

Comparative Evaluation of Apical Debris Extrusion from the Root Canal using Hand Files, Continuous Rotary Files and Reciprocating File System: An In-vitro Study

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ABSTRACT

Introduction: Root canal preparation is an important step of endodontic therapy. For successful endodontic therapy apical extrusion of debris through the apical foramen into the periradicular region should be minimal to avoid postoperative complication such as flare-ups.

Aim: To evaluate in-vitro, extrusion of apical debris from the root canal using continuous rotary files (using multiple files system and single rotary file system), reciprocating file system and hand files.

Materials and Methods: This in-vitro research was carried out in the Department of Conservative Dentistry and Endodontics, MM college of Dental Sciences and Research, Mullana, Ambala, Haryana, India, from November 2017 to January 2018. A total of 120 human mandibular premolar teeth that were caries free and single-rooted were split into four groups (each group with n=30) Group I: Hand ProTaper, Group II: Protaper Universal, Group III: F360 and Group IV: WaveOne Gold file system. The root canal

was instrumented according to manufacturer's Instructions; and standardised irrigation with distilled water was performed. The Myers and Montgomery's Model was employed to gather irrigant and debris that had been apically ejected. The analysis of data obtained was done using Posthoc Bonferroni test, One-way Analysis of Variance (ANOVA) and paired t-test.

Results: The findings indicate that all instrumentation techniques produced significant amount of extruded debris and irrigant. The mean apical debris extrusion using the One-way ANOVA test showed significant difference (p-value <0.001). WaveOne Gold file group showed least (0.0005±0.0001 mg) and Hand ProTaper file showed maximum (0.0017±0.0002 mg) apical debris and irrigant extrusion.

Conclusion: Less apical extrusion of irrigant and debris was observed in the engine-driven nickel-titanium systems than manual technique. Reciprocating file system when compared with hand and continuous rotary file system showed less debris extrusion.

Keywords: Irrigant, Protaper, Rotary endodontics, Single file system, WaveOne gold file

INTRODUCTION

In endodontic treatment, root canal preparation plays key role, for successful treatment, vital, necrosed tissue and dentinal debris must be removed from the root canal system [1,2]. However, there are chances that these materials get extruded during root canal preparation into the periapical tissues via apical foramen resulting in postoperative complications (such as flare-up), which is characterised by pain, periapical inflammation and swelling [3].

The root canal anatomy, instrument type, design and kinematics are the various variables which determine the apical extrusion of the debris. Studies have shown that less extrusion of debris with both crown-down and balanced force technique when compared with hand instrumentation using step back technique [4-6]. Biomechanical preparation of root canal can be done using hand files or rotary endodontic instruments. The two major movements that rotary instruments utilises are continuous rotating full sequence and reciprocating motion [7].

ProTaper Hand files (Dentsply Maillefer, Ballaigues, Switzerland) is a multiple file system consisting of shaping instruments (Sx, S1, S2) and finishing instrument (F1, F2, F3). ProTaper Universal NiTi rotary file system (Dentsply Tulsa Dental) was designed to offer more flexibility, greater safety and supreme efficiency [8]. WaveOne

(Dentsply/Maillefer, Ballaigues, Switzerland) single file systems are recommended for single use and feature a particular motor that executes the reciprocating motion (i.e. alternating clockwise and counterclockwise) [3,9].

The F360 (Komet, Brasseler GmbH & Co., Lemgo, Germany) is a single-use and consists of two file system with tip diameter 25 and 35 (4% taper). It has an improved S-shaped cross-sectional design with improved cutting efficiency, increased flexibility with large chip space and a twisted blade in order to flush out all the infected debris [10,11].

