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ORIGINAL ARTICLE

Apical extrusion of debris produced by the heat treated single-file systems XP-Endo Shaper, Reciproc Blue and ProDesign Logic

ABSTRACT

Aim: *This study evaluated the apical extrusion of debris during root canal preparation produced by the single-file systems XP-Endo Shaper (FKG Dentaire, La Chaux-de-Fonds, Switzerland), Reciproc Blue (VDW GmbH, Munich, Germany), and ProDesign Logic (Easy Equipamentos Odontológicos, Belo Horizonte, MG, Brazil).*
Methodology: *Thirty single straight root canals in mandibular premolar were prepared and randomly assigned to 3 groups (n=10), according to instrument used for root canal preparation: XP-Endo Shaper, Reciproc Blue, or ProDesign Logic. Root canal shaping technique was performed by root segments and the apically extruded debris were collected and quantified using a debris collection setup with Eppendorf tubes and agar gel. Mean values were obtained by subtracting the initial weight of the test apparatus without specimens from its weight after root canal preparation. Then, one-way analysis of variance (ANOVA) followed by Bonferroni post hoc test were applied for comparison of values. The statistical significance level was set at 5%.*
Results: *No significant difference was observed among groups (P>0.05), but all the instruments produced debris extrusion from the apical foramen.*
Conclusions: *The heat treated single-file systems XP-Endo Shaper, Reciproc Blue, and ProDesign Logic produce similar amounts of apically extruded debris during root canal preparation. All single-file systems evaluated promoted apical extrusion of debris.*

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Introduction

Regardless of working length adopted, root canal cleaning and shaping may force the contents from the intrarradicular space into the periapical region – such as dentinal debris, irrigating solutions, microorganisms and their by-products (1, 2). These irritants are capable to stimulate immunologic and/or infectious processes, what may originate clinical signs of inflammation, postoperative pain, delay in the process of periapical repair or flare-ups (1-4). The intensity of the acute inflammation after extrusion is defined by the volume of irritants in periapical tissues and the bacteria virulence (1, 5).
The production of extruded debris is associated with the preparation techniques and the endodontic files selected for root canal shaping as regards design and the type of instruments movement (1). Mechanized instrumentation can reduce extrusion compared to the use of manual instruments due to advances in design, such as radial lands, flute depth, different tapers and cross sections, and the use of different operational principles (1, 6). Also, it has been demonstrated that extruded debris are not influenced by the number of files (1, 6). In this sense, systems designed to prepare root canals with only 1 instrument have been advocated since they present efficiency and reduce working time (7). As for the use of reciprocating or rotary kinematics, it is known that both are capable of generating apical extrusion and expression of neuropeptides (1, 4).
Currently, heat treated nickel titanium (NiTi) single-file systems presenting improved properties can be found in either reciprocating [e.g., Reciproc (VDW GmbH, Munich, Germany), WaveOne (Dentsply Sirona Endodontics, Ballaigues, Switzerland)] or rotary [e.g., XP-Endo Shaper (FKG Dentaire, La Chaux-de-Fonds, Switzerland), ProDesign Logic (Easy Equipamentos Odontológicos, Belo Horizonte, MG, Brazil)] kinematics. However, scarce literature has evaluated the capacity of producing apically extruded debris by these newly developed systems, which is a relevant aspect for endodontic treatment. Furthermore, results of previous studies hamper a conclusion whether which single-file system reaches better extrusion standards (1, 4).
XP-Endo Shaper is a rotary file that presents a thermomechanically treated NiTi alloy named MaxWire (Martensite-Austenite-electropolish-fileX), providing shape memory effect and superelasticity (8). Moreover, Reciproc Blue (VDW GmbH) presents a blue thermal processing that changes its molecular structure yielding greater flexibility, resistance to cyclic fatigue, and the visible color blue to the file (9). XP-Endo Shaper has shown similar amounts of hard tissue debris extrusion in comparison to Reciproc (8), but superior results when compared to heat treated Reciproc Blue (9). In contrast, Reciproc Blue has demonstrated significantly less debris extruded than Reciproc (10).
In addition to that, the ProDesign Logic file, also known as Bassi Logic, presents a different hybrid design and controlled memory heat treatment. This system demonstrated some positive features in respect of general systems such as ProTaper Next (Dentsply Sirona Endodontics, York, PA, USA) and WaveOne Gold – adequate root canal and apical enlargement (11, 12), centered preparations (13), reduced percentage of debris and untouched surfaces in dentinal walls (11, 12), cyclic fatigue resistance (14), torsional strength (15), and fast preparation time (14, 16). Nevertheless, no study has quantified the amounts of extruded debris with the use of ProDesign Logic system. In this context, the aim of this study was to evaluate the apical extrusion of debris during root canal preparation produced by the single-file systems XP-Endo Shaper, Reciproc Blue, and ProDesign Logic. The tested null hypothesis was: there is no difference in the levels of apically extruded debris produced by the single-file systems evaluated.

