

## Comparison of triple antibiotic paste removal by different irrigation techniques

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This study compared different irrigation techniques in triple antibiotic paste (TAP) removal from root canals. Fifty-six maxillary anterior-teeth were filled with TAP for 28 days, and assigned into 5 experimental groups ( $n=10$ ): Syringe irrigation (SI), NaviTip FX (NFX), Vibringe-Syringe irrigation (V-SI), NaviTip FX-Vibringe (V-NFX), passive ultrasonic irrigation (PUI) and positive and negative control groups ( $n=3$  for each). Following the removal of the medicament, the remaining medicament was evaluated using 4-grade scoring-system. V-NFX and NFX showed similar performances ( $p>0.05$ ) while V-NFX was significantly more efficient than SI and PUI ( $p<0.05$ ) at all parts of root canals. VSI was less efficient at apical part when compared to NFX and V-NFX ( $p<0.05$ ) while not significantly different from PUI and SI at all parts of the root canals ( $p>0.05$ ). Regarding different parts of the root canals, V-SI and PUI were significantly less efficient at the apical part ( $p<0.05$ ). In conclusion, the brush form of irrigation delivery with and without sonic activation improved the removal of TAP from the root canals when compared to ultrasonic activation, syringe irrigation or sonic activation alone.

**Keywords:** NaviTip FX, Sonic, Triple antibiotic paste, Ultrasonic, Vibringe

### INTRODUCTION

Dental caries, trauma, and dental anomalies are potential causes of pulp necrosis of immature teeth, which leads to the cessation of root formation<sup>1</sup>. Revascularization is a contemporary treatment option that allows thickening of the root canal walls by mineralized tissue and continuing physiological root development<sup>2</sup>. The creation of a bacteria-free environment inside the root canal space through the use of intracanal medicaments and induction of stem cells and growth factors following the removal of medicament are the main elements of endodontic revascularization protocol<sup>3-5</sup>. The most widely used intracanal medicament in endodontic revascularization is triple antibiotic paste (TAP) developed by Hoshino *et al.*<sup>6</sup>, which is a mixture of metronidazole, ciprofloxacin, and minocycline. It is an effective antimicrobial agent and biocompatible material that creates conditions suitable for tissue revascularization<sup>6,7</sup>. However, it was reported that TAP had detrimental effects on stem cells from apical papilla<sup>8</sup>. Therefore, this paste should be removed from the root canal since the success of regenerative endodontic treatment depends on survival of stem cells<sup>9</sup>. Likewise, TAP should be removed completely to avoid an effect on tooth discoloration<sup>10</sup>.

Conventional irrigation with syringe is widely accepted method for irrigant delivery<sup>11</sup>. However, this method has been found insufficient for thorough cleaning of the root canal system<sup>12</sup>. Recently, different irrigation delivery devices have been recommended to increase the flow and distribution of irrigants within the root canal system<sup>11</sup>. Passive ultrasonic irrigation

(PUI) was introduced to increase the effectiveness of canal disinfection by agitating the irrigation solution previously placed inside the canal<sup>13</sup>. In this technique, an ultrasonic tip is activated in the canal up to working length and is moved passively in an up-and-down motion without binding to the root canal walls<sup>14</sup>. Irrigation with sonic irrigation devices<sup>15</sup> and brush covered needles<sup>16</sup> are other methods for irrigant delivery to root canal system.

Several studies have investigated the removal of TAP from the root canal system using a range of irrigation protocols and techniques<sup>17-19</sup>. However, no study has evaluated the efficiency of a brush-covered needle alone or in combination with sonic activation for TAP removal from root canal system. Overall, the present study aimed to evaluate the efficacy of different irrigation techniques in TAP removal from different parts of the root canal system. The null hypotheses were that the removal of antibiotic paste was not affected by the (1) irrigation technique or (2) the different parts of root canal system.

