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Evaluation of the Canal Transportation and Centering Ratio at Different Levels of Simulated Curved Canals Prepared by OneShape, Protaper Next, Protaper Gold and TwoShape Nickel Titanium Rotary Files

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ABSTRACT

Background: *Preparing and maintaining the original shape in conjunction with its disinfection, exclusive of any procedural error is mandatory in endodontic treatment. Nickel-titanium instruments are much more flexible than conventional stainless steel files combined with superior cutting efficiency. The purposes of this study were to measure and compare the canal transportation, centering ratio at different levels of simulated curved canals of the endodontic training resin blocks, which were instrumented by using of 4 Niti rotary endodontic systems' Protaper Next, OneShape, Protaper Gold, and TwoShape.* ***Material and Methods:*** *Total 60 resin blocks were randomly divided into 4 groups of 15 canals each; the 1st group was prepared with Protaper Next instruments, the 2nd was prepared with OneShape, the 3rd was prepared with Protaper Gold instruments, and the 4th was prepared with the TwoShape. All were prepared for the size of 25. Removal of material was measured at 5 different levels: at the canal orifice, halfway to the orifice in the straight sections; the beginning of the curve; the crest of the curve; the endpoint. Pre and post-operative photos of the simulated canals were taken in a standardized technique. An assessment of changes has been determined using Photoshop and Digimizer Software. The data were analyzed statistically using Shapiro-Wilk, ANOVA by SPSS software version 21.* ***Results:*** *Regarding the canal transportation, the direction of transportation of rotary NiTi instruments was usually towards the inner aspect at middle parts of the canal, towards the outer aspect of the curve at the apex of the curve and the end of preparation.* ***Conclusion:*** *The TwoShape produced the least amount of canal transportation and preserved the original curvature of the canal more than the other systems evaluated in this study.*

Keywords: Transportation, Centering ratio, Next, OneShape, Protaper gold, TwoShape

INTRODUCTION

Chemo-mechanical preparation is intended to promote root canal cleaning, disinfection, and shaping, involving enlargement and shaping of the root canal system preserving the location of the apical terminus, however, in curved canals, this task is difficult [1]. The flexibility of NiTi instruments enables them to be used in automated handpiece, increasing the efficiency of root canal preparation [2]. Iatrogenic transportation is a major compromise for the prognosis of the endodontic treatment, as some areas could not be prepared [3]. To maintain the root canal preparation as centralized as possible, NiTi systems enable root canal preparation that is wider in the apical portion, more centered and with fewer deviations [4]. Recently, many new endodontic NiTi systems with different characteristics developed to enhance the action of NiTi instruments [5]. The OneShape system (Micro Méga, France) is a single-file for use in continuous rotation with variable pitch, cross-sections, and a safety tip [6]. Protaper Next (Dentsply, Switzerland) instruments made of M-Wire alloy with a variable taper design and an off-center axis with a rectangular cross-section [7]. Protaper Gold (Dentsply, USA) was developed with proprietary advanced metallurgy. It features the same geometries as Protaper Universal [8]. TwoShape system (Micro Méga, France) is 2 rotary files manufactured from the heat-treated the T-Wire, ensuring resistance to instrument fracture and more flexibility for better negotiation of curvatures. TwoShape system represents the latest generation of cross-section with triple helix. The new asymmetrical cross-section is the perfect compromise between cutting efficiency and debris removal (TwoShape procedural brochure, 2017).

MATERIALS AND METHODS

Total 60 resin blocks were used in this study, divided into 4 groups. The resin block canals were 16 mm long, with the straight part being 11 mm and the curved 1 of 5 mm. The curvature was with a radius of 5.5 mm and an angle of curvature of 40° [9]. The samples were coded with a permanent marker. The blocks were marked with orientation dots, as references to guide later superimposition of images. Blocks were penetrated with #10 K-file hand instrument to the length of 15 mm. Later, all samples were injected with black ink using an irrigation syringe, to augment the contrast of the images. All blocks prior to imaging were placed above the illuminated table of the microscope in a repeatable standardized position. The millimetric calibration scale was used for the calibration process. Magnification power was set to 30X. The captured images were transferred through a USB digital microscope, to a personal computer [10-12]. The Endo-Mate AT endomotor (NSK, Japan) was used for instrumentation of the blocks, secured in bench vise [10,13]. Glycerin was used as a lubricant. Irrigation made with distilled water. The time of preparation was recorded [12]. All canals were enlarged to size 25. Each block was prepared by a new set of files following the instructions of instruments manufacturer's for each system. A postoperative image of each sample was taken under the same earlier settings except for injecting a red ink instead. The pre-operative and post-operative images were superimposed and overlapped using Adobe Photoshop software (Adobe Photoshop 2017). The top image layer was set as an overlay layer. Using Digimizer Image Analysis Software (MedCalc Software, Belgium), it was feasible to compute the expanse of resin material eradicated, Under 300X zoom to obtain digital measurement. The exact 1 mm seen in scale image was measured in pixels. The acquired number of pixels was set as a reference unit [14]. Measurements were taken at 5 constant points [15].

