

Apically Extruded Debris Using Reciprocating Single File and Additional Use of MaxWire Alloy File

Amanda Marques Machado,¹ Carolina Oliveira de Lima,¹ Natália Felizardo de Oliveira,¹ Amara Eulalia Chagas Santos,¹ Patrícia de Andrade Risso¹

¹Department of Endodontics, Federal University of Rio de Janeiro (UFRJ), Rio de Janeiro, RJ, Brazil

• Conflicts of interest: none declared.

ABSTRACT

Objective: the aim of this study was to evaluate the amount of apically extruded debris after the preparation with WaveOne Gold and additional use of XP-Endo Finisher file. **Material and Methods:** Forty human one-rooted premolars were selected and divided into two groups (n=20): WaveOne Gold and WaveOne Gold and XP-Endo finisher. Subsequently, the root canals were instrumented following the manufacturer's instructions and distilled water was used as irrigant. Apically extruded debris during instrumentation was collected into pre-weighed Eppendorf tubes. The weight of the dry extruded debris was established by subtracting the pre-instrumentation and post-instrumentation weight of the Eppendorf tubes for each group. **Results:** The data were analyzed using Shapiro-Wilk and Mann-Whitney tests, with significant level of 5%. There was no significant difference between groups (p=0.66) in relation to apically extruded debris. **Conclusion:** apically extruded debris occurred in both groups; however, the additional use of the XP-Endo Finisher instrument did not contribute to the significant increase of apical extrusion of debris when compared to the isolated use of WaveOne Gold.

Keywords: Dental pulp cavity; Root canal irrigants; Root canal preparation.

Introduction

Root canal preparation is one of the most important stages in endodontic treatment and includes mechanical cleansing with instruments and the use of irrigants.¹ During mechanical preparation, dentinal chips, pulp tissue remnants, microorganisms and irritants usually extrude into the periradicular space, which may lead to inflammation.^{2,3} The apical extrusion can be provoke an undesirable side effect that may induce inflammation, postoperative pain, and delay of periapical healing,⁴ adversely affecting the clinical outcome of endodontic treatment.⁵

Although previous studies indicate that all preparation techniques and instruments cause some extrusion of debris,^{6,7} the use of motor-driven instruments promotes less debris extrusion compared with hand file techniques.⁸ Furthermore, the extruded debris may differ according to the preparation technique and file system design.⁹

WaveOne Gold (WOG) reciprocating system (Dentsply Tulsa Dental, Tulsa, OK) is the new generation of single-file system that WaveOne instruments. It presents a special thermal treatment for improved physical properties (gold alloy technology), that provides more resistant to cyclic fatigue when compared to WaveOne files.^{10,11}

Previous studies assessed apically extruded debris promoted by WaveOne Gold files and verified that the amount of debris was less than hand files,⁵ Protaper Universal,¹² R-Endo system and Reciproc Blue.¹³ However, extruded debris was similar when compared WaveOne Gold system with Protaper Next files and Twisted File Adaptive system,¹³ which can be explained because the

differences on taper, motion and cross-sectional shape of the instruments.

Karatas *et al.*¹² evaluated the amount of apically extruded debris produced by WaveOne Gold system and reported that it produced significantly less apically extruded debris than the WaveOne system.

Additional methods have been proposed to improve the cleaning and disinfection of root canal system, allows irrigants to achieve difficult-to-reach areas.¹⁴ So, XP-Endo Finisher file (FKG Dentaire, La Chaux-de-Fonds, Switzerland) was introduced as a complementary supplementary instrument for use as a final step in improving root canal cleaning. It consists of a size 25 tip and a non-tapered rotary NiTi instrument made of a special alloy (MaxWire; Martensite-Austenite Electropolish Flex, FKG Dentaire). This file changes its shape at the body temperature within canals. This file expanded and contract to adapt itself to the canal morphology and clean areas that other instruments might not be able to reach.^{15,16}

Kfir *et al.*¹⁷ evaluated apically extruded debris during the preparation of oval canals with ProTaper Next supplemented by the XP-Endo Finisher file or a full-sequence self-adjusting file (SAF) and verified that the use of ProTaper Next and XP-Endo Finisher extruded significantly more debris than a full-sequence SAF system.

