https://dx.doi.org/10.22161/ijaers.712.17 *ISSN: 2349-6495(P) | 2456-1908(O)*

Effect of altering the reciprocation range and instrument speed on the shaping ability and working time of WOG NiTi instruments

Matheus Rosa da Luz[1], Carlos Eduardo da Silveira Bueno[2], Carlos Eduardo Fontana[3], Rina Andrea Pelegrine[4], Daniel Guimarães Pedro Rocha[5], Cláudia Fernandes de Magalhães Silveira[6], Alexandre Sigrist de Martin[7]

[1,2,4,6,7]Department of Endodontics, São Leopoldo Mandic Faculty, São Leopoldo Mandic Research Institute, Campinas, São Paulo, Brazil.
[3,5]Department of Endodontics, PUC-Campinas, Science and Health Center, Campinas, São Paulo, Brazil.

Received: 18 Nov 2020; Received in revised form: 08 Dec 2020; Accepted: 10 Dec 2020; Available online: 16 Dec 2020

Abstract**—***Introduction: The purpose of this study was to investigate the effect of altering the reciprocation range and speed of the WaveOne Gold instrument on its shaping ability regarding canal centering ratio and preparation time. Methods: Sixty simulated resin canal blocks with a S-shaped canal were divided into 6 equal groups according to the reciprocation range and speed of the primary WaveOne Gold instrument (n=10): G1: 170 counterclockwise (CCW)–50 clockwise (CW)/ 150 rpm; G2: 170 CCW–50 CW/ 300 rpm; G3: 90 CCW–30 CW/ 150 rpm; G4: 90 CCW–30 CW/300 rpm, G5: 150 CCW–30 CW/150 rpm, and G6: 150 CCW–30 CW/300 rpm. Pre- and post-instrumentation images were superimposed, and centering ratios were calculated at 2, 5, and 9 mm from the apex. The time taken to complete canal preparation was compared and the incidence of instrument fracture was recorded. The mean/standard deviation values were analyzed using analysis of variance and the Tukey post hoc test. The significance level was set at P < .05. Results: Regarding preparation time, G2, G4 and G6 had the lowest mean for the preparation time, which was statistically significant in comparison with the other experimental groups (P < .05). Results for canal centering ratio showed that at 2, 5, and 9 mm from the apex there were no significant differences between all groups tested. Conclusions: Altering the reciprocation range did not significantly affect the shaping ability of WaveOne Gold primary instruments. Increasing the speed of WaveOne instruments resulted in faster preparation times.*

Keywords**—Root Canal Preparation, Materials, Endodontics, Techniques, Root Canal Therapy.**

I. INTRODUCTION

Successful root canal treatment depends on effective debridement and shaping of the root canal system [1]. The purpose of mechanical instrumentation is to remove the infected soft and hard tissues from the root canal, to create access for the delivery of irrigating solutions and medicaments, and to create a sufficient taper for the subsequent placement of root filling materials [2], [3]. However, the complex anatomy of the root canal system and the inherent limitations of the enlarging instruments pose some challenges that can strongly affect the treatment outcomes [4], [5].

A new kinematics, reciprocating motion, has been proposed for NiTi instruments as an evolution of the balanced force technique [6]. It consists of a counterclockwise (cutting direction) and a clockwise motion (release of the instrument); the angle of the counter clockwise cutting direction is greater than the angle of the reverse direction. This kinematics subjects the instrument to lower stress values, rendering minimal distortion of the root canal shape and extended fatigue life. Moreover, shaping the root canal with a single instrument has been introduced to reduce the instrumentation time, cost, and cross-contamination risks [7], [8], [9]. Previous studies

https://dx.doi.org/10.22161/ijaers.712.17 *ISSN: 2349-6495(P) | 2456-1908(O)*

showed that canal shaping using single instruments with different kinematics did not compromise canal cleanliness and took less time to shape the canals compared with the traditional multi-instrument systems [2], [10].