As endodontic instruments differ in design and use, therefore a lot of variances is seen in apical extrusion of debris. Dagna A et al., performed Scanning Electron Microscope (SEM) evaluation of cleaning efficiency with F360 and F6 Skytaper [10]. Bürklein S et al., and Ehsani M et al., performed evaluation of apically extruded debris quantitatively using F360 with different file systems [12,13]. But still limited evidence is there that has assessed the amount of dentinal debris extruded during preparation with single rotary file system (F360 files system) and its comparison with reciprocation system. Thus, the present study was carried out with the null hypothesis to evaluate the extrusion of the debris from the apical portion of the root canal using hand, continuous (multiple and single rotary file system) and reciprocating file system.

MATERIALS AND METHODS

The present in-vitro study was performed in the Department of Conservative Dentistry and Endodontics, MM College of Dental Sciences and Research, Mullana, Ambala, Haryana, India, from November 2017 to January 2018. This study was approved by Review Board and Institutional Ethical Committee (IEC/726).

Sample size calculation: As per open EPI software version 3 (95% confidence interval and power of study 80%). The study's sample size calculation resulted in 28 samples per group, which were rounded up to 30 samples per group.

Inclusion criteria: Intact single-rooted mandibular premolar, extracted due to orthodontic and periodontal reason with mature apices with 0-10 degree curvature (according to Schneider method) were selected, confirmed with radiographs and then were included in the study [3].

Exclusion criteria: Teeth with root caries, calcification and open apices were excluded from the study.

Study Procedure

Preparation of sample: The teeth sample collected were cleaned with ultrasonic scaler to remove any soft tissue, gross debris and calculus deposits and were kept in 0.1% thymol as antifungal agent until their use. Each tooth's buccal cusp edge was flattened as a reference point using Endoaccess bur no. 2 (Dentsply Maillefer, Switzerland), to maintain length to 20 mm. The coronal access cavity was prepared and 10K file (Dentsply Maillefer, Switzerland) was used to check apical patency of all the canals. The apical width was approximated to a snug fit with a K file of size 15. The Working Length (WL) was achieved by subtracting 1 mm from apical foramen. Irrigation during instrumentation was done using 2 mL distilled water. The selected teeth were randomly assigned to four equal groups:

Group I: Hand ProTaper files (n=30): Protaper hand files were used for specimen preparation, according to manufacturer's instructions in a crown-down manner using a gentle in and out motions. Firstly, SX shaping file was used to 2 mm short of the working length, followed by S1 and then S2 files for coronal two-third of the canal. The apical one-third of the canal was then finished using F1 and F2 files, sequentially upto the working length. (Sequence: S1-Sx-S2-F1-F2)

Group II: Protaper Universal (n=30): The specimens were prepared with protaper rotary files in a crown-down manner according to manufacturer's instructions using a gentle in-and-out motions by torque-controlled electric motor (X-mart plus; Dentsply Maillefer). First, the shaping file SX was used upto 2 mm short of the working length, followed by S1 and S2 for the coronal two-third shaping of the canal. For apical one-third of the canal, F1 and F2 were used sequentially till working length. (Sequence: S1-Sx-S2-F1-F2).

Group III: F360 (n=30): A F360 file (Komet, Brasseler GmbH & CO., Lemago, Germany) with a size 25 at tip and taper 0.04 was used, with 300 rpm of rotational speed and 1.8 Ncm torque.

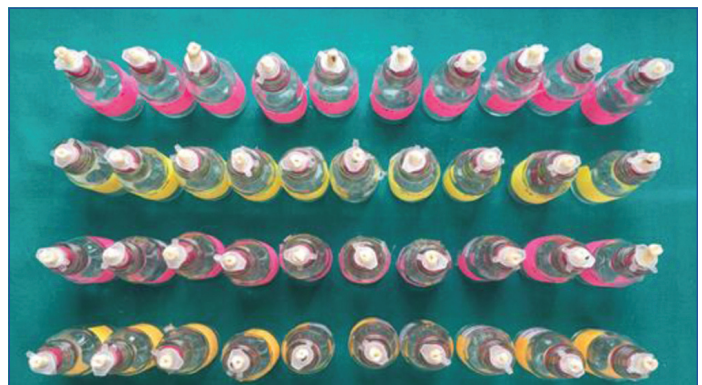
Group IV: WaveOne Gold (n=30): The WaveOne Primary file (25/08) was used with X-mart plus endomotor according to manufacturer's instructions. The file was used with an amplitude of 3 mm in a smooth back-and-forth motion. After three passes, dense sponge was used to clean the blades. Next, 2 mL of distilled water was used to irrigate the canal. At least three times, this procedure was repeated until the file reached the WL.