Materials and Methods

Teeth selection and preparation
This study was approved by the University Ethics Committee (Protocol: 3.017.382).

Based on previous study (17), a α=0.05 and a margin error of 0.00136 was selected for sample size. As a result, a total of 30 human single-rooted mandibular premolars consisted the sample of this study. Firstly, all teeth were analyzed using a digital radiographic system (Micro Imagem, São Paulo, Brazil) in buccal and proximal directions. Only premolars presenting one isolated canal (Type I of Vertucci's Root Canal Configuration) (18), which should be straight (canal curvature angle ≤5°, calculated using the methodology of Schneider (19), were selected. Teeth with incomplete root formation, apical foramen greater than 0.15 mm or any evidence of previous endodontic treatment, dental caries, dental cracks, calcifications and resorptions were excluded. After selection, specimens were cleaned by periodontal curettes, immersed in 5% sodium hypochlorite solution during 1 hour, and then maintained in saline solution at room temperature until use.

All teeth were decoronated at a root length of 17 mm from the anatomic apex, using a high-speed diamond bur with copious irrigation. Under a dental operating microscope (DF Vasconcelos, Rio de Janeiro, Brazil) at 20× magnification, the apical patency was confirmed when a size 10 K-file (MANI, Inc, Utsunomiya, Tochigi, Japan) exceeded the apex, and the root length was verified when the instrument reached the apical foramen. Following this, the diameter of apical foramen was standardized to the size of a 15 K-file (Dentsply Maillefer, Ballaigues, Switzerland).

Debris collection setup and evaluation

This test apparatus was based on the work of Uslu et al. (9), with modifications. Stoppers were separated from the total of 30 sterile Eppendorf tubes and a hole was created in the center of stoppers by the aid of sterile high-speed diamond burs. This stage aimed to reach the hole diameters similar to the cervical region diameter of each specimen. After that, roots were covered tightly with a Teflon band, leaving solely the apical foramen exposed (9). Specimens were then fixed in the prepared stoppers with apex down, up to 12 mm from the anatomic apex, using cyanoacrylate adhesive (9) followed by gingival barrier material. This leaved 5 mm of more coronal root region in the external area of Eppendorfs. The remaining 12 mm roots inside Eppendorffs tubes were divided into 3 regions, with 4 mm each: cervical, middle and apical. This setup of tooth-stoppers was individually weighed three times by an electronic balance (Sartorius Analytical, G€ottingen, Germany) with an accuracy of ±0.00001 g. The mean weight of each one was calculated (W1).

Following this measure, 2 mL of 1.5% agar gel was injected into Eppendorf tubes and the setup of roots-stoppers were reconnected to Eppendorfs. Then, tubes were inverted to immerse specimens in agar for 24 h, obtaining gelation of the agar. The complete setup of specimens associated with Eppendorfs containing agar were newly weighed as previously described. The mean weight of each specimen was calculated (W2). A third measure, representing the weight of isolated Eppendorfs containing agar (W3), was calculated by subtracting W1 of the samples from W2 values (19). This calculation was performed so that the Eppendorf tubes were only opened after root canal preparation, avoiding an agar displacement that could influence the final weighing.

