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ORIGINAL RESEARCH

Efficacy of EDDY, ultrasonic activation, XP-endo Finisher and needle irrigation on the removal of mTAP from artificially created grooves in root canals

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Abstract

This study analysed the effect of needle irrigation (NI), passive ultrasonic irrigation (PUI), EDDY and the use of the XP-endo Finisher (XPF) on the removal of modified triple antibiotic paste (mTAP) from artificially created grooves in root canals. Forty-eight maxillary incisors were prepared up to size 50, with a standard groove on one surface of the root canal wall and filled with mTAP. Re-attached roots were analysed based on the activation techniques applied for 180 s with 5 ml 3% sodium hypochlorite. The results showed that EDDY was more effective at removing mTAP than PUI, XPF and needle irrigation ($P < 0.05$), whereas XPF and PUI were significantly more effective than needle irrigation. ($P < 0.05$). No significant difference in mTAP removal was observed between XPF and PUI ($P > 0.05$). These findings suggest that the removal of mTAP can be more efficiently achieved with EDDY than with XPF, PUI or NI.

Introduction

The removal of microorganisms and their by-products from root canals is an essential part of root canal therapy. If all pathogens could be removed from the root canals, the successful performance of endodontic therapy would be at least 26% higher (1). The use of antibacterial medication may be one process that can eliminate bacteria in root canal treatments (2).

Triple antibiotic paste (TAP), a mixture of metronidazole, ciprofloxacin and minocycline, has been used for the disinfection of contaminated root canal dentine (3). Minocycline contained in TAP has been reported to cause discolouration of the teeth (4). Recent studies have therefore proposed the replacement of minocycline with another antimicrobial agent (5). Clindamycin was confirmed as effective against different endodontic pathogens (6) and was therefore used to replace minocycline in TAP in a new combination now defined as a modified triple antibiotic paste (mTAP) (7). Another negative effect of antibiotic pastes is their direct toxicity to stem cells when used at concentrations higher than 0.1 g ml^{-1} (8). Therefore, the complete removal of these pastes is important for clinical applications.

Conventional syringe-needle irrigation has been widely used for the removal of intracanal medicaments; however, it is not fully effective (9). For this reason, alternative irrigant activation appliances have recently been proposed to increase irrigant effects (10). One of these is the XP-endo Finisher (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland), which is a non-tapered file with a small core, size 25, based on nickel titanium (NiTi) alloy shape memory principles. This finisher was developed for use after any root canal preparation of size 25 or more to clear extremely complicated areas and sections that are tough to access, as well as to eliminate intracanal medications (11).

Another irrigation activation technique is the passive ultrasonic irrigation technique. Ultrasonic activation increases the influence of irrigation solutions in removing residues from root canal walls (12). Ultrasonically activated files are also used for mechanical cleaning of root canals, and they oscillate in the frequency range of 25–30 kHz (13). Some studies have shown a much more successful cleaning of the pulp tissue with PUI than with traditional irrigation, as well as better elimination of the smear layer and greater reduction of the number of bacteria (14).

Recently, EDDY (VDW, Munich, Germany) emerged as a new method for irrigant activation. The flexibility of the EDDY tip is a function of its polyamide construction and its manufactured size of 25.04. The EDDY tip is used with a conventional air scaler and generates a frequency of 6 kHz. The EDDY technique has a history of the successful removal of debris from root canals (15). However, the available literature is limited regarding the EDDY removal of antibiotic paste from root canals.

The current study was designed to compare various irrigation protocols needle irrigation (NI), passive ultrasonic irrigation (PUI), EDDY and XP-endo Finisher (XPF) in terms of their effectiveness in removing mTAP from artificial grooves in root canals. In this study, we tested the hypothesis that no variation exists between the groups in terms of the efficacy of removing mTAP from grooves artificially created in root canals.

