Efficacy of XP-Endo Finisher in the Removal of Triple Antibiotic Paste from Immature Root Canals

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Abstract

Introduction: The aim of this study was to evaluate and compare the effectiveness of the XP-Endo Finisher (FKG Dentaire, La Chaux-de-Fonds, Switzerland) with passive ultrasonic irrigation (PUI) and needle irrigation in the removal of triple antibiotic paste (TAP) from the straight immature root canals of extracted teeth. **Methods:** Thirty-four freshly extracted single-rooted teeth were used. All canals were prepared up to the ProTaper F5 file (Dentsply Maillefer, Ballaigues, Switzerland). Apices were drilled to simulate teeth with immature apices. The canals were filled with TAP, sealed, and incubated at 37°C and 100% humidity for 1 month. Samples were randomly assigned to 3 experimental groups according to the method used for TAP removal: XP-Endo Finisher, PUI, and needle irrigation (n = 10). Then, the roots were split into 2 halves. The amount of TAP residue in the apical portion of each segment was evaluated using a scanning electron microscopy and scored. **Results:** The amount of remaining TAP was significantly lower in the XP-Endo Finisher group compared with the needle irrigation and PUI groups ($P < .05$). Between the needle irrigation and PUI groups, there were no statistically significant differences ($P > .05$). **Conclusions:** Within the limitations of this study, the XP-Endo Finisher removed significantly more TAP than needle irrigation and PUI. *(J Endod 2017;■:1–4)*

Key Words

Passive ultrasonic irrigation, scanning electron microscopy, triple antibiotic paste, XP-Endo Finisher

Significance

Thorough removal of TAP is essential because of the possible development of resistant bacteria and discoloration, but it remains a challenge. We compared a novel instrument (XP-Endo Finisher) with PUI and needle irrigation to remove TAP from straight immature root canals.

Endodontic management of immature permanent teeth with necrotic pulps is both a clinical challenge for dental practitioners and a public health care problem (1). Immature teeth are at risk for pulp necrosis because of trauma, dental anomalies, and caries (2). Regenerative endodontic procedures have emerged as an alternative treatment option for young permanent teeth with immature roots (1, 3). Banchs and Trope (4) reported that if the canal could be effectively disinfected, a matrix into which new tissue could grow was created, and the coronal seal was achieved, then the repair should occur in immature permanent teeth.

The most essential factor influencing the success of both apexification and revascularization is disinfection of the root canal space (2, 3). Many disinfection protocols include the use of intracanal medicaments. The most commonly used intracanal medicament in regenerative endodontics is triple antibiotic paste (TAP), which is a mixture of metronidazole, ciprofloxacin, and minocycline (2, 3). Because of the possible development of resistant bacterial strains and tooth discoloration, thorough removal of TAP from the root canal space is essential (4, 5). The studies that evaluated the efficacy of irrigation protocols for the removal of TAP reported that the irrigation solutions alone were unable to remove TAP entirely from the root canals (2, 6).

The XP-Endo Finisher (FKG Dentaire, La Chaux-de-Fonds, Switzerland) instrument is a size 25 nontapered instrument that was recently introduced with the promise of enhancing root canal cleaning and disinfection (7). So far, few studies investigated the cleaning efficacy of the XP-Endo Finisher (8, 9). To date, no studies have evaluated the effect of the XP-Endo Finisher on the removal of TAP from root canals. Thus, the aim of this study was to evaluate the effectiveness of the XP-Endo Finisher and compare its efficacy with needle irrigation and passive ultrasonic irrigation (PUI) in the removal of TAP from straight immature root canals of extracted teeth. The null hypothesis was that there is no difference between the various techniques in removing TAP from root canals.

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Materials and Methods

Root Canal Preparation

Thirty-four freshly extracted, straight, single-rooted human teeth were used. Teeth were disinfected in 5% sodium hypochlorite (NaOCl) for 1 hour. After removing the tooth crowns, the roots were adjusted to a standardized root length of 15 mm. The simulation of roots with immature apices was performed using size 4 green 1.5-mm-diameter Unicore drills (Ultradent Products, Inc, South Jordan, UT). A size 15 K-file (MANI Inc, Tochigi, Japan) was placed until it became visible at the apical foramen. The working length (WL) was determined by subtracting 1 mm beyond the apex. All canals were instrumented with ProTaper Universal (Dentsply Maillefer, Ballaigues, Switzerland) up to F5 file size according to the manufacturer's instructions. Root canals were irrigated with 2 mL 5% NaOCl using a plastic syringe and a 27-G slot-tripped needle (Set Medical, Istanbul, Turkey) at every instrument change. The final canal irrigation was completed using 5 mL 17% EDTA for 1 minute and 5 mL 5% NaOCl for 1 minute followed by the final rinse with 5 mL distilled water. After drying with sterile paper points (Dentsply Maillefer), the specimens were fixed in an impression material. After removal from the impression material, longitudinal grooves were prepared on the buccal and lingual surfaces of each root with a diamond disc without penetrating the canal. The roots were then split into halves with a small chisel. The root halves were reassembled.

