sample-test was used to compare between two groups in related samples.

The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

3. Results

3.1. I-canal transportation results

3.1.1. Effect of file type and motion on transportation in all levels

No statistically significant difference was noted between all groups at the apical and middle levels ($P = 0.482$, 0.846 respectively). However, groups RB/R and RB/CCW exhibited significantly less transportation values than Groups WG/R and WG/CCW in the coronal level ($P < 0.001$).

3.1.2. Effect of root level on transportation in each group

In Groups RB/R and RB/CCW, the mean transportation value recorded at the middle level was significantly lower than the apical and coronal levels with no significant difference in between them ($P = 0.024$).

While in Groups WG/R and WG/CCW**, a** statistically significant difference was noted between apical, middle and Coronal levels where ($p < 0.001$).

The highest mean value was found in the coronal third followed by the apical third, while the lowest mean value was found in the middle) third. Table 1.

3.1.3. II-time results

Groups; RB/R and RB/CCW recorded significantly longer time than groups; WG/R and WG/CCW ($P < 0.001$).

No statistically significant difference was found between RB/R & WG/CCW. Table 2 and Fig. 1.

4. Discussion

During clinical treatment of curved root canals, conservation of the canal anatomy is of prime concern irrespective of the instrument type or the instrumentation technique. The efficiency of instrumentation techniques can be reflected in terms of: canal transportation and the preparation time. Where, the incidence of canal transportation may jeopardize the treatment, resulting in: inadequately cleaned canals, over-reduced sound dentin and destructed root integrity [13]. While,

Table 1
The mean, standard deviation (SD) values of reciprocating transportation in different groups.

Variables	Canal Transportation						
	Apical		Middle		Coronal		p-value
	Mean	SD	Mean	SD	Mean	SD	
Group RB/R	.0650 ^{aA}	.00758	.0482 ^{aB}	.00277	.0706 ^{bA}	.00802	**0.024***
Group WG/R	.0682 ^{aB}	.00497	.0478 ^{aC}	.00642	.0828 ^{aA}	.00526	**< 0.001***
Group RB/CCW	.0658 ^{aA}	.01026	.0476 ^{aB}	.00654	.0690 ^{bA}	.00474	**0.020***
Group WG/CCW	.0716 ^{aB}	.00410	.0504 ^{aC}	.00564	.0926 ^{aA}	.00522	**< 0.001***
p-value	**0.482ns**		**0.846ns**		**< 0.001***		

Superscripts with different small letters indicate statistically significance difference within the same column. Superscripts with different Capital letters indicate statistically significance difference within the same row*; significant ($p \leq 0.05$) ns; non-significant ($p > 0.05$).

Table 2
The mean, standard deviation (SD) values of time in different groups.

Groups	Time	
	Mean	SD
Group RB/R	68.09 ^{ab}	12.46
Group WG/R	37.52 ^{c}	10.24
Group RB/CCW	93.23 ^{a}	23.08
Group WG/CCW	45.73 ^{bc}	3.92
p-value	**< 0.001***	

Superscripts with different small letters indicate statistically significance difference within the same column. *; significant ($p \leq 0.05$) ns; non-significant ($p > 0.05$).

the preparation time demonstrates the clinical efficiency of the instrument. Considering the importance of root canal shaping, research on the shaping efficiency of a novel instrumentation technique is mandatory. Thus, the purpose of the present study was to compare the incidence of canal transportation and the required working time of WOG and RPC blue using a newly introduced counter-clockwise rotation (CCW) and reciprocating motion in curved canals.

Although examining the shaping ability on extracted teeth can be considered the best method to mimic the clinical conditions in terms of surface texture, hardness, and cross-sectional configuration the teeth cannot be anatomically standardized [14]. Thereby, the use of simulated canals in resin blocks enabled us to standardize the research design by excluding the parameters that could affect the outcome [15]. Where, the four groups were evened with respect to apical diameter, canal length, angle of curvature.

Both of the selected instruments (WG primary & RB 25) possess a tip diameter equivalent to a size 25 aiming to standardize the apical preparation size. Keeping in consideration that these files are designated for narrow and curved canals in accordance with the manufacturers recommendations. Preceding canal instrumentation, no glide path was established. However, all of the canals allowed passive placement of # 15 K-file to 1 mm of the apical foramen as recommended by the manufacturer when preparing a curved root canal.

According to the results of the present study, there was no significant difference between the canal transportation results among the four groups at the apical and middle sections of the canal. This can be justified in terms of:

(i) The similar manufacturing process used in the production of these super-elastic NiTi files. Whereas, WG is manufactured through proprietary thermal process (Ground NiTi files are heat-treated and slowly cooled) and post-machining procedure, producing the gold wire [16] While, the thermo-mechanical treatment of RB produced a reduced shape memory giving more flexibility [17].
(ii) The diameter of the core as well as the cross-sectional area of NiTi files have a substantial impact on their shaping ability. Where, both instruments had similar apical diameter of size 25 that showed fixed taper over the first 3 mm, with slight difference in the degree of taper (07 &08) for WG and RB respectively. As for the cross-section, WG has an alternating offset parallelogram-shaped cross-section, with two 85° cutting edges in contact with the canal wall, having only one cutting edge in contact with the canal wall. Thus, reducing the contact between the file and dentin to only 1 or 2 points at any cross-section. Thereby, the taper-lock is reduced. While, RB bears an S-shaped cross-section, with two cutting edges.
(iii) Both systems utilize unequal CCW/CW angles, with larger CCW rotation angle, overcoming the limitations associated with systems having equal CW/CCW angles. This unequal motion enables the files to possess high cutting efficiency, proceed toward the working length more readily without the need for excessive inward pressure

