Comparison of apical debris extrusion during root canal preparation using instrumentation techniques with two operating principles: An in vitro study

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Abstract

Aims: The aim of this study was to quantify the debris extruded apically from teeth using rotary and reciprocation instrumentation systems.

Subjects and Methods: Eighty extracted human mandibular premolars with single canals and similar lengths were instrumented using ProTaper Universal (40, 06; Dentsply Maillefer, Ballaigues, Switzerland), ProTaper Next (40, 06; Dentsply Maillefer, Ballaigues, Switzerland), WaveOne (40, 06; Dentsply Maillefer, Ballaigues, Switzerland), and Reciproc (R40; VDW GmbH, Munich, Germany). Debris extruded during instrumentation was collected into preweighed Eppendorf tubes, which were then stored in an incubator at 70°C for 5 days. The final weight of the Eppendorf tubes with the extruded debris was calculated after obtaining the mean of three consecutive weights obtained for each tube.

Statistical Analysis Used: Statistical analysis was performed using SPSS version 16.0 software. The groups were compared using the Kruskal–Wallis test for all variables.

Results: There was no statistically significant difference between the groups (P = 0.1114). However, the ProTaper Universal group produced more extrusion and ProTaper Next produced least debris extrusion among the instrument groups (P > 0.05).

Conclusions: All instrumentation techniques were associated with extruded debris.

Keywords: Apical extruded debris; ProTaper Next; ProTaper Universal; Reciproc; Reciprocation; Rotary; WaveOne

INTRODUCTION

Root canal preparation is an important step in endodontic treatment and thorough debridement of the root canal system is essential for successful root canal treatment. Debridement involves instrumentation and irrigation and both appear equally important for favorable outcome.[1] However, during the biomechanical preparation of the root canal, materials may be extruded through the apical foramen into the periapical tissues[2] which could result in undesirable postoperative complications such as flare-ups.[3]

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The aim of this study was to compare the amount of apically extruded debris during preparation with ProTaper Universal (Dentsply Maillefer, Ballaigues, Switzerland), ProTaper Next, both rotary motion instrument; WaveOne (VDW GmbH, Munich, Germany), Reciproc file (VDW GmbH, Munich, Germany), which have reciprocating motion. The null hypothesis was that there would be no difference among the instruments in terms of the quantity of apically extruded debris.

SUBJECTS AND METHODS

Eighty freshly extracted single-rooted human mandibular premolar teeth with mature apices and curvatures between 0° and 10° were selected for the study. Only single-rooted teeth with a single canal and a single apical foramen were included in the study. This was verified by viewing their buccolingual and mesiodistal radiographs. The occlusal surface was flattened to standardize the working length (WL) of all the teeth to 15 mm. Conventional straight line access preparation was performed and apical patency was confirmed by inserting a number 10 K-file through apical foramen. The file was inserted into the canal until its tip was slightly visible at the apical foramen and WLs were set by deducting 1 mm from the initial length. The root canal width near the apex was controlled with a size 15 K-file; teeth with an apical width size larger than 15 were excluded from the study. The eighty teeth thus selected for the study were randomly assigned to four groups for instrumentation as follows (n = 20).

ProTaper Universal group
ProTaper instruments were used according to manufacturer’s instructions up to F4 (40.06) till the WL. Canal recapitulation was performed after use of each file.

ProTaper Next group
The root canals were prepared using the ProTaper Next system up to X4 (40.06), according to manufacturer’s instructions.

WaveOne group
The root canals were instrumented with a WaveOne reciprocating single file (40/0.08) with a gently in-and-out pecking motion.

Reciproc group
A R40 Reciproc file having a size forty and a taper of 0.06 was used in a reciprocating, slow in-and-out pecking motion according to manufacturer’s instructions.

Five milliliters of distilled water was used as irrigant in between the files and throughout the instrumentation for all the groups.

Debris collection
In this study, the experimental model described by Myers and Montgomery[4] was followed. Before assembling the whole apparatus, the Eppendorf tubes were weighed by placing them in an electronic weighing machine with an accuracy of ±0.001 g that was present within an enclosed housing with its windows closed. Three consecutive measurements were taken for each tube and the mean measurement for each tube was considered to be its weight.

The Eppendorf tubes were placed in the glass vial and the opening was sealed with modeling wax. The modeling wax was sealed to the mouth of the glass vial with a heated instrument. The teeth were then inserted in the Eppendorf tubes till the cementoenamel junction and the interface between the teeth and the wax were sealed with cyanoacrylate (super glue) to prevent leakage of the irrigating solution through the hole. A needle was placed alongside the tooth into the Eppendorf tubes to balance the external and internal air pressure [Figure 1]. An aspirator was used to suction excess irrigating solution overflowing from the tooth crown. Aluminum foils were used to cover the glass vials to prevent any operator bias during the instrumentation procedure.