To the best of the authors' knowledge there is no evidence on the amount of debris extrusion after use WaveOne Gold followed by XP-Endo finisher file. Therefore, this study evaluated the amount of apically extruded debris after the preparation with WaveOne Gold and additional use of XP-Endo Finisher file.

Material and Methods

Sample selection

This study was approved by the local ethics committee of University Hospital of Federal University of Rio de Janeiro (n. 1398480). Forty mandibular premolars with mature apices, single canal, curvatures between 0 and 15°¹⁸ were selected. The teeth were radiographed in the buccolingual and mesiodistal directions to confirm the presence of a single root canal.

The crowns of the teeth were cut with a carborundum disk until the teeth reached 15 mm in length. The apical patency was determined by inserting a size 10 K-file (Dentsply Maillefer, Ballaigues, Suíça) into the root canal until its tip was visible at the apical foramen and the working length (WL) was established at 1mm short of the apical foramen. After WL measurement, the foramen diameter of all teeth was standardized to a size 30 K-file (Dentsply Maillefer, Ballaigues, Suíça).

The groups were randomly distributed into 2 groups (n=20) according to the file used for the preparation of root canals: WaveOne Gold group (WOG) and WaveOne Gold and XP-endo Finisher (WOG + XP).

Root canal instrumentation

All the instrumentations were operated by a low torque motor (X-Smart Plus® (Dentsply Maillefer, Tulsa, OK, USA).

Waveone gold group (WOG): The specimens were instrumented with WaveOne file with a size 35 tip and a taper of 0.06, according to the manufacturer's instructions with a reciprocating slow in-and-out pecking motion at full WL. The flutes of the instrument were cleaned after three pecks. The apical patency was verified by inserting a size 10 K-file. In each sample, a total of 10mL distilled water was used as an irrigating solution with a 5mL disposable syringe and a 31-gauge double side-port needle (NaviTip Sideport; Ultradent, USA).

Waveone gold group (WOG) and XP-Endo Finisher: The instrumentation was performed following the protocol already described. After the use of WOG, The WL was pre-marked on the XP-endo Finisher file and verified using the instrument's special plastic tube to adjust the rubber stopper, while the file was cooled down inside the tube with a cold spray (Maquirá, Paraná, Brazil).

Prior to irrigation, the distilled water was warmed to 37 °C to allow the XP-Endo Finisher file to optimally work during the austenite phase.¹⁵ The file was used with an endodontic motor (X-Smart Plus) at 800 rpm and 1 Ncm. The file was used inside the root canal for 60 seconds using slow and gentle 7–8-mm lengthwise in-and-out movements. This was followed by a final flush with 2 mL of distilled water.

Debris Collection

The experimental model used to evaluate debris extrusion was adapted to that described by Myers & Montgomery.¹⁹

Stoppers were separated from Eppendorf tubes and holes were created with cylindrical drill (KG Sorensen, Cotia, SP, Brasil) in these stoppers to place teeth into the tubes. Each tooth was inserted up to the cemento-enamel junction and then fixed with cyanoacrylate (Loctite Super Bonder; Henkel Ltda, São Paulo, SP, Brazil). A 27-gauge needle (Ultradent, South Jordan, UT, EUA) was inserted into the rubber stopper to balance internal and external pressures, allowing debris extrusion.

Before root canal preparation, an analytical balance (Shimadzu, AUY-220 model) with an accuracy of 10⁻⁴ g was used to measure the initial weights of the tubes. Three consecutive weights were obtained for each tube and the mean value was calculated.

To avoid variation and eliminate biases, the cleaning, shaping, and irrigation of all samples were completed by the same trained operator. The operator was blinded from seeing the root apex during instrumentation by an aluminum leaf that covered the Eppendorf tube.

