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SHAPING ABILITY OF WAVEONE GOLD AND RECIPROC BLUE WITH AND WITHOUT THE USE OF GLIDE PATH IN CURVED CANALS: A CBCT STUDY

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ABSTRACT

Aim: To compare the shaping ability of two reciprocal NiTi files with and without the use of glide path (GP) instruments in the preparation of curved root canals in terms of canal transportation and centering ability.

Materials and Methods: The mesiobuccal canals of sixty mandibular first molars were used in the study. Samples were divided into four equal groups (n=15) according to the mechanical preparation technique: WaveOneGold (WOG), WOG &GP, ReciprocBlue (RB), and RB &GP. Pre and postinstrumentation cone beam computed tomographic images (CBCT) were taken at 3, 5and 7mm from the apex and were evaluated to detect canal transportation and centering ability. Statistical analysis was performed with one-way ANOVA followed by Tukey's post hoc for the intergroup comparisons. While, repeated measures ANOVA followed by Bonferroni post hoc test were applied for intragroup comparisons.

Results: WOG showed significanthigh values of canal transportation than other groups ($p<0.001$). However, no significant differencewas detected in the values of centering ability measured at different distances from the apex for all the tested groups ($p>0.05$).

Conclusion: The use of Glide path significantly improved the behavior of WaveOne Gold (WOG) in terms of canal transportation. However, the use of Glide path with Reciproc Blue (RB) had no influence on the canal transportation or the centering ability.

KEYWORDS: Canal transportation, Centering ability, Glide path, Reciproc Blue, Wave One Gold

INTRODUCTION

The goal of endodontic treatment is to clean and shape the canal in a way that allows creation of the largest diameter at the orifice and the narrowest diameter at the apical tip. This ideal shape is very difficult to achieve in curved root canals or S-shaped root canals. Maintaining root canal anatomy is an important thing, especially when treating curved

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root canals [1]. Overzealous preparation of the canal walls causes unnecessary dentin reduction, which weakens the tooth structure. During root canal treatment, deviation from the initial root canal shape may occur and contribute a negative effect on the success of endodontic treatment. The efficiency of the preparation technique can be judged by the absence of procedural errors, i.e: canal transportation and lack of centrality. [2].

Huge progress has been implied on the field of mechanical root canal preparation. The enhancement of novel nickel titanium alloys, through improvements made to their properties, allows for the production of rotary instruments that can meet the requirements needed for root canal preparation. By this way, the incidence of instrument fractures and procedural errors can be considerably reduced.

The use of reciprocating rotary NiTi files allows for preparing the root canals in an asymmetric oscillatory motion. Researches has mentioned that reciprocal motion being superior to continuous rotation motion as it showed outstanding results in shaping curved canals [3,4].

WaveOne Gold file (WOG) (Dentsply, Maillefer, Ballaigues, Switzerland) is a reciprocating NiTi file that has an offset parallelogram cross-section. This design causes the cutting edges of the file to be in contact with the root canal walls at one or two points, thereby improving the efficiency and fracture resistance of the file [5].

The Reciproc Blue files (RB) (VDW, Munich, Germany) are identical to the Reciproc instruments (M wire) with improved metallurgical properties that were enhanced by the proprietary heat treatment [6]. The heat-treated gold and blue wire instruments are characterized by being pre-bendable and having a controlled reset effect. These files are more flexible than conventional NiTi files [7] and are more resistant to cyclic fatigue [8].

Another important aspect that is worth consideration is preparing a glide path along the working length of the canal. This step is recommended to be used in narrow and curved canals before the introduction of rotary instruments to the root canals. Preparing the glide path mechanically preserve the original course of the canal in a better way than when prepared with manual stainless-steel files [9]. The path created during glide path preparation allows for better centering ability of the succeeding files, thereby, reducing the procedural mishaps such as root canal transportation, ledge formation and instrument fracture [10]. Yet, till now, contradictory results regarding the benefit of introducing glide path NiTi files on the canal shaping have been conveyed. The aim of the present study was to compare the canal transportation and centering ability of two reciprocal NiTi files (WOG and RB) in the preparation of curved root canals with and without the use of glide path (GP) files. The null hypothesis was that there would be no significant difference among the tested groups.