Debris collection: Myers and Montgomery's experiment model (1991) was used to assess the extruded debris [14]. All tubes were incubated (at 37°C) in a biological incubator for 15 days; to evaporate the remaining irrigating solution from the tubes. The

Eppendorf Tubes were preweighed using the analytical balance (Sartorius-Germany) with an accuracy of 10^{-4} . The Eppendorf tubes' stoppers were created with an opening, and the teeth were put through the orifice until the Cemento-enamel Junction (CEJ) was 1-2 mm above the stopper. A rubber-dam sheet was used to check seepage of overflowing irrigant during irrigation and this assembly was fitted onto a glass vial [Table/Fig-1,2].



[Table/Fig-1]: Apparatus used to collect debris and irrigant during endodontic preparation.



[Table/Fig-2]: All samples ready for biomechanical preparation (Overview).

STATISTICAL ANALYSIS

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) software version 22.0 (Chicago, IL, USA). Data collected was analysed statistically to compare between the groups by using paired t-test, One-way ANOVA test and Posthoc Bonferroni test for multiple comparison. Level of statistical significance was set at p-value <0.05.

RESULTS

Hand ProTaper file showed maximum and WaveOne Gold file group showed the least apical debris and irrigant extrusion. The mean apical debris extrusion using the One-way ANOVA test showed

significant difference (p -value <0.001), when compared between Hand ProTaper, Protaper Universal, F360 and WaveOne Gold groups [Table/Fig-3].

Endodontic files	Mean	Standard deviation	F-value	p-value
Hand ProTaper	0.0017	0.0002	281.148	<0.001
Protaper Universal	0.0013	0.0001		
F360	0.0009	0.0001		
WaveOne Gold	0.0005	0.0001		

[Table/Fig-3]: Mean apical extrusion of debris of all file systems. Mean values presented in mg. One-way ANOVA test used. The p-values in bold font indicates statistically significant values

The comparison of mean pre and post weight was done using the paired t-test. The mean weight increased significantly from pre to post weight measurement in all the groups [Table/Fig-4]. The intergroup comparison of mean apical debris extrusion was done using the Posthoc Bonferroni test. Hand ProTaper had significantly more apical extrusion of debris followed by ProTaper Universal, then F360 and least with WaveOne Gold file system [Table/Fig-5].

Endodontic files	Prewrite (mg)		Postweight (mg)		Mean difference	t-test value	p-value
	Mean	SD	Mean	SD			
Hand ProTaper	0.5210	0.0327	0.5227	0.0327	-0.0017	-40.834	<0.001
ProTaper Universal	0.5147	0.0396	0.5160	0.0396	-0.0013	-46.065	<0.001
F360	0.5157	0.0323	0.5166	0.0367	-0.0009	-28.687	0.024
WaveOne Gold	0.5163	0.0391	0.5168	0.0391	-0.0004	-19.741	0.038

[Table/Fig-4]: Prewrite and postweight mean difference of apical extrusion of debris of all file systems. Mean difference values presented in mg; Paired t-test

Endodontic file	Compared endodontic file	Mean difference (mg)	p-value
Hand ProTaper	ProTaper Universal	0.0004	<0.001
	F360	0.0007	
	WaveOne Gold	0.0012	
ProTaper Universal	Hand ProTaper	-0.0004	<0.001
	F360	0.0004	
	WaveOne Gold	0.0008	
F360	Hand ProTaper	-0.0007	<0.001
	ProTaper Universal	-0.0004	
	WaveOne Gold	0.0005	
WaveOne Gold	Hand ProTaper	-0.0012	<0.001
	Protaper universal	-0.0009	
	F360	-0.0005	

