Comparison of cleaning effectiveness of single rotary file OneShape and reciprocating F2 Protaper with Protaper Universal sequence: A SEM analysis

Adish A. Saraf^{a,*}, Anand C. Patil^b, T.M. Mangala^a, Rushikesh Mahaparale^a, Sneha Mali^a, Sagar Pawar^a

^a School of Dental Sciences, KIMSUDU, Karad, 415539, India

^b KLE VK Institute of Dental Sciences, KAHAR, Belgavi, 590010, India

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ABSTRACT

Aim: This in vitro study intend to compare the cleaning effectiveness of Protaper universal sequence with reciprocating F2 Protaper and single rotary file One shape.

Materials and method: 30 extracted human 1st mandibular molars were chosen for the analysis. Three NiTi file systems were used for mechanical preparation, ProTaper full sequence in rotary motion, single F2 Protaper file used in reciprocating motion, and One shape single file used in a circular motion. Irrigation was carried out after each instrument use using 5 ml of 5% NaOCl followed by normal saline. The root canal surface was evaluated at three different areas (coronal, middle and apical thirds) using Scanning Electron Microscopy. Debris and the Smear layer were evaluated. Data were analyzed statistically using the Friedman test and Kruskal–Wallis test ($p \leq 0.05$).

Results: A statistically significant difference ($p \leq 0.05$) was observed in the debris score of the Protaper universal group when the 3 thirds of the root were compared. Intergroup comparisons confirmed a statistically significant difference at the coronal and apical third of the roots when debris scores were evaluated. Intragroup comparison for the smear layer demonstrated a statistically significant difference ($p \leq 0.05$) at all the 3 levels of the radicular canal for the 3 groups studied. Intergroup comparisons revealed a statistically significant difference ($p \leq 0.05$) in the middle and apical 1/3rd when the smear layer was evaluated.

Conclusion: The Protaper full sequence group provided better results than Single F2 ProTaper and One shape groups when debris and smear layer removal was investigated.

1. Introduction

Effective canal shaping is a requisite to eliminate microbiota from the root canal.¹ The mechanical objectives are primarily focused on removing all the pulp tissue, bacteria, and their derivatives while providing adequate canal shape to fill the canal.² The flexible and highly efficient rotary nickel-titanium (Ni–Ti) instruments have been widely used to achieve the mechanical objective to potentiate the biological objectives. Nitinol instruments are steeply-priced which forces the practitioners to use these instruments multiple times. Repeated usage of Nitinol files leads to disease transmission as well as a fracture in narrow and/or curved canals.

Dr. Yared G¹ introduced a novel preparation method with only one single instrument, F2 ProTaper operated in a reciprocating motion and called the single-file F2 ProTaper technique. The advantage of this

technique was it was a simplified, cost-effective technique as it reduced the cyclic stresses on the file. The universal ProTaper is designed with three radial lands and a convex core.³ It has three positive rake angles and a safe cutting tip. Another single file One Shape (Micro- Mega, France) used in rotary motion has an apical variable taper with 3 cutting edges; before the transition from apical to the middle portion, has a cross-section that evolves from 3 to 2 cutting edges and coronally ends up with 2 cutting edges.

All endodontic instruments regardless of the technique generate dentine debris and a smear layer on root canal walls.^{4,5} Debris holds back dentin chips, residual vital or necrotic pulp tissue, and micro-organisms while smear layer (1–2μ) quay bacteria, prevents disinfecting agents from penetrating the dentinal tubules thus compromising the impervious seal of the obturated canal.⁶ Scanning electron microscopic (SEM) investigation is an efficient and economical method to study

* Corresponding author.

E-mail addresses: adishsaraf@gmail.com (A.A. Saraf), dranandp@gmail.com (A.C. Patil), tmangala9@gmail.com (T.M. Mangala), rushikeshmahaparale@yahoo.in (R. Mahaparale), drmsnehar@gmail.com (S. Mali), drsagar1786@gmail.com (S. Pawar).

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three-dimensionally the root dentin surface after shaping and cleaning.⁷

The aforementioned files with a diverse method of use and varied cross-sections make it purposeful to carry out this comparative investigation in terms of their cleaning effectiveness.