The measurements were as follows (Figure 1):

- **Level 1:** 5 mm from the orifice
- **Level 2:** 7 mm from the orifice
- **Level 3:** at the beginning of the curve
- **Level 4:** at the apex of the curve
- **Level 5:** 15 mm from the orifice

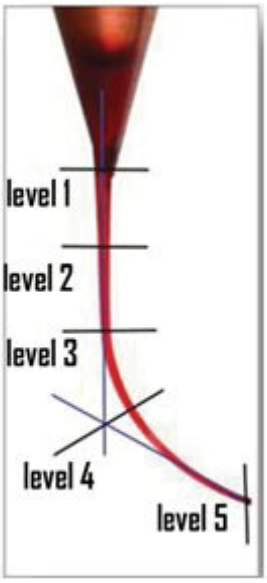

Figure 1 Five levels of measurements

The amount of deviation was measured and the centering ratio was computed as follows: Do-Di/Dt × 100 (values in mm) where;

Do: Outer resin removed

Di: Inner resin removed

Dt: The total width of the canal after preparation (Figure 2).

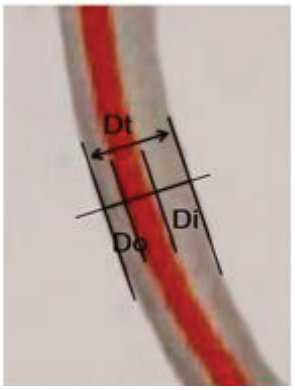

Figure 2 Centering ratio measurement

RESULTS

Neither instrument fracture, nor major canal aberration; have been made during this study. The Data were analyzed with SPSS software version 21 (SPSS, Chicago, IL). The results of the descriptive statistics are shown in (Table 1). The centering ratio closer to 0 indicates better centering ability [16].

Table 1 Descriptive statistical of the canal centering ratio

Levels		N	Mean	Std. Deviation	Minimum	Maximum
Centering ratio level 1	One Shaper	15	-12.2	4.2	-19	-2.1
	Protaper Next	15	-16.9	3.0	-21.5	-12.3
	Protaper Gold	15	-8.2	2.8	-12.2	-2.2
	TwoShape	15	-1.1	3.1	-5.5	3.6
Centering ratio level 2	One Shaper	15	-9.6	4.4	-17.8	-1.0
	Protaper Next	15	-13.6	2.6	-18.3	-10.3
	Protaper Gold	15	-5.9	1.7	8.2	-1.3
	TwoShape	15	-2.1	2.2	-4.5	3.9
Centering ratio level 3	One Shaper	15	19.1	6.5	9.5	29.3
	Protaper Next	15	26.7	11.6	11.9	45.0
	Protaper Gold	15	11.7	3.3	6.2	15.9
	TwoShape	15	3.1	2.2	-1.9	5.7
Centering ratio level 4	One Shaper	15	-21	2.9	-25.3	-15.4
	Protaper Next	15	-25.9	3.8	-32.7	-21.0
	Protaper Gold	15	-15.8	3.2	-20.8	-11.0
	TwoShape	15	-3	1.5	-6.3	-1.1
Centering ratio level 5	One Shaper	15	-17.2	3.7	-23.6	-12.0
	Protaper Next	15	-20.9	2.6	-26	-16.5
	Protaper Gold	15	-8.2	0.7	-9.3	-7.1
	TwoShape	15	-1.8	1.0	-3.6	1.3

The normality of the data was confirmed with the Shapiro-Wilk test. Data were analyzed with ANOVA (Table 2), with Tukey's post-hoc (Table 3). The level of significance was 0.05 [14].

Table 2 ANOVA test results of the canal centering ratio

Levels		Sum of squares	d_f	Mean Square	F	Sig.
Centering ratio level 1	Between groups	2009.8	3.0	669.93	60.5	0.000
	Within groups	619.7	56.0	11.07		
	Total	2629.5	59.0			

Centering ratio level 2	Between groups	1098.2	3.0	366.08	433.6	0.000
	Within groups	470.6	56.0	8.40		
	Total	1568.9	59.0			
Centering ratio level 3	Between groups	4597.9	3.0	1532.60	31.8	0.000
	Within groups	2698.7	56.0	48.20		
	Total	7296.6	59.0			
Centering ratio level 4	Between groups	4394.2	3.0	1464.70	164.2	0.000
	Within groups	499.6	56.0	8.9		
	Total	4893.8	59.0			
Centering ratio level 5	Between groups	3390.3	3.0	1130.10	202	0.000
	Within groups	313.4	56.0	5.60		
	Total	3703.7	59.0			

