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Ability of Debridement and Shaping of Single Reciprocating Files Compared with Full Turn Rotary Files

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Abstract

Aim: **The aim of this study was to evaluate shaping and debridement ability of two single Reciprocating Files (Wave-One and single F2) with full turn rotary files (Complete Sequence of Protaper) in oval and round shaped root canals.** ***Materials and Methods:*** **The selected root specimens were divided into 2 main groups according to the shape of canal; oval (group 1) or round (group 2) and each group was subdivided into 3 subgroups according to the instrument that was used for root canal preparation; Wave-One, single F2, and complete sequence of ProTaper. Cone-Beam Computed tomography was used to measure the pre-and post-instrumentation dentin thickness using, and then applied in an equation ability of the three systems.** ***Results:*** **Regarding transportation, oval root canals recorded higher mean of transportation than round shaped root canals at the middle and coronal levels when prepared by complete sequence of Protaper. Regarding centering ratio, there was no significant difference between centering ratio of oval and round shaped root canals using the three systems both in labio-lingual and mesio-distal, except at middle level of round shaped root canals prepared by complete sequence of Protaper. Regarding pulp remnants, in the three subgroups, the round-shaped root canals recorded the lower statistically significant difference mean value than oval ones at the three levels.** ***Conclusions:*** **Wave-One had less transportation than single F2 and complete sequence of ProTaper in oval and round shaped root canals. Also, the shaping of round shaped root canals and its debridement was better than oval shaped root canals after instrumentation by the three techniques.**

Key words: Wave-One, Single F2, Transportation, Centering ratio, Debridement ability

Introduction

The main objectives of root canal treatment are to remove all the pulp tissue, bacteria and their by-products while providing adequate canal shape that follow initial anatomy to fill the canal. Therefore, proper cleaning and shaping of the whole root canal space particularly in curved, narrow, or oval shaped canals is considered a real challenge[(1)]. The introduction of rotary Nickel-Titanium (Ni-Ti) endodontic instruments offer many advantages over conventional stainless steel hand files, they are flexible, have increased cutting efficiency, maintain the original canal shape during preparation and have a reduced tendency to transport apical foramen[(2)]. Usually Ni-Ti instruments were designed for use a continuous rotation motion at low speed. Recent studies observed that Ni-Ti instruments were significantly safer and have an

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extended cyclic fatigue life when used with reciprocating movement than when used with continuous rotation. Yarad[3] suggested a new concept for canal preparation using only one specifically designed Ni-Ti instrument in reciprocation. Single use was recommended for this single file to reduce the instrument fatigue and possible cross contamination. Wave-One is a reciprocating Ni-Ti rotary system, made of M-wire that was newly introduced as a single file use in canal preparation which claimed to have better flexibility, greater resistance to cyclic fatigue and better cleaning ability. Recent innovation in 3D evaluation of change in canal shapes and geometry after instrumentation was made possible using the recently introduced Cone Beam Computed Tomography (CBCT). It is a non- destructive method for studying, the root canal systems in three dimensions[4]. Although the first clinical impressions of the single Ni-Ti file technique appeared to be promising, Other important parameters still need to be properly assessed by both clinical and laboratory studies as pulp tissue remnant and shaping ability. Thus, this study will be conducted to assess the root canal debridement quality and shaping ability of 2 single reciprocating files technique in comparison with full conventional Protaper sequence in both oval-shaped and round-shaped canals.

Materials and Methods

1) Collection and selection of teeth: Sixty extracted human incisor teeth (mandibular canine and upper lateral) were collected. The teeth were placed for 15 min. in 5.25% sodium hypochlorite (NaOCL) for disinfection and to remove surface soft tissue and debris. Radiographs were taken in labio-lingual and mesio-distal directions to select only teeth with single root canals. The space corresponding to root canal lumen was measured 5 mm from the apex, when the mesio-distal diameter was 2.5 times larger than the labio-lingual diameter, the canal was classified as oval shaped. For round shaped canals, the mesio-distal diameter had to be similar to the labio-lingual diameter. Teeth with fully formed apices, straight root canals were selected to be used in this study. Any tooth presenting isthmus, curvature, and lateral or 2 canals was eliminated. Teeth not fulfilling the previous criteria were replaced until 30 teeth with round shaped and 30 with oval shaped root canals were collected. *2) Preparation of the specimens:* Teeth were decoronated to standardize the root length to 15 mm. The root canal patency was confirmed by inserting # 20 K-file taper 0.2. The working length was established by observing the tip of the file protruding through the apical foramen and subtracting 1mm from the recorded length. Shallow mesial, distal, labial, and lingual grooves were done on the external surface of the root along the root length (Figure 1), by disc on low speed hand piece to standardize the point of measurements before and after preparation. The roots were covered with pink wax to avoid penetration of acrylic resin into root canal system and to easily remove the specimens from the acrylic resin blocks for histologic evaluation. *3) Embedding of the specimens in acrylic resin block:* A plastic mold (8cm x 8cm x 16mm) with 25 holes (15 mm diameter each) arranged in 5 columns and 5 rows were constructed (Figure 2). The sides of the mold were named and marked according to root surfaces as mesial, distal, labial and lingual sides corresponding to left, right, front and back sides of the mold respectively. Furthermore, a box shaped cavity was made on the mesio-labial corner of the mold and filled with amalgam for easy identification of the surfaces on the exposed radiographs. These constructed molds were placed on a glass slab that previously brushed with separating medium.