After instrumentation, teeth were separated from the rubber stop and the debris adhering to the tooth surface, were collected by washing the tooth with 2mL of distilled water. Then, the Eppendorf tubes were stored in an incubator at 37°C for 7 days to evaporate all moisture content before weighing the dry debris. Three consecutive weights were obtained for each tube, and mean value was calculated and recorded. The weight of the extruded debris was determined by subtracting the weight of the preweighed collection assembly from the final weight of the collection assembly.

Statistical analysis

The mean extrusion values and standard deviation for each group were evaluated. The samples in both groups did not show the normal distribution ($p < 0.05$), according to Shapiro-Wilk test. The difference between the groups was evaluated by Mann-Whitney test at a significance level of $p < 0.05$. All statistical analyses were performed with SPSS version 21.0 for Windows (SPSS Inc., Chicago, IL, USA).

Results

The apical debris extrusion occurred in both groups, without statistical significance difference ($p = 0.66$). Table 1 shows the results of apical debris extrusion of WaveOne group and WaveOne Gold group + XP Endo Finisher.

Table 1. Mean and standard deviation of initial and final weight of Eppendorf tubes (10-4)(g)

Group	Initial weight	Final weight	Difference
WaveOne Gold	6.643 (±0.016)	6.690 (±0.090)	0.047 (±0.089)
WOG + XP Endo Finisher	6.637 (±0.015)	6.695 (±0.094)	0.057 (±0.096)

Discussion

The results of this study confirm the theory that all the instrument systems was associated with apically extruded debris. The additional use of XP-Endo Finisher instrument to agitate irrigating solution did not increase the debris extrusion when compared to isolated use of WaveOne Gold, which demonstrated the possible to use XP-endo Finisher as a supplementary method to assist in removing biofilm and smear layer,^{22,24} after root canal preparation, without promoting further debris extrusion and thus avoid undesirable side effect to periapical tissue, like inflammation or delay of periapical healing.⁴

The reciprocating movements tend to throw the debris to the periapical region while the rotatory movements facilitate the exit of the debris through the coronal transport.²⁰ However, some studies have shown that this statement is controversial and reciprocating movement extrude less than continuous rotary movement.²¹ It is the reason the WaveOne Gold was chosen for this study.

One study compared the apically extruded debris and irrigants produced by WaveOne Gold and WaveOne system and concluded that WaveOne Gold produced significantly less apically extruded debris.¹² Other recent study evaluated the apical extrusion of debris between WaveOne Gold, Twisted File Adaptive and hand files, the WaveOne Gold had less extrusion than the other systems.⁵ According to Keskin *et al.*¹³ WaveOne Gold and ProTaper Next instruments caused less apically extruded debris than R-Endo and Reciproc Blue Files.

During the root canal preparation, instruments as XP-Endo Finisher has been used to help the cleaning and debris removal of complex anatomical areas which are not reached by mechanical instruments.^{15,22} So, the XP-Endo Finisher instrument can be able to promote an impact at the debris extrusion over endodontic treatment. Some studies demonstrated that XP-Endo Finisher instrument is effective in biofilm removal,²³ smear layer²⁴ and debris,^{22,25} due to its ability to change its shape in contact with body temperature, allowing its expansion within the root canal and allowing the reach of areas of difficult access and great agitation of the irrigation solution.²⁶

The use of XP-Endo Finisher did not cause significant debris extrusion in the present study when compared to the isolated use of WaveOne Gold. Corroborating this conclusion, Azim *et al.*²⁷ verified that the volume of irrigant apically extruded of XP-Endo Finisher, EndoActivator and standard needle irrigation was low and similar, but when compared to EndoVac they extruded larger volumes of irrigant.

The findings of the present study did not corroborate with Kfir *et al.*¹⁷, which verified that the use of XP-Endo Finisher instrument was responsible for the biggest debris extrusion when compared with the Self-adjusting File (SAF). This difference is because Kfir *et al.*¹⁷ verified the XP-Endo Finisher action after root canal instrumentation with ProTaper Next and compared only with the SAF, without the associated use of ProTaper Next. The present study used the same instrumentation system (WaveOne Gold) associated or not with the XP-Endo Finisher instrument and it was possible to verify the apical extrusion provided by the additional use of it.

