IEJ
Iranian Endodontic Journal

Canal Transportation and Centering Ability of Reciproc Blue, WaveOne Gold and ProTaper Next in Simulated Curved Canals

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ARTICLE INFO

Article Type:
Original Article

Received: 03 May 2018
Revised: 09 Aug 2018
Accepted: 25 Aug 2018
Doi: *10.22037/iej.v13i4.21790*

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ABSTRACT

Introduction: The aim of this study was to evaluate the canal transportation and centering ability of ProTaper Next (PTN), WaveOne Gold (WOG) and Reciproc Blue (RCB) in simulated curved resin canals. **Methods and Materials**: A total of 43 blocks of simulated resin canals with 40° of curvature were prepared to an apical size of 0.02. Flexofile #15 instruments were used along the root canal to reach patency. The blocks were randomly assessed and sequence instruments were used according to each system: PTN, RCB and WOG. The imposition of pre and post instrumentation images were composited and analyzed. The canal transportation and apical centralization were measured using the software GIMP (2.8.4, Creative Commons - Share Alike 4.0 International License, 2013). Data were statistically analyzed using the Shapiro-Wilk test, ANOVA test and Tukey's test. The level of significance was set at 0.05. **Results:** There were no statistical differences in canal transportation between three systems. The general assessment of three systems presented the RCB group with higher values of centralization and more numbers of centralized points with significant differences between the PTN and RCB groups ($P<0.05$). **Conclusion:** In this *in vitro* study, there were no statistical differences in canal transportation between the RCB, WOG and PTN systems. The lowest transportation was observed in the apical region at 3 mm performed with RCB system, followed by WOG and PTN systems. The RCB demonstrated higher values of centralization and more centralized points when assessed by regions.

Keywords: Canal Transportation; Centering Ability; Reciprocating; Rotary Instrumentation

Introduction

The chemical-surgical preparation aims to model and clean the root canal system using endodontic instruments and auxiliary chemical substances. This process aims the disinfection and maintenance of the continuous conical root format with larger cervical and lower apical diameter, foraminal centralization and the canal original position [1]. On the other hand, the instruments mode of action can weaken root dentin, transport the apical area, extrude debris and induce vertical root fracture [2-6]. The current changes on the Ni-Ti alloys, design and kinematics of instruments aim to increase the flexibility without losing its ability to modeling the root canal [7].

WaveOne Gold instruments (WOG) (Dentsply Maillefer, Ballaigues, Switzerland) are made with M-Wire alloy, reciprocating kinematics and with parallelogram design cross-section having two cutting edges. The WaveOne Gold manufacturing process modifies M-Wire alloy into the GOLD alloy based on the heating and then slow cooling to improve flexibility of the instruments [3, 8].

ProTaper Next instruments (PTN) (Dentsply Maillefer, Ballaigues, Switzerland) are made from M-Wire, a unique NiTi