[Table/Fig-5]: Mean difference of debris apical extrusion between different files. Posthoc Bonferroni test used

DISCUSSION

Major cause of intertreatment flare-ups and postoperative pain after root canal treatment is apical extrusion of debris during root canal preparation [15]. The amount of extruded debris is affected

by multiple factors, including design, number, and size of the instruments used in each system, preparation technique, and kinematics [16]. Thus, the present study aim was to compare and evaluate hand, continuous rotary and reciprocating files regarding the amount of apically extruded debris after preparation of root canals of permanent mandibular premolar. As the presence of more than one canal may alter the final quantity of apical extrusion, the present study examined single-rooted mandibular premolars with a single apical foramen [17,18].

Because distilled water does not have the same solvent effect as NaOCl, it was used as an irrigant in all of the experimental groups. As a result, the extrusion of debris is only dependent on the mechanical activity of the instruments. Additionally, the sodium crystallisation phenomenon is a side-effect of using NaOCl, which may have impacted the study's findings [19]. The amount of debris extruded apically has been measured using a variety of approaches, including the scoring system and microbalance weighing. The Myers and Montgomery's method affords more precise measurements, repeatable and standardised method, hence was used in the present study [16,20].

The result showed that the WaveOne Gold (Group IV) files produced significantly less debris than F360 (Group III), Universal Protaper (Group II) And Hand ProTaper (Group I) files. The result of present study is in accordance with previous study Cavides-Bucheli J et al., and Tomer AK et al., which claimed that balanced force and pressure-less mechanics are the factors for decreased debris extrusion of reciprocating systems [20,21].

WaveOne Gold's unique design includes an alternating cross-section that allows only one cutting edge to come into contact with the canal wall, thereby, decreasing the contact area between the file and canal. Thereby, providing more space for coronal debris removal and less extrusion of apical debris. These results are similar to the study which concluded that the reciprocating system produced smaller quantities of apical debris compared to the continuous rotary file system [22-24].

The F360 file taper (4%) is smaller when compared to the tapers of ProTaper Hand (8%), further the cross-sectional designs of the F360 is S-shaped which facilitate the movement of debris in coronal direction hence less debris extrusion when compared to Hand ProTaper and Universal Protaper File system [10,16]. Rotary ProTaper Universal System (Group IV) showed less apical extrusion when compared with Hand ProTaper as contact with apical area for rotary ProTaper is for a limited time period and also the torque and rotational speed are fixed [25].

Hand ProTaper had significantly more apical extrusion of debris than rotary instruments (Protaper Universal, F360 and WaveOne Gold), as rotary motion tends to direct debris towards the orifice which will avoid compaction, thereby decreasing the apical debris extrusion, this is in accordance with Goering AC et al., study [24]. Comparative evaluation of similar studies has been done in [Table/Fig-6] [3,21,22,26-29]. As a result, it was determined in the current study that rotary devices are superior to manual filing systems because they lessen apical extrusion of debris during canal preparation.

S. No.	Author and year of the study	Place of the study	Sample size	Files compared	Parameters assessed	Conclusion
1	Ozsu D et al., [3] (2014)	Turkey	56 single-rooted mandibular premolars	<ul style="list-style-type: none"> ProTaper Universal, ProTaper Next, WaveOne, SAF (self-adjusting files) 	Amount of apically extruded debris	All systems extruded debris beyond the apical foramen.
2	Tomer AK et al., [21] (2017)	Ghaziabad, India	80 human teeth with straight single canal were selected.	<ul style="list-style-type: none"> WaveOne Gold One Shape, F360 Reciproc 	Apical extrusion of debris	WaveOne Gold extruded less amount of periapical debris than the other file systems.

