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SHAPING ABILITY OF RECIPROCATING SINGLE-FILE AND PROTAPER ROTARY SYSTEMS IN CURVED SIMULATED ROOT CANALS

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ABSTRACT

Objective: The objective of this study was to compare the shaping ability of different rotary instruments operated either with continuous rotation or with reciprocating motion using Reciproc and WaveOne systems compared with ProTaper system in curved canals of simulated resin blocks.

Methods: A thirty resin blocks with simulated curved canals (VDW, Munich Germany) were divided into three groups, ten blocks in each group. Teeth were prepared according to manufacturers' recommendation for each corresponding system. Preoperative and postoperative photographs were taken using digital camera (450D Canon) with micro lens (Canon EF 100mm. F/2.80). A fixed positioner was maintained for standardization and reproducibility. Measurements were made on superimposed pre and post instrumentation digital images and were carried out with Adobe Photoshop (CS3 Extended, version 10) at four points: orifice (O), beginning of the curve (BC), apex of the curve (AC) and end-point (EP). Difference in shaping ability and the amount of canal transportation were analyzed using one-way ANOVA test. Difference giving a p-value of <0.05 were considered statistically significant.

Results: All instruments maintained the original canal curvature with significant difference between different files. The Pro-Taper group caused significantly greater widening of canals than Reciproc system at all points except at orifice level ($P<0.05$). Reciproc system showed the least amount of resin removed at all points. Pro-Taper system showed the highest transportation at all points except EC point ($p<0.05$). Reciproc showed the least transportation at all points. The direction of transportation at all points was toward the outer curvature except in Reciproc at BC and EP points. The Pro-Taper and WaveOne showed minor transportation toward the outer curvature, both groups caused significantly greater transportation than Reciproc at the BC point.

Conclusion: Under the conditions of this study, all instruments maintained the original canal curvature and were safe to use. Reciproc system showed a better shaping ability than other systems at all points. ProTaper had the highest tendency for transportation.

KEY WORDS: Shaping ability, single file technique, Reciprocation, Reciproc, WaveOne

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INTRODUCTION

The main objectives of root canal preparation are: prevention of apical periodontitis and/or the promotion of healing in cases where apical periodontitis already exists. These goals are achieved through chemo mechanical debridement of the root canal system and three dimensional canal filling [(1)]. Numerous trials have been made to improve and facilitate mechanical root canal preparation with a comprehensive range of different nickel-titanium rotary files being available to achieve these goals [(2)].

Over the last decade, nickel titanium has became part of the armamentarium of root canal therapy and has been increasingly used by generalists and specialists to facilitate the cleaning and shaping of root canals. In 2006, the ProTaper (Dentsply Maillefer, Ballaigues, Switzerland) was launched with modified design features. Similarly to the original ProTaper, the ProTaper Universal files have a changing percentage of tapers over the length of the cutting blades. The ProTaper instruments have a convex, triangular cross section, a changing helical angle and pitch over the cutting blades, and a non-cutting modified guiding tip. The ProTaper system is composed of three shaping and five finishing files. The shaping files (Sx, S1, S2) have increasingly larger percentage tapers over the length of their cutting blades. The finishing files (F1, F2, F3) are designed to prepare the apical 4mm only.

In an effort to improve preparation safety and quality, new instrument designs and advanced preparation techniques have been developed, one of which is the single file preparation concept. Yard in 2008[(3)] introduced a novel canal preparation technique using a single file ProTaper F2 based on the reciprocating movement of this instrument. Recently, in 2012 Reciproc nickel titanium system (VDW, Munich, Germany) have been introduced for preparation of root canal with only one instrument. These instruments are made of special Ni-Ti alloy called M-Wire that is created by an innovative thermal-mechanical treatment process. Also these files are used in a reciprocal motion that requires special automated devices. Reciproc files are available in different sizes 25 taper 0.08, 40 taper 0.06 and 50 taper 0.05.

WaveOne (Dentsply Maillefer,Ballaigues, Switerland) is another reciprocating motion system. It has a convex triangular cross-section and an advanced flute design that has multiple tapers within the shaft. Another unique design feature of the Wave-One files is that they have a reverse helix and 2 distinct cross-sections along the length of their active part. In a 3 engaging/disengaging cutting cycles, the file will turn 360^{o} which promotes inward movement and has the potential to push the debris out of the canal. WaveOne is available in sizes 21 taper 0.06, 25 taper 0.08 and 40 taper 0.08.The reciprocation working motion consists of a counterclockwise (cutting direction) and a clockwise motion (release of the instrument), while the angle of the counter-clockwise cutting direction is greater than the angle of the reverse direction.