Materials and methods

Forty-eight extracted maxillary incisors with single roots with the least distance of 18 mm and a single root canal were included in the study. These were permanent teeth with an intact apex and without previous root canal treatment. Exclusion criteria were the presence of root caries, large oval canals and root surface cracks. Soft tissues and residues were removed from the teeth. Mesiodistal and buccolingual radiographs were obtained from the examples to examine morphology. All teeth were shortened to 17.5 mm in length.

The working length was set using a 10 K-file size (Diadent, Chongju, Korea) to the terminus of the root canal, and 0.5 mm was deducted from this value. The samples were prepared using NiTi rotary instruments (Reciproc files; VDW) up to size #50. During preparation, irrigation was performed using 2 ml of 3% NaOCl via a 30-gauge open-ended needle (Diadent, Chongju, Korea) after each three-pecking motion. Following preparation, all the roots were grooved longitudinally at the mesial and distal root surfaces with a diamond disc under copious water irrigation, avoiding penetration into the root canal. The roots were then split into two halves with a small chisel. An artificial groove was created 2–6 mm from the root tip on one side of the root canal wall. The length, width and depth of the prepared groove were 4, 0.2 and 0.5 mm, respectively (16). This was performed with a 1S Cavitron tip (Satelec, Acteon Group, Merignac, Fransa) that was coupled to the file-holding adapter of the handpiece of a Satalec P5 Newtron ultrasonic system (Acteon Group, Merignac, France). Grooves were prepared under a stereomicroscope (Novex, Arnhem, The Netherlands) to ensure standardisation. Debris was removed from the grooves with a brush. A final irrigation was applied using 5 ml of 3% NaOCl, and the root canals of the samples were dried.

A mixture of mTAP was prepared by freshly mixing antibiotics, including 150 mg clindamycin (Bilimilaç, Istanbul, Turkey), 250 mg ciprofloxacin (Biofarma, Istanbul, Turkey) and 250 mg metronidazole (IE Ulagay, Istanbul, Turkey) with 1 ml distilled water (a powder/liquid ratio of 3:1) (17). The mTAP was placed into the grooves, the root halves were reassembled, the apical foramen and peripheries of the roots were covered with wax, and the samples were placed in Eppendorf vials. The samples were stored at 37°C for 2 weeks in a full humidity environment.

After two weeks of storage, the samples were randomly allocated into four groups: NI, EDDY, PUI and XPF.

Needle irrigation

A 30-gauge syringe was inserted into the canal 1 mm from the root tip and moved in and out at 5 mm intervals. A 5 ml volume of 3% NaOCl was applied for 60 s (30 s irrigation + 30 s passive standby), and this process was repeated twice.

Passive ultrasonic irrigation

Ultrasonic activation with a P5 Newtron (Acteon Group, Mount Laurel, NJ, USA) was delivered according to the manufacturer's instructions with the power level of the ultrasonic device set to "endodontic mode" (frequency = 28–36 kHz). The root canal was filled with 3% NaOCl, and an ultrasonic file (DTE Endo File; EMS, Nyon, Switzerland) (25, 0.02) was inserted into the canal at 1 mm from the working length. The file was moved with oscillations of 4–5 mm in the canal for 30 s. A 5 ml volume of 3% NaOCl was applied for 30 s, and this process was repeated twice.

EDDY

Irrigation was done with a syringe containing 5 ml 3% NaOCl. The NaOCl treatment was assisted with an air scaler (Micron, Tokyo, Japan) at a frequency of 6000 Hz. The EDDY tip was placed 1 mm from the working length, and a pecking movement was performed with 4–5 mm oscillations in the canal for 30 s. A 5 ml volume of 3% NaOCl was applied for 30 s, and this process was repeated twice.

The XP-endo finisher

The XPF was used according to the manufacturer's instructions at 1000 rpm and under 1 Ncm of torque.