MATERIALS AND METHODS

Sample size

A power analysis was designed to have adequate power to apply a statistical test of the null hypothesis would be found among the tested groups. By adopting an alpha level of (0.05) a beta of (0.2); power=80% and an effect size (f) of (0.441) calculated based on the results of a previous study (11); the predicted sample size (n) was a total of 60 samples (i.e. 15 samples per group). Sample size calculation was performed using G*Power version 3.1.9.7

Sample selection

A total of sixty permanent mandibular first molars collected from the Department of Oral Surgery, Faculty of Oral and Dental Medicine, Future University in Egypt were employed in the study. Peri-

apical radiographswere taken to inspect the angle of root curvature of the mesial roots according to Schneider's method [12]. Inclusion criteria were complete root formation, two separate canals present in the mesial root with separate foramina and the angle of curvature of the mesiobuccal canal (20°to 35). Teeth that showed resorptive defects, fractures or open apices were excluded from the study.

Sample preparation

Teeth were disinfected with 5.25% NaOCl then, decoronation and root separation was performed with a safe-sided diamond disc. Presence and patency of two separate mesial canals were established by simultaneous introduction of two #10 K-files (Maillefer, Ballaigus, Switzerland) in the canals. Mesiobuccal canals were utilized in this study. The working length was as 1 mm short of the apical foramen. Then, the roots were vertically mounted in a transparent acrylic resin (Acrostone, Dental & Medical Supplies, Cairo, Egypt) mixed according to the manufacturer's instructions in a silicon mold(10 cm x 10 cm). Wax (Wilson, Sao Paulo, Brazil) was used to seal the apices of the roots to prevent resin penetration. To confirm standardization of the specimens during tomographic scanning, the long axis of each root was placed parallel to the long axis of the mold. Additionally, an amalgam filling was inserted at the Distobuccal line angle of the specimens.

Pre instrumentation scanning

CBCT (Scanora 3D, Soredex, Palodexgroup, Finland) set at 85 kVp and 15 mA was used for root scanning and canal shape detection before initiation of instrumentation. For each specimen, three tomograms were selected as follows: 3, 5 and 7 mm from the root apex to present apical, middle and coronal thirds of the canal. A software program (On Demand 3D, Cybermed, South Korea) was used for scans evaluation.

Root Canal Preparation

Root samples were randomly divided into 4 equal groups (n = 15) as follows:

- ***Group I:*** WaveOne Gold group (WOG); Roots were instrumented using Primary WaveOne Gold file (25/ 0.07).
- ***Group II:*** WaveOne Gold& Glide path (WaveOne Gold Glider) group. (WOG & GP). A glide path was first created in the canal by using WaveOne Gold Glider (15/.02 variable taper) followed by Primary WaveOne Gold file (25/ 0.07).
- ***Group III:*** Reciproc Blue group (RB), where roots were mechanically prepared using R25 (25/ 0.08).
- ***Group IV:*** Reciproc Blue &Glide path group: (RB & GP): Roots were prepared with R-Pilot file (12.5/0.04) followed by R25 (25/ 0.07).

X-smart plus endodontic motor (Dentsply, Tulsa Dental, Tulsa, OK) was used for root canal instrumentation of all the samples, following the manufacturer's instructions for each instrument. All instruments advanced the canals in a reciprocating, pecking motion. The instrument was removed from the canal once it had reached the working length. Each instrument was used for preparing only three canals. Freshly prepared 2.5% NaOCl (Clorox, Cairo, Egypt) was employed for irrigation using a 30-gauge needle tips (NaviTip, Ultradent, South Jordan, UT, USA) inserted without binding as deeply as possible. Then, a final flush with 10 ml distilled water was used.

Post instrumentation scanning

After mechanical preparation, the root canals were scanned with CBCT. Pre-and post-instrumentation scans were superimposed to assess the degree of canal transportation and the centering ability of the tested groups. A length measuring tool was used to measure the shortest distance from the

edge of the canal to the root periphery (mesial and distal) on the reconstructed cross-sectional scans.