3	Tinoco JM et al., [22] (2014)	Brazil	45 human single-rooted mandibular incisors	<ul style="list-style-type: none"> • Single File System (Reciproc, WaveOne) • Conventional Multifile Rotary system (BioRace) 	Apical bacterial extrusion	All instrumentation systems extruded bacteria beyond the foramen. However, both reciprocating single-file systems extruded fewer bacteria apically than the conventional multifile rotary system.
4	Keskin C and Sanyilmaz E [26] (2018)	Turkey	100 single-rooted mandibular premolar teeth	<ul style="list-style-type: none"> • Reciproc Blue, • ProTaper Next, • R-Endo, WaveOne Gold systems 	Apically extruded debris and irrigants	All the instruments caused apical extrusion. ProTaper Next and WaveOne Gold systems were associated with significantly less apical extrusion.
5	Elashiry MM et al., [27] (2020)	Cairo, Egypt	60 mesiobuccal canals of mandibular molars	<ul style="list-style-type: none"> • WaveOne Gold, • RECIPROC Blue, • HyFlex EDM One file 	Apical extrusion of debris	Difference between WaveOne Gold and HyFlex EDM suggests that file design and motion kinematics affect the quantity of debris extrusion.
6	Roshdy NN and Hassan R [28] (2022)	Egypt	51 mesiobuccal canals with severe curvatures (25-40°)	<ul style="list-style-type: none"> • TRUShape 3D • TruNatomy files, WaveOne Gold 	Apical extrusion of debris	Debris extrusion occurs independently of the motion or design of the instrument.
7	AlChalabi A et al., [29] (2022)	Iraq	60 mandibular premolars with single root.	<ul style="list-style-type: none"> • Neoflex Neonita1, • WaveOne Gold ProTaper Next 	Apical extrusion of debris	WaveOne Gold was found to be the least apical extruded debris system among all groups.
8	Present study	Haryana, India	120 single-rooted mandibular premolars teeth	<ul style="list-style-type: none"> • Hand ProTaper • Protaper Universal • F360 • WaveOne Gold 	Apical extrusion of debris from the root canal using hand files, continuous rotary file and reciprocating file system	Rotary files showed less apical debris extrusion compared to hand files. Amongst rotary files reciprocating file system showed least amount of debris extrusion.

[Table/Fig-6]: Comparison with other similar studies [3,21,22,26-29].

Limitation(s)

The utilisation of various rotary systems with various numbers of files, tapers, rotational speeds, and kinematics was one of the study's drawbacks. In addition to offering better, more accurate settings to create consistent comparisons between the tested groups, in-vitro investigations could serve as a benchmark for future clinical studies. An in-vivo model may give different result, as no attempt in simulating the presence of vital pulp and periapical tissues has been done as these tissues may act as a natural barrier, inhibiting the extrusion of debris.

CONCLUSION(S)

The null hypothesis tested stated that the amount of apically extruded debris does not vary in-between the instrumentation systems. According to the findings of the present study, it can be concluded that apical extrusion of debris is an unavoidable consequence of root canal instrumentation. WaveOne Gold (Reciprocating File system) extruded minimum amount of debris because, it is a single file technique having a unique design feature of alternating offset parallelogram-shaped cross-section when compared with Hand ProTaper (hand files), Rotary Protaper (continuous rotary Files) F360 (single rotary file system).

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PLAGIARISM CHECKING METHODS: [\[Jain H et al.\]](#)

- Plagiarism X-checker: Dec 17, 2022
- Manual Googling: Feb 15, 2023
- iThenticate Software: Mar 16, 2023 (17%)

ETYMOLOGY: Author Origin

EMENDATIONS: 8

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? NA
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Dec 16, 2022**

Date of Peer Review: **Jan 17, 2023**

Date of Acceptance: **Apr 08, 2023**

Date of Publishing: **Jun 01, 2023**