The operation was carried out with an endodontic motor (VDW Gold Reciproc). The canal was first filled with irrigation solution, and the XP-Endo Finisher was then placed 1 mm from the working length. A pecking movement was performed with 4–5 mm oscillations in the canal for 30 s. A 5 ml volume of 3% NaOCl was applied for 30 s, and this process was repeated twice.

The irrigation procedure was performed in equal time (30 s irrigation + 30 s activation) and with equal NaOCl volume in all groups. The halves of the roots were detached to evaluate the removal of mTAP from the grooves after the irrigation procedures. A mobile phone was connected to a stereomicroscope, and the specimens were examined under 25× magnification. The obtained images were evaluated using a computer.

The amount of mTAP remaining in the grooves was independently scored by calibrated and blinded operators according to the assessment scale used by van der Sluis et al (18).

Score 0: empty groove.

Score 1: mTAP is present in less than half of the groove.

Score 2: mTAP is present in more than half of the groove.

Score 3: The groove is completely filled with mTAP (Figure 1).

Inter-examiner reliability was analysed with the Kappa test, and intra-examiner reliability was also analysed. The Kruskal–Wallis and Mann–Whitney U tests were used to verify statistical significance at the 95% confidence interval ($P < 0.05$). The data were analysed using SPSS software (SPSS Inc., Chicago, IL, USA).

Results

The intra-individual reproducibility for the first and second observers was 91% and 88%, respectively. The reliability between the researchers was very good (Kappa value: 0.828), and the difference never surpassed one unit between the matched scores.

Figure 2 presents the mTAP scores for all groups. The Kruskal-Wallis test was used to verify statistical significance, and differences were observed between the groups ($P < 0.05$). Table 1 shows the results of the Mann–Whitney U tests between groups. EDDY was superior in removing mTAP compared to NI ($P < 0.001$), PUI ($P < 0.05$), and XPF ($P < 0.05$). XPF and PUI were more effective than NI ($P < 0.05$) in the removal of mTAP. No significant variation was found between the XPF and PUI in terms of removal of mTAP from the artificially created grooves ($P > 0.5$).

Discussion

This study examined the effects of EDDY, the XP-endo Finisher (XPF), and PUI compared with NI for cleaning mTAP from artificially created grooves in root canals. The current literature contains only limited evidence regarding the efficacy of EDDY removal of TAP. One study by Urban et al. (15) revealed that EDDY performed equally well as PUI in root canals in terms of the removal of debris and the smear layer. EDDY and PUI in the apical part of the root canals were also superior to XPF in terms of satisfactory removal results (19). However, in the present study, mTAP removal was better in the EDDY group than in the NI, PUI, and XPF group. Therefore, we rejected our