The formula presented by Gambill et al.[13] was employed to calculate the degree of canal transportation

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

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

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

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

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

CT equal to 0 (zero) presented lack of transportation.

Centering ability ratio was calculated according to the following equation:

Centralization ability ratio = (M1 M2)/(D1 D2) or (D1D2)/(M1M2)

The formula was selected in a way that the lowest of the results acquired through the difference should be the numerator. Perfect centralization was denoted by a result equal to 1. When the value was nearer to zero, it signified the reduced capability of the instrument to maintain itself in the central axis of the canal.

Assessment of root canal preparation

All the procedures were performed by a single operator, while assessment of the canal curvatures (before and after instrumentation procedures) was performed by separate examiner who was blinded to the tested groups.

Statistical analysis

Numerical data were presented as mean and standard deviation (SD) values. Shapiro-Wilk's test was used to test for normality. Homogeneity of variances was tested using Levene's test. Data showed parametric distribution and variance homogeneity and were analyzed using one-way ANOVA followed by Tukey's post hoc test for intergroup comparisons and repeated measures ANOVA followed by Bonferroni post hoc test for intragroup comparisons. The significance level was set at $p<0.05$ within all tests. Statistical analysis was performed with R statistical analysis software version 4.1.1 for Windows.

RESULTS

Results of inter and intragroup comparisons for transportation presented in table (1) and figure (1) showed that for all distances from the apex there was a significant difference between different file types ($p<0.05$). Post hoc pairwise comparisons for 3 mm from the apex, showed WOG to have a significantly higher value than other files ($p<0.001$). For 5 mm, they showed WOG to have a significantly higher value than RB and RB&GP ($p<0.001$). For 7 mm, they showed WOG to have a significantly higher value than RB&GP ($P<0.001$). Overall, they showed WOG to have significantly higher value than other files ($p<0.001$). In addition they showed WOG&GP to have a significantly higher value than RB&GP ($p<0.001$). For all files, there was no significant difference between values measured at different distances from the apex ($p>0.05$).

Results of inter and intragroup comparisons for centering ratio presented in table (2) and figure (2) showed that for 5 and 7 mm from the apex there was no significant difference between different file types ($p>0.05$). However, for 3 mm from the apex and overall the difference was statistically significant ($p<0.05$) with (WOG) having a significantly lower value than (RB & GP) ($p<0.001$). For all files, there was no significant difference between values measured at different distances from the apex ($p>0.05$)

TABLE (1): Inter and intragroup comparisons for transportation

Distance from the apex	Transportation (Mean±SD)				p-value
	WOG	*WOG&GP*	*RB*	*RB&GP*	
3 mm	0.23±0.09^{Aa}	0.11±0.07^{Ba}	0.07±0.06^{Ba}	0.05±0.03^{Ba}	**<0.001***
5 mm	0.20±0.14^{Aa}	0.11±0.09^{ABa}	0.06±0.05^{Ba}	0.04±0.03^{Ba}	**0.021***
7 mm	0.16±0.12^{Aa}	0.08±0.05^{ABa}	0.07±0.06^{ABa}	0.03±0.02^{Ba}	**0.011***
p-value	**0.485**	**0.572**	**0.754**	**0.277**	
Total	0.20±0.12^{A}	0.10±0.07^{B}	0.07±0.05^{BC}	0.04±0.03^{C}	**<0.001***

Different upper and lowercase superscript letters indicate a statistically significant difference within the same horizontal row and vertical column respectively *significant (p<0.05)

TABLE (2): Inter and intragroup comparisons for centering ratio

Distance from the apex	Centering ratio (Mean±SD)				p-value
	WOG	*WOG&GP*	*RB*	*RB&GP*	
3 mm	0.24±0.17^{Ba}	0.42±0.18^{ABa}	0.53±0.31^{ABa}	0.59±0.28^{Aa}	**0.040***
5 mm	0.39±0.29^{Aa}	0.53±0.27^{Aa}	0.47±0.28^{Aa}	0.63±0.19^{Aa}	**0.334**
7 mm	0.28±0.20^{Aa}	0.40±0.19^{Aa}	0.29±0.35^{Aa}	0.48±0.42^{Aa}	**0.505**
p-value	**0.393**	**0.319**	**0.354**	**0.595**	
Total	0.30±0.23^{B}	0.45±0.21^{AB}	0.43±0.32^{AB}	0.57±0.31^{A}	**0.012***