The use of single file technique has many advantages: first, it reduces instrument fatigue. Both F2 ProTaper and R25 Reciproc showed improved resistance to flexural fatigue and cyclic fatigue when operated in reciprocating movement. Second, reciprocating movement reduces instrumentation time. Third, single file technique provides simplicity, cost effectiveness and safety. Fourth, it eliminates a possible side effect of debris and prion protein contamination [(4-8)]. However, there is a need for extensive laboratory and clinical studies of several parameters as transportation, centering ability, incidence of instrument fracture and working safety. The use of simulated root canals in resin blocks allows for standardization of the degree, location, and radius of the curvature as well as diameter and hardness characteristics [(9).]

Up to date, there aren't enough studies available concerning the shaping ability of the different kinematic systems. Within this background, the current study was to compare the shaping ability

of different instruments operated either with continuous rotation motion or with reciprocating motion using Reciproc, and WaveOne systems compared with ProTaper system in curved canal of simulated resin blocks.

MATERIALS AND METHODS

A total of thirty resin blocks with simulated curved canals (VDW, Munich Germany) with 16 mm length, radius of curvature of 3.5mm and an angle of 35º, measured according to the method described by Pruett, et al.[10].Teeth were divided intro three groups, ten blocks in each group.

Canal Preparation

The canal length was measured using size 10 FlexoFile (Dentsply, Maillefer, Johnson City, TN, USA) at the canal terminus minus 1mm. Each block had two orientation holes cut into the acrylic with 330 carbide bur (Komet, Lemgo, Germany) in a high-speed hand piece. Standardized photographs prior to instrumentation were taken using digital camera (450D Canon; Canon Corporation, Japan) with a macro lens (Canon EF 100mm, f/2.8). The blocks were placed into custom-made mold in order to maintain a constant position and distance. All teeth were prepared according to manufacturer's recommendation for each corresponding system by one expert operator to reduce the variation in the final results.

Pro-Taper group: ProTper instrument (SX, S1, S2, F1 and F2) were used according to the manufacturer's instruction using a gentle in and out motion. The instruments were operated at 300 rpm, using a slow-speed high-torque endodontic electric motor (TC Motor 3000; Nouvag, Goldach, Switzerland), with a 16:1 gear reduction hand piece (W&H 975; Dentalwerk, Bürmoos, Austria).

Reciproc group: R25 Reciproc file having a size 25 and taper .08 was used in reciprocating, in and out picking motion according to the manufacturer's instructions.

WaveOne group: primary reciprocating Wave-One file having a size 25 and .08 taper was used in reciprocating, in and out picking motion according to the manufacturer's instructions.

After each instrument, the canals were flushed with 2ml of saline using a plastic syringe with 30-gauge side- vented Max-i-Probe needle (Hawe-Neos, Dentsply, Bioggio, Switzerland).

Following the completion of instrumentation, postoperative photograph of each canal was taken at the same magnification as that used prior to instrumentation.

Assessment of the preparation

To evaluate the shaping ability of different systems, the amount of resin removed at different levels in the root canal and the change in the working length were measured. A composite image was produced from the pre and post instrumentation images of each canal using two holes in the resin blocks (Figure.1). Measurements were made on superimposed digital images using Adobe Photoshop (CS3 Extended, version 10) with an accuracy level of 0.001mm. The removed resin was at four different points (Figure 1.C) established on each canal using a modification of the method described by Calberson et al [11].

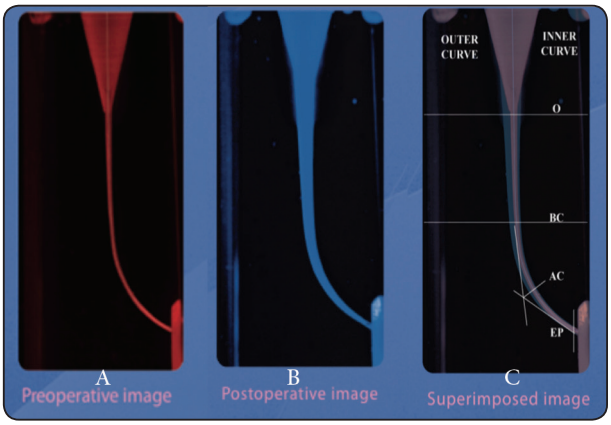

Fig. (1) A. Preoperative image B. Postoperative image C. Superimposed image of a simulating canal with the four points. O: Orifice, BC: beginning of the curve, AC: apex of the curve and EP: endpoint.

