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ORIGINAL RESEARCH

Shaping Ability of ProTaper Next, WaveOne, and Reciproc in Simulated Root Canals

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ABSTRACT

Introduction: The study aimed to compare the shaping and preservation of the original curvature of simulated curved root canals using the following instruments: Reciproc (Rcp), WaveOne (Wo), and the ProTaper Next system (Ptn).

Materials and methods: A total of 45 resin blocks with simulated curved root canals were divided into three groups (n = 15), prepared using the Rcp (R25), Wo (25/0.8), and Ptn (X2) instruments. Standardized photographs were taken before and after canal instrumentation. After the superimposition of the images, the amount of resin removed from the curvature's inner and outer walls was measured at six apical levels, at intervals of 1 mm. The canals' angles of curvature before and after instrumentation were subtracted.

Results: There were no significant differences between the instruments in terms of the total amount of resin removed of the inner or outer walls of the apical curvature ($p > 0.05$). The Rcp instruments provided the best resin removed ratios between the walls. The means of the change in angle were as follows: Wo = 2.15°, Ptn = 0.92°, and Rcp = 0.21°. WaveOne caused significantly higher deviations than Rcp.

Conclusion: All of the instruments demonstrated a tendency to straighten the simulated root canal. Instruments that use rotary movement achieved an effect similar to that of the reciprocating instruments in relation to change in angle.

Clinical significance: Deviations from the original shape of the root canal could have a negative impact on the quality of a filling and consequently on the success of the endodontic treatment.

Keywords: Endodontics, Root canal preparation, Rotary system.

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INTRODUCTION

The main objective of endodontic treatment is to promote the cleaning of the root canal, to attribute a conical shape in the direction of the crown to the apex, and to preserve the original curvature. However, during instrumentation, deviations from the original shape of the root canal may occur at some point.[1] These changes could have a negative impact on the quality of a filling and consequently on the success of the endodontic treatment.[2]

At the present time, there are no available instruments capable of symmetrically shaping the root canal walls;[3-5] however, nickel–titanium rotary instruments produce more centralized preparations and with a lower transportation than stainless steel instruments.[6]

In 2008, Yared proposed a new instrumentation technique using just one instrument employing reciprocating movements,[7] demonstrating advantages, such as the reduction in the number and cost of instruments, operator fatigue, and the elimination of the possibility of cross-contamination during treatment.

With this technique, the instrument rotates counterclockwise and clockwise, there being a difference of 120° between the two movements. Every three cycles, there is a complete rotation of the instrument. Accordingly, in 10 cycles of alternating movement per second, an equivalent of 300 rpm is used. When the instrument rotates in the direction of the cut, it will advance and attach itself to the dentin in order to cut it. When it rotates in the opposite direction (slower rotation), the instrument is immediately released. The end result is a forward movement of the instrument into the root canal with just slight apical pressure. This action reduces cyclic fatigue[7-9] and requires a shorter working time.[10]

Currently, different single-use reciprocating instruments are available, including the Reciproc (VDW, Munich, Germany) and WaveOne (Dentsply Maillefer, Ballaigues, Switzerland) files. Both systems are manufactured using NiTi alloys called M-Wire, which improves the mechanical properties of the endodontic instruments.[11-13]

ProTaper Next (Dentsply Maillefer, Ballaigues, Switzerland) is a new file, manufactured using M-Wire NiTi alloys, that demonstrates greater flexibility and resistance to cyclic fatigue.[14] They have a variation in taper in one and the same instrument and an off-centered rectangular cross-sectional design providing asymmetric movement that increases the efficiency of the instrumentation.[15] They are, however, used in continuous rotary movements.

Thus, the aim of this study is to compare the shaping ability and the preservation of the original curvature in simulated root canal by employing ProTaper Next files activated using rotary movement and the Reciproc and WaveOne instruments, with their reciprocating cinematics.

