



Evaluation of Apically Extruded Debris and Irrigants during Root Canal Preparation using Different Rotary Instrumentation Systems: An *In-vitro* Comparative Study

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ABSTRACT

Background: Different instrumentation systems and techniques are used in the instrumentation of the root canal system which can result in debris formation that may be extruded beyond the apical foramen and cause post-operative pain. **Aim of the study:** Aim of the current study was to compare the amount of apically extruded debris and irrigants during instrumentation using 2 reciprocating single file systems (WaveOne Gold, Reciproc blue) and 2 continuous rotation file systems (ProTaper Gold, 2Shape) and comparing them to the control group (ProTaper Universal). **Materials and Methods:** Total 50 palatal roots of freshly extracted human maxillary first molars were collected for this study. Teeth were decoronated to a unified length of 15 mm, and then pushed through a pre-perforated rubber cap of pre-weighed glass vial then the root-cap complex was fitted on a glass vial and rubber dam ligated with dental floss was used to cover the glass vial for preventing the coronally extruded debris and irrigants from contaminating the external surface, gauge 25 needle was inserted parallel to the root surface through the rubber dam and cup. Samples were then randomly divided into 5 groups. **Results:** Data obtained were statistically analyzed using One Way ANOVA and LSD tests. The result showed that all groups resulted in apical extrusion of debris and irrigants, as it showed that the 2Shape Group B, Wave One Gold Group C and Reciproc blue Group D are statistically comparable, while ProTaper Gold Group A and ProTaper Universal Groups E showed statistically significant difference ($p < 0.05$). **Conclusions:** All of the systems resulted in apical extrusion. There was no influence of kinematic movements on apical extrusion. The 2shape file system produced the least amount of apical extrusion while the ProTaper Universal showed the greatest amount.

Keywords: Apical extrusion, 2shape, Reciproc blue, WaveOne gold

INTRODUCTION

Even small amounts of apical extrusion can promote postoperative inflammation, pain and delay healing. All instrumentation techniques result in extrusion of debris and irrigants into the periradicular tissues but with different amount depending on instruments type and designs, even though the preparation doesn't reach the apical terminus. Manual instrumentation techniques usually produce more debris extrusion in comparison to rotary nickel-titanium systems [1]. The flare-ups incidence during endodontic treatment is ranged between 1.4% up to 16%. The extruded debris results in an antigen-antibody complex formation which lead to a severe inflammatory response and postoperative flare-up [2]. While irrigants extrusion apically as sodium hypochlorite can causes inflammation, hematoma, ecchymosis, and even more complication as paresthesia and necrosis [3].

Cleaning and shaping of the root canal system is improved by the introduction of motor-driven nickel-titanium instruments and the advanced metallurgy. Introduction of new instruments generation for root canals shaping such as WaveOne Gold (Dentsply Maillefer, Ballaigues, Switzerland) Reciproc blue (VDW GmbH, Munich, Germany) and 2Shape (Micro Mega, Besancon, France) instruments which haven't been evaluated extensively in terms of debris extrusion, further study is mandatory [3,4].

Reciproc Blue (VDW GmbH, Munich, Germany) is a thermally treated nickel-titanium single file system which is the improved version of the original Reciproc. It has S-shaped cross-sectional design having 2 cutting edges, an increased

resistance to cyclic fatigue and greater flexibility [5]. WaveOne Gold (Dentsply Maillefer, Ballaigues, Switzerland) single file system is designed with a reverse cutting helix, operates in a 150° counter clockwise direction and disengages 30° in a clockwise direction, the net movement is 120° cutting cycle, so after 3 cycles the instrument will have made 360° reverse rotation [6]. ProTaper Gold (Dentsply Maillefer, Ballaigues, Switzerland) has a characteristics similar to those of the ProTaper Universal except the advance metallurgy of PTG (CM wire), while the PTU is conventional NiTi wire, therefore; the PTG exhibits increased flexibility and resistance to cyclic fatigue [7]. The 2Shape (Micro Mega, Besancon, France) is a continuous rotation two shaping files which have been thermally treated using the T Wire technology. The instruments' flexibility provides user comfort and an excellent negotiation in canal curvatures, it can return to their original shape after each use [8].