The vast majority of previous studies^{12,13,17,27} regarding extrusion calculated the extrusion debris by weight, similar to the present study, however, this method does not simulate the resistance offered by periapical tissue, which is a limitation of the evaluation method. The use of distilled water as an irrigant was carried out to avoid any mineral residues accumulation from sodium hypochlorite when the solution is dried by evaporation.²⁰ Therefore, distilled water is indicated only for *in vitro* studies and not for clinical use. Moreover, our results should be carefully evaluated when transferred to the clinical situation because the absence of a physical back pressure given by the periapical tissues, the apical extrusion is not limited during the *in vitro* instrumentation.²⁸ According to Myers & Montgomery¹⁹ it is an imminent failure of the *in vitro* studies without periapical resistance.

Conclusion

Both instrumentation protocols showed apical debris extrusion, however, the additional use of XP-Endo Finisher instrument did not contribute to the significant increase in debris extrusion when compared to the isolated use of WaveOne Gold.

References

- Gondim Jr E, Setzer FC, Dos Carmo CB, Kim S. Postoperative pain after the application of two different irrigation devices in a prospective randomized clinical trial. *J Endod.* 2010;36(8):1295-1301.
- Reddy SA, Hicks ML. Apical extrusion of debris using two hand and two rotary instrumentation techniques. *J Endod.* 1998;24(3):180-183.
- Siqueira JF, Rôças IN, Favieri A, Machado AG, Gahyva SM, Oliveira JCM, *et al.* Incidence of postoperative pain after intracanal procedures based on an antimicrobial strategy. *J Endod.* 2002;28(6):457-460.
- Seltzer S, Naidorf IJ. Flare-ups in endodontics: I. Etiological factors. *J Endod.* 1985;11(11):472-478.
- Boijink D, Costa DD, Hoppe CB, Kopper PMP, Grecca FS. Apically extruded debris in curved root canals using the WaveOne Gold reciprocating and Twisted File Adaptive systems. *J Endod.* 2018;44(8):1289-1292.
- al-Omari MA, Dummer PM. Canal blockage and debris extrusion with eight preparation techniques. *J Endod.* 1995;21(3):154-158.
- Azar NG, Ebrahimi G. Apically-extruded debris using the ProTaper system. *Aust Endod J.* 2005;31(1):21-23.
- Ferraz CC, Gomes NV, Gomes BP, Zaia AA, Teixeira FB, Souza-Filho FJ. Apical extrusion of debris and irrigants using two hand and three engine-driven instrumentation techniques. *Int Endod J.* 2001;34(5):354-358.
- Üstün Y, Çanakçı BC, Dinçer AN, Er O, Düzgün S. Evaluation of apically extruded debris associated with several Ni-Ti systems. *Int Endod J.*

2015;48(7):701-704.

10. Webber J. Shaping canals with confidence: WaveOne Gold single-file reciprocating system. *Roots*. 2015;1:34-40.11. Adigüzel M, Capar ID. Comparison of Cyclic Fatigue Resistance of WaveOne and WaveOne Gold Small, Primary, and Large Instruments. *J Endod*. 2017;43(4):623-627.12. Karataş E, Ersoy İ, Gündüz HA, Uygun AD, Kol E, Çakıcı F. Influence of Instruments used in root canal preparation on amount of apically extruded debris. *Artif Organs*. 2016;40(8):774-777.13. Keskin C, Inan U, Demiral M, Keleş A. Cyclic fatigue resistance of Reciproc Blue, Reciproc, and WaveOne Gold reciprocating instruments. *J Endod*. 2017;43(8):1360-1363.14. Siqueira JF, Rôças IN. Optimising single-visit disinfection with supplementary approaches: a quest for predictability. *Aust Endod J*. 2011;37(3):92-98.15. Alves FR, Marceliano-Alves MF, Sousa JC, Silveira SB, Provenzano JC, Siqueira JF Jr. Removal of root canal fillings in curved canals using either reciprocating single- or rotary multi-instrument systems and a supplementary step with the XP-Endo Finisher. *J Endod*. 2016;42(7):1114-1119.16. Silva EJNL, Belladonna FG, Zuolo AS, Rodrigues E, Ehrhardt IC, Souza EM. *et al.* Effectiveness of XP-endo Finisher and XP-endo Finisher R in removing root filling remnants: a micro-CT study. *Int Endod J*. 2018;51(1):86-91.17. Kfir A, Moza-Levi R, Herteanu M, Weissman A, Wigler R. Apical extrusion of debris during the preparation of oval root canals: a comparative study between a full-sequence SAF system and a rotary file system supplemented by XP-endo finisher file. *Clin Oral Investig*. 2018;22(2):707-713.18. Schneider SW. A comparison of canal preparations in straight and curved root canals. *Oral Surg Oral Med Oral Pathol*. 1971;32(2):271-275.19. Myers GL, Montgomery S. A comparison of weights of debris extruded apically by conventional filing and Canal Master techniques. *J Endod*. 1991;17(6):275-279.