Eppendorf tubes were then positioned in a glass vial using a rubber dam to hold the apparatus and to prevent the operator from observing the root apex during endodontic therapy. After completion of root canal shaping, Eppendorfs were removed from the glass vials, and the configuration of roots-stoppers were removed from these tubes. Eppendorf tubes containing agar after root canal preparation were weighed as previously described (W4). Finally, the amount of extruded debris was calculated by subtracting the weight value of the initial Eppendorf tubes containing agar (W3) from the postpreparation weight value (W4). The mean of each setup was recorded (W5).

Root canal preparation

Root canal preparation was performed by a single operator. All files had single use.

All systems were powered by the torque-controlled Silver Reciproc endodontic motor (VDW GmbH), set at the designated function according to the used system.
The 30 specimens were randomly assigned to three groups, according to the single-file system used (n=10): XP-Endo Shaper (G1), Reciproc Blue (G2) and ProDesign Logic (G3). Root preparation was not operator blinded due to visible differences in the endodontic files evaluated. The working length (WL) was established in the total root length (17 mm). Root canal preparation was accomplished in all groups by root segments, starting with cervical region (WL=9 mm) and followed by middle (WL=13 mm) and apical (final WL=17 mm) thirds. During the use of all instruments, when a resistance requiring more apical pressure was detected, the file was removed and the flutes were cleaned with sterile gauzes soaked in alcohol. Patency was constantly confirmed using a #10 C-Pilot file (VDW GmbH) after finishing the use of single-files in each root segment. The protocol of each system, which followed manufacturers' instructions, is described in Table 1.
Each specimen was irrigated in endodontic therapy with a total volume of 8 mL of 0.9% sterile saline solution (SS), delivered using 27-G x 25 mm Endo-Eze irrigator tip (Ultradent products, South Jordan, UT, USA) by means of a peristaltic pump (LAP-101-3; MS Tecnopon, Piracicaba, SP, Brazil), using a flow rate of 5 mL/min. Before irrigation of root canals, the solution reservoir was preheated at 35 ºC. During preparation, 1 mL of SS was used before and after the insertion of each NiTi file. The irrigant was delivered in the predetermined WL for cervical and middle segments, but 2 mm short from the apical foramen (15 mm) in the apical region. Lastly, after finishing preparation of specimens, a final irrigation with 2 mL of SS was performed.

Statistical analysis
Preliminary analysis of data normality was performed with the Shapiro-Wilk test, showing that data were normally distributed. The one-way analysis of variance (ANOVA) followed by Bonferroni *post hoc* test were applied for comparison of values using SPSS 20.0 software (IBM Corp., Armonk, NY, USA). The statistical significance level was set at 5%.

Results

Mean, minimum and maximum values of the amount of apically extruded debris for each single-file system are presented in

Table 1

Manufacturer, features and preparation protocols according to groups of single-file systems evaluated

Groups	Manufacturer	File (tip.taper)	Preparation protocol
G1 XP-Endo Shaper	FKG Dentaire	30.01 initial taper; during use, this instrument expands to a minimum taper of 0.04	XP-Endo Shaper file was activated in continuous rotation kinematics at 800 rpm and 1 Ncm. Long and light up-and-down movements were applied inside root canals until reaching the intended WL in the root segment.
G2 Reciproc Blue	VDW GmbH	25.08	Reciproc Blue was activated in reciprocating kinematics. The file was gently inserted with an up-and-down pecking motion with a maximum amplitude of 3 mm until reaching the intended WL in the root segment.
G3 ProDesign Logic	Easy Equipamentos Odontológicos	25.06	ProDesign Logic file 25.06 was activated in continuous rotation kinematics at 950 rpm and 4 Ncm. The file was applied with gentle pecking motion and gentle apical pressure to advance the instrument until reaching the intended WL in the root segment.