Thus, this SEM study compared the ultrastructural morphology of root canal walls of extracted teeth prepared using two different single rotary NiTi systems against a full sequence rotary system. The cleaning efficacy was determined by quantitatively assessing the debris and smear layer using a scanning electron microscope. The null hypothesis was that there will be no difference observable between the experimental groups in terms of debris and smear layer on canal walls.

2. Materials and method

The institutional Ethics committee approved the in-vitro study before it was conducted at the School of Dental Sciences, KIMSUDU, Karad. 30 human 1st mandibular molars, freshly extracted with intact mesial roots of similar lengths were selected. The teeth were put in distilled water throughout the study. The teeth were decoronated right angles to the vertical axis at the cemento-enamel junction (CEJ) using a diamond coated bur supplemented with water cooling to acquire a root segment of 12 mm length. The mesial roots were then detached by using a diamond disc (Horico, Germany). Randomization of the 30 samples was done and divided into 3 groups ($n = 10$) which would be subjected to mechanical preparation using the following instrumentation systems.

Group 1- ProTaper (DENTSPLY Maillefer) full sequence rotary instrumentation of canal;

Group 2- Single F2 Protaper (DENTSPLY Maillefer) file used in reciprocating motion;

Group3- One shape (Micro Mega, France) single file used in a circular motion.

2.1. Canal preparation

Canal preparation was carried by a single operator. Initial scouting was done with a 10 and 15 K-file till the apex of the tooth. Patency of the apical foramina was standardized by inserting a size 15 K-file (Mani, Japan) which went just beyond the root apex. Working length (WL) was calculated 0.5 mm short of this position for every sample. Teeth with sclerotic canals, aberrations, apical diameter greater than size 15, or with an altered apex were not included.

Each canal was irrigated with 5% sodium Hypochlorite and Normal saline. A dual motion Endodontic electric motor (X-Smart Plus, DENTSPLY Maillefer) was used.

2.1.1. Group 1: Protaper (DENTSPLY Maillefer) full sequence rotary instrumentation of canal

Rotary instrumentation was accomplished in a crown down approach by using SX at 2/3rd of WL, S1 at WL – 1 mm, S2, F1, F2 at WL in a torque-controlled system (X-Smart Plus, DENTSPLY- Maillefer) set at 250 rpm and 2.5N/cm torque. After each instrument, 1 ml of 5% NaOCl was used for irrigation, and apical patency was maintained using a size 10 K-file.

2.1.2. Group 2: single F2 Protaper (DENTSPLY Maillefer) file used in a reciprocating motion

The root canal preparation was performed with one ProTaper F2 in a reciprocating manner with clockwise (CW) and anticlockwise (ACW) motion with 400 rpm rotational speed. The preparation was done in a coronal-apical manner employing light apical pressure with slow pecking action. The file was retrieved and flutes were cleaned with NaOCl soaked sponge when the file failed to progress. This sequence was adhered to until the working length was reached.

2.1.3. Group3- one shape (Micro Mega, France) single file used in a circular motion

The root canal preparation was performed in a crown down technique using a single file in a continuous rotary clockwise motion. The file was progressed with light apical pressure using a slow pecking motion. The speed of rotation was set at 400 rpm and torque at 2.5N/cm as recommended by MICRO-MEGA®.

Each file to be used was observed under $2.5\times$ magnification loupe (GL3-2.5 $\times$ Unicorn Dentmart Ltd, India) for debris, and then wiped thoroughly with a sponge soaked in NaOCl to prevent carrying debris from one sample to the other. After each instrumentation, the samples were irrigated with 5 ml of 5% NaOCl followed by equal amounts of normal saline using a 2 ml leuc lock syringe and 26 gauge open-ended beveled needle (UNOLOK, Hindustan Syringes, and Medical devices Ltd, India).