Position1: canal orifice (O)

Position 2: beginning of the curve (BC)

Position 3: apex of the curve of the original canal (AC)

Position 4: end point of the preparation (EP)

Total width of the prepared canal and the width of the resin removed from the inner and outer walls of the canal were measured at each of the four points. All measurements were accomplished perpendicular to the axis of the original central canal path using image analysis software.

Statistical Analysis

Mean and standard deviation were calculated for each group. One-way ANOVA and Tukey *post hoc* tests were used to compare the data using SPSS 17.0 (SPSS Inc., Chicago, IL, USA). Paired *t*-test was used to analyze the difference between the mean of the material removed from the inner canal wall and that removed from the outer canal wall at all measuring points for each system. The level of statistical significance was set at $p < 0.05$.

RESULTS

Canal width and Amount of resin removed:

The results are summarized in (Table 1 and Figure 2). The ProTaper group caused significantly greater widening of canals than Reciproc system at all points. Reciproc system showed the least amount of resin removed at all points.

TABLE (1) Mean total canal width (mm) of the canals at the different measuring points after instrumentation.

Systems / Measurement points	Reciproc	WaveOne	ProTaper
Orifice	9.79 (±0.53)	10.02(±1.72)	10.61(±0.59)
Beginning of the curve	6.42 (±0.42)	7.7 (±1.21)	8.39 (±0.56)
Apex of the curve	4.83 (±0.52)	6.34 (±0.74)	6.89 (±1.81)
End point of the preparation	3.23 (±0.44)	4.14 (±0.51)	5.09 (±1.87)

The numbers in parentheses are the standard deviations

TABLE (2) Mean outer and inner width measurements (mm) of the canals at different measuring points

Systems	Point (BC)			Point (AC)			Point (EP)		
	Outer	Inner	Difference	Outer	Inner	Difference	Outer	Inner	Difference
Reciproc	3.79	4.19	- 0.4	3.63	1.44	2.19	1.66	1.68	-0.02
Wave-one	4.98	2.67	2.3	4.48	1.86	2.62	3.74	1.75	1.99
ProTaper	5.34	3.35	1.99	4.6	2.29	2.31	2.69	2.2	0.49

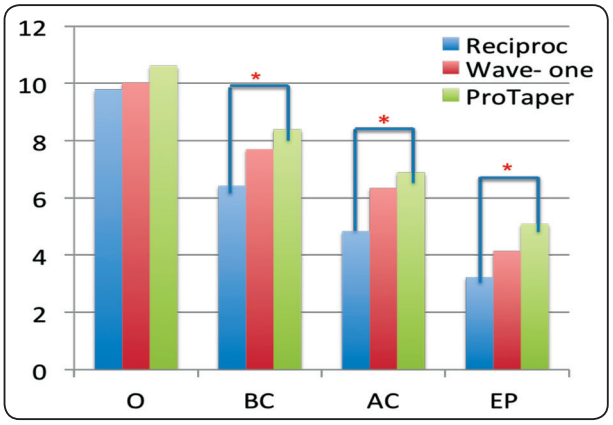

Fig. (2)Bar chart showing overall comparison of canal width at different measuring points after instrumentation, O: Orifice, BC: beginning of the curve, AC: apex of the curve and EP: endpoint.
** Sign indicates statistically significant difference between groups (P<0.05)*

