Original Article

Micro-cleanliness of Hard Tissue Debris After Advanced Irrigation and Comparison Between EndoVac and XP-endo Finisher: A Microcomputed Tomographic Study

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Abstract

Introduction: Conventional irrigation techniques do not remove debris adequately. The remaining tissue debris cause infection inside the root canal and may also affect the seal of the root canal. The study aimed to compare the ability of EndoVac (EV) with XP-endo finisher (XPF) in debris removal using micro-CT analysis. **Materials and Methods:** We used 12 lower first permanent molar human teeth for this study. The root canals were instrumented using a small TF adaptive system. Then, the volume of debris was calculated. Teeth were divided into two groups, according to advanced irrigation methods, with six teeth per group: EV group and XPF group. The volume of debris was calculated again. The paired-sample *t*-test was used to compare the volume of the debris before and after the use of advanced irrigation methods with the statistical significance of $P < 0.05$. The percentage of debris reduction was also calculated. **Results:** Both EV and XPF showed a significant decrease of debris in the mesial canals ($P < 0.05$), whereas EV only showed a significant reduction of debris in the distal canals. **Conclusion:** Both EV and XPF were able to significantly reduce debris after instrumentation in the mesial canals of lower first mandibular molars. **Clinical Significance:** The study provides insight into the recent advanced methods used in debris removal and canal disinfection.

Keywords: *Accumulated debris, EndoVac, microcomputed tomographic scans, root canal, XP-endo finisher*

Received : 14-12-20
Revised : 25-03-21
Accepted : 24-04-21
Published : 30-07-21

Highlights

- The goal of the study is to compare the ability of EndoVac with XP-Endo finisher file in debris removal.
- Our findings will help endodontists in the selection of the best root canal irrigation methods.
- Micro-CT analysis will provide quantitative information about the remaining debris inside the root canal.
- The study gives insights for future studies to assess canal disinfection.

Access this article online

Quick Response Code:

Website: www.jispcd.org

DOI: 10.4103/jispcd.JISPCD_430_20

Introduction

Root canal instrumentation results in debris that is composed of remnants of the pulp tissue, dentin chips, and loosely attached infected particles.[1] The debris tends to accumulate in fins, isthmus areas, and canal walls after root canal instrumentation.[2] Conventional irrigation techniques do not remove debris adequately,[3] and remaining debris may hamper

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How to cite this article: Alsofi L, Al Harbi M, Al-Habib M, Stauber M, Balto K. Micro-cleanliness of hard tissue debris after advanced irrigation and comparison between EndoVac and XP-endo finisher: A microcomputed tomographic study. J Int Soc Prevent Communit Dent 2021;11:457-62.

the disinfection of the root canal.[4,5] It may also affect the seal of root canals.[6] Therefore, advanced irrigation methods are needed to reduce debris, such as sonic devices, passive ultrasonic techniques, or the EndoVac (EV) system (KaVo Scandinavia AB, Upplands Väsby, Sweden).[7-9] These methods aid in delivering irrigants into the anatomical complexities inside the root canal system.

The EV system is a negative pressure irrigation system. It is composed of master delivery tip (MDT), macrocannula, and microcannula. The MDT delivers the irrigation solution into the pulp chamber and evacuates the irrigant concomitantly. The macrocannula acts as a suction tip inserted into the root canal to the middle third to remove the debris and irrigation solution. While the microcannula works in the same way as its counterpart, it can be inserted to the full working length.[10]

XP-endo Finisher (XPF) (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland) is a new file that has been recently brought to the market.[11,12] The XPF is a size 25 non-tapered instrument that is used in the final irrigation protocol. The manufacturer claims that XPF acts as a scavenger of debris due to its flexibility and ability to adapt to the root canal, where it can effectively clean the inaccessible areas.[13]

The present study aimed to investigate the micro-cleanliness of root canals after EV and XPF to remove accumulated hard tissue debris (AHTB). The micro-cleanliness was determined by micro-CT analysis.