TAP was prepared by taking equal portions of ciprofloxacin (Biofarma Pharmaceutical Company, Istanbul, Turkey), metronidazole (Eczacıbaşı Pharmaceutical Company, Istanbul, Turkey), and minocycline and mixing them with distilled water in a ratio of 3:1; it was packed to the WL of each canal using a Lentulo spiral (MANI Inc). Then, cotton pellets were placed over the canal orifices, and the apical and coronal parts of the roots were sealed with Cavit (3M ESPE, Seefeld, Germany). The roots were stored at 37°C in 100% relative humidity for 1 month.

Experimental Groups according to TAP Removal Techniques

XP-Endo Finisher Group. The XP-Endo Finisher file was used in this group. The plastic rubber stop was set at 1 mm from the WL. An endodontic motor (X-Smart Plus, Dentsply Maillefer) was set at 800-rpm speed and 1-Ncm torque and was operated for 1 minute with a gentle up and down motion, flushing the canals with a total of 10 mL 5% NaOCl at 37°C followed by a final flush using 2 mL 17% EDTA.

PUI Group. Ultrasonic irrigation using a piezoelectric unit (NSK Varios, NSK, Japan) was used to remove TAP residues. A noncutting ultrasonic tip was placed 1 mm from the WL and was activated at Endo mode. The frequency of the device was approximately 30 kHz. Oscillation of the ultrasonic tip and irrigation began at the same time. Root canals were ultrasonically irrigated using a continuous flow. Ultrasonic irrigation was operated in 2 cycles of 1 minute. In the first cycle, the canals were irrigated using 10 mL 5% NaOCl (37°C) for 1 minute, and in the second cycle 17% EDTA was used for 1 minute.

Needle Irrigation Group. Root canals were cleaned using a size 15 K-file 1 mm behind the radiographic apex. Root canals were then irrigated with 10 mL 5% NaOCl using a plastic syringe and a 27-G closed-end needle for 1 minute. The final irrigation was completed using 2 mL 17% EDTA. During irrigation, the needle was constantly moved up and down within the apical third.

Control Groups

Two canals that were not filled were used as negative controls. Two canals that were filled with TAP but no cleaning procedures were applied served as the positive control group.

Scanning Electron Microscopic Evaluation

The roots were disassembled to evaluate the removal of TAP. The roots were left to dry at room temperature for 24 hours and then coated with 20 nm gold-palladium particles for scanning electron microscopic (SEM) examination (JSM-T330 SEM; JEOL, Tokyo, Japan).

At ×1000 and ×1500 magnifications, digital images were taken at the center of the apical thirds of each canal in both root segments to evaluate the presence of TAP residues. To standardize the SEM examination area, the central beam of the scanning electron microscope was directed to the center of the segment under ×10 magnification. Magnification was gradually increased to ×1500, and then the canal wall region appearing on the screen was photographed and scored. This method was previously described by Paqué et al (10).

The following scoring system (6, 11) was used to evaluate the presence of TAP residues on root canal walls:

1. Score 0: Absence of any residue
2. Score 1: Small amount of residues (up to 20% of the surface covered)
3. Score 2: Moderate amount of residues (20%–60% of the surface covered)
4. Score 3: Large amount of residues (more than 60% of the surface covered) (Fig. 1)

Evaluation was performed by 2 calibrated examiners independently and in a blind manner.

Statistical Analysis

Kappa values were calculated for intra- and interobserver agreement evaluation. Differences in the TAP residue score among the 3 experimental groups were analyzed using Kruskal-Wallis and Mann-Whitney *U* tests at a significance level of $P < .05$. All statistical analyses were performed using IBM SPSS Statistics 22 software (IBM, Armonk, NY).

Results

Calibration

Thirty random SEM images were scored by examiners. After a discussion on the images, evaluation was performed by the same examiners and repeated 1 week later. During the complete scoring procedure, high intraobserver reproducibility and interobserver agreement were detected. The kappa value was 0.667 between the examiners. The kappa values for the intraobserver agreement were 0.6364 and 0.6694 for the first and second examiner, respectively.

