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# Effectiveness of XP-endo Finisher and XP-endo Finisher R in removing root filling remnants: a micro-CT study

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## Abstract

**Silva EJNL, Belladonna FG, Zuolo AS, Rodrigues E, Ehrhardt IC, Souza EM, De-Deus G.** Effectiveness of XP-endo Finisher and XP-endo Finisher R in removing root filling remnants: a micro-CT study. *International Endodontic Journal*.

**Aim** To evaluate the efficacy of filling material removal from oval-shaped canals after the use of supplementary files (XP-endo Finisher and XP-endo Finisher R) through microcomputed tomographic (micro-CT) analysis.

**Methodology** The root canals of twenty maxillary single-rooted teeth were prepared with Reciproc R25 files and filled with gutta-percha and AH Plus sealer using the continuous wave of condensation technique. The root canals were then retreated using Reciproc R25 and R40 instruments. After this, the specimens were assigned to two groups according to the supplementary cleaning approach, using XP-endo Finisher and XP-endo Finisher R. The surface area and volume of removed filling material was assessed using micro-CT imaging before and after the use of the XP-endo instruments. Data were analysed statistically with a significance level of 5%.

**Results** Removal of filling material at 66.8% and 59.4% in volume and 67.3% and 61.4% in surface area was seen for the XP-endo Finisher and the XP-endo Finisher R files, respectively. The amount of filling material removed by both supplementary files was highly significant ($P = 0.000$). No significant difference in the percentage of removed filling material was detected for the XP-endo instruments ($P = 0.636$ for volume and $P = 0.667$ for surface area).

**Conclusions** Both XP-endo files were equally effective in the removal of remaining filling material from straight oval-shaped canals. None of the instruments were able to remove all the residual filling material.

**Keywords:** endodontic retreatment, remnants filling material, XP-endo Finisher, XP-endo Finisher R.

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## Introduction

Primary root canal treatment is considered a safe and predictable procedure with a success rate of up to 93% (Ng *et al.* 2011). Nevertheless, in some cases, success is not achieved, and post-treatment apical disease remains (Sjogren *et al.* 1990, Friedman & Mor 2004, Ricucci *et al.* 2011). The major reason for persistent apical periodontitis is intraradicular infection (Siqueira 2001, Nair 2006, Ricucci & Siqueira 2010). Therefore, the clinician's foremost priority when performing root canal retreatment is to reduce the bacterial population inside the root canal to a level below that necessary to cause or maintain disease (Siqueira & Rôças 2008), and to thoroughly clean and disinfect the canal. The previous contaminated filling material must be removed, allowing instruments and irrigants

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to act throughout the entire canal (Stabholz & Friedman 1988). This may be achieved with hand files, burs, heated instruments, solvents and more recently nickel–titanium (NiTi) rotary and reciprocating systems (Imura *et al.* 1996, Bramante *et al.* 2010, Zuolo *et al.* 2013, 2016). Although these techniques can be considered effective, the complete removal of filling material cannot be achieved irrespective of the retreatment technique used. Thus, additional methods have been proposed to improve the removal of filling material (van der Sluis *et al.* 2007, Hammad *et al.* 2008, Alves *et al.* 2016a).

Recently, a new type of anatomical finishing file, the XP-endo Finisher (FKG Dentaire, La Chaux-de-Fonds, Switzerland), was introduced for use as a final step in improving root canal cleaning. It consists of a size 25 tip and a nontapered rotary NiTi instrument made of a special alloy (MaxWire; Martensite-Austenite Electropolish Flex, FKG Dentaire). The file changes its shape according to the temperature. At room temperature, in its martensitic phase (M-phase), the file is straight. However, when submitted to body temperatures, it enters its austenitic phase (A-phase) and assumes a spoon shape of 1.5 mm depth in the final 10 mm of its length. According to the manufacturer, when the instrument is placed inside the canal in rotation mode, the A-phase shape allows the file to access and clean areas that other instruments might not be able to reach, without damaging dentine or altering the original canal shape. Although this new concept looks promising, only a few reports have analysed its performance (Alves *et al.* 2016a,b, Azim *et al.* 2016, Uygun *et al.* 2016, Bao *et al.* 2017, Elnaghy *et al.* 2017, Keskin *et al.* 2017, Leoni *et al.* 2017, Wigler *et al.* 2017).

The XP-endo Finisher R (FKG Dentaire) is a new variation of the XP-endo Finisher file. According to the manufacturer, it has been developed for retreatment cases, and the file displays a larger core diameter (tip size 30) and variations in the instruments tip, making it stiffer and therefore more aggressive. The aim of these changes is to increase its effectiveness in touching and displacing root filling materials that remain after conventional techniques.