MATERIALS AND METHODS

Resin Blocks

A total of 45 transparent resin blocks were used with simulated curved root canals (IM do Brasil Ltd., São Paulo, Brazil), standardized (ISO 15, taper 0.02), 19 mm long, comprising 13 mm for the straight part of the crown and 6 mm for the curved part of the root tip, with a 35° angle of curvature.[14] The blocks were divided at random into three experimental groups: Reciproc (n = 15), WaveOne (n = 15), and ProTaper Next (n = 15).

Root Canal Instrumentation

All the canals were instrumented by just one operator using the motor Gold Reciproc (VDW, Munich, Germany) and 25-mm files. The Reciproc (R25-25/0.08) and WaveOne (25/0.06) files were used by applying reciprocating movements, while the ProTaper Next (Ptn; X2) instruments were used with rotary movement (velocity of 300 rpm and torque of 320 g cm).

Working length was first determined with the help of a no. 10 Kerr-type file (Dentsply Maillefer, Ballaigues, Switzerland). The file was inserted into the canal and when the tip could be seen in the foramen, it was retracted by 1 mm to determine the working length. Each instrument was used only once using three pecking movements until they attained the working length. The simulated canal was irrigated with water with syringe and needle (Endo-Eze® Irrigator 27G; Ultradent, USA) and with water as an irrigant. The instrumentation was considered complete when the instrument attained the working length.

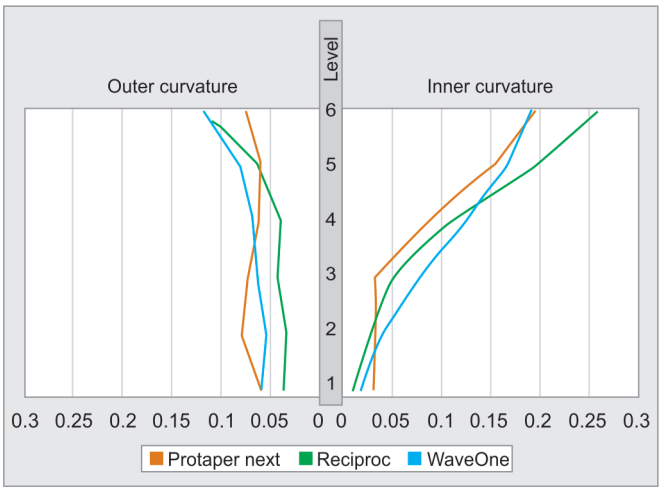
Evaluation of the Canal Preparation

Image processing was based on a previously described methodology.[16] Photographs were taken before and after the instrumentation of the simulated root canals using a digital camera (EOS Rebel T3i, Canon, Japan) attached to a copy stand (Tokina Company Ltd., Hong Kong, China). The images, in TIFF format, were digitally processed using the application Adobe Photoshop CS6 (Adobe System Incorporated, San Jose, California, USA) in order to demarcate the area of the canal.

The images of the simulated root canals before and after instrumentation were subtracted using software Regeemy version 0.2.43 (http://regima.dpi.inpe.br), developing a final image. In this image, the part corresponding to the curved region of the canal (apical 6 mm) was divided into six levels. The basis for the division was a point at the center of the canal at the apical tip in the root canal image prior to instrumentation. From this point, six circular arcs were drawn with radii at intervals of 1 mm (AutoCad 2014, Autodesk Inc., San Rafael, California, USA). The final image was analyzed using the application Image J 1.48r (http://rsbweb.nih.gov/ij/) and calibrated using the analyze/set scale tool with the aid of a millimeter rule, photographed together with the resin block. The adjust/threshold tool was used to highlight the prepared region of the root canal and with the aid of the tools/ROI manager and Wand, the inner and outer areas of the curvature were calculated at each level.

The amount of resin removed ratios between the inner and outer walls of the curvature were calculated by dividing the amount of resin removed values of the inner wall by those of the outer wall.