2.2. Preparation of samples for Scanning Electron Microscopy

The samples were longitudinally split immediately after instrumentation by using a chisel and mallet by striking on the longitudinal grooves made initial to the instrumentation. The samples were processed and observed with SEM (JEOL 5200; JEOL, Tokyo, Japan). Representative sections of the apical, middle and coronal third of the canal were used for evaluation at a magnification of $200\times$ for debris and $1,000\times$ for smear layer. The images of the most representative area were saved digitally and graded in a dual-blind approach by two professionals. The cleaning ability of the file was evaluated using the debris and smear layer score systems introduced by Hulsmann et al.⁶ In a blinded approach, two examiners independently scored the images of apical, middle and coronal third of the canal. The examiners were initially calibrated to the Hulsmann scoring system. The two examiners then self-determined; agreed on a score and documented the final score. Whenever disagreement occurred, they discussed the sample and its scoring and agreed on a score.

2.3. Statistical analysis

Data was systematically collected and analyzed using SPSS software (SPSS Inc, Chicago, USA. Version 18.) Friedman test was applied for intragroup comparison and Kruskal–Wallis test was applied for intergroup comparisons. The level of significance was set at $p \leq 0.05$.

3. Results

Table .1 gives a detailed summary of the scores obtained. The bar graphs (Fig. 1 and Fig. 2) show the results for each parameter amongst the three groups and at the three radicular canal areas (coronal, middle, and apical thirds).

3.1. Debris

The Intragroup comparisons done using the Friedman test showed that there was a statically significant difference ($p \leq 0.05$) when debris in coronal middle and apical 1/3rd of Protaper universal group was compared. Intergroup comparisons were done using the Kruskal- Wallis test revealed that there was a statically significant difference in debris score at coronal 1/3rd ($p = 0.049$) and apical 1/3rd ($p = 0.004$) of the groups compared. The least amount of debris in apical third was found in the Protaper Universal group and maximum debris was found in the coronal third of the Single F2 Protaper file (Fig. 3).

3.2. Smear layer

The Intragroup comparisons done using Friedman test for the Smear layer showed that there was a statistically significant difference ($p \leq 0.05$) at apical, middle, and coronal 1/3rd of all the 3 groups.

Table 1

The Debris and Smear layer scores for the 3 Groups at 3 different levels of the root canal with intra group and intergroup comparisons with values.

Group	Means of Debris score				Means of Smear layer			
	Coronal 1/3rd	Middle 1/3rd debris	Apical 1/3rd debris	Friedman test p value	Coronal 1/3rd	Middle 1/3rd debris	Apical 1/3rd debris	Friedman test p value
Protaper Full sequence	3.60 (0.843)	3.20 (1.229)	2.60 (0.843)	0.05*	2.80 (0.422)	3.20 (0.422)	2.80 (0.422)	0.018*
Single F2 File	4.00 (0.667)	3.80 (0.422)	3.80 (0.422)	0.513	3.00 (0.0)	3.20 (0.422)	3.60 (0.516)	0.030*
One Shape	3.00 (0.943)	3.60 (0.516)	3.00 (0.667)	0.11	3.20 (0.422)	3.80 (0.422)	3.00 (0.0)	0.006*
Kruskal- Wallis test p value	0.049*	0.319	0.004*		0.055	0.008*	0.01*	

Level of significance set at $p \leq 0.05$.

* Denotes significant difference.

(SPSS Inc, Chicago, USA. Version 18.).

Fig. 1. Debris score of the three groups at three different levels*Intergroup comparison depicting statistical significance ($p \leq 0.05$). **Fig. 2.** Smear layer score of the three groups at three different levels.*Intergroup comparison depicting statistical significance ($p \leq 0.05$).

Intergroup comparisons were done using the Kruskal- Wallis test revealed that there was a statistically significant difference in smear layer score at middle 1/3rd ($p = 0.008$) and apical 1/3rd ($p = 0.001$) of the groups compared. The least quantity of smear layer was appreciated in the apical third and coronal third of the Protaper Universal group and the maximum smear layer was found in the middle third of One Shape single file system (Fig. 4).