Aim of the current study was to compare the amount of apically extruded debris and irrigants during instrumentation using two reciprocating single file systems (WaveOne Gold, Reciproc Blue) and 2 continuous rotation file systems (ProTaper Gold, 2Shape) and comparing them to the control group (ProTaper Universal).

MATERIALS AND METHODS

Sample Selection and Preparation

Total 50 freshly extracted maxillary first molars were collected from different specialized dental centers (extracted for periodontal reason and the patient's age ranged from 45-55 years old). The palatal roots of teeth were selected according to specific criteria. The selected extracted teeth were cleaned from bone, calculus and soft periodontal tissue by cumine scaler, and immersed in 6% NaOCl for 1 hour [9], and then the root surfaces were checked for any visible cracks or fractures [10]. Then teeth were stored in normal saline until the time of use [11]. Teeth with calcification open or fractured apices, curved canals, internal and external resorption were excluded from the study. The teeth were then decoronated to a length of about 15 mm to achieve similar teeth lengths [12,13]. The vials were weighed without the rubber cup using the sensitive electrical balance with a precision of (0.0001) (Sartorius, Germany). The weight was recorded after having 3 consecutive readings, and then the mean of them was calculated to obtain the pre-instrumentation weight [14]. The rubber cup of each vial was perforated in the center using a hot instrument [15,16]. The root was pushed through the hole except the coronal third. Rubber dam ligated with dental floss was used to cover the glass vial to prevent contaminating the external surface of glass vial with the coronally extruded debris with irrigants which may affect the accuracy of the result. Flowable composite was injected all around the root surface to enhance sealing and a gauge 25 needle was inserted alongside the root surface through the rubber cup to equalize the pressure between the inside and outside of the vial [12].

Sample Grouping

The samples were randomly divided into 5 groups (n=10) and instrumented with the following systems which were used according to the manufacturer instructions:

- Group A: ProTaper Gold File system
- Group B: 2Shape File system
- Group C: WaveOne Gold reciprocating single file system
- Group D: Reciproc Blue reciprocating single file system
- Group E: ProTaper Universal File system (Control group)

Collection of Debris

The vials with the collected samples were placed in a hot air oven at 100°C for 2 hours [17]. Then the vials were weighed using the electronic balance, in the same manner and circumstance as we did for pre-instrumentation weights. About 3 consecutive weights were recorded and the mean value was calculated, which represented the post-instrumentation weight. The weight of debris of each sample was calculated from subtracting the values of pre-weight from post-weight of the vial for each group [18].

RESULTS

The results of this study showed that all groups resulted in extrusion of debris and irrigants with different values. The

mean values (in mg), and SD, min and max of apical extrusion of debris and irrigants for all groups are shown in Table 1 and Figure 1.

Table 1 The mean values of amount of apically extruded debris and irrigants (in mg) SD, min and max for all groups

Group	No.	Mean	SD	Min.	Max.
Pro Taper Gold	10	0.0369	0.01156	0.02	0.05
2Shape	10	0.0201	0.00655	0.01	0.03
Wave One Gold	10	0.0216	0.00694	0.01	0.03
Reciproc Blue	10	0.0212	0.00421	0.01	0.03
Pro Taper Universal	10	0.0443	0.00882	0.03	0.05