An important determinant of the performance of reciprocating instruments, in terms of shaping ability and fatigue life, is the reciprocation range. WaveOne Gold files are designed with a reverse cutting helix, engage and cut dentine in a 150-degree counter-clockwise (CCW) direction and then, before the instrument has a chance to taper lock, disengages 30 degrees in a clockwise (CW) direction. The net file movement is a cutting cycle of 120 degrees and therefore after three cycles the file will have made a reverse rotation of 360 degrees [11]. Alterations in reciprocation range might affect the instrument's fatigue life and/or shaping ability inside the root canal [4].

Another factor that may influence root canal transportation is speed (rotations per minute [rpm]).Yared et al.demonstrated that the lower speed (150 rpm) did not result in any locked, deformed, or separated instrument [12]. However, Peters et al.found that increased rotational speed was associated with increased cutting efficiency [13]. In another study by Bardsley et al.it was found that instruments at 400 rpm generated less torque and force compared with 200 rpm [14].

To the best of our knowledge, there are no data in the literature related to the effect of different speed settings and CCW/CW angles for reciprocating motion on canal centering ratio and working time. Therefore, the aim of the present study was to evaluate centering ability and instrumentation time after artificial root canal preparation using different reciprocating ranges at 150 rpm and 300 rpm. The null hypothesis was that there would be no significant difference between different reciprocation ranges and instrument speed in terms of canal centering ratio and instrumentation times.

II. MATERIAL AND METHODS

Artificial Root Canal Instrumentation

Sixty simulated resin canal blocks with double curvature (S-shaped) root canals (Endo Training Bloc, 0.02 taper, 16-mm length; IM do Brasil, São Paulo, Brasil) were used. Instrumentation was performed by a single operator trained on the technique. The working length (WL) was set 1.0 mm short the apex of the simulated resin canal blocks. A glide path was created manually with #10 stainless steel K-files (Dentsply Maillefer, Ballaigues, Suíça). The blocks were then randomly divided into 6 experimental groups (n = 10 each) according to the reciprocation range and speed of the primary WaveOne Gold instrument used (n=10): G1: 170 counterclockwise (CCW)–50 clockwise (CW)/ 150 rpm; G2: 170 CCW–50 CW/ 300 rpm; G3: 90 CCW–30 CW/ 150 rpm; G4: 90 CCW–30 CW/300 rpm, G5: 150 CCW–30 CW/150 rpm, and G6: 150 CCW–30 CW/300 rpm.Each block was fixed on a bench vice with vacuum suction cup.

The shaping procedure was performed with an in-and-out motion, not exceeding an amplitude of 3–4 mm, with gentle apical pressure. After 3 motions, the instrument was removed from the root canal, and its flutes were cleaned with gauze. All instruments were operated using an electric motor with speed, torque, and reciprocation control (Dentflex Endodontic Motor - D Force 1000 Endo model, Dentflex Indústria e Comércio Ltda, Ribeirão Preto, Brasil). The torque was fixed at 2.8 Ncm. Irrigation with distilled water was performed between preparation of each canal third, with a total volume of 5 ml, using a 30-gauge needle (NaviTip; Ultradent, Indaiatuba, Brasil) that was inserted 3 mm short of the WL, and patency was maintained using size a #10 K-file.

Evaluation of Instrumentation

Images of the blocks before and after instrumentation were taken with a digital operative microscope at 16X magnification (661; Alliance, São Carlos, Brasil) coupled to a camera (EOS Rebel T6i; Canon, Manaus, Brazil).To determine the canal centering ratios at 2, 5, and 9 mm from the apex, pre- and post-instrumentation images were superimposed with image analyzing software (PaintShop Pro 2020; CorelDraw, Ottawa, Canada).The centering ratio was calculated by the following formula: (amount of resin removed from outer side) - (amount of resin removed from inner side)/post-instrumentation canal diameter at each measuring point [15]. Using this formula, a value of 0 indicated perfect centering, and positive and negative values indicated transportation to the outer and inner side, respectively.