Then, a pink acrylic resin was mixed according to the manufacturer instructions and poured in 10 holes, into which the round root canals of one subgroup were inserted. Similarly, a transparent acrylic resin was mixed according to the manufacturer instructions and poured in the other 10 holes of the mold into which the oval root canals of the same subgroup were inserted (Figure 3). The root portions were placed vertically into the soft acrylic mass and then glass slab was removed. *4) Grouping of the specimens:* The root canals were divided into 2 main groups according to the shape of the canal as follow: Group 1: 30 Oval-shaped root canals. Group 2: 30 Round-shaped roots canals. Each group was subdivided into 3 subgroups (n= 10) according to the technique of preparation as follow: Subgroup A: Root canals were prepared by Wave-One. Subgroup B: Root canals were prepared by single F2. Subgroup C: Root canals were prepared by complete sequence of ProTaper. The distribution of the specimens among groups and subgroups is shown in figure (1). All previous subgroups were examined for shaping ability with cone beam computed tomography (CBCT) by measuring pre-and post-instrumentation dentin thickness (figure 2) and calculation of transportation and centering ratio then histologically for debridement quality.

Results

Regarding transportation, oval root canals recorded higher mean of transportation than round shaped root canals at the middle and coronal levels when prepared by complete sequence of Protaper (subgroup C). Otherwise, there was no significant difference between round and oval root canals using the other systems (Table 1, Figure 3). *Centering ratio:* There was no significant difference between centering ratio of oval and round shaped root canals using the three systems (subgroup A, B, C) both in labio-lingual and mesio-distal, except at middle level of round shaped root canals prepared by complete sequence of Protaper that recorded a lower mean value of labio-lingual centering ratio (1.04 ± 0.82 mm) than oval shaped root canals (2.59 ± 1.92) (Table2, and Figure 4). *Remnants pulp tissue:* In the three subgroups; A (Wave-One), B (single F2), and C (complete sequence of Protaper), the round-shaped root canals recorded the lower statistically significant difference mean value of remnants pulp tissue than oval-shaped root canals at the three levels (apical, middle, and coronal) (Table 3, Figure 5).

Figure 1: A photograph showing arrangements of specimens of each subgroup in acrylic resin block.

Discussion

Effective cleaning and shaping of the root canal system is essential for achieving the biological and mechanical objectives of root canal treatment[1]. The objectives are to remove all the pulp tissue, bacteria and their by-products while providing adequate canal shape to fill the canal. Several problems were reported during cleaning and filling of oval-shaped root canals[5].

Figure 2: Measuring mesial, distal, labial, and lingual dentin thickness

Table 1: Comparison between oval and round shaped root canals subgroups regarding transportation among Wave-One, single F2, and complete sequence of Protaper.

Transportation			N	Mean	SD	t	P value
	Level	Group					
A Wave-One	*Apical*	*Oval*	10	0.75	.47	0.37	0.71
		Round	10	0.67	.52		
	Middle	*Oval*	10	0.71	.43	-2.06	0.06
		Round	10	1.0	.13		
	Coronal	*Oval*	10	0.79	.40	-1.03	0.32
		Round	10	0.97	.37		
B F2	*Apical*	*Oval*	10	0.88	0.13	-1.13	0.27
		Round	10	0.95	0.17		
	Middle	*Oval*	10	0.93	0.04	-2.02	0.06
		Round	10	1.03	0.14		
	Coronal	*Oval*	10	0.92	0.09	-1.76	0.10
		Round	10	1.03	0.17		
C Protaper	*Apical*	*Oval*	10	1.09	.09	1.11	0.28
		Round	10	1.03	0.13		
	Middle	*Oval*	10	1.05	0.31	2.23	0.04▪
		Round	10	0.66	0.45		
	Coronal	*Oval*	10	1.04	0.31	2.30	0.03▪
		Round	10	0.63	0.47		