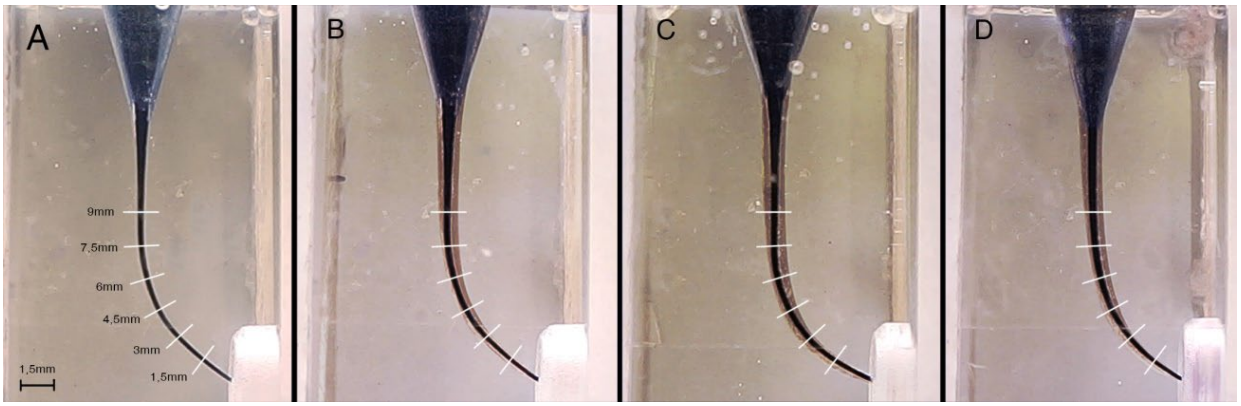

Figure 1. Representative images of original simulated canal with and after instrumentation *A)* WOG; *B)* PTN; *C)* and *D)* RCB groups

alloy manufactured by a thermal treatment process that increases flexibility and resistance to cyclic fatigue. These instruments have a centered rectangle geometric design with two cutting edges and eccentric movement [9, 10].

The Reciproc Blue instruments (VDW, Munich, Germany) are submitted to thermal treatment at the manufacturing process, the nickel titanium molecular structure alter the color into blue. This treatment controls the transition temperatures, creating a shape memory alloy, which results in more flexibility. These instruments have a double helix cross section with two cutting edges, with an inactive tip [11, 12]. Considering the technical and scientific progress of the NiTi instruments and the adverse effects on root canal instrumentation such as ledges, zips, perforation, microcrack formation [13, 14], this study aims to evaluate the canal transportation and the centering ability of ProTaper Next, WaveOne Gold and Reciproc Blue systems in simulated curved resin canal. The null hypothesis tested was the absence of significant differences between the PTN, WOG and RCB systems in analyzed terms.

Materials and Methods

Sample calculation

The sample calculus was based on a previous study that observed the canal transportation and centering ability [15-17]. A minimum size of 11 specimens per group was required using the Student's *t*-test (95% confidence intervals) (Minitab®Statistical Software 16.1, Minitab Inc., URL: www.minitab.com) with α=5%, power of 95% and ratio of 1.00. A total of forty-three resins blocks (Endo Training Block, Dentsply Maillefer) with 40° angle and radius, and 0.02 mm apical diameter were randomly divided into three groups.

Table 1. Mean (SD) for wear pattern of canals after instrumentation

System	Min	Max	Med	Mean (SD)
RCB	-0.15	0.17	0.00	-0.00 (0.05)
WOG	-0.13	0.37	0.00	0.02 (0.09)
PPTN	-0.23	0.31	0.00	0.02 (0.09)

Canal preparation

The instrumentation was performed by a single operator, specialist in endodontics. The systems were coupled to a 16: 1 reduction contra-angle driven by the X-Smart Plus electric motor (Dentsply-Maillefer, Ballaigues, Switzerland). Flexofile #15 instruments (Dentsply-Maillefer, Ballaigues, Switzerland) were used along the root canal to reach patency. The blocks were instrumented with sequence instruments according to the manufacturer's instructions. The solution used was distilled water (Quimesp Química, Guarulhos, SP, Brazil) with syringes (Ultradent Products, Inc., South Jordan, UT, USA) and NaviTip 21 mm (yellow)-30g (0.30 mm) tips. During instrumentation, each simulated canal was irrigated using 20 mL of distilled water. The working length was 17.5 mm, the resin blocks were instrumented 1 mm from the foramen.

ProTaper Next group (PTN)

This group was prepared with ProTaper Next system (Dentsply Maillefer, Ballaigues, Switzerland). The X-Smart Plus electric motor was used, at a pre-programmed movement format as "ProTaper Next" mode. The X2 file (25/0.06), X3 file (30/0.07) and X4 (40/0.06) was used until reaching the working length.

WaveOne Gold group (WOG)

In this group, the simulated curved resin canals were prepared by using WaveOne Gold® system (Dentsply-Maillefer, Ballaigues, Switzeland), powered by X-Smart Plus electronic motor, at a pre-programmed movement format as "WaveOne Gold" mode. The WOG Primary file (25/0.07), WOG Medium file (35/0.06), WOG large file (45/0.05) were used until reaching the working length.