Statistical Analysis

All data were tested for normality using the Shapiro Wilk test. All variables had a symmetric distribution. The mean ± standard deviation values were analyzed using analysis of variance and the Tukey post hoc test. The significance level was set at $P < .05$.

III. RESULTS

Statistical analysis of the mean ± standard deviation values showed that altering the reciprocation

https://dx.doi.org/10.22161/ijaers.712.17 *ISSN: 2349-6495(P) | 2456-1908(O)*

range, the root canal level, and the interaction between them had no significant effect on canal centering ratio (Table 1 and Figure 1).

Regarding preparation time, G2, G4 and G6 had the lowest mean for the preparation time, which was statistically significant in comparison with the other experimental groups ($P < .05$). The ascending order of time in seconds was: group 2 <group 6 <group 4 <group 5 <group 3 <group 1 (Table 2).

Statistical analysis of the mean ± standard deviation values for preparation time (seconds) are presented in Table 3. No file separation occurred during instrumentation of the specimens.

IV. DISCUSSION

In root canal shaping, from the aspect of the success of endodontic treatment, it is very important to maintain the original form of the canal as far as possible while the root canal is being gradually enlarged from the apical to the coronal region [3]. NiTi files are usually used, however, despite the advantages resulting from high flexibility, such as reduced transport and intracanal irregularities, they can fracture due to cyclic fatigue, especially in narrow and curved root canals.To prevent fracture in NiTi files caused by cyclic fatigue, single-file reciprocation motion systems are recommended [6], [7].

The present study assessed the effect of altering the reciprocation range and speed of the WOG instrument on its shaping ability regarding canal centering ratio at 2, 5, and 9 mm from the apex there and preparation time. Despite the absence of difference regarding the shaping ability, the null hypothesis was rejected, once there was a significative difference between the preparation time for the groups tested at 300 rpm.

Natural teeth and simulated resin canals are used to compare the shaping abilities of NiTi files. However, in studies using natural teeth, it is very difficult to maintain standardization because of the anatomic variations of the teeth. Peters et al. argued that when natural teeth are used, the anatomic variations of these teeth affect the results more than NiTi files [16]. In studies using S-shaped simulated canals, by easily comparing the pre- and post-shaping images of roots via various computer programs, it is possible to compare the shaping abilities of NiTi files [17]. For this reason and considering these conditions, the S-shaped simulated canals were used to eliminate the anatomic variations that natural teeth have. The major limitation of the present study was the fact that the hardness of resin and the dentin is not the same [18], [19].

In the present study, no significant differences among the 150 or 300 rpm in the ability of the instrument to remain centered in the canal. A similar finding was found in the study by Yildiz et al.who found no significant differences among the WOG instruments tested at 750, 1300, or 2000 rpmin centering ratio at the three levels (3 mm, 5 mm, and 7 mm) [8]. Maki et al. evaluated how the speed of up-and-down motion could affect the canal centering ability of ProTaper Next rotary instrument, using simulated resin canal blocks with a J-shaped canal. Authors found that the highest up-and-down speed group showed the best centering ability, probably because the contact time of the PTN instruments to the outer canal wall was the shortest and thus the instruments removed the smallest amount of resin from the outer wall [19].

Faster preparation time allows the clinician to focus on the most important aspect of clinical endodontics, disinfection, thus fulfilling the mechanical and biological objectives of shaping canals. According to the results, using WaveOne Gold NiTi system at higher rotational speed resulted in faster canal preparation times. According to the study of Yildiz et al. WOG instruments used at 600 rpm was significantly faster than 300 rpm in root canal preparation [8].

A manual glide path was created before instrumentation; this is in agreement with Berutti et al. who reported that canal modifications are significantly reduced when a glide path is created before using reciprocating files [2].

Results of this study showed that altering the reciprocation range did not affect significantly the shaping ability and preparation time of WOG instruments. A possible explanation for this may be the fact that altering the difference between the counterclockwise and clockwise reciprocity angles, the cutting capacity of the parallelogram-shaped cross section is modified, keeping it more balanced and centered in the canal. This is in agreement with Saber & Sadat who investigated the effect of altering the reciprocation range and found no significant effect on canal transportation and the canal centering ratio. Authors also found a linear inverse relation between decreasing the reciprocation range and the time needed by the reciprocating file to reach the working length. Inconsistency in the results of different studies seems to be related to the differences in kinematics and speed used as well as to the design of the instrument [4].