Materials and Methods

Tooth selection and preparation

After local research Ethics Committee approval (protocol no. 2016/145, KSA), 100 extracted human mandibular first permanent molars were obtained from a pool of teeth. The inclusion criteria were teeth that are two-rooted (two mesial canals and one distal canal), teeth that have completely formed roots, and teeth that have both mesial canals connected by a single and continuous isthmus.[14] Teeth should also be free of caries, root resorption, or visible cracks. Root curvature should range from 15° to –20° in both the mesiodistal and buccolingual directions. From this set, 12 teeth were randomly selected to be included in this study. The canal width for all teeth was measured at the apex and was approximately equal to a size 10 K-file (FKG, Dentaire SA, La Chaux-de-Fonds, Switzerland). Teeth were cleaned using an ultrasonic scaler and inspected under magnification using a dental operating microscope (Carl Zeiss AG, Oberkochen, Germany).

The teeth were mounted to a special micro-CT sample holder with a radiolucent rubber base impression material. The tip of the roots was covered with utility wax to create a closed-end system and to prevent the intrusion of the rubber base material into the apical part of the canal. Standard occlusal access cavity preparation was made using a diamond-coated bur. The working length was determined using a size 15 K-file (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland), with the aid of a straight preapical radiograph (Carestream, Rochester, NY, USA). Irrigation was performed using a 30-gage side-vented needle (Ultradent, South Jordan, UT, USA) with a 5-mL syringe. The total amount of irrigant for each canal was 5 mL of 5.25% NaOCl. The teeth were irrigated by 1 mL of 5.25% NaOCl for each step of canal preparation as follows: irrigation with 1 mL of 5.25% NaOCl before instrumentation, between each instrument, and after instrumentation. An additional final flush was conducted with 2 mL of 5.25% NaOCl.

The 12 first mandibular molars were prepared using the TF Adaptive rotary system (SybronEndo, Orange, CA, USA) according to the manufacturer's instructions after establishing the glide path to full working length using a size 15 K-file. The teeth were prepared with TF adaptive small canal system SM1 20/0.4, SM2 25/0.6, and SM3 35/0.4 to full working length using an Elements Motor (SybronEndo) at the recommended setting for the TF Adaptive in adaptive motion. Standard irrigation, as described earlier, was performed between each file. Teeth were divided randomly into two groups: group A: EV (n = 6 mesial canals and n = 6 distal canals) and group B: XPF (n = 6 mesial canals and n = 6 distal canals).

All irrigation solutions that we used in the supplementary irrigation protocol were heated to 35°C using a syringe warmer (Vista Dental Products, Racine, WI, USA). Group A was irrigated using EV according to the manufacturer's instructions as follows. Irrigation was started by using the MDT at the access cavity to deliver the irrigation solution. The macrocannula was placed inside the canal about 3–4 mm from the working length. An aliquot of 2.5 mL of 5.25% NaOCl was delivered using the MDT and suctioned by the macrocannula. Then, the macrocannula was removed, and the microcannula was inserted to the full working length. Again, the MDT delivered 2.5 mL of 5.25% NaOCl solution. After that, the microcannula was removed, and the canal was dried with absorbent paper point 35/4% (Dentsply Maillefer, Tulsa, OK, USA). In group B, XPF was placed in a contra-angle Elements Motor handpiece (SybronEndo). Each canal was filled with 0.5 mL of 5.25% NaOCl. According to the manufacturer's instructions, the instrument was adjusted to the working length and then cooled down with Endo-Frost (Roeko, Langenau, Germany). The plastic tube was removed, and the instrument was inserted into the canal without rotation. Afterward, the rotation was turned on to 800 rpm and 1 N/cm torque in a continuous rotation motion. The instrument was activated for 1 min using slow 7–8 mm up and down movements to the entire length of the canal. This step was repeated for each canal. After that, the instrument was removed, and a final irrigation protocol was performed using a 30-gage side-vented needle with 4.5 mL of 5.25% NaOCl for each canal. Each canal was dried with absorbent paper points 35/4% (Dentsply Maillefer).