Different upper and lowercase superscript letters indicate a statistically significant difference within the same horizontal row and vertical column respectively *significant (p<0.05)

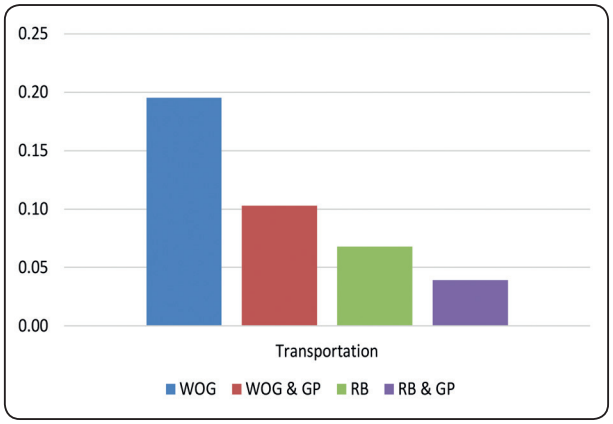

Fig. (1): Bar chart showing average transportation in different files

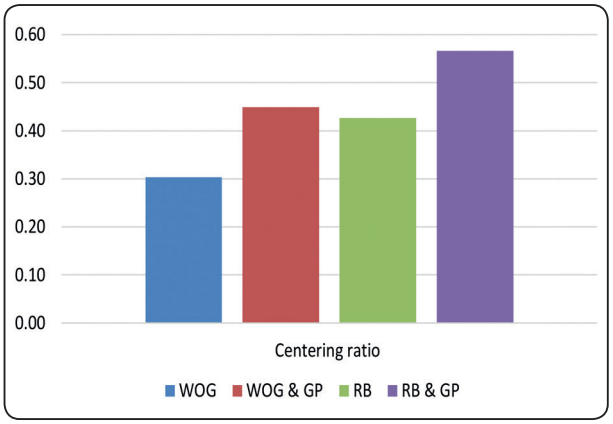

Fig. (2): Bar chart showing average centering ratio in different files

DISCUSSION

Cleaning and shaping procedures of root canals are considered essential steps for achieving proper irrigation, disinfection, and obturation. Maintaining the anatomical shape, size and position of the apical foramen is a crucial step[14, 15]. In curved canals, transportation occurs in different parts of the canal resulting in ledges, perforations or zipping with loss of its centric ability. Multiple factors have a definite effect on the incidence of canal transportation such as canal anatomy, instrumentation technique, file design and alloy16. However, the influence of glide path preparation prior to instrumentation on the occurrence of canal transportation remains controversial. The glide path can guide the direction of preparation for subsequent endodontic instruments. A smooth, central glide path may prevent iatrogenic errors and complications during chemo-mechanical preparation such as canal transportation, taper lock and instrument fracture [17].

This study aimed to compare the shaping ability of two reciprocating NiTi files in the preparation of curved root canals with and without the use of glide path (GP). In this study, the selection of WOG and RB rotary instruments was based on that both files are of the same generation and are based on the gold and blue heat-treated types.

WOG and RB share similar manufacturing process. Whereas, a proprietary thermal process (Heat-treatment of NiTi files followed by slow cooling) and post-machining procedure are used to manufacture WOG. Novel heat treatments that can alter the molecular structure are used to produce RB [8].

Mesiobuccal canals of first mandibular molars were selected to simulate the clinical situation, thereby provides a realistic appraisal of the instruments' performance[18]. Three levels of measurements were selected at the 3, 5, and 7 mm from the apex, to present curvatures with high vulnerability to iatrogenic mishaps at the apical, middle, and coronal thirds of the root canals. CBCT provides an efficient means for measuring dentin thickness, canal transportation and centering. CBCT provides a thorough three-dimensional imaging of the root canal anatomy with ambient resolution and fast reconstruction scheme [19, 20.]