### MATERIALS AND METHODS

#### *Specimen preparation*

Following the university ethics committee approval (Ethics Board No: GO-15/703), fifty-six maxillary anterior teeth were selected and the soft tissues and calculus were removed mechanically from the root surfaces with a periodontal scaler. The preparation of the specimens was performed according to the previous studies<sup>17,20</sup>. The tooth length was standardized to 20 mm. Then, the working length (WL) was established 1 mm short of the root length. The root canals were prepared with ProTaper rotary files (Dentsply Maillefer,

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Ballaugues, Switzerland) up to a F4 master apical file size. The irrigation was performed using 2 mL of 1% NaOCl between the files during instrumentation and the final irrigation was performed using 5 mL of 1% NaOCl and 5 mL of 17% EDTA. TAP, a mixture of ciprofloxacin, metranidazole and minocycline was prepared in the proportion of 1:1:1. TAP was applied into the root canals with a lentulo spiral until the excess medicament was visible at the apical foramen. The access of the root canals was sealed with a cotton pellet and a temporary filling material (Cavit, ESPE, Seefeld, Germany) and the specimens were stored at 37°C under 100% humidity for 28 days.

#### Experimental procedure

The apex of each root canal was sealed with a cyanoacrylate glue to simulate clinical conditions. The specimens were randomly divided into 5 experimental groups ( $n=10$ ) and positive and negative control groups ( $n=3$ ). In positive control group, TAP was not removed while the root canals were not filled with TAP in the negative control group.

#### Group 1—Syringe irrigation (SI)

A 30-G side-vented needle (Maxi-i-probe, Dentsply, Rinn, Elgin, IL, USA) was inserted until 1 mm short of WL. The irrigation was performed with 10 mL 2.5 % NaOCl solution for 90 s.

#### Group 2—NaviTip FX (NFX)

A NaviTip FX tip (Ultradent, South Jordan, UT, USA), a 30-G irrigation needle covered with brush (Fig. 1), was inserted until 1 mm short of WL, and irrigation was performed with 10 mL 2.5 % NaOCl solution for 90 s.

#### Group 3—Vibringe-Syringe irrigation (V-SI)

Vibringe system (Vibringe, Amsterdam, Netherlands) is composed of a cordless handpiece that fits into a 10 mL disposable Luer-Lock syringe and combines manual delivery and sonic activation of the solution at low frequency (2–3 kHz). In this group, 10 mL 2.5% NaOCl solution was delivered while sonically activated for 90 s via Vibringe system using a 30-G side-vented needle.

#### Group 4—Vibringe-NaviTip FX (V-NFX)

While sonically activated for 90 s via Vibringe system using the NaviTip FX needle, 10 mL 2.5 % NaOCl solution was delivered.

#### Group 5—Passive ultrasonic irrigation (PUI)

While activated using a smooth ultrasonic file (size #15 K-file, 0.02 taper) coupled to the file-holding adapter of a Satelec P5 Newtron XS ultrasonic system handpiece (Acteon Group, Merignac, France), 10 mL of 2.5% NaOCl was continuously delivered into the canal. The ultrasonic file was inserted into the 1 mm short of the WL without touching the walls, enabling it to vibrate freely. The irrigant was passively activated for 1.5 min at power setting 6 without engaging the file against the dentinal walls.



Fig. 1 NaviTip FX needle tip.

All irrigation procedures were applied with up and down motion to produce agitation and prevent binding or wedging of the needle. After the final irrigation, 5 mL of distilled water was used to remove any remaining NaOCl solution and the canals were then dried with paper points (Dentsply Maillefer). The orifice of each access cavity was sealed using a temporary filling material (Cavit-W, 3M ESPE, Seefeld, Germany) to prevent contamination of the root canal space during sectioning procedures. Two longitudinal grooves were prepared on the buccal and lingual surfaces of each root using a fine diamond disc (Brasseler, Savannah, GA, USA), avoiding penetration into the root canals. Each root was then split longitudinally into two halves using a hammer and chisel, thus, 20 specimens were obtained from each group.