Table 3 Tukey's (HSD) test of the canal centering ratio

Levels	Groups		Mean Difference	Std. Error	Sig.
Centering ratio level 1	OneShape	Protaper Next	4.67*	1.21	0.002
	Protaper Gold	OneShape	3.98*	1.21	0.009
		Protaper Next	8.65*	1.21	0.000
	TwoShape	OneShape	11.11*	1.21	0.000
		Protaper Next	15.78*	1.21	0.000
		Protaper Gold	7.13*	1.21	0.000
Centering ratio level 2	OneShape	Protaper Next	3.99*	1.06	0.002
	Protaper Gold	OneShape	3.77*	1.06	0.004
		Protaper Next	7.76*	1.06	0.000
	TwoShape	OneShape	7.51*	1.06	0.000
		Protaper Next	11.50*	1.06	0.000
		Protaper Gold	3.73*	1.06	0.005
Centering ratio level 3	OneShape	Protaper Next	-7.66*	2.53	0.019
	Protaper Gold	OneShape	-7.36*	2.53	0.026
		Protaper Next	-15.03*	2.53	0.000
	TwoShape	OneShape	-15.97*	2.53	0.000
		Protaper Next	-23.63*	2.53	0.000
		Protaper Gold	-8.60*	2.53	0.007
Centering ratio level 4	One Shape	Protaper Next	4.90*	1.09	0.000
	Protaper Gold	OneShape	5.27*	1.09	0.000
		Protaper Next	10.17*	1.09	0.000
	TwoShape	OneShape	18.06*	1.09	0.000
		Protaper Next	22.96*	1.09	0.000
		Protaper Gold	12.78*	1.09	0.000
Centering ratio level 5	OneShape	Protaper Next	3.72*	0.86	0.000
	Protaper Gold	OneShape	9.04*	0.86	0.000
		Protaper Next	12.76*	0.86	0.000
	TwoShape	OneShape	15.43*	0.86	0.000
		Protaper Next	19.15*	0.86	0.000
		Protaper Gold	6.40*	0.86	0.000

DISCUSSION

In the presence of curvatures, there is a predisposition to reroute the canal further from the original configuration [17]. Failure to reproduce the outline of the canal leads to imperfect cleaning and shaping and excessive eradication of the radicular dentine in one or both of the canal walls [18].

Apical transportation of the canal in excess of 0.3 mm endangers the treatment owing to the reduced sealing effectiveness [19]. Rotary NiTi instruments have revealed superior ability to retain the original canal curvature, even in exceedingly curved canals [20].

No significant difference was seen between extracted teeth and resin blocks in canal transportation [21]. Several approaches have been advocated to assess the centering ability and canal transportation of NiTi instruments. Digital photographic superimposition ensures experiment better standardization [22].

To facilitate studying centering abilities and canal transportation amid dissimilar instruments, a matching apical diameter of the preparation is essential [23]. In this study, the last files being 25 as the greater part of root canals embrace a size underneath 25 [24].

All of the 4 systems produced some degree of canal straitening so far TwoShape system displayed the highest capability to conserve the original configuration of the canal. These finding could be related to the proprietary thermal treatment (T-wire), which has a significant impact upon file flexibility, reducing unbalanced stresses in the canal and enhance negotiation of curvatures [25].

The asymmetrical cross-section with triple helix is the ideal compromise between cutting effectiveness and debris elimination, reducing cutting edges pressure transmitted against canal walls [26]. Reduction of one of the cutting edges to a secondary one, shrinking core material enhance flexibility [27,28].

The shorter the sequence the least the transportation, combined with the enhanced instrumental dynamics had been reported to be effectual in conserving the tissue structure especially at the curvatures of the canals [22,29,30].

The taper differences as the TwoShape design, which utilize a constant taper of 4% for the TS1 and 6% for the TS2, whilst the Protaper gold and the Next employ progressive taper, also the relative smaller taper increase instrument flexibility and decrease the jeopardy of canal straightening [31-33].

The higher transportation means by PG compared to the TwoShape could be attributed to the larger number of PG files required [22,34]. Sharp cutting flutes, clustering blades stress on the canal wall straightening curvatures [26]. Decreased flexibility with tip stiffness associated with the progressive taper and relative larger tapers as compared to constant tapers of TwoShape [35,36].

The better results of the OneShape compared with the Next could relate to the divergent cross-section [36,37]. The taper differences and constant taper [35,36]. It's a safety tip which guarantee smooth apical progress [38].

CONCLUSION

Within the limitations of this study, it can be concluded that:

- The TwoShape produced the least amount of transportation
- Files manufactured with post machining heat treatment showed the best centering ratios

DECLARATIONS

Ethical Clearance

Ethical clearance was obtained from Mustansyria Dentistry College conservative dentistry department committee.

Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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