4. Discussion

The present study evaluated the cleaning efficacy of Protaper Universal, Single F2 file, and One shape single file in terms of debris

and smear layer produced. This study compared a full sequence rotary Protaper files with a single F2 Protaper file used in reciprocating motion and single One shape file in rotary motion. Advanced instrument designs like increased taper, altered helical angle, cross-sections, non cutting tip and specific flute design help to remove vital/necrotic tissue and infected dentin and debris but affect the cleaning effectiveness of the canal walls. To study the precise effect of the 3 file systems in this study only mesiobuccal canal of all the samples were instrumented for standardization. The mesiobuccal canal of mandibular molar is very narrow apically and usually present with an apical curvature. This byzantine anatomy amasses debris and smear layer.⁸ Samples were standardized to an apical ISO size no. 25. Mechanical preparation of the

Fig 3. SEM Photomicrographs for Debris (200x)**Group 1:- Protaper Full sequence**

Coronal 1/3rd (4)*

Middle 1/3rd (5)*

Apical 1/3rd (4)*

Group 2:- F2 Single file in Reciprocation

Coronal 1/3rd (4)*

Middle 1/3rd (5)*

Apical 1/3rd (4)*

Group 3:- One Shape single file in circular motion

Coronal 1/3rd (2)*

Middle 1/3rd (2)*

Apical 1/3rd (3)*

* Depicts the Debris Score according to Hulsman et al criteria

Fig. 3. SEM Photomicrographs for Debris (200×).

Group 1: Protaper Full sequence.

Group 2: F2 Single file in Reciprocation.

Group 3: One Shape single file in circular motion.

* Depicts the Debris Score according to Hulsman et al. criteria.

canals was carried out using the ProTaper full sequence (#25- 8%) and One shape single file system (#25-6%) in clockwise rotational motion and F2 Protaper single file (#25-8%) in reciprocating motion according to manufacturer's instructions. The major objective of the present investigation was to solely compare the cleaning effectiveness of the three instrument systems and hence any influence of different irrigation solutions was avoided.⁵ The irrigation protocol hereby used was 5% NaOCl alternated with normal saline delivered using an open ended beveled needle of 26 gauge. In the current study SEM analysis was carried out with all the samples to determine the debris and smear layer score. All of the instrumented samples examined validated the presence of debris and smear layer at the three levels (coronal, middle, apical) of root canals. There was a significant difference observed at the three levels of the root canal (Coronal, middle and apical 1/3rd) for Protaper full sequence group when the debris ($p = 0.05$) and smear layer ($p = 0.018$) scores were compared. The Protaper full sequence gave the

cleanest canal in the apical 1/3rd in terms of debris (mean = 2.60) and smear layer (mean = 2.80) and this was in accordance to the study conducted by Foschi et al.³ This can be attributed to the instrument configuration which has a convex triangular cross-section, efficient cutting angle, helical angle and a final taper of 8% which allows deeper irrigation penetration.⁹ The results of this study are also in accordance to the previous studies conducted.^{3,10} The Single F2 file in reciprocation showed greatest amount of debris at the coronal and apical 1/3rd of the root canal and demonstrated a statistically significant difference in smear layer ($p = 0.03$) formation when the 3 levels of the roots were evaluated. De-Deus¹⁰ conducted a study comparing single F2 Protaper file in reciprocation against a full sequence Protaper files and found out that single F2 Protaper file in reciprocation had poor debridement quality in the apical 1/3rd of the canal than the full sequence Protaper files. The shortcoming of a single F2 Protaper file in reciprocation is that an apical force is needed to advance the file to the WL; unlike the

Fig. 4. SEM Photomicrographs for Smear layer (1000×).

Group 1: Protaper Full sequence.

Group 2: F2 Single file in Reciprocation.

Group 3: One Shape single file in circular motion.

* Depicts the Smear Score according to Hulsmann et al. criteria.

Protaper full sequence files this file contacts and cuts the coronal and middle third of the canal when the file tip reaches the working length creating additional amount of debris and smear layer; the reduced preparation time using single files systems simultaneously reduces the quantity of irrigant penetrating the canal leading to poor cleaning efficacy.¹⁰ One shape single rotary file showed a statistically significant difference between the means for smear layer formation at the three levels of the root canal and the least mean value of debris was at the coronal 1/3rd of the canal. This is attributed to the instrument configuration where in the apical segment has 3 positive cutting edges and changes to 2 cutting surfaces in coronal portion of the file. This reduces canal engagement and results in greater auguring of debris from the canal.¹¹ The intergroup comparisons revealed a statistically significant difference in the debris score in the coronal third ($p = 0.049$) and apical third ($p = 0.004$) of the canal and this was in accordance to the study¹² which demonstrated that the movement kinematics, single file or full sequence systems had no influence on the debris removal from