Difficult areas for instrumentation and obturation are the buccal and lingual extensions of these irregular canals. It has been reported that the rotary instruments frequently produced a circular blug in the canal while the buccal and lingual extension remained unprepared. Also, cleanliness has been found poor in oval canals with much remaining debris in unprepared extension [6]. Hence, in this study the shaping and debridement ability were evaluated in round versus oval canals. The introduction of Ni-Ti rotary instruments resulted in great improvement in quality of mechanical preparation of the root canal space. The basic problem with all rotary systems is the centering of files in root canals during rotation and leaving uncleaned areas and potentially infected tissue in fins and isthmus after preparation[7]. Recently reciprocating motion has been advocated as an effective way to prepare curved canals.

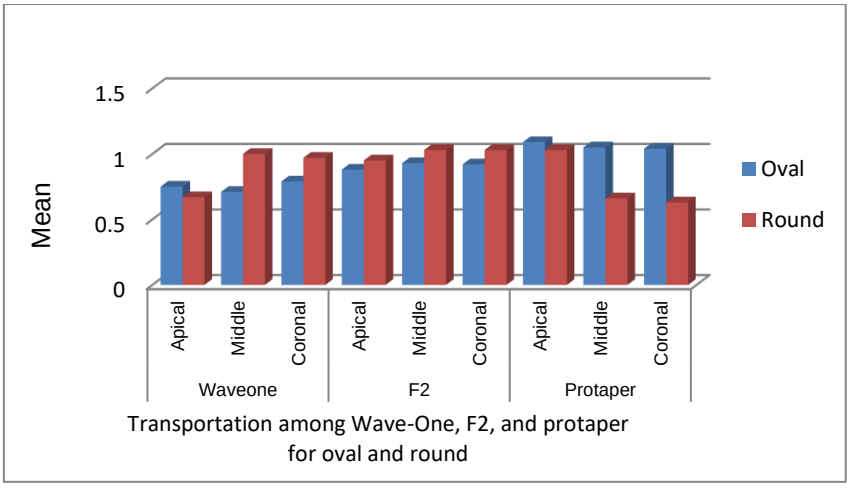

Figure 3: Bar chart representing comparison between oval and round groups regarding transportation among Wave-One, F2, and ProTaper.

Table 2: Comparison between oval and round shaped root canals subgroups regarding centering ratio (labio-lingual) among Wave-One, Single F2, and Complete sequence of ProTaper

Centering Ratio (bucolingual)			N	Mean	SD	t	P value
	Level	Group					
A Wave-One	*Apical*	*Oval*	10	0.71	1.53	1.35	0.20
		Round	10	1.03	.46		
	Middle	*Oval*	10	1.82	1.42	2.01	0.06
		Round	10	0.86	0.54		
	Coronal	*Oval*	10	1.19	0.82	1.21	0.24
		Round	10	0.79	0.62		
B F2	*Apical*	*Oval*	10	1.25	0.93	-0.60	0.56
		Round	10	1.49	0.87		
	Middle	*Oval*	10	1.06	0.89	0.92	0.37
		Round	10	0.74	0.67		
	Coronal	*Oval*	10	0.82	0.45	0.44	0.66
		Round	10	0.73	0.47		
C Protaper	*Apical*	*Oval*	10	1.72	1.39	1.74	0.10
		Round	10	0.88	0.65		
	Middle	*Oval*	10	2.59	1.92	2.36	0.03▪
		Round	10	1.04	0.82		
	Coronal	*Oval*	10	1.47	0.84	0.48	0.64
		Round	10	1.28	0.93		

The Independent-Samples T Test, Significant at P ≤ 0.05, Different letters indicating significant between groups

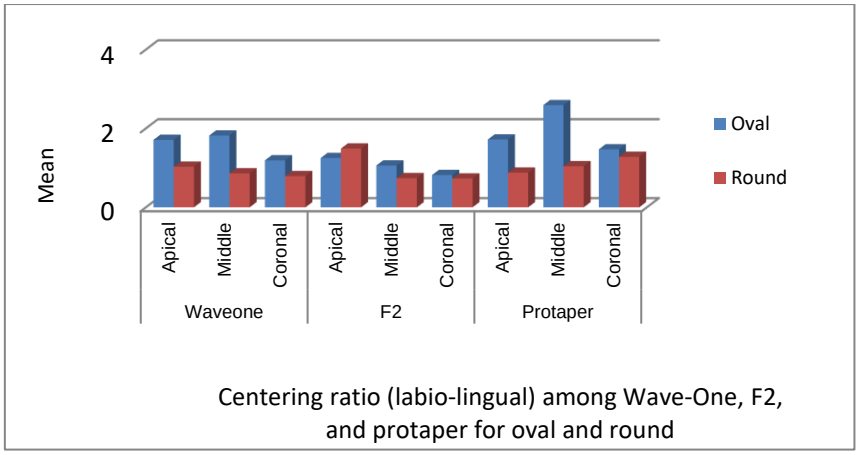

Fig. 4: *Bar chart representing comparison between oval and round shaped root canals subgroups regarding centering ratio (labio-lingual) among Wave-One, F2, and ProTaper*