Finally, the mathematic formula of Gambill et al. 13 was applied to quantify the centering ability and transportation without subjective judgment of different evaluators,

This study showed that the WOG presented a significantly higher values of transportation than other files ($p<0.001$). In addition, the use of glide path significantly improved the performance of WOG. However, our study showed no significant effect of the use of glide path on the performance of RB. For all the tested groups, there was no significant difference among values measured at different distances from the apex ($p>0.05$).

Several studies demonstrated the efficiency of glide path preparation in reducing the incidence of procedural mishaps and canal straightening[21,22], especially when the root canals are mechanically prepared by inexperienced operators [23, 24].Yilmaz. et al,[25] and Keskin. et al,[26] stated that glide path had an effect on maintaining the original canal route, minimizing the incidence of iatrogenic errors and alterations of the canal curvature. Nazarimoghadam et al.[27] showed that a significant drop in the rate of canal transportation in the apical third of the canal was associated with the creation of glide path. Berutti et al. [23] found a significant alteration in the canal curvature when using WaveOne files in the absence of glide path. Elnaghy and Elsaka 7 reported that the highest transportation values were detected in the groups that lack the creation of glide path prior to mechanical canal instrumentation.

On the other hand, other studies reported that using glide path had no impact on the incidence of apical transportation or other canal deviations [28, 29]. These contradictory findings could be explained by the lack of standardization between the used methodologies; i.e using simulated root canals. Reciproc NiTi files showed an enhanced ability

of reaching the working length before glide path creation [30-32].

Both WOG and RB have super-elastic properties, but the thermo-mechanical treatment of the RB reduces the shape memory of this instrument, making it more flexible. The diameter of the core and the cross-section of NiTi files have a considerable influence on their shaping ability. As the cross-sectional shape of the RB, which does not have a cutting section at the tip of the file makes RB better at maintaining the position of the apical foramen than WOG 15, [33]. According to Wu et al [34], the apical seal is jeopardized when transportation values are greater than 0.3 mm. Thereby, it could be stated that in terms of clinical significant implication of canal transportation, none of the tested groups caused reduction of the apical seal.

In this study, there was no significant difference among centering ratio values measured at different distances from the apex ($p>0.05$).Results showed that for 5 and 7 mm from the apex there was no significant difference among different groups ($p>0.05$). However, the tested groups showed a statistically significant difference at 3 mm from the apex ($p= 0.040$) with WOG having a significantly lower value than (RB&GP) ($p<0.001$).

The results of the present study are in accordance with those reported with of Nazarimoghadam and Lim et al [27, 32]. **Keskin et al.** [26] stated that glide path preparation enhanced the centering ability of RB (R25) instruments, especially at the apical curvature area. The RB instrument showed a better ability at centralizing the preparation and maintaining the position of the apical foramen than WOG [35].

File #25 of the WOG and RB systems almost share the same taper degrees (7% for WOG and 8% for RB), so there is no significant difference in the changes of the coronal curvature. This is supported by Susantio, et al, 33 who stated that the increase in percentage of the apical area volume of the root canal instrumentation with file #25 of the WOG file was 91.16%, compared with the RB file of 42.18%. This shows that the WOG preparation is capable of widening the apical area of the curved canals 36. This could be accredited to the regressive taper of the RB files, starting at 3 mm from the tip till it reaches a diameter of 1.05 mm at D16 [15]. De Carvalho et al [37] stated that reciprocating instruments showed tendency to deviate from the main path of the canals when no glide path was created.

Such results can be attributed to the small taper and high flexibility of the glide path files, favoring a precise conservation to the original root canal path, ensuring that the reciprocating files will follow this path to the apical foramen [38]. Hage et al [11] stated that the creation of a glide path reduced the canal transportation and resulted in a better centering ability of both R25 and RB[25].

It has to be mentioned that in this study only the centering ability and canal transportation parameters were evaluated. Other advantages of glide path preparation such as; less instrument breakage, less post-operative pain, and faster root canal preparation should not be overlooked.

CONCLUSION

Glide path significantly improved the behavior of WOG in terms of canal transportation. However, the use of Glide path with Reciproc Blue did not have an influence on either the canal transportation or the centering ability.

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