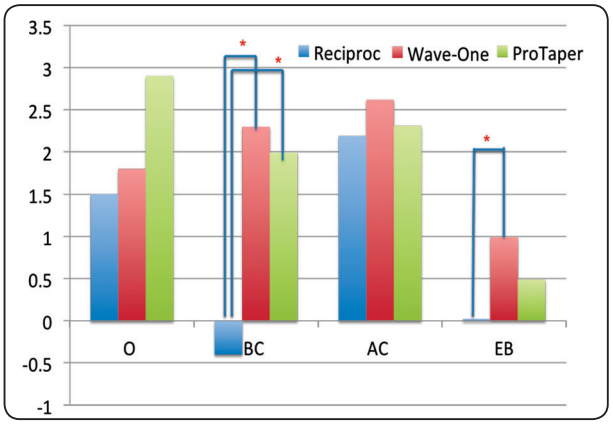

Fig. (3) Bar chart showing overall comparison of change in canal width across the inner (transportation) and outer wall of the canals at different measuring points after instrumentation, O: Orifice, BC: beginning of the curve, AC: apex of the curve and EP: endpoint.
** Sign indicates statistically significant difference between groups (P<0.05)*

The mean amount of material removed at both the inner, outer and the difference in canal walls is detailed in Table 2 and Figure 3. Statistical analysis using paired *t*-test revealed that in the mean resin removal, Reciproc showed the least transportation at all points. The direction of transportation at all points was toward the outer curvature except in Reciproc at BC and EP points. The ProTaper and WaveOne showed transportation toward the outer curvature. Both groups caused significantly greater transportation than Reciproc at the BC point. As well, there was a significant difference between Waveone and Reciproc at EP point.

DISCUSSIONS

One of the important goals of successful root canal preparation strategy is to perform a progressively tapered emanation for the root canal while keeping its original shape [12]. But iatrogenic mishaps may occur during shaping of curved canals such as canal transportation, ledge formation and obstruction [13,14]. The aim of the present study is to compare the shaping ability of single-file systems Reciproc and WaveOne with ProTaper system in curved simulated root canals. Reciproc and Wave-One are instruments designed specifically to be used in reciprocating motion.

Commonly, two models have been used to evaluate the shaping ability of different teeth such as root canals in extracted human teeth and simulated root canals in resin blocks. In spite of the use of natural teeth which provides closer conditions to the clinical case, however, it has a greater variation in root canal morphology [15]. On the other hand, the use of simulated root canal in resin blocks enables the standardization of canal conditions such as diameter, length and curvature of root canal. This method has the disadvantage of being unable to evaluate root canal and its cross section in three dimensional views. Furthermore, the mechanical properties of the resin are different from those of human teeth. However, as the conditions are identical for various instruments tested, a comparison of canal shape using simulated canals in resin blocks may be validated for natural teeth [16].

When comparing the shaping ability of different systems of different root canal files, it is important to have similar apical preparation diameter [17]. In this study, the final diameter of the

apical preparation was always performed using instruments with a tip diameter equivalent to size 25. For single file systems, the Reciproc (R 25) file and primary WaveOne reciprocating file were chosen. Also ProTaper have the same tip size of 25. The preparations were performed in accordance with the recommendation of the manufactures as these sizes are designed for narrow curved canals when hand instruments do not passively reach the full working length. To overcome the problem of curved canal, balanced force technique was proposed by Roane et al [18]. Reciprocating motion is designed to work in similar manner but in a reverse motion. Large rotating counter clockwise angle motion determines advancement of the instrument in the canal and engagement of the dentin whereas a smaller clockwise angle motion allows the file to disengage the dentin and safely progress in the root canal. These angles are specific for the different systems. These differences could have influenced the results of the study.

The ideal shape of the root canal should follow the anatomy of the root canal. Which means that the resin removed from the inner and outer wall of the root canal should maintain the same proportion and cause less displacement of the apical foramen [12]. In this regards, the ProTaper system removed the largest amount of resin at all points. This undesirable effects possibly occurred due to the large number of instruments used or could be associated with rotary motion, which has been proved to be less effective in maintaining the original curvature of the root canals when compared with instruments employing reciprocating motion [19, 20]. Measurements were specified at certain well-defined points. In a previous study [21] measurements were made at a total of 9 points and a modification of this method was used [22]. In the present study, the measuring points could be defined by using the method described by Schafer et al [23]. By this method, we were able to maintain certain distance from the apical foramen and remove any subjective factors that might influence in deciding the measuring points.

CONCLUSIONS

Under the conditions of this study, two reciprocating single- file are superior to ProTaper in their shaping ability. Reciproc and WaveOne instruments maintained the original canal curvature in curved root canals better than ProTaper which tend to transport towards the outer walls of curved root canal.

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