Table 2
Amount of apically extruded debris (g) according to single-file groups

Groups	Mean (standard deviation)	Minimum	Maximum	P value
XP-Endo Shaper	0.0104 (0.0184)	0.0059	0.0087	0.787*
Reciproc Blue	0.0059 (0.0087)	0.0088	0.0153	
ProDesign Logic	0.0088 (0.0153)	0.0104	0.0184	

*No significant difference was observed among groups.

Table 2. No significant difference was observed among groups (P>0.05), but all the instruments produced debris extrusion from the apical foramen.

Discussion

Several single-file systems are routinely used. As avoiding or decreasing the apically extruded debris from the apex is a relevant aspect for endodontic success, the evaluation of files performance is an important factor to be undertaken. This study quantified the apically extruded debris promoted by three heat treated single-file systems.

Formerly, aiming to simulate the resistance of periapical tissues in debris collection setups, a piece of flower arrangement foam was attached to roots specimens (20, 21). However, this may lead to misinterpretation of results since this product may absorb debris and irrigants while acting as an apical barrier (21). For this reason, empty Eppendorf tubes have also been used in debris collection evaluations (22); but the absence of back-pressure, representing no periapical resistance, does not reflect clinical conditions. At the present study, 1.5% agar gel was used because it does not interfere in debris collection and it presents similar values of density to periapical tissues (17). As a result, covering roots with agar gel created a matrix to satisfactory collect the extruded material and also offered a slight resistance to apical extrusion in a more realistic form (9).

Another methodology point that should be addressed is the root canal irrigation. In the current study, solely sterile saline solution was used. The use of chemical solutions was avoided because the creation of residues could have caused alterations in the results. For instance, sodium crystals formed with the evaporation of sodium hypochlorite could be attached to the hard tissues debris and lead to erroneous values of extrusion (9, 23). Moreover, a peristaltic pump was used to standardize the total volume and flow rate of saline solution, ensuring equal irrigating conditions for all groups and preventing biases. Although it was not used in the present study, it should also be pointed that supplementary irrigation protocols influence the total removal of accumulated hard tissue debris (24, 25) and, as a result, possibly in debris extrusion (23).

As regards root canal preparation technique, it is important to emphasize that coronal flaring prior to root canal shaping was accomplished. It has been demonstrated that this procedure is a relevant step that allows superior irrigation and cleaning of root canals (26), besides reducing significantly the production of dentin defects (27), and the amounts of extruded debris (21, 27). Therefore, the segmented canal preparation technique may have permitted higher debris removal from intracanal space and thus low debris extrusion for all files tested

According to data obtained, regardless of differences in files design and movements, all single-file systems presented some degree of debris extrusion from the apex. This consists with the overall findings of previous studies, in which no instrument was capable of rendering root canal therapy completely free of debris extrusion (6, 17, 21, 27). XP-Endo Shaper is a rotary snake-shaped file that presents a triangular Booster Tip (8). This instrument is ca-

pable to adapt to the morphology of the root canal system, since it significantly expands its initial taper at 37 °C (9). Reciproc Blue file presents a S-shaped cross-section that cuts dentinal walls counterclockwise, allowing deeper cutting and also favoring the removal of dentin chips (9). Finally, ProDesign Logic file also presents a S-shaped cross-section, but it is used in centric rotary motion, what the manufacturer states to reduces the screw-in effect, and has variable helical angles with two cutting edges (11, 14).

Statistical analysis did not reveal a significant difference between the evaluated instruments. Therefore, the null hypothesis was accepted. The design and the type of files movement did not interfere in the results of the present study. Previous literature presents inconsistent finding regarding the performance of endodontic instruments and thus the best approach in debris extrusion (4, 21). This results from a wide range of testing conditions and methodologies in *in vitro* studies to compare the systems (4). For this reason, it seems that the choice of endodontic systems should be mainly based in further relevant features such as root canal shaping, dentinal defects, cyclic fatigue and torsional failure.