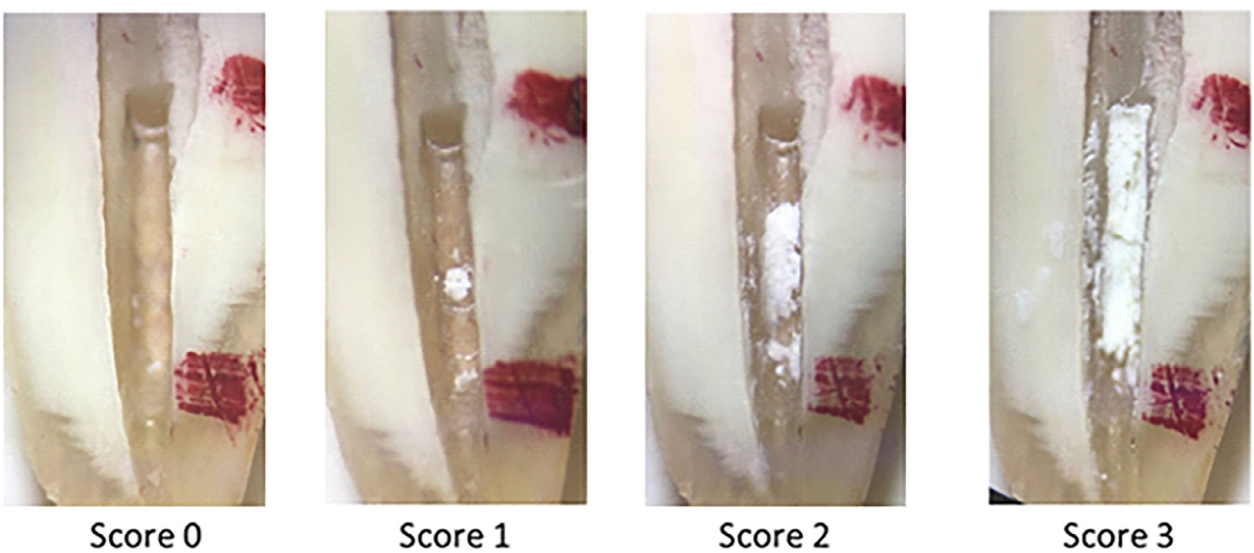

Figure 1 Examples of the different score scales.

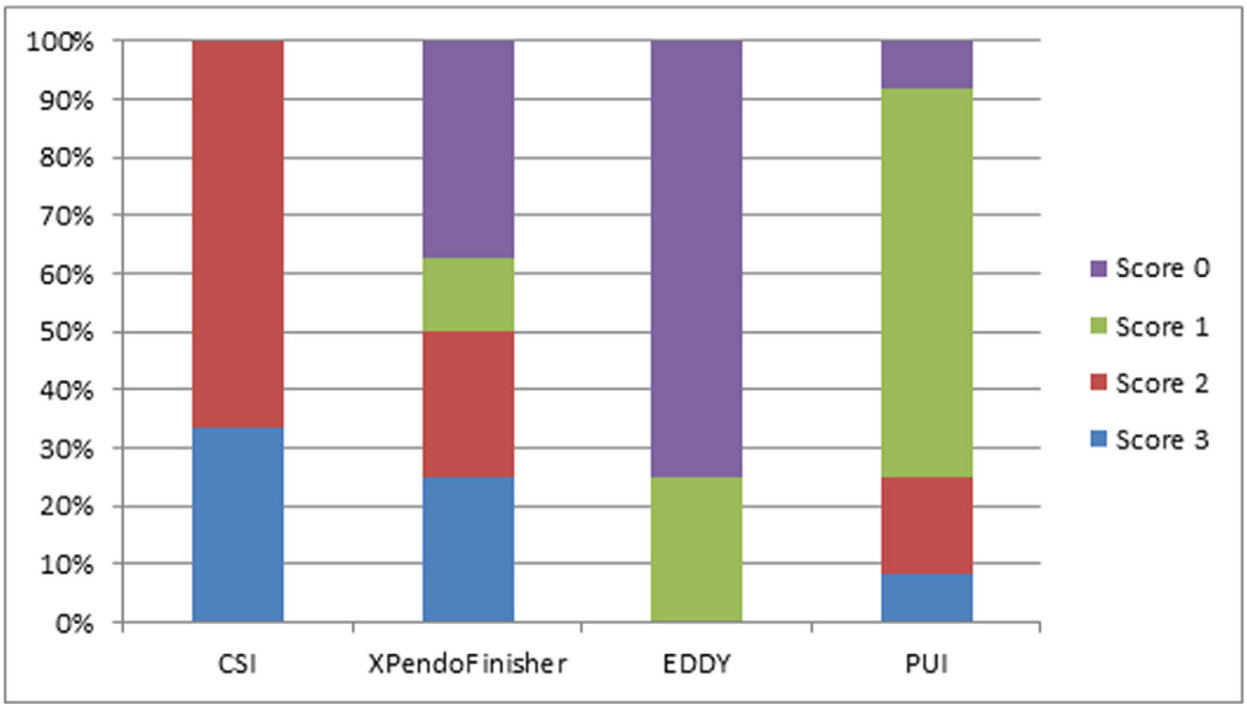

Figure 2 Presents the mTAP scores left for all groups in the canals.