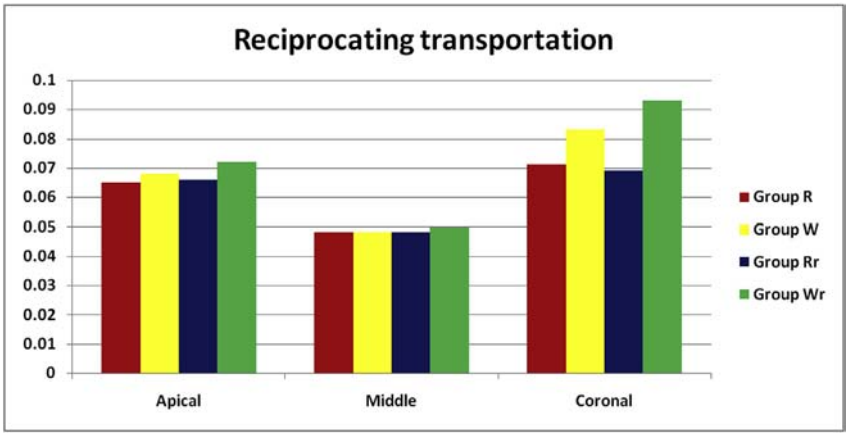

Fig. 1. Bar charts representing results in different groups when comparing the four groups within each level of the canal.

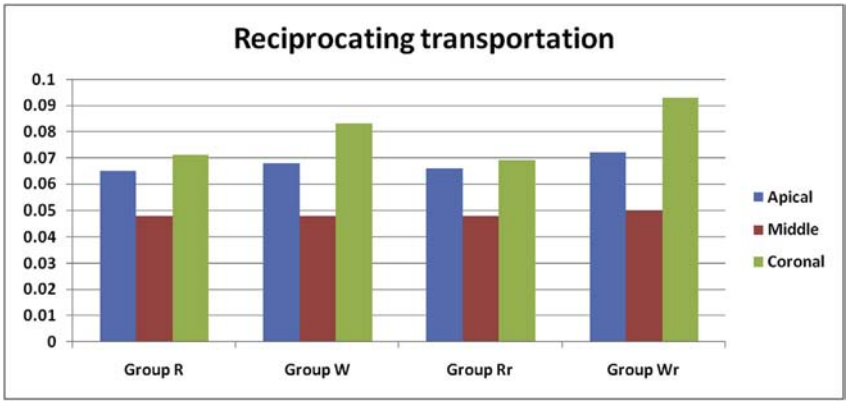

Fig. 2. Barchart representing transportation in different groups at all three canal levels.

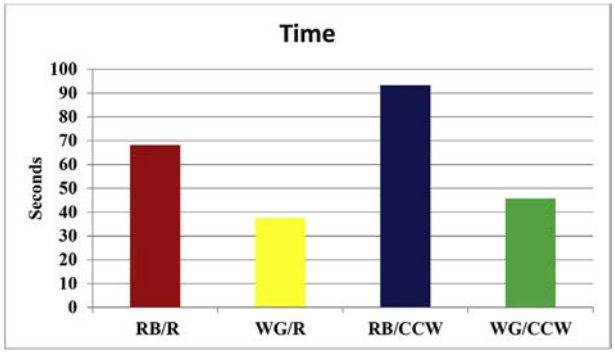

Fig. 3. Bar chart representing time in different groups.

and enhance auguring debris out of the canal [18,19].

Though primary WG shows progressive decrease in taper over the working length, which serve to preserve dentin., groups RP/R & RP/CCW exhibited significantly less transportation values than Groups WG/R & WG/CCW in coronal level. This can be attributed to the regressive taper RB possess, starting at 3 mm from the tip till it reaches a diameter of 1.05 mm at D16. It was stated that it has an increased resistance to cyclic fatigue and produces greater flexibility.

Our concept in working with only CCW rotation, is that it represents the forward rotation in other words the cutting direction. This direction allows the files to proceed in the canal, engaging dentine and cutting it. Usually, the CCW engaging angle is designed to be less than the elastic limit of each file(18) However, there is insufficient information discussing the torsional elastic limit of NiTi instruments. Further, evidence on the appropriate angle for reciprocation with the conventional rotary instruments is still missing.

As no previous studies have compared the canal transportation of the RPC Blue and WOG systems, results of our present study cannot be directly compared with other studies. It was stated that the **shaping ability** of WOG has been improved in longer, narrower and curved canals. Where, the primary WOG file is 80% more flexible, 23% more efficient and 50% more resistant to cyclic fatigue when compared to Primary WaveOne file. Also, it was stated that its cross-section improves safety, increases cutting efficiency and provides more space to direct the debris coronally, when compared to the original WaveOne file [18]. According to the manufacturer, the cyclic fatigue resistance of RPC Blue files is approximately twice that of RPC files [20].

With regard to the tested instruments, the WOG implemented a significant shorter preparation time than the RCP Blue instruments regardless of the instrumentation method, possibly due to their active cutting properties. This can be attributed to the constant reverse helical angle design of 24° along the active length of the WOG instrument, which ensures little or no screwing in. Also, WOG has a semi-active, roundly tapered guiding tip, which reduce the mass of the centre of the tip. Thereby, the design features enable the file to easily move and safely progress through manually reproduced canals [12and18]. comparable to the RCP Blue non-cutting tip.

5. Conclusion

Within the limitations of this study, the concept of counter clockwise rotation can be introduced as a novel alternative to the reciprocating rotary shaping technique.

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