Theoretically this motion might be more adequate than rotary one. It is assumed that oscillating file will move in all directions touching the entire canal wall with its side to side milling action[3,7,9]. So, the effect of reciprocating motion on the shaping ability and debridement of root canal was investigated in comparison to continuous clockwise rotation. Most recently, a call appeared for more simplification and more time and cost saving with less or no instrument separation. This is by adoption of a single file concept to perform the whole shaping procedure. This came also along with single use of files to reduce or eliminate cross infection. So, in the current study wave-one (M wire) and F2 Protaper (Ni-Ti) files were investigated as a representative of single and reciprocating files versus full sequence Protaper system. The centering ability within the canal was assessed by measuring two parameters: the canal transportation and the canal centering ratio at the coronal, middle, and apical levels. The canal transportation was calculated using the formulae of Gambill et al[10].

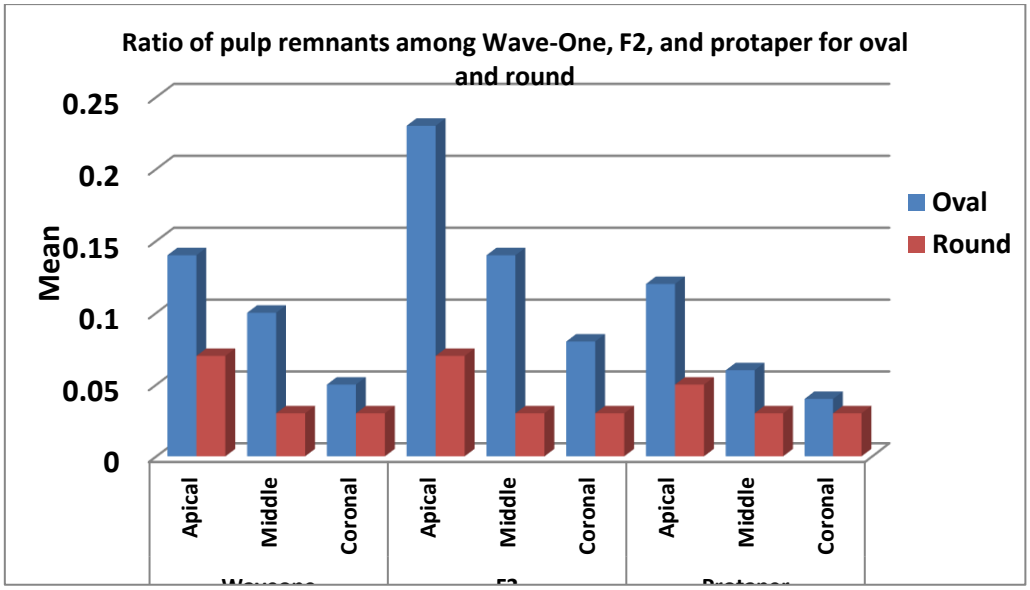

Figure 5: *Bar chart representing comparison between oval and round shaped root canals subgroups regarding remnants pulp among Wave-One, single F2, and complete sequence of Protaper at different levels.*

Table 3: Comparison between oval and round shaped root canals groups regarding ratio of pulp remnants among Wave-One

Ratio of Pulp Remnants			N	Mean	SD	t	P value
	Level	Group					
A Wave-One	*Apical*	*Oval*	10	0.14[a]	0.04	4.29	0.000▪
		Round	10	0.07[b]	0.02		
	Middle	*Oval*	10	0.10[a]	0.06	3.42	0.003▪
		Round	10	0.03[b]	0.01		
	Coronal	*Oval*	10	0.05[a]	0.02	3.72	0.002▪
		Round	10	0.03[b]	0.01		
B F2	*Apical*	*Oval*	10	0.23[b]	0.10	5.05	0.001▪
		Round	10	0.07[a]	0.02		
	Middle	*Oval*	10	0.14[b]	0.05	6.43	0.000▪
		Round	10	0.03[a]	0.01		
	Coronal	*Oval*	10	0.08[b]	0.04	4.01	0.001▪
		Round	10	0.03[a]	0.01		
C Protaper	*Apical*	*Oval*	10	0.12[b]	0.05	4.22	0.001▪
		Round	10	0.05[a]	0.02		
	Middle	*Oval*	10	0.06[b]	0.03	3.35	0.004▪
		Round	10	0.03[a]	0.01		
	Coronal	*Oval*	10	0.04[b]	0.02	2.31	0.03▪
		Round	10	0.03[a]	0.01		