Investigation

Table 1 shows the mean, median, and minimum-maximum values of the amount of remaining TAP on the apical root section for each experimental group. All specimens in the positive control group (root canals completely filled with TAP) showed a score of 3, and all specimens in the negative control group (root canals not filled with TAP) showed a score of 0. The positive and negative control groups were found to be statistically different from all other groups ($P < .05$). None of the experimental groups removed TAP entirely from the root canals. The Kruskal-Wallis test revealed that there were statistically significant differences in the amount of remaining TAP among the experimental groups ($P < .05$). The amount of remaining TAP was significantly lower in the XP-Endo Finisher group compared with the needle irrigation and PUI groups ($P < .05$). Between the needle irrigation and PUI groups, there were no statistically significant differences ($P > .05$).

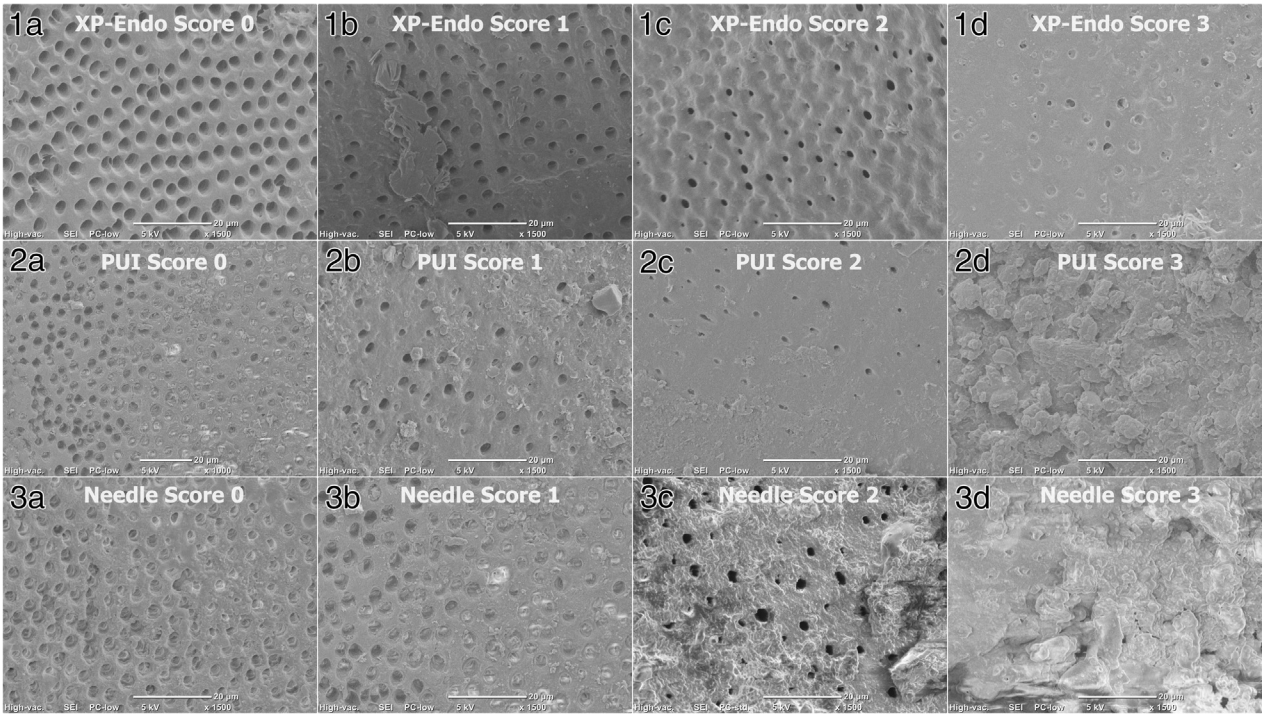

Figure 1. Representative SEM images of the apical thirds of (*row 1*) the XP-Endo Finisher group, (*row 2*) the PUI group, and (*row 3*) the needle irrigation group. (*a*) Score 0, (*b*) score 1, (*c*) score 2, and (*d*) score 3.

Discussion

The remnants of TAP on the canal walls could affect the outcome of regenerative endodontic treatment (2); therefore, they should be removed from the root canals. In the present study, the ability of several irrigation solutions to remove TAP from the straight immature root canal walls after 1 month of placement was investigated.

The advantage of using an immature apex model is that the width and length of the root canal space can be standardized (12). However, it might not accurately reflect the natural root canal system with respect to the complex anatomy. Thus, it may be easier to remove TAP from simulated immature teeth than from natural immature teeth.