Micro-CT scanning and evaluation

The teeth were embedded in a special sample holder to ensure reproducible positioning for the repetitive measurements. The specimens were scanned with a μCT 100 (Scanco Medical AG, Brüttisellen, Switzerland) at an energy of 90 kVp, an intensity of 88 μA, and an integration time of 500 ms per projection. The data were reconstructed to an isotropic voxel size of 14 μm using a filtered back-projection algorithm. These settings were used for all base and follow-up measurements. All samples were scanned two times: after instrumentation and after advanced irrigation.

The outer contour of each tooth was generated automatically by using a special-purpose script. The contour was limited to a region that started at 50 slices above the slice, where the root canals merged and ended at the tip of the root. Within this outer contour, the root canals could be extracted using global segmentation procedures.

Calculation of debris

AHTD was calculated after instrumentation (V_{BF}) and after advanced irrigation (V_{AF}). These calculations were done by measuring the difference between non-instrumented and instrumented root canal space. The presence of any material with a density similar to dentine in regions previously occupied by air in the non-prepared root canal space was considered as debris. The debris was calculated in cubic millimeters (mm^3) and expressed as a percentage of the total canal system volume after preparation (vol %).

Percentage reduction of the AHTD was calculated according to the formula:

$1 - [V_{AF}/V_{BF}]$, where V_{BF} is the volume of AHTD after instrumentation and V_{AF} is the volume of AHTD after advanced irrigation.

Statistical analysis

The Shapiro–Wilk normality test was used to test all after preparation measurements from mesial and distal roots. Before and after irrigation data for debris volume were compared for the two advanced irrigation methods. Statistical analysis was done using the paired sample *t*-test (*P*-value of 0.05 for significance). The Prism software (GraphPad Prism Version 8.00 for Mac, GraphPad Software, La Jolla, CA, USA) was used for statistical analysis.

Results

The Shapiro–Wilk normality test showed that after preparation, debris data were normally distributed. In the mesial canals, the use of both EV and XPF advanced irrigation methods significantly reduced the volume of debris (paired-sample *t*-test, $P < 0.05$) [Figure 1A]. However, in the distal canal, only EV advanced irrigation method significantly reduced the volume of debris (paired-sample *t*-test, $P < 0.05$ [Figure 1B]. Figure 2 shows three-dimensional computer reconstructions of μCT scans of debris after instrumentation and after EV advanced irrigation. Figure 2A and C shows debris in mesial canals after instrumentation and after advanced irrigation, respectively. Figure 2B and D shows debris in the distal canal after instrumentation and after advanced irrigation, respectively. Figure 3 shows three-dimensional computer reconstructions of μCT scans of debris after instrumentation and after XPF advanced irrigation. Figure 3A and C shows debris in mesial canals after instrumentation and after advanced irrigation, respectively. Figure 3B and D shows debris in the distal canal after instrumentation and after advanced irrigation, respectively. In the mesial canals, the percentage of debris reduction was 59.87 ± 21.21% and 40.77 ± 19.41% for EV and XPF, respectively. In the distal canals, the percentage of debris reduction was 60.18 ± 22.03% and 48.61 ± 24.34% for EV and XPF, respectively.