The Independent-Samples T Test, ▪Significant at P ≤ 0.05, Different letters indicating significant difference between oval and round root canal groups.

Mesial, distal, labial and lingual dentin thickness were measured at 2 mm and 4 mm (apical), 5 mm and 7mm (middle), 9 mm and 11 mm (coronal) from the apex. This was done for gradual following of the instruments' performance at these levels which are considered the critical canal levels where most procedural mishaps occur. The aim of the present study was two folds: First, to evaluate two different Ni-Ti instrument movements namely reciprocation and continuous rotation in their ability to shape oval and round shaped root canals. Second, to investigate the ratio of the remnants pulp tissue (PRPT) after mechanical instrumentation by the above-mentioned movements. Results of this study showed that, Wave-One recorded the least statistically significant mean value of transportation at the apical level of both round and oval shaped root canals than other systems. This might be attributed to the unique design of Wave-One system as it is characterized by the coexistence of different cross sectional designs over the entire length. In the tip region, the cross section presents a modified triangular convex design with radial land, while at the middle and coronal part it is a convex triangular cross section[11]. Also, this might have attributed to increase of cutting efficiency of complete sequence of Protaper due to its triangle cross section. These results agreed with Tambe et al[12] who concluded that, the canal preparation by wave-one file showed less canal transportation and better centering ability than One shape and Protaper. Regarding comparison between oval and round shaped root canals Wave-One and single F2 files recorded insignifi-

cant difference of transportation in apical, middle, and coronal levels. While, complete sequence of Protaper recorded significantly less transportation in round shaped root canals than oval one in middle and coronal levels but not in the apical level. This may be attributed to advantages of reciprocation motion of Wave-One and single F2. Theoretically this motion might be more adequate than rotary one as the reciprocating files will move in all directions touching the entire canal wall with its side to side milling action[3,7,9]. On the other hand, rotational movement lead to deviation from oval pattern and may showed key-hole, dumbbell-shaped, and central blug effects[13]. Regarding centering ratio which represents the ability of instruments to remain centered in the prepared canals. Although in round-shaped root canals there were insignificant differences between the three systems studied in the both mesio-distal and labio-lingual directions, Wave-One had the best centering ratio followed by single F2 and finally complete sequence of Protaper. On the other hand, in labio-lingual centering ratio of oval-shaped root canals, Wave-One and single F2 recorded significantly the best centering ratio than complete sequence of Protaper at apical, middle and coronal levels. This was in accordance to Mahdi and Maruish[14] who concluded that Wave–One recorded better centering ability especially at apical level of root canals compared with Protaper. This might be attributed to assumption of the reciprocating files move in all directions with its side to side milling action[3,7,9]. In this respect, Burklein et al.[15] showed that root canal shaping with Wave-One instrument can be performed with a good centering ability in regularly curved canals. Additionally, in comparison between oval and round shaped root canals; complete sequence of Protaper had the best significant labio-lingual centering ratio at middle level of round shaped root canals than oval shaped root canals. These results might be attributed to reports of Sjögren et al[1], who reported that the wide variations among different teeth prepared by the same technique appears to result from variations in root canal anatomy rather than from the instrument or technique itself. In comparison between oval and round shaped root canals, round shaped root canals had the significant lowest ratio of remnant pulp tissue at the three root canal levels with the three systems tested. This result was in accordance with that of Eid and Amin[13] as they concluded that the single- file F2 Protaper technique displayed the similar ratio of remnants pulp tissue to full range of Protaper instruments in round canals. However, the debridement quality of the single-file F2 Protaper technique was suboptimal in oval canals.

Conclusion

From the obtained results in this study the following conclusion could be drawn out: 1) In oval-shaped root canals, centering ability of two single reciprocating files (Wave-One and single F2) was better than rotational complete sequence of ProTaper. 2) Wave-One removed less dentin than single F2 and complete sequence of ProTaper and so the least transportation in oval and round shaped root canals. 3) The shaping of round shaped root canals and also its debridement was better than oval shaped root canals after instrumentation by the three techniques.

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