Reciproc Blue group (RCB)

In this group, the endodontic motor X-Smart Plus was adjusted to pre-programmed movement format as "Reciproc" mode. The canals were instrumented with the sequences files R25 (25/0.06) and R40 (40/0.06) until reaching the working length.

Canal transportation assessment

The 0.01% methylene blue dye (Chimiolux-DMC) was injected with syringes in all simulated canals before instrumentation for photographic control. The resin blocks were photographed by a Handheld Digital Microscope (Celestron) before and after preparation, the images were transferred to a computer, superimposed and analyzed using Adobe Photoshop CS2 software (Adobe Systems, California, USA).

To compare canal transport degree, a technique developed by Gambill *et al.* [18] was used. According to the authors, the root canal transport corresponds to the axis deviation (in millimeters) after the instrumentation compared to control group. The formula (A1-A2)-(B1-B2) was used for all 6 measurement points determined along the simulated canal from the foraminal outlet (1.5 mm, 3 mm, 4.5 mm, 6 mm, 7.5 mm, 9 mm). Point A analyzed the mesial wall and B the distal wall; 1 and 2 refers to pre and post-instrumentation wear, respectively [19, 20]. The measurement points represent the regions: apical (1.5 mm and 3 mm), medium (4.5 mm and 6 mm) and coronal (7.5 mm and 9 mm).

For wear assessment, results equal to 0 represent no canal transport and any other value indicates that canal transport occurred. Negative values mean transport to the external face of curvature, and positive values represent transport to the internal face of the curvature [18].

Centering ability assessment

According to Gambill *et al.* [18], the mean centering rate indicates the ability of the instrument to remain centralized in the root canal. The formula selected for centering ability evaluation: (A1-A2)/(B1-B2) or (B1-B2)/(A1-A2). Point A analyzed the mesial wall and B the distal wall; the numbering 1 and 2 refers to pre- and post-instrumentation wear, respectively [19, 20]. If the results of the two formula options are different, the smaller value between the two results is considered. Results equal to 1 mean perfect centering, while 0 means totally decentralized [18].

The pre- and post-operative images of the simulated canals with curved roots were recorded in fixed-base photographs. The standardized blocks were placed in the same position, with the constant distance between the camera and the block. The superimposed photos, before and after the instrumentation were analyzed using GIMP software 2.8.4 (Creative Commons Attribution-Share Alike 4.0 International, 2013).

Table 2. Mean (SD) of canals after instrumentation in various regions

System	Region (mm)	Min	Max	Mean (SD)
RCB	1.5	-0.08	0.00	-0.04 (0.02)
	3.0	-0.03	0.03	0.00 (0.01)
	4.5	0.00	0.10	0.05 (0.03)
	6.0	-0.03	0.17	0.03 (0.06)
	7.5	-0.12	0.13	-0.01 (0.06)
	9.0	-0.15	0.05	-0.04 (0.05)
WOG	1.5	-0.13	0.13	-0.04 (0.06)
	3.0	-0.05	0.17	0.00 (0.05)
	4.5	-0.03	0.25	0.07 (0.08)
	6.0	-0.07	0.37	0.10 (0.12)
	7.5	-0.07	0.14	0.03 (0.06)
	9.0	-0.12	0.03	-0.04 (0.05)
PTN	1.5	-0.23	0.00	-0.04 (0.06)
	3.0	-0.12	0.01	-0.03 (0.04)
	4.5	-0.02	0.31	0.08 (0.09)
	6.0	-0.03	0.27	0.12 (0.08)
	7.5	-0.03	0.17	0.04 (0.06)
	9.0	-0.18	0.08	-0.03 (0.07)