Discussion

In this study, we compared the performance of two advanced irrigation systems, EV and XPF, with respect to AHTD reduction. EV and XP systems reduced AHTD of around 60/40% in mesial canals and 60/48% in the distal canals, respectively. Previously, it has been reported that passive ultrasonic irrigation (PUI) and EV systems were the most effective for irrigant penetration up to the working length.[15] Mancini *et al.*[16] reported that the EV system was superior to PUI in the removal of the smear layer at all levels of the root canal. In contrast, Susin *et al.*[17] found that

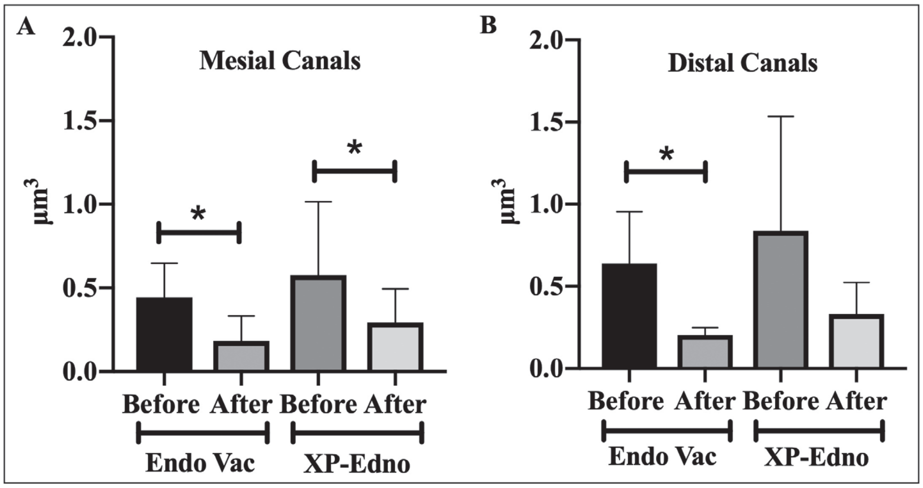

Figure 1: (A) Graph shows debris volume data from the mesial canals, before and after the use of advanced irrigation methods, EX and XPF. (B) Debris volume data from the distal canals, before and after the use of advanced irrigation methods, EV and XPF. * indicates statistical significance difference in the volume of the debris before and after the use of advanced irrigation methods

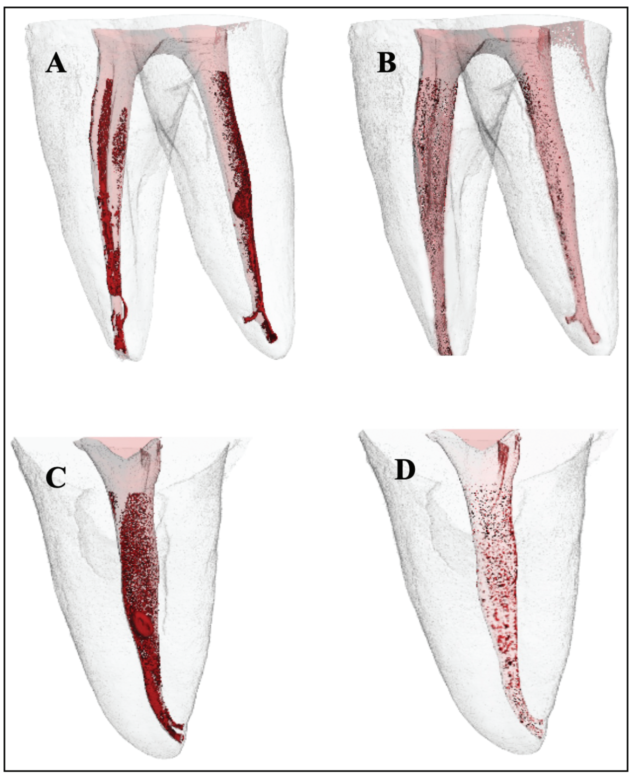

Figure 2: Three-dimensional computer reconstructions of the μCT scans showing the amount of debris after instrumentation in mesial canals (A) and distal canals (C) after using EV for irrigation in mesial canals (B) and distal canals (D)