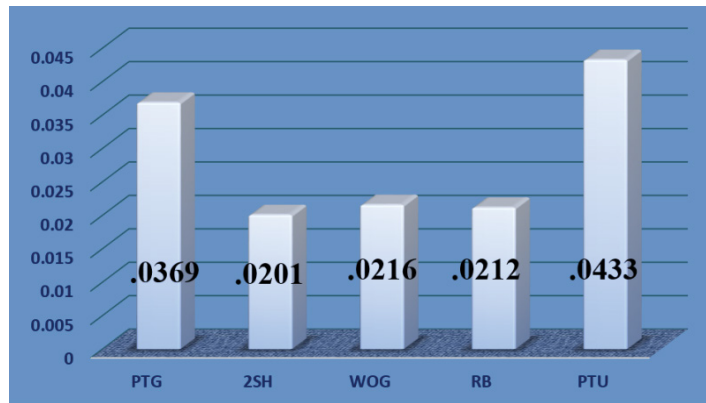


Figure 1 Bar chart for means of apically extruded debris and irrigants among the groups

2Shape group showed the lowest mean value of apically extruded debris and irrigants (0.0201 ± 0.0655) followed by Reciproc blue, WaveOne Gold, ProTaper Gold, and ProTaper Universal groups respectively. While ProTaper Universal had showed the highest mean value (0.0443 ± 0.00882). ANOVA test showed a highly significant difference among groups ($p \leq 0.001$) (Table 2).

Table 2 ANOVA of apical extrusion between tested groups files

Variables	Sum of Squares (ss)	df	Mean Square	F-Test	p-value	Sig.
Between Groups	0.005	4	0.001	17.970	0.000	HS
Within Groups	0.003	45	0.000	0.000		
Total	0.007	49	0.000	0.000		

* $p \geq 0.05$ Non-Significant (NS); $p < 0.05$ Significant (S); $p \leq 0.01$ High Significant (HS)

The least significance difference test (LSD) was performed for multiple comparisons between groups which showed that Group A ProTaper Gold had a highly significant difference with Group B 2Shape, Group C WOG and Group D Reciproc blue ($p \leq 0.001$), while it showed non-significant difference with Group E ProTaper Universal ($p \geq 0.05$). Group B 2Shape showed a non-significant difference with Group C WaveOne Gold and Group D Reciproc blue ($p \geq 0.05$), it also showed highly significant difference with Group E ProTaper Universal ($p \leq 0.001$). Group C WaveOne Gold showed a non-significant difference with Group D Reciproc blue ($p \geq 0.05$) and highly significant difference with Group E ProTaper Universal ($p \leq 0.001$). Group D Reciproc blue showed a high significant difference with Group E ProTaper Universal ($p \leq 0.001$) Table 3.

Table 3 Multiple Comparisons of AED between groups using LSD

Group-I	Group-J	Mean Difference (I-J)	SE	p-value	Sig.
PTG	2SH	0.01680*	0.00358	0.000	HS
	WOG	0.01538*	0.00358	0.000	HS
	RB	0.01574*	0.00358	0.000	HS
	PTU	-0.00632	0.00358	0.084	NS

2SH	WOG	-0.00142	0.00358	0.693	NS
	RB	-0.00106	0.00358	0.768	NS
	PTU	-0.02312*	0.00358	0.000	HS
WOG	RB	0.00036	0.00358	0.920	NS
	PTU	-0.02170*	0.00358	0.000	HS
RB	PTU	-0.02206*	0.00358	0.000	HS

DISCUSSION

Different rotary instrumentation systems possess different shapes and properties that affect the outcome of their actions, apical extrusion is one of the actions of using rotary instruments. Many factors contribute to apical extrusion as the instrumentation techniques, type and size of files, working length, and irrigant solution [19].

In this study normal saline solution was used as a canal irrigants, despite the salty precipitate that occurs after the desiccation which may affects the result. It may be considered as an indirect measure for the irrigants extrusion because under clinical condition there isn't any extrusion without using irrigants solution during preparation of canal and both debris and irrigants are included in the apical extrusion, therefore, the measurement accuracy of the apical extrusion may be increased [20].

