Comparison of Different Irrigation Activation Regimens and Conventional Irrigation Techniques for the Removal of Modified Triple Antibiotic Paste from Root Canals

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Abstract

Introduction: The aim of this study was to compare the efficacy of irrigation activation regimens and conventional syringe irrigation technique in the removal of modified triple antibiotic paste (mTAP) from root canal walls. **Methods:** Fifty-six extracted human mandibular premolars were prepared using ProTaper rotary files (Dentsply Maillefer, Ballaigues, Switzerland) up to size F4. The root canals were filled with mTAP medicament, and after 21 days, the roots were randomly assigned to 5 groups ($n = 10$) according to the irrigation regimens used: conventional syringe irrigation (CI), Self-Adjusting File (SAF; ReDent-Nova, Ra'anana, Israel), EndoVac (Discus Dental, Culver City, CA), EndoActivator (Dentsply, Tulsa, OK), and passive ultrasonic irrigation (PUI). In 3 teeth, mTAP was not removed (positive controls), and another 3 teeth were not filled with mTAP (negative controls). The roots were sectioned, and the amount of remaining medicament at each root half ($n = 20$) was evaluated at 30× magnification using a 4-grade scoring system. Data were evaluated using the Kruskal-Wallis and Mann-Whitney *U* tests. **Results:** There were statistically significant differences among all experimental groups; of which, the CI group was the significantly least efficient in removing mTAP from the root canal ($P < .05$). At the apical and middle third, the PUI, SAF, EndoVac, and EndoActivator groups removed significantly more mTAP medicament than the CI group ($P < .05$); however, there were no significant differences between these groups ($P > .05$). The SAF and PUI showed significantly better performances in removing mTAP from the coronal third ($P < .05$). **Conclusions:** The use of irrigation activation regimens significantly improves the removal of mTAP from root canals when compared with CI. *(J Endod 2015;41:720–724)*

Key Words

EndoActivator, EndoVac, modified triple antibiotic paste, Self-Adjusting File, ultrasonic

Endodontic regeneration has been introduced as a treatment option for necrotic immature permanent teeth. One of the essential elements for a successful endodontic regeneration protocol is the creation of a bacteria-free environment inside the root canal space through the use of intracanal medicaments (1). The most widely used intracanal medicament in endodontic regeneration is triple antibiotic paste (TAP) described by Hoshino et al (2), which is a mixture of metronidazole, ciprofloxacin, and minocycline. Minocycline has been discarded from TAP because of its discoloration effect (3); cefaclor has been included instead, and it is described as modified triple antibiotic paste (mTAP) (4). After the disinfection procedure, the treatment strategy included TAP removal followed by the placement of mineral trioxide aggregate (5).

Ruparel et al (6) reported that TAP had a detrimental effect on human stem cells in the apical papilla. Thus, this paste should be removed completely from the root canals to inhibit its detrimental effects on stem cells. Likewise, TAP should be removed to avoid an effect on sealer penetration and tooth discoloration (7). Sodium hypochlorite (NaOCl) irrigation solutions are commonly used for the removal of TAP with traditional syringe irrigation techniques (5, 8). However, this is insufficient for complete cleaning of the complex anatomy of the root canal system (9). Recently, different devices for irrigation delivery have been recommended to increase the flow and distribution of irrigating solutions within the root canal system (10).

A novel instrumentation and irrigation device, the Self-Adjusting File (SAF) system, was introduced by ReDent-Nova (Ra'anana, Israel). The SAF has proven to be effective in areas of the root canal that are inaccessible to most other instruments. Moreover, the design of the SAF allows a continuous flow of irrigant through its hollow file while the solution is continuously activated by its vibrating motion (11). The EndoVac System (EV) (Discus Dental, Culver City, CA) is an apical negative pressure irrigation device that is designed to drain irrigation solution at the apical third level of the canal system and to remove debris via a negative pressure mechanism (12). The EndoActivator System (EA) (Dentsply, Tulsa, OK) is a sonically driven irrigant activation system designed to produce vigorous intracanal fluid agitation that has been shown to increase the efficacy of irrigation better than traditional syringe irrigation (13). Passive ultrasonic irrigation (PUI) (Acteon Group Ltd, Merignac, France) uses a stainless steel file to activate the irrigant in the canal, and PUI is able to disrupt the endodontic biofilm, facilitating better penetration of irrigants throughout the endodontic dentinal walls (10, 14).

To date, no studies have evaluated the mTAP removal ability of the different irrigation activation regimens. Therefore, the aim of this study was to compare the efficacy of the irrigation activation regimens and conventional syringe irrigation (CI) techniques in the removal of mTAP from the root canal walls.

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Materials and Methods

Fifty-six mandibular single-rooted premolars were selected, and the crowns of the teeth were sectioned at 12 mm from the apex to standardize the length of the roots. The root canals were instrumented with ProTaper rotary files (Dentsply Maillefer, Ballaigues, Switzerland) up to F4 (size 40). At every instrument change, the root canals were irrigated with 2 mL 1% NaOCl solution. Final irrigation was performed using 5 mL 5.25% NaOCl and 5 mL 17% EDTA.

mTAP was prepared by mixing antibiotic powders compounded in equal portions of mTAP containing metronidazole (IE Ulagay, Istanbul, Turkey), ciprofloxacin (Biofarma, Istanbul, Turkey), and cefaclor (Actavis, Istanbul, Turkey) with distilled water. For the antibiotic pastes, a 1000-mg/mL solution is needed to create a pasty slurry with a consistency similar to the mixture used clinically. mTAP was applied to the canal spaces with a lentulo spiral until the medicament was visible at the apical foramen. Access to the root canals was temporarily sealed with a cotton pellet and Cavit (ESPE, Seefeld, Germany), and the teeth were stored at 37°C with 100% humidity for 21 days.