#### Determination of the remaining TAP

The amount of remaining medicament at each root half was evaluated ( $n=20$ ). Images of the coronal (12 mm from the apex), middle (8 mm from the apex), and apical (4 mm from the apex) parts of the root canal surfaces were acquired using a digital camera mounted on a stereomicroscope (Leica MZ16 A, Leica Microsystems, Wetzlar, Germany) at 24× magnification and transferred to the computer. The remaining medicament was evaluated by two calibrated endodontists in a blind manner using a 4-grade scale as follows (Fig. 2),

1. Less than 25% of the root canal filled with TAP (great cleanliness)
2. 25–50% of the root canal filled with TAP (partial cleanliness)
3. 50–75% the root canal filled with with TAP (light cleanliness)
4. 75–100% of the root canal filled with TAP (no cleanliness)

#### Statistical analysis

The kappa test was used to analyze interexaminer agreement. The differences in the TAP scores amongst

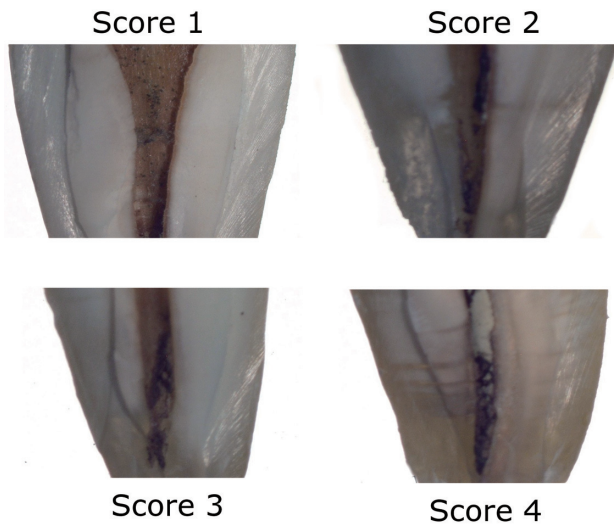


Fig. 2 Representative images of TAP removal scores.

the experimental groups were analyzed with Kruskal-Wallis and Mann Whitney-*U* tests with a Bonferroni adjustment for multiple comparisons. The Friedman's test was used to analyze the results from each root part of the same specimen and pairwise comparison was done with Wilcoxon test. The testing was performed at the 95% confidence level ( $p=0.05$ ). All statistical analyses were performed using SPSS software (SPSS, Chicago, IL, USA).

## RESULTS

A kappa test showed that the interexaminer agreement was 97.2%. The positive control group showed that the canal walls were completely filled with TAP, and the negative control group showed no TAP on the root canal walls. There were significant differences among the experimental groups according to the different parts of the root canals ( $p<0.05$ ). The distribution of TAP removal scores in experimental groups was shown in Table 1. According to that, SI was significantly less

Table 1 Distribution of the TAP removal scores at different parts of the root canals ( $n=20$ )

| Scores       | 1  | 2  | 3 | 4  | Kruskall-Wallis analysis ( $p<0.05$ )* |                 |
|--------------|----|----|---|----|--|-----------------|
|              |    |    |   |    | Median                                 | Root canal part |
| <b>SI</b>    |    |    |   |    |  |                 |
| Coronal      | 6  | 8  | 6 | —  | 2                                      | A               |
| Middle       | 3  | 8  | 7 | 2  | 2                                      | A               |
| Apical       | 1  | 1  | 3 | 15 | 4                                      | B               |
| <b>NFX</b>   |    |    |   |    |  |                 |
| Coronal      | 17 | 3  | — | —  | 1                                      | A               |
| Middle       | 15 | 5  | — | —  | 1                                      | A               |
| Apical       | 15 | 5  | — | —  | 1                                      | A               |
| <b>V-SI</b>  |    |    |   |    |  |                 |
| Coronal      | 14 | 3  | 3 | —  | 1                                      | A               |
| Middle       | 10 | 4  | 6 | —  | 1.5                                    | A               |
| Apical       | 6  | 2  | 6 | 6  | 3                                      | B               |
| <b>V-NFX</b> |    |    |   |    |  |                 |
| Coronal      | 20 | —  | — | —  | 1                                      | A               |
| Middle       | 20 | —  | — | —  | 1                                      | A               |
| Apical       | 20 | —  | — | —  | 1                                      | A               |
| <b>PUI</b>   |    |    |   |    |  |                 |
| Coronal      | 9  | 10 | 1 | —  | 2                                      | A               |
| Middle       | 5  | 9  | 6 | —  | 2                                      | A               |
| Apical       | 5  | 1  | 8 | 6  | 3                                      | B               |