In the current study, the 2Shape file system showed the lowest amount of debris and irrigants extrusion (mean=0.0201) in comparison to other tested groups and a highly significant difference with the PTG group and the control group (PTU file) ($p \leq 0.01$), this finding may be due to the file design with new asymmetrical cross-section having triple helix with two main cutting edges for improved cutting efficiency and one secondary cutting edge for improved removal of debris [8], this asymmetrical cross-section provides the non-uniform and reduced contact points between the instrument and the canal wall, also it may be related to the 0.06 taper since the lesser taper is the lesser preparation of the dentinal walls and thus may be promoting lesser debris extrusion. This agreed with the other study [21].

According to the result of this study, ProTaper Universal file system (the control group) showed the greatest amount of apically extruded debris and irrigants (mean=0.0443) when compared to the other tested groups and non-significant difference with ProTaper Gold file systems, this may be due to the advanced metallurgy of PTG which is the only difference between them and it imparts the greater flexibility and greater resistance to cyclic fatigue to PTG while the PTU had greater resistance to torsional stress and micro-hardness [22], these properties of PTG instrument may explain the lesser amount of debris and irrigants extrusion than the PTU system [23], both PTU and PTG files have a convex triangular cross-sectional design and a flute design that combines multiple tapers within the shaft, they claimed to cut the dentine more effectively with increased risk of debris and irrigants extrusion, the long pitch design of the ProTaper instruments can cause greater amount of debris and irrigants to be extruded [19]. Also the tapering of ProTaper files favors the preparation of the apical third as soon as the instrumentation begins thus wear occurs early throughout the whole canal because the instrument reaches the working length at the beginning of the preparation causing greater apical extrusion [24]. Another explanation is that both of them have the same sequence and number of files and the high number of files used for preparation may be another contributing factor for more debris and irrigants extrusion during instrumentation [25]. The result of this study agreed with other study [23].

In this study the Wave One Gold reciprocating single file system had showed highly significant difference ($p \leq 0.01$) with the control group, and non-significant difference ($p \geq 0.05$) with Reciproc blue reciprocating single file system in term of debris and irrigants extrusion, this may be due to the WOG instrument properties that it has 85°parallelogram cross-sectional design with an alternating offset and with every other millimeter the file has one or two points of contact and so forth [26], the 2 points then 1 point increase the spaces available for debris removal, therefore less apical extrusion, the 0.07 taper for the WOG primary instruments as compared to 0.08 for the PTU and PTG may be another cause for the less amount of debris production and this result agreed with the other study [27].

The Reciproc blue reciprocating single file system also showed highly significant difference with the control group (PTU) ($p \leq 0.01$), this may be due to file design with specific s-shaped cross-section and a larger space to accommodate dentine debris, no radial lands, thermally improved raw material and non-cutting tip for a gentle treatment near the apex, this result agreed with the other study [20,28]. The Reciproc blue file is similar to Reciproc file but it is thermally treated which is proposed to perform better than Reciproc in term of debris extrusion. Reciproc is a single file root canal preparation system.

Recently, Bürklein, et al., reported that the Reciproc system produced more debris than the ProTaper system, which they attributed to the cross-sectional design and cutting efficiency of the instruments [20]. In contrast, we found no differences among the systems, likely because of the increased WL diameter [10]. The Reciproc instrument produced less debris compared with the other instruments. This result is in agreement with another study reporting that reciprocating instruments were associated with reduced debris extrusion [19]. Reciproc is a single file root canal preparation system.

This study showed that the reciprocating single file system associated with less apical extrusion than the rotary instrumentation file systems (PTG and PTU) and this agreed with other study [29], but more apical extrusion than the 2Shape rotary file system which may be due to the new generation of cross-section with tripe helix and the lesser taper of the 2Shape instrument concluding that the kinematic movements have no influence on apical extrusion, further study is mandatory [8].

CONCLUSIONS

The kinematic movements have no influence on the apical extrusion of debris and irrigants. The ProTaper Universal file system associated with the greatest amount of apical extrusion while the 2Shape file system showed the least amount of apical extrusion, further study is mandatory.

DECLARATIONS

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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