Most studies evaluating apical extrusion of debris perform root canal treatment at room temperature (1, 4, 9). However, Uslu et al. (9) attempted to the intrarradicular temperature, which is approximately 35°C (28), and emphasized the importance of simulating these conditions; mainly considering that heat treated NiTi files can be affected by the ambient temperature. For instance, XP-Endo Shaper maintains its martensite phase at room temperature (8). Nevertheless, as a result of its MaxWire alloy, at body temperature this instrument convert to austenite phase and expands its structure (8, 9). Therefore, it is clear that analysis of apical extrusion of debris should mimic clinical conditions to achieve reliable results.

Scarce literature compared the extruded debris promoted by the single-files evaluated in the present study. Even though this study was based on the methodology of Uslu et al. (9), contrasting results were find since the authors observed less debris values from XP-Endo Shaper compared to Reciproc Blue. In this study, the intrarradicular temperature of 35 °C was also simulated. However, this temperature was obtained by heating the reservoir of irrigating solution before its application through the peristaltic pump. This is a limitation of the present study since temperature of solutions rapidly decrease inside intrarradicular space to reach equilibrium in the apical part of the root canal (28). In the study of Uslu et al. (9), the test apparatus was placed inside a glass bottle and immersed into 35 °C water to mimic intracanal temperature. Therefore, the thermodynamic behaviors of irrigating solutions within root canals may explain the difference in results of the present study compared to that of Uslu et al. (9).

Additionally, in the present study, total volume and flux of solution was controlled by a peristaltic pulp. This could have also influenced the results.

It is relevant to point out that the results of an *in vitro* study should be interpreted with caution. Even with best efforts, it is not possible to obtain identical clinical conditions. Moreover, as regards apical extrusion, bacterial virulence and host immune defenses are as important as the amount of extruded debris (29).

Conclusions

The heat treated single-file systems XP-Endo Shaper, Reciproc Blue, and ProDesign Logic produce similar amounts of apically extruded debris during root canal preparation. All single-file systems evaluated promoted apical extrusion of debris.

Clinical Relevance

This study compared for the first time the apical extrusion of debris produced by the heat treated single-fyle systems XP-Endo Shaper, Reciproc Blue, and ProDesign Logic. Despite considerable differences in design and kinematics, the evaluated instruments presented similar results. Moreover, all NiTi single-file systems evaluated promoted apical extrusion of debris.

Conflict of Interest

The authors deny any conflicts of interest.