The results of this study are disputable from a clinical aspect, and the shaping efficiencies on natural teeth may differ. However, these results are important for clinicians to have knowledge about the WOG NiTi files'

https://dx.doi.org/10.22161/ijaers.712.17 *ISSN: 2349-6495(P) | 2456-1908(O)*

shaping efficiencies with security and to be capable of dealing with the anatomic difficulties, such as S-shaped root canal.

V. FIGURES AND TABLES

Table 1. Centralization ratio (means and standard deviations) of the sample groups and statistical analysis of ANOVA (Tukey)

Nível	G1	G2	G3	G4	G5	G6	(p)
2	-0.0646 (0.1174)[a]	0.0364 (0.0859)[a]	0.2000 (0.1922)[a]	-0.1795 (0.1502)[a]	0.0114 (0.0493)[a]	0.0597 (0.0844)[a]	0.0571
5	-0.0907 (0.0644)[a]	-0.0103 (0.0688)[a]	0.2417 (0.0708)[a]	-0.0813 (0.0991)[a]	0.2169 (0.1161)[a]	0.2033 (0.1852)[a]	0.8674
9	-0.1331 (0.1123)[a]	-0.0399 (0.1154)[a]	0.1621 (0.2742)[a]	-0.1415 (0.1059)[a]	-0.2142 (0.1474)[a]	-0.1746 (0.0848)[a]	0.1694

Same letters in the horizontal direction: no statistically significant differences.

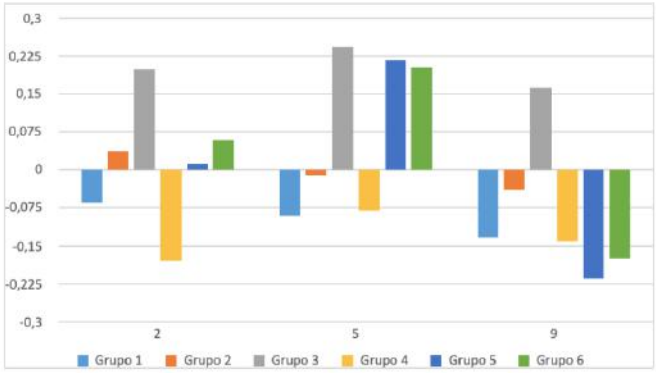

Fig.1: Centralization ratio (means) of the sample groups

Table 2.Arithmetic means and standard deviations of time (seconds) of the sample groups

Grupo 1	Grupo 2	Grupo 3	Grupo 4	Grupo 5	Grupo 6
196.90 (28.38)	143.20 (12.51)	178.20 (14.72)	149.60 (11.33)	175.10 (29.25)	146.00 (15.72)

Table 3. ANOVA (Tukey) statistical analysis of the time (seconds) of the sample groups.

	Grupo 2	Grupo 3	Grupo 4	Grupo 5	Grupo 6
Grupo 1	<0.01*	>0.05	<0.01*	>0.05	<0.01*
Grupo 2	_____	<0.01*	>0.05	<0.01*	>0.05
Grupo 3	_____	_____	<0.05*	>0.05	<0.01*
Grupo 4	_____	_____	_____	>0.05	>0.05
Grupo 5	_____	_____	_____	_____	<0.05*

*: statistically significant differences.

VI. CONCLUSION

Within the limitations of this study, altering the reciprocation range did not affected neither the canal centering ability nor the working time of WaveOne Gold instruments. The high-speed groups showed faster preparation times.

ACKNOWLEDGEMENTS

The authors deny any conflicts of interest related to this study.

REFERENCES

[1] Schilder H. Cleaning and shaping the root canal. Dent Clin North Am 1974;18: 269–96.