The root canal angles before and after instrumentation were calculated using the Tool Angle resource in the Image J application, in accordance with the



Graph 1: Mean of resin removed of the inner and outer walls at the six levels of apical curvature of the simulated root canal

Schneider method,[17] by two independent evaluators. Average values were applied. The difference between the values of the angle of curvature, before and after instrumentation, served as a parameter for evaluating the maintenance of the original curvature of the simulated root canals.

Statistical Analysis

The means and standard deviations of the worn areas were calculated for each instrument at each level. After ascertaining that the data presented a non-normal distribution (Shapiro–Wilk, $p < 0.05$), it was checked if significant differences existed between the groups: (i) for total resin removed of the inner and outer walls, (ii) for the amount of resin removed at each level of the inner and outer curvature, (iii) for the amount of resin removed ratio between the walls, and (iv) in the change of angle after instrumentation. The Kruskal–Wallis and Dunn's *post hoc* tests were employed to test the hypotheses.

The statistical program used was Statistical Package for the Social Sciences 23.0 (IBM, Armonk, New York, USA) at a level of significance of 5%.

RESULTS

The mean and standard deviation of the worn areas for each level are shown in Table 1. There was no significant difference in total amount of resin removed between the instruments, neither for the outer wall ($p = 0.141$) nor for the inner wall ($p = 0.306$).

When comparing the means of amount of resin removed at each level, for the outer curvature, there was only a difference at level 2, while for the inner curvature, there were differences at levels 3, 4, and 6. The results of the instrument comparisons can be found in Table 1.

Table 1: Mean (standard deviation) of the worn areas at each level, on the inner and outer walls, by instrument

	Outer curvature				*Inner curvature*			
	Wo	*Rcp*	*Ptn*	*Significantly different ($p < 0.05$)*	*Wo*	*Rcp*	*Ptn*	*Significantly different ($p < 0.05$)*
Level 6	0.122 (±0.122)	0.120 (±0.056)	0.077 (±0.051)	–	0.259 (±0.093)	0.192 (±0.054)	0.195 (±0.091)	Wo-Rcp
Level 5	0.064 (±0.047)	0.082 (±0.053)	0.060 (±0.051)	–	0.193 (±0.067)	0.165 (±0.057)	0.153 (±0.076)	–
Level 4	0.041 (±0.026)	0.068 (±0.038)	0.062 (±0.104)	–	0.106 (±0.054)	0.124 (±0.049)	0.085 (±0.075)	Rcp-Ptn
Level 3	0.043 (±0.029)	0.064 (±0.034)	0.073 (±0.069)	–	0.051 (±0.038)	0.076 (±0.047)	0.034 (±0.041)	Rcp-Ptn
Level 2	0.035 (±0.027)	0.055 (±0.033)	0.079 (±0.050)	Wo-Ptn	0.028 (±0.020)	0.040 (±0.035)	0.075 (±0.231)	–
Level 1	0.037 (±0.028)	0.060 (±0.037)	0.060 (±0.057)	–	0.011 (±0.008)	0.019 (±0.027)	0.031 (±0.069)	–
Total	0.344 (±0.172)	0.450 (±0.199)	0.414 (±0.253)		0.652 (±0.256)	0.619 (±0.246)	0.575 (±0.337)	

Table 2: Ratio of amount of resin removed between the outer and inner curvature

Level	*Wo*	*Rcp*	*Ptn*
6	0.45	0.68	0.87
5	0.35	0.61	0.50
4	0.50	0.68	1.86
3	2.02	1.30	6.59[#]
2	2.36	1.98	7.17[#]
1	4.99	4.14	7.73

Value close to 1 = best ratio of wear between the walls; Values > 1 – greater resin removed on the outer curvature; Values < 1 – greater resin removed on the inner curvature; [#]Statistically significant difference ($p < 0.05$)

Table 2 shows the amount of resin removed ratio between the walls. With the exception of level 6, the Reciproc instruments obtained the best ratios. The Ptn attained significantly higher values than the other instruments at levels 2 and 3 ($p < 0.05$). Graph 1 shows the mean values for amount of resin removed at each level, according to the instrument used.