20. Bürklein S, Schäfer E. Apically extruded debris with reciprocating

single-file and full-sequence rotary instrumentation systems. *J Endod*. 2012;38(6):850-852.21. De-Deus G, Brandão MC, Barino B, Di Giorgi K, Fidel RA, Luna AS. 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(3):390-394.22. Leoni GB, Versiani MA, Silva-Sousa YT, Bruniera JF, Pécora JD, Sousa-Neto MD. Ex vivo evaluation of four final irrigation protocols on the removal of hard-tissue debris from the mesial root canal system of mandibular first molars. *Int Endod J*. 2017;50(4):398-406.23. Bao P, Shen Y, Lin J, Haapasalo M. In Vitro Efficacy of XP-endo Finisher with 2 different protocols on biofilm removal from apical root canals. *J Endod*. 2017;43(2):321-325.24. Zand V, Mokhtari H, Reyhani MF, Nahavandizadeh N, Azimi S. Smear layer removal evaluation of different protocol of Bio Race file and XP-endo Finisher file in corporation with EDTA 17% and NaOCl. *J Clin Exp Dent*. 2017;9(11):e1310-e1314.25. Elnaghy AM, Mandorah A, Elsaka SE. Effectiveness of XP-endo Finisher, EndoActivator, and File agitation on debris and smear layer removal in curved root canals: a comparative study. *Odontology*. 2017;105(2):178-183.26. Lacerda MFLS, Marceliano-Alves MF, Pérez AR, Provenzano JC, Neves MAS, Pires FR *et al.* Cleaning and shaping oval canals with 3 instrumentation systems: a correlative micro-computed tomographic and histologic study. *J Endod*. 2017;43(11):1878-1884.27. Azim AA, Aksel H, Margaret Jefferson M, Huang GT. Comparison of sodium hypochlorite extrusion by five irrigation systems using an artificial root socket model and a quantitative chemical method. *Clin Oral Investig*. 2018;22(2):1055-1061.28. Bonaccorso A, Cantatore G, Condorelli GG, Schäfer E, Tripi TR. Shaping ability of four nickel-titanium rotary instruments in simulated S-shaped canals. *J Endod*. 2009;35(6):883-886.

Mini Curriculum and Author's Contribution

1. Amanda Marques Machado - DDS; Contribution: Experimental design. ORCID: 0000-0002-1790-0473

2. Carolina Oliveira de Lima - DDS; MsC. Contribution: The idea, interpretation of data and wrote the manuscript. ORCID: 0000-0003-2132-4373

3. Natália Felizardo de Oliveira - DDS; MsC. Contribution: Experimental design and wrote the manuscript ORCID: 0000-0003-0455-7917

4. Amara Eulalia Chagas Santos - DDS; PhD. Contribution: Critical review of the work and discussion section. ORCID: 0000-0002-6164-055X

5. Patrícia de Andrade Rizzo - DDS; PhD. Contribution: The idea, hypothesis and design study ORCID: 0000-0002-9961-6678

 Submitted: 08/03/2020 / Accepted for publication: 08/30/2020

Corresponding author

Carolina Oliveira de Lima

E-mail: c.oliveiradelima@hotmail.com