TAP is a highly effective antimicrobial agent (13) that has been used in regenerative endodontic procedures (1, 14). Recent studies (3, 15) showed that this medicament when used at various concentrations has an adverse effect on stem cell survival even after attempts to remove them from the root canals. Moreover, TAP can cause significant staining (16), demineralization (17), and reduced microhardness and fracture resistance (18). Because of its potential adverse effects on the microenvironment of the root canal system, it is crucial that the TAP be adequately removed from the root canal once it has served its antimicrobial purpose (2, 6).

The results of this study showed that it was difficult to completely remove TAP from the root canal. A study by Berkhoff et al (2) in which TAP removal was compared with calcium hydroxide also concluded that TAP had high retention within dentin regardless of the removal efforts with different irrigation methods (6).

Factors such as the type of irrigant used (2), solution agitation (12), penetration depth of the irrigation needle (19–21), and the instrumentation technique used (22) affect the attainment of clean root canals. Antibiotic pastes were previously removed using various irrigating solutions such as NaOCl, EDTA, and sterile saline (23–25). Therefore, an irrigation protocol adopted from Arslan et al (23) was used.

In the present study, TAP was removed from the root canals using various techniques. The amount of residual TAP on root canal walls has been assessed in varied ways from calculating the volumes of residues by stereomicroscopy (24) to radioactive labeling (2). In this study, 2 calibrated examiners evaluated the presence of TAP residue in longitudinally sectioned root halves based on digitally recorded SEM images at ×1500 magnification to reveal the remaining paste inside the dentinal tubules using a modified scoring system (26). This scoring system was recently used by Wigler et al (8) and Capar et al (27).

TABLE 1. The Mean, Median, and Minimum-maximum Values of the Amount of Remaining Triple Antibiotic Paste on the Apical Root Section for Each Experimental Group

	Amount of remaining debris			
Groups	Mean ± SD	Median	Minimum–maximum	*P* value
XP-Endo Finisher	0.85 ± 0.87	1	0–2	
PUI	2.55 ± 0.60	3	1–3	.001*
Needle Irrigation	2.30 ± 0.73	2	0–3	

PUI, passive ultrasonic irrigation; SD, standard deviation.

*Kruskal-Wallis test, $P < .05$.

Even though the scoring method used in the present study involved qualitative analysis, it is a simple scoring system performed by 2 calibrated examiners with concordance between them.

Recent studies evaluated the cleaning efficacy of needle irrigation (2), sonic irrigation (6), PUI (2, 24), CanalBrush (Coltene/Whaledent GmbH+ Co KG, Langenau, Germany) (6), EndoActivator (Dentsply, Tulsa, OK)(2), and EndoVac (SybronEndo, Coppell, TX) (2) on the removal of TAP. Compared with traditional needle irrigation, PUI can be an important supplement for cleaning the root canal system because it removes more organic tissue and debris from the root canal (24). However, in this study, there were no significant differences between needle irrigation and PUI in terms of TAP removal.

The XP-Endo Finisher is formed using a proprietary NiTi alloy (Martensite-Austenite Electropolish-FleX; FKG Dentaire, La Chaux-de-Fonds, Switzerland). The instrument is straight in its martensite phase at room temperature, but it changes to the austenite phase at body temperature and develops a spoon shape; when rotated and moved up and down in the canal, this shape makes the instrument expand and contract to touch the canal walls and shake the irrigant solution (7, 28). The idea behind this is that in rotation mode the austenite phase shape will allow the file to contract and expand according to the root canal anatomy, accessing and cleaning areas that are otherwise impossible to reach with standard instruments (7). This expectation was realized in the present study in terms of TAP. Recent studies showed that the irrigation of root canals using the XP-Endo Finisher appeared to be more effective on debris and smear layer removal than needle irrigation (8), which was in accordance with our findings. In previous studies, the XP-Endo Finisher showed similar results to PUI (8) and the EndoActivator (9). However, in this study, the XP-Endo Finisher showed better cleaning efficacy than PUI. Therefore, the null hypothesis that there is no difference between the various techniques was rejected because the XP-Endo Finisher removed significantly more TAP than PUI and needle irrigation. This can be attributed to its metallurgy (7).

Within the limitations of this study, the XP-Endo Finisher removed significantly more TAP than the needle irrigation and PUI groups. The XP-Endo Finisher can be used as an alternative irrigation method for the removal of TAP from straight immature root canals when used in combination with NaOCl and EDTA.

Acknowledgments

The authors deny any conflicts of interest related to this study.

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