Angle of Curvature

Inter-rater agreement for the measurement of the angles of root canal curvature was carried out using the intraclass correlation coefficient, which showed agreement of 0.95 ($p < 0.001$) for the measurements prior to instrumentation and 0.92 ($p < 0.001$) for the measurements after instrumentation.

The measurements of the difference between the angle before and after instrumentation are shown in Table 3. There was a significant difference between the instruments ($p = 0.039$). The WaveOne instruments caused significantly higher deviations than the Reciproc group.

DISCUSSION

The proposal of this study is to compare the shaping ability of three instruments recommended for the preparation of curved root canals, two of which are activated by reciprocating movement and one by continuous rotary movement. The following parameters were evaluated: Amount of resin removed of the inner and outer parts of the canal curvature at six levels; the ratio of amount of resin removed between the outer and inner wall; and maintenance of the canal's original curvature.

Table 3: Means (standard deviation) of the change in angle (in degrees) between groups

	Groups	*Mean (Std. deviation)*
Change in angle	WaveOne[a]	2.15 (1.96)
	ProTaper Next[ab]	0.92 (2.13)
	Reciproc[b]	0.21 (1.87)

There was a significant difference (Kruskal–Wallis test, $p < 0.05$). Different letters = statistically significant difference (Dunn *post hoc*)

The disadvantages of using resin blocks to evaluate instrumentation techniques are well documented, namely, the inability to evaluate the root canal and its cross-section in a three-dimensional view. In addition to the resin's mechanical properties being different from those of human teeth, the resin may soften due to the generation of heat during instrumentation.[18] These factors may lead to the results of studies using resin blocks not reflecting clinical conditions. Nevertheless, the use of resin blocks enables the standardization of the canal morphology, such as angle, radius of curvature, diameter, and length and, as the conditions are identical for the different instruments, the results obtained can be validated for natural teeth.[19,20]

The ideal instrumentation should follow the anatomy of the root canal, in other words, the ratio of amount of dentin removed between the inner and outer walls should be close to 1. In this regard, it was ascertained that, regardless of the cinematics applied, all the instruments used in this study caused a higher ratio of wear on the outer part at the start of the curvature and the inner part at the end of the curvature (Graph 1), in other words, they demonstrated a tendency to straighten the canal. This outcome agrees with that of Wu et al.[21] However, the Reciproc instrument showed a ratio of dentin removed closer to 1 at the majority of levels when compared with the other instruments, and, moreover, it was the instrument that best preserved the canal's original curvature, in agreement with Maia Filho et al.[16]

The main feature was the fact that the ProTaper Next instrument achieved the worst ratio values at levels 2 and 3 in the outer part of the curvature, demonstrating this instrument's tendency to produce greater wear on the apical portion of the canal. This was not, however, a factor that had any influence on the change in angle, as the use of this rotary instrument produced a change similar to the other (reciprocating) instruments used. Similar results were observed by Burklein et al[22] who also found no difference between the use of rotary and reciprocating instruments. Similarly, Capar et al[23] found no difference between WaveOne and ProTaper Next in terms of the transportation of the root canal and the centralization ratio.

It was also noted that there was a significant difference with regard to the change in angle between the instruments employing reciprocating movement (WaveOne > Reciproc). This difference may be related to the angle of rotation and instrument speed. While the Reciproc is capable of rotating 150° in a counterclockwise direction and 30° in a clockwise direction at a speed of 300 rpm, the WaveOne rotates 170° in a counterclockwise direction and 50° in a clockwise direction at a speed of 350 rpm.[24] Another possible explanation may be due to the difference in flexibility of the instruments. The WaveOne was found to be less flexible than the Reciproc.[25]

CONCLUSION

Within the limitations of this study, we may conclude that all the instruments have a tendency to straighten the root canal.

Instruments that use rotary movement achieve a similar effect to reciprocating instruments with regard to the change in angle.

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