Table 3. Centralization values by different systems and regions

System	Region (mm)	Min	Max	Mean (SD)
RCB	1.5	0.50	1.00	0.69 (0.15)
	3.0	0.80	1.00	0.93 (0.07)
	4.5	0.53	1.00	0.77 (0.16)
	6.0	0.41	1.00	0.81 (0.18)
	7.5	0.50	1.00	0.84 (0.18)
	9.0	0.50	1.00	0.79 (0.14)
WOG	1.5	0.36	1.00	0.69 (0.22)
	3.0	0.27	1.00	0.83 (0.19)
	4.5	0.32	1.00	0.66 (0.23)
	6.0	0.22	1.00	0.63 (0.27)
	7.5	0.50	1.00	0.79 (0.15)
	9.0	0.53	1.00	0.80 (0.18)
PTN	1.5	0.25	1.00	0.74 (0.26)
	3.0	0.31	1.00	0.76 (0.23)
	4.5	0.34	1.00	0.67 (0.25)
	6.0	0.29	1.00	0.59 (0.20)
	7.5	0.42	1.00	0.79 (0.17)
	9.0	0.48	0.95	0.78 (0.15)

Statistical analysis

The data were analyzed using SPSS software (SPSS version 20, SPSS, Chicago, IL, USA) *via* Shapiro-Wilk test, ANOVA test and Tukey's test. Level of significance was set at 0.05.

Results

The mean and standard deviation for wear pattern of canals after instrumentation are shown in Table 1. There were no statistically differences in the canal transportation between the three systems (Table 2). The general assessment of centralization was performed with ANOVA test and showed a significant difference between the groups. Subsequently, the Tukey's test proved this difference between the PTN and RCB groups ($P<0.05$) (Figure 1). The general assessment of the three systems presented the RCB group with higher values of centralization and more numbers of centralized points when analysis by regions 3 mm: 0.9370, 7.5 mm: 0.8440, 6 mm: 0.8123 and 4.5 mm: 0.770 (Table 3).

Discussion

The present study evaluated the canal transportation and centering ability of three systems in curved canal of resin blocks, according other studies [19, 21, 22]. The wear assessment was measured at nine points equidistant to mesial and distal wall in different regions: apical, middle and coronal. The simulated canals in resin blocks have standardized anatomy: angle of curvature, radius of curvature, root canal diameter and root length [21-23], resulting reliable data by similar values [12, 21].

In cervical modeling, is recommended to use a larger tapered instrument for the careful removal of dentin in the canal safety area to avoid accidents [19]. The assessment of the cervical region transport showed a greater wear performed by the WOG and PTN groups similar to studies [9, 12, 17, 29, 30] in which the curved portion of the canal presented higher wear values compared to the straight part of canal. However, PTN group caused less transport in the apical section [17] and curved section than WOG group, emphasizing the comparison in centralization assessment using different kinematics [21, 31]. Also, the WOG files maintain the original foramen size when compared to PTN [32].

The differences on instruments NiTi alloy, design, cross section and conicity do not affect the centralization capacity or canal transport on the curved canals preparation [28] similar to our collected data. These results are important for the clinical knowledge of NiTi systems and its modeling features, such as the safety zone proximity that directs the choice of the reciprocation or rotary instruments to avoid accidents. However, the most significant disadvantages of this methodology are the differences in the hardness level between resin blocks and dentin. For these reasons, it is important to extend these studies and evaluate in clinical conditions terms [12, 21, 33].

Conclusion

In this *in vitro* study, there were no statistically differences in the canal transportation between the RCB, WOG and PTN systems. The lowest transport was observed in the apical region at 3 mm performed with the RCB system, followed by the WOG and PTN systems. The RCB demonstrated higher values of centralization and more centralized points when assessed by regions with significant result between the PTN and RCB groups ($P<0.05$).

Acknowledgement

The authors report that a financial affiliation exists for this paper. This research was financed in part by the Coordenação de Aperfeiçoamento de pessoal de Nível Superior-Brasil (CAPES)-Finance Code 001.

Conflict of Interest: 'None declared'.

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Please cite this paper as: Florentino Silva P, Coelho E, Chagas Carvalho Alves N, Andrade Silva S, Cavalcanti Pereira F, Santana Albuquerque D. Canal Transportation and Centering Ability of Reciproc Blue, WaveOne Gold and ProTaper Next in Simulated Curved Canals. Iran Endod J. 2018;13(4):498-502. *Doi: 10.22037/iej.v13i4.21790*.