The purpose of this study was to evaluate the efficacy of removing remaining root filling material from oval-shaped canals after the use of supplementary files (XP-endo Finisher and XP-endo Finisher R) through microcomputed tomographic (micro-CT) analysis. The hypotheses tested were the following: no differences would be found in the amount of filling material before and after the use of XP-endo files, and differences would be found in the performance of filling material removal between the XP-endo instruments.

## Materials and methods

### Specimen selection

After the approval of the local Ethics Committee, a sample of seventy-five maxillary single-rooted teeth with a single canal and similar root length was selected from a pool of teeth extracted for reasons not related to this study. Mesiodistal and buccolingual radiographs were taken, oval canals were selected and canal configurations were measured according to the technique described previously (Wu & Wesselink 2001). Root canal curvature was determined based on the angle of curvature initiated at the coronal aspect of the apical third of the root using Schneider's method (Schneider 1971). After acquiring digital images of each specimen, the angle of curvature was measured with the aid of an image analysis program (AxioVision 4.5; Carl Zeiss Vision, Hallbergmoos, Germany). Teeth with root curvature <10° and an initial apical size equivalent to a size 15 K-file (Dentsply Sirona, Ballaigues, Switzerland) were included ($n$ = 20).

### Root canal procedures

An experienced operator prepared the roots canals using Reciproc R25 instruments (VDW, Munich, Germany) at the working length (WL), which was established as being 1 mm short of the apical foramen. The root canals were irrigated copiously with a total volume of 25 mL of 2.5% NaOCl and were checked for apical patency with a size 15 K-file throughout the instrumentation procedures. Irrigation was performed using a 31-G NaviTip double side port needle (Ultradent Inc., South Jordan, UT, USA) taken up to 1 mm short of the WL. Then, the smear layer was removed using 3 mL of 17% EDTA followed by 1 mL of bi-distilled water. Afterwards, the canals were dried with R25 paper points (VDW) and were subsequently filled using R25 gutta-percha cones (VDW) and AH Plus Sealer (Dentsply De Trey, Konstanz, Germany) using the continuous wave of condensation technique. The down pack was established 5 mm from the WL. After that, the cervical and middle thirds of the canals were filled with the aid of a gutta-percha condenser (Dentsply Sirona), and the access cavities were sealed with Cavit (3M ESPE, Seefeld, Germany).

The quality of the root fillings was confirmed by buccolingual and mesiodistal radiographic projections. If voids were detected, the tooth was discarded and replaced. All specimens were kept at 37 °C and 100% humidity for 2 weeks to allow for the full setting of the sealer.

Retreatment procedures were accomplished by removing the previous filling material from each canal using the Reciproc R25 and R40 (VDW) instruments. The files were moved in the apical direction in a reciprocating motion using in-and-out pecking motions of 3 mm in amplitude. After three pecking motions, the instrument was removed and cleaned. All instruments were used up to the WL with a brushing motion towards the canal walls. Each root canal was irrigated with 10 mL of 2.5% NaOCl during the retreatment procedures. The criteria for the completion of the retreatment procedures were smooth canal walls and no evident filling material on the files.

### Supplementary cleaning approach

Following the retreatment procedures, the specimens were assigned to two groups according to the supplementary cleaning approach: XP-endo Finisher and XP-endo Finisher R. In both groups, the XP-endo files were used in the same way, as recommended by the manufacturer. The instrument was placed in a contra-angle hand piece (VDW), cooled (Endo-Frost; Roeko, Langenau, Germany) and was removed from the plastic tube in rotation mode by applying a lateral movement. Each canal was filled with 1 mL of 2.5% NaOCl, and the XP-endo file was inserted into it without rotation. Then, rotation was initialized (800 rpm and 1 Ncm), and the instrument was activated for 1 min using slow and gentle 7–8 mm lengthwise movements up to the WL. The instrument was pressed (brushed) against the side walls of the canals during the procedure. Finally, each root canal was irrigated with 5 mL of 2.5% NaOCl using the syringe/needle 1 mm short of the WL. All procedures with the XP-endo files were performed at 37 °C inside a cabinet containing a heater (800-Heater; PlasLabs, Lansing, MI, USA). Each XP-endo instrument was used in two canals and was then discarded.

### Micro-CT imaging analysis

The sample was scanned through a micro-CT device (SkyScan 1174v2; Bruker microCT, Kontich, Belgium) at three time-points (after initial root canal preparation, after retreatment and after supplementary approach procedures) with the following parameters: 50 kV, 800 mA, isotropic resolution of 21.8 μm, 360° rotation around the vertical axis with a rotation step of 0.5° and frame averaging of three, using a 1.0-mm-thick aluminium filter. The acquired images were reconstructed into cross-sectional slices using NRecon v.1.6.9 software (Bruker microCT), and the volume of interest was selected to extend from the amelo-cemento junction to the apex of the root, resulting in the acquisition of 700–800 transverse cross sections per tooth. The residual filling material volume ($mm^3$) and surface area ($mm^2$) was quantified for all the root canals using the CTAn v.1.16.1 software (Bruker microCT) after the retreatment and after the supplementary approach procedures. Quantitative three-dimensional evaluation of the remaining filling surface and volume was obtained using the plugin three-dimensional analysis tool.