the canal. In terms of smear layer there was a statistically significant difference in the middle ($p = 0.008$) and apical ($p = 0.001$) third of the root canal when the 3 files systems were compared. The present SEM study demonstrated that multifile Protaper universal fared better than single file systems and this was in accordance to the previous study.¹³ SEM methodology enabled identification of size, shape, texture and composition of the debris and smear layer only on the surface of the canal wall without giving any information of the depth. Future studies utilizing Micro Computed Tomography for three dimensional quantification of debris and smear layer detection can be carried out as this technique is non invasive and non destructive.¹⁴ Thus within the limitations of the study with respect to canal cleanliness, none of the instrument groups produced a dentin surface free from debris and smear layer at all levels of root canals. Thus the null hypothesis was rejected as there was a significant difference observable between the experimental groups in terms of debris and smear layer on canal walls.

5. Conclusion

The Protaper full sequence system provided better results than the Single F2 Protaper file used in reciprocation and One shape single file used in circular motion groups when debris and smear layer removal were investigated.

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Declaration of competing interest

The authors declare that they have no Conflict of Interest.

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References

- Yared G. Canal preparation using only one NiTi rotary instrument: preliminary observations. *Int Endod J.* 2008;41:339–344.
- Schilder H. Cleaning and shaping the root canal. *Dent Clin.* 1974;18:269–296.
- Foschi F, Nucci C, Montebugnoli L, et al. SEM evaluation of canal wall dentine following use of Mtwo and ProTaper NiTi rotary instruments. *Int Endod J.* 2004;37:832–839.
- Torabinejad M, Hanisides R, Khademi AA, Bakland LK. Clinical implication of the smear layer in endodontics: a review. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 2002;94:658–666.
- Jeon IS, Spångberg LS, Yoon TC, Kazemi RB, Kum KY. Smear layer production by 3 rotary reamers with different cutting blade design in straight root canals: a scanning electron microscopic study. *Oral. Surg Oral Med Oral Pathol Oral Radiol Endod.* 2003;96:601–607.
- Hülsmann M, Rummelin C, Schäfers F. Root canal cleanliness after preparation with different endodontic handpieces and hand instruments: a comparative SEM investigation. *J Endod.* 1997;23:301–306.
- Ahlquist M, Henningsson O, Hulténby K, Ohlin J. The effectiveness of manual and rotary techniques in the cleaning of root canals: a scanning electron microscopy study. *Int Endod J.* 2001;34:533–537.
- Schäfer E, Lohmann D. Efficiency of rotary nickel-titanium FlexMaster instruments compared with stainless steel hand K-Flexofile-Part 2. Cleaning effectiveness and instrumentation results in severely curved root canals of extracted teeth. *Int Endod J.* 2002;35:514–521.
- Ponce de Leon Del Bello T, Wang N, Roane JB. Crown-down tip design and shaping. *J Endod.* 2003;29:513–518.
- De-Deus G, Barino B, Zamolyi RQ, et al. Suboptimal debridement quality produced by the single-file F2 ProTaper technique in oval-shaped canals. *J Endod.* 2010;36:1897–1900.
- Guillén RE, Nabeshima CK, Caballero-Flores H, et al. Evaluation of the WaveOne gold and one shape new generation in reducing *Enterococcus faecalis* from root canal. *Braz Dent J.* 2018;29:249–253.
- Fredson Marcio Acris de Carvalho, Leonardo Cantanhede de Oliveira Gonçalves, André Augusto Franco Marques, Alves Vanessa, Carlos Eduardo da Silveira Bueno, and Alexandre Sigris de Martin. Cleaning effectiveness of a reciprocating single-file and a conventional rotary instrumentation system. *Open Dent J.* 2016;10:704–713.
- Kansal R, Rajput A. Comparison of root canal cleaning ability of rotary and reciprocating file techniques: a SEM study. *JSM Dent Surg.* 2018;3(1):1030.
- Robinson JP, Lumley PJ, Cooper PR, Grover LM, Walmsley AD. Reciprocating root canal technique induces greater debris accumulation than a continuous rotary technique as assessed by 3-dimensional micro-computed Tomography. *J Endod.* 2013;39:1067–1070.