SI, Syringe Irrigation; V-SI, Vibringe Syringe Irrigation; V-NFX, Vibringe-NaviTip FX irrigation; PUI, Passive Ultrasonic Irrigation. \*Different letters showed significant differences between the root parts of each experimental group.

efficient in removing TAP than V-NFX and NFX ( $p < 0.05$ ) while showed similar performances with PUI and V-SI at all root parts ( $p > 0.05$ ). NFX was more efficient than V-SI at the apical part ( $p < 0.05$ ) while no significant difference was observed at the coronal and the middle parts ( $p > 0.05$ ). NFX and V-NFX were similarly effective in TAP removal at all root parts ( $p > 0.05$ ). NFX showed significantly more TAP removal than PUI group at the middle and apical parts ( $p < 0.05$ ) while no significant difference was observed at the coronal part ( $p > 0.05$ ). V-SI group was less efficient than V-NFX at the apical part ( $p < 0.05$ ) while they showed similar performances at the coronal and middle parts ( $p > 0.05$ ). V-SI showed similar efficiency in TAP removal with PUI at all root parts ( $p > 0.05$ ). V-NFX presented better performance than PUI at all root parts ( $p < 0.05$ ).

Regarding the distribution of the TAP removal scores at different parts of the root canals, SI, V-SI and PUI showed similar efficiency at the coronal and middle parts ( $p > 0.05$ ) while presented significantly higher scores at the apical part ( $p < 0.05$ ). NFX or V-NFX was efficient in TAP removal from all root parts ( $p > 0.05$ ).

## DISCUSSION

The aim of this study was to compare the efficacy of different irrigation techniques in the removal of TAP from the apex to the coronal part. Various methods have been used to evaluate the amount of remaining material on the root canal walls, such as the use of digital photographs, stereomicroscopes, scanning electron microscopes, and micro-computed tomographic imaging<sup>17,19,21,22</sup>. In the current study, we used stereomicroscopy to evaluate the remnants of TAP on the root canal walls using a modified scoring method of previous studies<sup>17,21</sup>. Based on our results, there were significant differences in the removal of TAP according to the irrigation techniques and the different parts of the root canal system. Thus, the first and second null hypotheses were rejected.

In the literature, various irrigation protocols and activation regimes have been evaluated for TAP removal efficiency<sup>17,19</sup>. In a previous study, 2.5% NaOCl was reported to remove significantly more TAP as compared to 1% NaOCl, ethanol and 17% EDTA<sup>22</sup>. For this reason, 2.5% NaOCl was used as an irrigation solution for the removal of TAP in the present study. Uptodate, no study has evaluated the use of NFX, the brush covered needle, alone or with sonic activation for TAP removal. In a recent study, it was reported that NFX was not totally efficient in producing cleaner root canal walls by simply using it as the irrigating needle during root canal preparation and suggested that further development of the technique is necessary<sup>16</sup>. According to our results, NFX presented efficient removal of TAP from all root parts when used alone and in combination with sonic activation as well. Mechanical scrubbing of the root canal walls with a continuous flow of the irrigant through the NFX needle may have allowed better removal of the medicament. This result is confirmed