[2] Berutti E, Chiandussi G, Paolino DS, Scott N, Cantatore G, Castellucci A, et al. Canal shaping with WaveOne Primary reciprocating files and ProTaper system: a comparative study. J Endod. 2012;38(4):505-509.

[3] Peters OA. Current challenges and concepts in the preparation of root canal systems: a review. J Endod. 2004 Aug; 30(8): 559–567.

[4] Saber SD, Sadat AESM. Effect of altering the reciprocation range on the fatigue life and the shaping ability of WaveOne nickel-titanium instruments. J Endod. 2013; 39(5):685-688.

[5] van der Vyver PJ, Paleker F, Vorster M, de Wet FA. Root Canal Shaping Using Nickel Titanium, M-Wire, and Gold Wire: A Micro-computed Tomographic Comparative Study of One Shape, ProTaper Next, and WaveOne Gold Instruments in Maxillary First Molars. J Endod. 2019;45(1):62-67.

[6] Yared G. Canal preparation using only one Ni-Ti rotary instrument: preliminary observations. Int Endod J 2008;41:339–44.

[7] Kim HC, Kwak SW, Cheung GS, Ko DH, Chung SM, Lee W. Cyclic fatigue and torsional resistance of two new nickel-titanium instruments used in reciprocation motion: Reciproc versus WaveOne. J Endod. 2012;38(4):541-544.

[8] Yildiz ED, Arslan H, Sumbullu M, Bayrakdar IS, Sumbullu MA, Karatas E. Effect of instrument speed when used in reciprocating motion on root canal transportation and centering ability. J Conserv Dent. 2017;20(4):234-236.

[9] Jamleh, A., Alfadley, A., & Alfouzan, K. (2018). Vertical Force Induced with WaveOne and WaveOne Gold Systems during Canal Shaping. J Endod. 2018;44:1412-15.

[10] Çapar ID, Ertas H, Ok E, et al. Comparative study of different novel nickel-titanium rotary systems for root canal preparation in severely curved root canals. J Endod. 2014;40:852–6.

[11] Webber J. Shaping canals with confidence: WaveOne GOLD single-file reciprocating system. Roots 2015;1:34–40.

[12] Yared GM, Bou Dagher FE, Machtou P. Influence of rotational speed, torque and operator's proficiency on ProFile failures. Int Endod J. 2001;34(1):47-53.
[13] Peters OA, Morgental RD, Schulze KA, Paqué F, Kopper PM, Vier-Pelisser FV. Determining cutting efficiency of nickel-titanium coronal flaring instruments used in lateral action. Int Endod J. 2014;47(6):505-513.
[14] Bardsley S, Peters CI, Peters OA. The effect of three rotational speed settings on torque and apical force with vortex rotary instruments in vitro. J Endod. 2011;37(6):860-864.
[15] Paleker, F., & van der Vyver, P. J. Comparison of Canal Transportation and Centering Ability of K-files, ProGlider File, and G-Files: A Micro-Computed Tomography Study of Curved Root Canals. J Endod. 2016;42(7):1105–1109.
[16] Peters OA, Laib A, G€ohring TN, Barbakow F. Changes in root canal geometry after preparation assessed by high-resolution computed tomography. J Endod 2001; 27:1–6.
[17] Bonaccorso, A., Cantatore, G., Condorelli, G. G., Schäfer, E., & Tripi, T. R. Shaping Ability of Four Nickel-Titanium Rotary Instruments in Simulated S-Shaped Canals. J Endod. 2009;35(6):883–886.
[18] Peters OA, Barbakow F. Dynamic torque and apical forces of ProFile.04 rotary instruments during preparation of curved canals. Int Endod J 2002;35:379–89.
[19] Maki K, Ebihara A, Kimura S, Nishijo M, Tokita D, Okiji T. Effect of Different Speeds of Up-and-down Motion on Canal Centering Ability and Vertical Force and Torque Generation of Nickel-titanium Rotary Instruments. J Endod. 2019;45(1):68-72.e1.