Table 1 Results of the Mann–Whitney U tests between groups

	Pairwise comparisons, *P*-values			
Groups	CSI	EDDY	XPendo Finisher	PUI
CSI	–	**0.000**	**0.019**	**0.003**
EDDY	**0.000**	–	**0.008**	**0.001**
XPendo Finisher	**0.019**	**0.008**	–	0.874
PUI	**0.003**	**0.001**	0.874	–

Bold letters indicate significant differences.

hypothesis that no difference exists between the groups in terms of removing mTAP from root canals. The better efficacy of EDDY sonic activation in the apical third could reflect its elastic tips, which might be advantageous when compared to the solid metal tips typically used when performing PUI (15).

Topçuoğlu et al. (20) measured the efficacy of PUI, a sonic technique (Vibringe), and conventional syringe irrigation (CSI) for the removal of TAP and determined that PUI and Vibringe showed better results than CSI in the apical third. Arslan et al. (21) investigated the efficacy of different irrigation techniques for the elimination of TAP from root canals and concluded that the PUI technique was more efficient than the conventional syringe irrigation technique for removing TAP. This difference may be ascribed to acoustic streaming (15), which refers to the swift progression of liquid around the vibrating file. A study by Jiang et al. (22) on PUI emphasised the importance of fluid flow velocity and direction. The authors explained that the jet-shaped liquid flow emerging from the ultrasonic file tip removed more debris from the grooves and that the fluid flow was able to spread to more areas due to the gaps formed in the grooves (22).

XPF has been reported to be superior to manual irrigation for removing intracanal medications (23). The XPF file changes shape in the austenite phase during application and can provide greater cleaning efficiency in root canals (11). The asymmetrical structure of XPF and its use at high speeds increase the effectiveness of the irrigation solution and provide an advantage in cleaning the grooves on the canal surface (11). Further, these files are affected by ambient temperature, and when exposed to intracanal temperature, they change from a martensitic state to an austenitic state and assume a curved shape (19). In the present study, the solutions were used at 20°C to maintain standardisation.

Türkaydın et al. (24) compared the removal of TAP using NI, PUI, and the XPF in the apical thirds and reported that TAP was removed more effectively with XPF than with NI. These findings could be related to the specific shape of the XPF instrument during rotation. The use of PUI is associated with excellent or parallel results when compared with XPF in cleaning intracanal medication from artificial grooves (25). Similarly, Gawdat et al.

(26) reported no significant difference in the apical third between PUI and XPF. The findings of the present study are compatible with the findings of these previous studies. According to the study by Donnermeyer et al. (19), PUI can be a valuable complement for the removal of root canal dressings in the apical third part. Contrary to our observations, however, an investigation by Gokturk et al. (27) on the efficacy of PUI and XPF techniques for the removal of intracanal medicaments from artificial grooves in root canals revealed a significant difference between the two groups. However, in the present study, no major variations were noted between XPF and PUI in terms of mTAP elimination.

TAP is an intracanal medical substance consisting of a mix of minocycline, ciprofloxacin, and metronidazole and is used as a disinfectant in necrotic teeth and for regenerative procedures (28). In previous studies, minocycline was replaced by cefaclor or clindamycin due to the discolouration effects of minocycline (9,29), and clindamycin-modified TAP resulted in successful clinical outcomes (29). In the current study, a clindamycin-modified TAP was used because this combination can achieve effective root canal disinfection.

Conclusion

Within the limitations of the present study, NI was less effective than the other irrigation procedures for the removal of mTAP, while EDDY was markedly more successful than either XPF or PUI.

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Author contributions

All authors have contributed significantly and all authors are in agreement with the submitted manuscript.

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