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References

1. Caviedes-Bucheli J, Castellanos F, Vasquez N et al. The influence of two reciprocating single-file and two rotary-file systems on the apical extrusion of debris and its biological relationship with symptomatic apical periodontitis. A systematic review and meta-analysis. Int Endod J 2001;49:255-70.
2. Gunes B, Yesildal Yeter K. Effects of Different Glide Path Files on Apical Debris Extrusion in Curved Root Canals. J Endod 2018;44:1191-4.
3. De-Deus G, Brandão MC, Barino B et al. Assessment of apically extruded debris produced by the single-file ProTaper F2 technique under reciprocating movement. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;110:390-4.
4. Pedrinha VF, Brandão JMDS, Pessoa OF, Rodrigues PA. Influence of File Motion on Shaping, Apical Debris Extrusion and Dentinal Defects: A Critical Review. Open Dent J 2018;28:189-201.
5. Mittal R, Singla MG, Garg A, Dhawan A. A Comparison of Apical Bacterial Extrusion in Manual, ProTaper Rotary, and One Shape Rotary Instrumentation Techniques. J Endod 2015;41:2040-4.
6. Koçak S, Koçak MM, Sağlam BC et al. Apical extrusion of debris using self-adjusting file, reciprocating single-file, and 2 rotary instrumentation systems. J Endod 2013;39:1278-80.
7. Küçükyilmaz 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.
8. Alves FRF, Paiva PL, Marceliano-Alves MF et al. Bacteria and Hard Tissue Debris Extrusion and Intracanal Bacterial Reduction Promoted by XP-endo Shaper and Reciproc Instruments. J Endod 2018;44:1173-8.
9. Uslu G, Özyürek T, Yılmaz K et al. Apically Extruded Debris during Root Canal Instrumentation with Reciproc Blue, HyFlex EDM, and XP-endo Shaper Nickel-titanium Files. J Endod 2018;44:856-9.
10. Doğanay Yıldız E, Arslan H. The effect of blue thermal treatment on endodontic instruments and apical debris extrusion during retreatment procedures. Int Endod J 2019;52:1629-34.
11. Pinto JC, Pivoto-João MMB, Espir CG et al. Micro-CT evaluation of apical enlargement of molar root canals using rotary or reciprocating heat-treated NiTi instruments. J Appl Oral Sci 2019;27:e20180689.
12. Stringheta CP, Bueno CES, Kato AS et al. Micro-computed tomographic evaluation of the shaping ability of four instrumentation systems in curved root canals. Int Endod J 2019;52:908-16.
13. Pinheiro SR, Alcalde MP, Vivacqua-Gomes N et al. Evaluation of apical transportation and centring ability of five thermally treated NiTi rotary systems. Int Endod J 2018;51:705-13.
14. Menezes SEAC, Batista SM, Lira JOP, de Melo Monteiro GQ. Cyclic Fatigue Resistance of WaveOne Gold, ProDesign R and ProDesign Logic Files in Curved Canals In Vitro. Iran Endod J 2017;12:468-73.
15. Alcalde MP, Duarte MAH, Bramante CM et al. Torsional fatigue resistance of pathfinding instruments manufactured from several nickel-titanium alloys. Int Endod J 2018;51:697-704.
16. Coelho BS, Amaral RO, Leonardi DP et al. Performance of Three Single Instrument Systems in the Preparation of Long Oval Canals. Braz Dent J 2016;27:217-22.
17. Lu Y, Wang R, Zhang L et al. Apically extruded debris and irrigant with two Ni-Ti systems and hand files when removing root fillings: a laboratory study. Int Endod J 2013;46:1125-30.
18. Vertucci FJ. Root canal anatomy of the human permanent teeth. Oral Surg Oral Med Oral Pathol 1984;58:589-99.
19. Schneider SW. A comparison of canal preparations in straight and curved root canals. OralSurg Oral Med Oral Pathol 1971;32:271-5.
20. Hachmeister DR, Schindler WG, Walker WA 3rd, Thomas DD. The sealing ability and retention characteristics of mineral trioxide aggregate in a model of apexification. J Endod 2002;28:386-90.
21. Topçuoğlu HS, Üstün Y, Akpek F et al. Effect of coronal flaring on apical extrusion of debris during root canal instrumentation using single-file systems. Int Endod J 2016;49:884-9.
22. Altundasar 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.
23. Tanalp J, Güngör T. Apical extrusion of debris: a literature review of an inherent occurrence during root canal treatment. Int Endod J 2014;47:211-21.
24. Chan R, Versiani MA, Friedman S et al. Efficacy of 3 Supplementary Irrigation Protocols in the Removal of Hard Tissue Debris from the Mesial Root Canal System of Mandibular Molars. J Endod 2019;45:923-9.
25. Barbosa-Ribeiro M, Arruda-Vasconcelos R, Fabretti FL et al. Evaluation of Apically Extruded Debris Using Positive and Negative Pressure Irrigation Systems in Association with Different Irrigants. Braz Dent J 2018;29:184-8.
26. Vanni JR, Santos R, Limongi O et al. Influence of cervical preflaring on determination of apical file size in maxillary molars: SEM analysis. Braz Dent J 2005;16:181-6.
27. Borges ÁH, Damião MS, Pereira TM et al. Influence of Cervical Preflaring on the Incidence of Root Dentin Defects. J Endod 2018;44:286-91.
28. de Hemptinne F, Slaus G, Vandendael M et al. In Vivo Intracanal Temperature Evolution During Endodontic Treatment After the Injection of Room Temperature or Preheated Sodium Hypochlorite. J Endod 2015;41:1112-5.
29. Elmsallati EA, Wadachi R, Suda H. Extrusion of debris after use of rotary nickel-titanium files with different pitch: a pilot study. Aust Endod J 2009; 35:65-9.