To simulate clinical conditions, the apices were sealed with hot glue. The specimens were randomly divided into 5 groups according to the irrigation regimens used. In 3 teeth, mTAP was not removed (positive controls), and another 3 teeth were not filled with mTAP (negative controls).

Group 1: CI

A 27-G irrigation syringe (Ayset, Adana, Turkey) was inserted as deep apically as possible without binding, and irrigation was performed with 10 mL 3% NaOCl solution for 1 minute.

Group 2: SAF

The SAF was operated in the root canal for 1 minute under constant irrigation with 10 mL 3% NaOCl. The SAF was operated with a vibrating handpiece at an amplitude of 0.4 mm and 5000 vibrations per minute attached to a special irrigation device that provided a continuous flow of the irrigation solution at a rate of 10 mL/min.

Group 3: EV

The canals were first irrigated for 30 seconds with 5 mL 3% NaOCl using macrocannulas. The microcannulas were then inserted to the full working length, and the canals were irrigated with 5 mL 3% NaOCl for 30 seconds.

Group 4: EA

Ten milliliters of 3% NaOCl was flushed into the canal using a 27-G syringe and activated using an EA handpiece set at 10,000 cycles per minute with a red (25/04) tip inserted 2 mm short of the working length for 1 minute.

Group 5: PUI

Ten milliliters of 3% NaOCl was agitated using a size 15 K-file (Acteon Group Ltd) coupled to the file-holding adapter of a Satelec P5 Newtron XS ultrasonic system handpiece (Acteon Group, Merignac, France). The ultrasonic file was placed into the canal 1 mm short of the working length without touching the walls, enabling it to vibrate freely. The ultrasonic file was activated at power setting 6 for 1 minute, and the irrigants were continuously delivered at a rate of 10 mL/min through the unit.

After the final irrigation, 2 mL distilled water was used to remove any remaining NaOCl. The canals were dried with paper points, and longitudinal grooves were prepared on the buccal and lingual surfaces of each root with a diamond disk without penetrating the canal. Ten roots in each group were sectioned into 2 halves; thus, 20 samples were obtained from each group (n = 20). The amount of remaining medicament at each root half was evaluated. Images of the coronal (12 mm from apex), middle (8 mm from apex), and apical (4 mm from apex) thirds of the root canal surfaces were acquired for this purpose using a digital camera mounted on a stereomicroscope (Leica MZ16 A; Leica Microsystems, Wetzlar, Germany) at 30× magnification and transferred to the computer. Three calibrating dentists were blinded to the technique used to remove mTAP, and the amount of mTAP remaining in the canal was scored using the following scoring system described by Van Der Sluis et al (15): score 0, the canal was empty; score 1, mTAP was present in less than half of the canal; score 2, mTAP covered more than half of the canal; and score 3, the canal was completely filled with mTAP (Fig. 1*A–D*).

The kappa test was used to analyze interexaminer agreement. Statistical analyses were performed with the Kruskal-Wallis and Mann-Whitney U tests. The level of statistical significance was set at 95% confidence ($P < .05$).

Results

The kappa test showed that the interexaminer agreement was 96.5% for mTAP medicament removal. Interexaminer reliability was confirmed using kappa statistics (kappa value >0.94). The distribution of scores for the removal of mTAP medicament is summarized in box plots showing the median, interquartile ranges, and outliers (Fig. 2). The mean scores and medians of mTAP removal are shown in Table 1 as well as the statistical comparisons between the thirds of the same group.

The positive control group showed that the canal walls were completely filled with mTAP, and the negative control group showed no mTAP on the canal walls. None of the groups showed complete removal of mTAP from the root canals (Table 1). The Kruskal-Wallis test revealed that there were statistically significant differences among all experimental groups ($P = .00$). However, CI was found to be the least efficient technique to remove mTAP.

At the apical third and middle third, CI showed the highest score values ($P = .001$ and $P = .001$, respectively), and no statistically significant difference was found among the other irrigation activation regimens ($P > .05$). At the coronal thirds, CI and EV showed the highest scores, EA showed middle scores, and SAF and PUI showed the lowest score values ($P = .00$).

When the thirds were compared for each group, no significant difference was found in the CI group for mTAP removal at the apical, middle, and coronal thirds ($P = .14$). The SAF ($P = .008$) and PUI ($P = .00$) were significantly efficient for the removal of mTAP at the apical and coronal thirds when compared with the middle third ($P < .05$). Finally, EV ($P = .00$) and EA ($P = .00$) were significantly efficient at the apical third when compared with the middle and coronal thirds ($P < .05$).

Discussion

The aim of this study was to compare the efficacy of the irrigation activation regimens and CI in the removal of mTAP from the root canal walls, from the apex to the coronal third. An *in vitro* closed-end canal model was used because it more accurately simulates *in vivo* conditions (16). Various methods have been used to investigate the amount of residue on the canal walls, such as the use of digital photographs, stereomicroscopes, scanning electron microscopes, micro–computed tomographic imaging, and spiral computed tomographic imaging (17–20). In our study, stereomicroscopy was used, and the remnants of mTAP on the root canal walls were evaluated using a scoring method similar to that used in a previous study (15).