Once instrumentation was complete, the cover, needle, and tooth were removed. The debris adhered to the root surface was collected by washing the apical part with 1 mL distilled water in the tube. Before weighing the dry debris, the tubes were stored in an incubator at 70°C for 5 days to evaporate the distilled water [Figure 2].

The Eppendorf tubes were weighed using the same analytical balance to obtain the final weight of the tubes including the extruded debris. Three consecutive weights were obtained and the mean was considered. The amount of apically extruded debris was calculated by subtracting the initial weight of tube from the final weight.

Figure 1: Experimental setup
Statistical analysis was performed using SPSS version 16.0 software (SPSS Inc., Chicago, IL, USA). Data are presented as median (minimum–maximum) values. The groups were compared using the Kruskal–Wallis test for all variables. $P < 0.05$ was considered to indicate statistical significance for all tests.

**RESULTS**

All instrumentation systems resulted in some amount of apical extrusion of debris. Although no statistically significant differences among the groups were identified ($P = 0.1114$), the ProTaper Universal rotary group produced the highest mean extrusion value. Among both the rotary and reciprocating systems, the ProTaper Next group produced least debris. The mean values and standard deviations for all groups are listed in Table 1.

**DISCUSSION**

The results of this study revealed that among the instrumentation systems, the ProTaper Universal rotary system resulted in maximum debris extrusion and the ProTaper Next rotary system resulted in minimum debris extrusion but with no statistically significant difference.

Many factors play a role in affecting the amount of debris extrusion such as tooth type, canal size and curvature, instrument size, type, instrumentation technique and endpoint, apical stop, irrigation solution, and irrigation delivery system.$^[5]$ In the present study, for the purpose of standardization, only single-rooted mandibular premolar with mature apices and single canal and curvature between 0° and 10° determined by conventional Schneider’s method$^[6]$ was followed. The WL of all the teeth was standardized by decoronation at the same length of 15 ± 1 mm with an apical size of number 15 K-file. All teeth were enlarged till apical width of size forty and the generally accepted method of Myers and Montgomery$^[4]$ for quantitative assessment of apical extrusion of debris was used. The drawback of this experimental setup is the absence of a physical back pressure provided by the periapical tissues which are said to be able to resist debris and irritant extrusion. A simulation of back pressure of the periapical tissues using floral foam has been proposed by Altundasar et al. and Hachmeister et al.,$^[7,8]$ but this setup suffers from several disadvantages such as absorption of irritant and debris. Therefore, in the present study, no attempt was made to simulate periapical resistance.

Bidistilled water was used as an irrigant in this study to prevent misleading weight measurements as a result of possible crystallization of sodium hypochlorite solution. The total amount of irrigant used during the instrumentation procedure was kept constant to a total of 5 mL for all the samples to eliminate the effect of quantity of irrigant on debris extrusion.

WL was kept 1 mm short of the apical foramen in this study as it has been shown that when the instrumentation was performed to the apical foramen, significantly more debris was forced apically than when instrumentation was 1 mm short.$^[9]$ In the present study, the ProTaper Universal rotary system extruded more debris than the other groups. The ProTaper Universal instrumentation system is characterized by changing percentage taper over the length of its cutting blades. It also has convex, triangular cross-sections, a changing helical angle and pitch over the cutting blades and a noncutting, modified guiding tip. The shaping instruments have increasingly larger percentage tapers over the length of their cutting blades. The reasons for higher debris extrusion with the ProTaper Universal instruments could be: The large apical taper may result in more aggressive preparation of the root canals, which could have led to larger quantity of debris being extruded apically.$^[10]$ The instruments reach the WL in the beginning of the preparation$^[11]$ and more number of files are required for shaping the canal and achieving the appropriate apical foramen size, which could also contribute to increased debris production. The three cutting edges with radial lands to support the blades lead to a relatively small chip space which might have enhanced transportation of debris apically.$^[12]$
The rotary ProTaper Next instrumentation system is an improvement in design over the ProTaper Universal system. The lower amount of debris extrusion with the rotary ProTaper Next system could be related to their off-centered rectangular cross-section, swaggering motion in continuous rotation, the lower taper which results in removal of more debris in the coronal direction resulting in less debris extrusion apically; Furthermore, lesser number of files are required to optimally shape the root canal. A study comparing the amount of extruded debris after canal preparation using ProTaper Universal and ProTaper Next files concluded that ProTaper Next files was associated with significantly less extruded apical debris, attributing this to the offset design feature of the ProTaper Next system.