### Statistical analysis

An initial screening for data normality was performed using Shapiro–Wilk test. The canal volume ($mm^3$) and surface area ($mm^2$) of the prepared canals were compared (Student's *t*-test) to confirm the hypothesis of similar anatomical conditions between the groups. To assess whether the amount of remaining filling material removed by the XP-endo files was similar between the groups, the volume and surface area of the residual filling material (after retreatment) were compared (Mann–Whitney *U*-test). A Wilcoxon test was used to identify further the significance of the amount of residual material removed after the use of each XP-endo instrument. Finally, the percentage of the filling material removed from the root canal walls was compared between the XP-endo instruments (Student's *t*-test). The level of significance was set at $\alpha = 5\%$ (SPSS v.17; SPSS Inc., Chicago, IL, USA).

## Results

The student's *t*-test confirmed the similar configuration of the prepared canals between the groups ($P = 0.757$ for volume and $P = 0.518$ for surface area). The baseline of the remaining filling material area after retreatment was also comparable between the groups, according to the Mann–Whitney *U*-test ($P = 0.762$ for volume and $P = 0.597$ for surface area).

Removal of filling material at 66.8% and 59.4% in volume and 67.3% and 61.4% in surface area was

found for the XP-endo Finisher and the XP-endo Finisher R files, respectively (Fig. 1). The amount of filling material removed by both files was highly significant (Wilcoxon test, $P = 0.000$ for both volume and surface area). No significant difference was detected between the percentages for the removal of filling remnants between the XP-endo instruments (Mann–Whitney *U*-test, $P = 0.636$ for volume and $P = 0.667$ for surface area). Figure 2 summarizes the overall results.

## Discussion

Removing root filling material, shaping and cleaning, and then refilling the root canal are the main goals of a successful retreatment (Nair 2006, Ricucci & Siqueira 2010). However, numerous studies have shown that regardless of the retreatment technique used, filling material remains in the root canal system (Imura *et al.* 1996, Bramante *et al.* 2010, Zuolo *et al.* 2013, 2016). Therefore, a supplementary technique

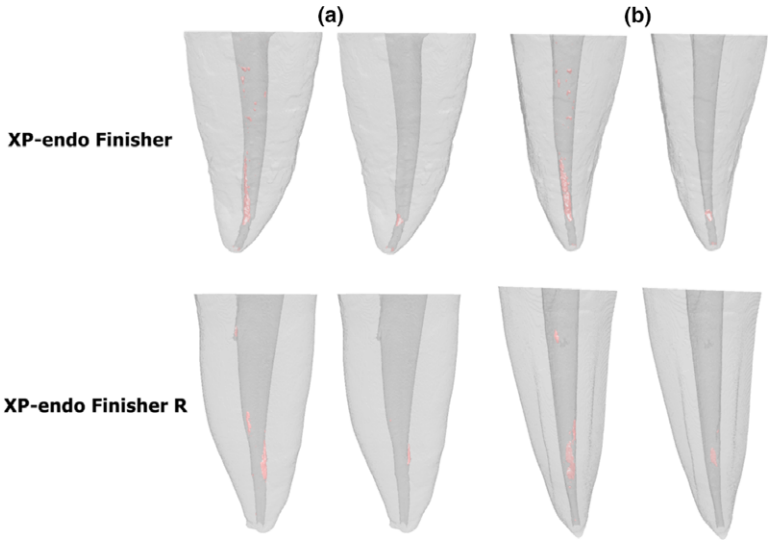


**Figure 1** Reconstructed three-dimensional micro-CT images after retreatment procedures and after the use of each supplementary file in front (a) and lateral view (b).