by the study of Zmener *et al.*<sup>23</sup>, who showed that using NFX was the most effective way to clean the root canal walls in comparison to brushless needle. In addition to the mechanical brushing effect, NFX performed well when used with up and down movements inside the root canal<sup>23</sup>. For this reason, we used NFX needle with up and down movement rather than a passive manner to increase its efficiency. In the present study, NFX and V-NFX showed comparable results to PUI at the coronal part while they were better than PUI in cleaning the middle and apical parts. This cleaning efficiency is in the line with the study of Goel and Tewari<sup>24</sup> which found NFX more effective than PUI in smear layer removal at the apical part. Despite the higher driving frequency of ultrasound (30 kHz) in comparison to the sonic device (2–3 kHz), PUI presented similar removal efficiency to sonic activation with Vibringe in the present study. Similar results were described by Klyn *et al.*<sup>25</sup> reported no significant difference between PUI and sonically activated irrigation in debris removal. However, it should be noted that the efficacy of Vibringe at the apical part was significantly improved with the combined use of NFX. The brushing effect of NFX needle may have improved with the higher oscillation amplitude of sonically activated needle at the tip which could lead to better removal of the medicament at the apical part<sup>15</sup>. Furthermore, longitudinal vibration of the NFX needle may have increased the fluid velocity and so the efficiency of the brush<sup>15</sup>.

In general, many studies indicated that irrigant activation systems were more effective than standard needle irrigation to remove medicament from the root canals<sup>19,22,26,27</sup>. Although NFX and V-NFX were better than standard needle irrigation, other irrigant activation systems performed similar removal efficacy to standard needle irrigation in the present study. Similar to this finding, a recent study also reported no significant difference in TAP removal between standard needle irrigation and PUI<sup>20</sup>. One important similarity between the aforementioned study and the present study is to use of side-vented needle for standard needle irrigation. Different needle designs and irrigant delivery methods may explain the different results between the studies. Several previous studies have used open-ended irrigation needles at a constant place while delivering the irrigant<sup>17-19</sup>. In the current study, we used side-vented needle with up and down movement in the SI group. The use of side-vented needle may have improved the removal efficacy of the technique with the turbulent motion of irrigant around and beyond the needle<sup>28</sup> and applying up and down movement might have resulted in the agitation of the solution and increase the cleaning efficiency<sup>11</sup>.

Previous studies have evaluated the effectiveness of various irrigation techniques for the removal of TAP regardless of the root canal parts<sup>19,20,29</sup>. However, we performed the evaluations according to the coronal, middle and apical root parts separately due to the probable unequal distribution of the remaining medicament at different root levels. Based on the results

of the present study, SI, V-SI, and PUI were less effective at the apical parts. This finding is in agreement with previous reports that indicated the apical part as the most difficult part of the root canal system to clean<sup>28,30</sup>. On the other hand, we observed no significant difference for NFX and V-NFX in the removal of TAP regarding the root parts. According to that, both techniques were efficient for TAP removal from all parts of the root canals.

TAP has been recommended to remain up to 3–4 weeks for regenerative endodontic procedures<sup>31</sup>, and in this study, TAP was left for 4 weeks in the root canals to simulate clinical conditions. Previous studies that evaluated TAP removal, left the medicament in the root canal system for 1–3 weeks<sup>17,19</sup>. It is noteworthy to mention that intracanal medication time may have an effect on the removal efficiency of TAP, since minocycline in the TAP can bind to the calcium ions *via* chelation<sup>32</sup>. Besides, minocycline has been associated with discoloration after intracanal medication with TAP<sup>10</sup>. Thus, intracanal medication time may also affect the discoloration degree. In the present study, it was observed that TAP discolored the root canal walls and also itself, similar to the finding of a recent study<sup>19</sup>. The prolonged storage time of TAP in the root canal system may be the reason why we mainly observed discoloration of root canal walls and TAP itself. However, there are no data in the literature on this issue. Thus, further research is necessary to evaluate the effect of intracanal medication time on the discoloration effect and removal efficiency of TAP.

Within the limitations of the current study, it can be concluded that NFX, as a brush covered needle alone or when it was sonically activated with Vibringe were the most efficient techniques in the removal of TAP from all root parts. The removal efficacy of V-SI, PUI and SI were similar and they were less effective at the apical part.

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