In the present study, among the reciprocating systems, Reciproc instrumentation systems extruded more debris than WaveOne, but the difference was not statistically significant. WaveOne system has triangular or modified triangular cross-section with thick metal core and shallow grooves and a reciprocal motion of 130° counterclockwise and 50° clockwise motion. \[14\] The Reciproc system on the other hand has a S-shaped cross-section along the entire length of the working part, sharp cutting edges, and no radial lands. A study by Bürklein and Schäfer\[12\] showed Reciproc extruded significantly more debris than WaveOne reciprocating system. In another study\[14\] comparing apical extrusion of debris in canals prepared with two reciprocating file systems: Reciproc and WaveOne, the Reciproc system extruded more debris than the WaveOne system. Furthermore, the standard error mean analysis used in that study showed that WaveOne large file had a D\(_90\) 20% lower than that reported by the manufacturer, whereas for the R40 file, the D\(_90\) was compatible with the measurements published by the manufacturer. This particular finding suggested that according to the taper established by the manufacturer, at D\(_90\) the WaveOne Large file is 0.40 mm and the R40 is 0.46 mm. The authors then concluded that this lower diameter of the WaveOne Large file may have contributed to the reduced debris extrusion of WaveOne reciprocating system as compared to Reciproc file.

Various studies have been conducted to compare the apical extrusion of debris between the rotary and reciprocating instrumentation systems.\[15\] A study by Bürklein and Schäfer\[12\] showed that full-sequence rotary instrumentation was associated with less debris extrusion compared with the use of reciprocating single-file systems. Some recent studies suggest that Reciproc and WaveOne are better at squeezing debris into the flutes and carrying the debris out of the root canal orifice, thereby reducing apical extrusion of debris.\[16\] However, the ProTaper Next rotary system with its unique off-centered design is believed to provide efficient cutting with minimal debris extrusion. Further clinical studies are required to evaluate the rotary and reciprocating instrumentation systems to confirm these findings.

**CONCLUSIONS**

Within the limitations of this study, it can be concluded that both the rotary and the reciprocating instrumentation resulted in apical extrusion of debris. Even though there were no significant differences among the ProTaper Universal, ProTaper Next, Reciproc, and WaveOne systems, instrument design and working principles and the type of instrument motion (rotary or reciprocating) may have an impact on apical debris extrusion.

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**Conflicts of interest**

There are no conflicts of interest.

**REFERENCES**

1. Hsieh YD, Gau CH, Kung Wu SF, Shen EC, Hsu PW, Fu E. Dynamic recording of irrigating fluid distribution in root canals using thermal image analysis. Int Endod J 2007;40:11-7.
2. Bürklein S, Benten S, Schäfer E. Quantitative evaluation of apically extruded debris with different single-file systems: Reciproc, F960 and OneShape versus Mtwo. Int Endod J 2014;47:405-9.
3. Ozsu D, Karatas E, Arslan H, Topcu MC. Quantitative evaluation of apically extruded debris during root canal instrumentation with ProTaper Universal, ProTaper Next, WaveOne, and self-adjusting file systems. Eur J Dent 2014;8:504-8.
4. Myers GL, Montgomery S. A comparison of weights of debris extruded apically by conventional filing and Canal Master techniques. J Endod 1991;17:275-9.
5. Radeva EN, Vassileva RL. Comparative study of apically extruded debris and irrigant after using two rotary systems (K3, Race). J IMAB 2014;20:459-63.
6. Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol 1971;32:271-5.
7. Attundasar E, Nagas E, Uyanik O, Serper A. Debris and irrigant extrusion potential of 2 rotary systems and irrigation needles. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;112:e31-5.
8. Hachmeister DR, Schindler WG, Walker WA 3rd, Thomas DD. The sealing ability and retention characteristics of mineral trioxide aggregate in a model of apexitification. J Endod 2002;28:386-90.
9. Taneja J, Gängör T. Apical extrusion of debris: A literature review of an inherent occurrence during root canal treatment. Int Endod J 2014;47:211-21.
10. Kustarci A, Akdemir N, Siso SH, Altunbas D. Apical extrusion of intracanal debris using two engine driven and step-back instrumentation techniques: An in vitro study. Eur J Dent 2008;2:233-9.
11. Garlapati R, Venigalla BS, Patil JD, Raju R, Rammohan C. Quantitative evaluation of apical extrusion of intracanal bacteria using K3, Mtwo, RaCe and protaper rotary systems: An in vitro study. J Conserv Dent 2013;16:300-3.
12. Bürklein S, Schäfer E. Apically extruded debris with reciprocating single-file and full-sequence rotary instrumentation systems. J Endod 2012;38:850-2.
13. Kocak MM, Cicak E, Kocak S, Saglam BC, Yilmaz N. Apical extrusion of debris using ProTaper Universal and ProTaper Next rotary systems. Int Endod J 2015;48:283-6.
14. Xavier F, Neavres G, Romeiro MK, Gonçalves K, Gominho L, Albuquerque D. Apical extrusion of debris from root canals using reciprocating files associated with two irrigation systems. Int Endod J 2015;48:661-5.
15. Kucukkyzylaz E, Savas S, Saygili G, Uysal B. Assessment of apically extruded debris and irrigant produced by different nickel-titanium instrument systems. Braz Oral Res 2015;29:1-6.
16. Lu Y, Chen M, Qiao F, Wu L. Comparison of apical and coronal extrusions using reciprocating and rotary instrumentation systems. BMC Oral Health 2015;15:92.