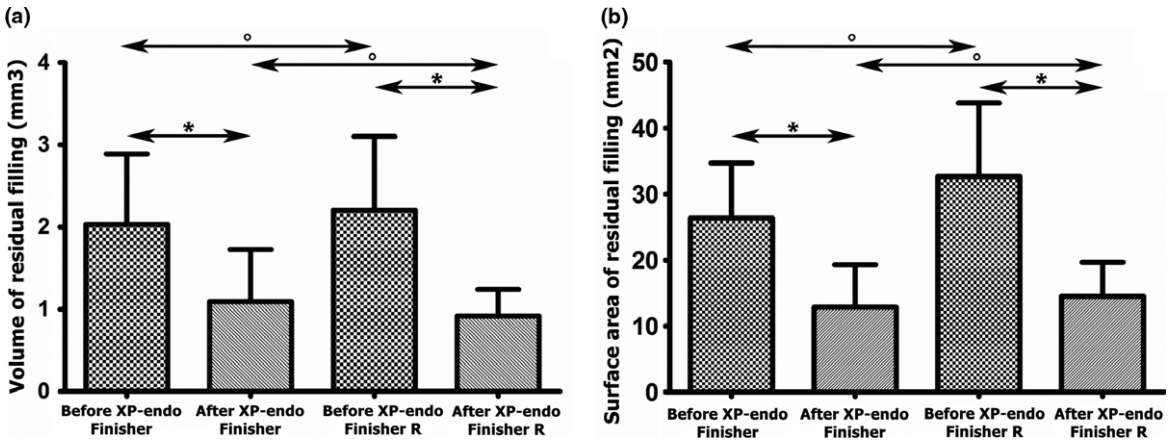


**Figure 2** Mean and SEM of the remaining filling material in the root canals before and after the use of XP-endo Finisher and XP-endo Finisher R files. Arrows designate group comparison. °indicate no significance and *indicate significance at $P < 0.05$. (a) Data for volume ($mm^3$) and (b) data for surface area ($mm^2$).

aiming to maximize the amount of area covered by endodontic instruments and irrigating solutions would be beneficial, especially for retreatment procedures in which the clinician often has to overcome challenges such as intraradicular infection, removal of residual contaminated filling material and management of disrupted canal anatomy (Siqueira 2001, Gorni & Gagliani 2004).

The topic of the present study was the efficacy of two novel supplementary files in removing filling material from root canals during root canal retreatment. Both supplementary files were effective in the removal of additional filling material, with a significant reduction in the volume of residual filling material by 66.8% and 59.4% after the use of the XP-endo Finisher and the XP-endo Finisher R files, respectively ($P < 0.05$). Thus, the first hypothesis was rejected. The lack of a significant difference in the removal of residual root canal filling material between the two supplementary files ($P > 0.05$) led to the rejection of the second hypothesis. In addition, residual filling material remained in all specimens, irrespective of the XP-endo instrument used. This finding is in accordance with previous reports that also demonstrated that no retreatment technique was able to produce root canals completely free of filling material (Imura *et al.* 1996, Bramante *et al.* 2010, Zuolo *et al.* 2013, 2016).

To date, few studies have evaluated the performance of the XP-endo Finisher instruments. Their ability to remove hard-tissue debris (Elnaghy *et al.* 2017, Leoni *et al.* 2017), bacteria (Alves *et al.* 2016b, Azim *et al.* 2016, Bao *et al.* 2017) and calcium hydroxide paste (Uygun *et al.* 2016, Wigler *et al.* 2017, Keskin *et al.* 2017) has been demonstrated. The ability of this instrument to remove filling material during root canal retreatment was reported to be 69% mean reduction in volume (Alves *et al.* 2016a), which was similar to the results observed in the present study. Although these results are similar, it is important to highlight that there are differences in the methodology. In the former study, the authors used curved canals from the mesial roots of mandibular molars with circular cross sections and only evaluated the apical 5 mm of the canals, whilst the present study used straight oval-shaped canals and the entire root canal space was analysed. Oval-shaped canals were selected for this study because the noncircular anatomy provides additional challenges for the removal of root fillings (Versiani *et al.* 2013).

The XP-endo Finisher R instrument differs in its core diameter and in the angulation of its tip compared to the XP-endo Finisher file, which makes it potentially more aggressive for removing filling material. However, a significant difference in the removal of residual filling material was not observed between the supplementary files ($P > 0.05$). Despite the manufacturer's recommendation of using solvent for the XP-endo Finisher R file, it was not used in the current study to standardize experimental conditions. Although the real impact that the use of solvent may have in the amount of filling material remnants after using XP-endo Finisher R is unknown, it is worthwhile mentioning that solvents may create a fine layer of softened gutta-percha, which adheres to the root canal wall and accentuates the challenge of filling removal, resulting in a longer operating time (Sae-Lim *et al.* 2000, Gu *et al.* 2008).

Future studies should evaluate the performance of XP-endo instruments associated with a solvent or not. It might be speculated that the larger diameter of the XP-endo Finisher R instrument cleans better in the apical region. However, in the present study, the apex was enlarged from an initial size 25 to size 40 before further instrumentation. Thus, the possible advantage of the larger instrument was not detected. However, it is important to emphasize that, according to the manufacturer's instructions, XP-endo Finisher R instruments should be used following any retreatment case involving a diameter of 30 or more.

## Conclusions

The XP-endo Finisher and the XP-endo Finisher R files were both equally effective in the removal of residual root filling material from straight oval-shaped canals. None of the instruments were able to remove all residual filling material.

## Conflict of interest

The authors have stated explicitly that there are no conflict of interests in connection with this article.

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