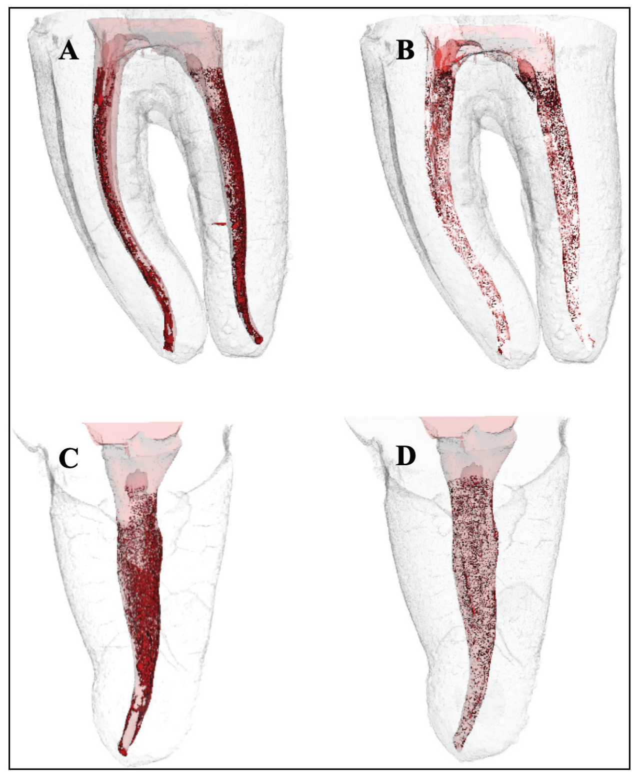

Figure 3: Three-dimensional computer reconstructions of the μCT scans showing the amount of debris after instrumentation in mesial canals (A) and distal canals (C) after using XPF for irrigation in mesial canals (B) and distal canals (D)

30% of the isthmus was obliterated, even with the use of the EV system. de Gregorio *et al.*[18] showed that the irrigant could reach the working length more effectively when the EV system was used, whereas PUI allowed effective distribution in the lateral canals. To date, only one study attempted to quantify AHTD using the XPF system.[19] In that study, they found that XPF was able to reduce AHTD by 89.7% compared with 91% for PUI, 45.7% for needle irrigation, and 43.3% for self-adjusting file (SAF) system in mesial canals of lower first molar (Vertucci's Type I configuration).

In this study, both XP and EV reduced the amount of AHTD significantly in mesial canals when compared with conventional irrigation alone. However, only EV reduced the amount of AHTD significantly in the distal canals. Clinically, the impact of AHTD on success or failure of root canal treatment remains unclear, and further studies are necessary to evaluate its effects on hard tissue. It may be hypothesized that there is a threshold of AHTD within the root canal system, below which a favorable host response is expected. However, removal of as much debris as possible from inside the root canal is essential for subsequent disinfection.

Conclusion

In conclusion, both EV and XPF systems were associated with a significant reduction of hard tissue debris compared with conventional irrigation techniques. Their use could help in the elimination of a large number of microbes from inaccessible areas inside the root canal.

Acknowledgement

The authors have no acknowledgments.

Financial support and sponsorship

This research was funded by King Abdulaziz City for Science and Technology (KACST) with grant number 285-36.

Conflicts of interest

There are no conflicts of interest.

Authors contributions

Conceptualization, L.A. and K.B.; methodology, M.H.; software, M.S.; validation, M.H., K.B., and M.S.; formal analysis, M.H.; investigation, M.S.; resources, K.B.; data curation, M.H.; writing—original draft preparation, L.A. and M.A..; writing—review and editing, L.A. and M.A.; visualization, K.B.; supervision, K.B.; project administration, K.B.; funding acquisition, M.H. All authors have read and agreed to the published version of the manuscript.

Ethical policy and institutional review board statement

Ethical review and approval were waived for this study, due to the fact that the study is in accordance with the guidelines of the Ethical Review Committee, Faculty of Dentistry, King Abdulaziz University, Jeddah, Saudi Arabia.

Patient declaration of consent

Not applicable.

Data availability statement

The data presented in this study are available on request from the corresponding author. The data are not publicly available due to intellectual reasons.

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