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Original Article

Efficacy of EDDY, passive ultrasonic irrigation and manual irrigation on the removal of orange-brown precipitate

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Abstract

Aim: The aim of this study was to compare the different irrigation activation techniques for removing the orange-precipitate formed after irrigation with sodium hypochlorite (NaOCl) and chlorhexidine (CHX).
Methodology: In total, 45-single rooted extracted human teeth were prepared with the ProTaper Next rotary system. The roots were respectively irrigated with 5% NaOCl and 2% CHX solutions, and an orange-precipitate formed on the canal walls. The teeth were divided longitudinally, and the precipitate was evaluated with a dental operating microscopy (DOM) at 16x magnification before the sections were joined. The halves of roots were then combined, and EDDY, passive ultrasonic activation (PUI) and manual irrigation (MI) techniques were applied for 1 min with 5 ml of distilled water to remove the precipitate. The halves were re-evaluated under the DOM and the residual of percentage of precipitate removed was calculated. The data were evaluated statistically by Kruskal-Wallis tests.
Results: A residual orange-precipitate was found in all groups. Although the orange precipitate was effectively removed in the EDDY group, there was no statistically significant difference among EDDY, PUI and MI ($p > 0.05$).
Conclusion: None of the techniques used completely removed the orange precipitate from the root canal surfaces. Among the irrigation activation techniques, there was no superior technique for removing the orange-precipitate from the root canals.

Keywords: EDDY, orange precipitate, Parachloraniline, PUI

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Introduction

The main goal of root canal treatment is to eliminate and reduce microorganisms and to remove inflammation and necrotic pulp tissue (1). Due to the complex anatomy of the root canal system, chemical irrigation solutions should be used in addition to mechanical instrumentation. For this purpose, different irrigation solutions, such as sodium hypochlorite (NaOCl), chlorhexidine (CHX), and ethylene diamine tetraacetic acid (EDTA) are used (2,3). None of these solutions individually has all three of the following characteristics: organic tissue solvent properties, inorganic tissue solvent properties, and antibacterial effects. Therefore, it is recommended to use NaOCl and CHX together to increase the antimicrobial efficacy in the treatment of root canals where microbial flora is high (4). However, when these irrigation solutions are used together, the solutions mix and form by-products (5). These by-products may be solid precipitates that block the dentine tubules, form a barrier between the sealer and the dentin surface, and increase coronal microleakage, and these by-products may be toxic to periapical tissues (6). When NaOCl and CHX are used together to increase antibacterial activity, a dense orange precipitate called parachloraniline can be formed (5,7). Clinically, this precipitate stains the canal walls, causing tooth discoloration. In addition, it has negative effects on dentin tubule obstruction and root canal filling and has cytotoxic effects on periapical tissues due to its carcinogenic potential (6,8).

Manual irrigation (MI) is generally used in root canal irrigation. However, due to differences in root canal anatomy, MI can not completely reach the lateral canals, and there are limitations, such as inadequate root canal cleaning (9). Many irrigation activation devices are recommended to ensure that the irrigant can reach all parts of the root canal and clean effectively by removing debris and medications from the root canal (10,11).

Passive ultrasonic irrigation (PUI) is a system based on ultrasonic activation of irrigation solutions for effective removal of tissue residues and microorganisms (12). Sonic activation with EDDY (VDW, Munich, Germany) is driven by an air scaler at approximately 6000Hz. EDDY is used with a polyamide tip and prevents active cutting of the root canal dentin. The tips are for single use (13). The three-dimensional movement of the polymer material of EDDY causes a cleaning effect such as cavitation and acoustic flow in the irrigant (14).

After chemical irrigation with NaOCl, it is recommended that the remaining NaOCl residue be irrigated with an intermediate irrigation solution to prevent formation of a toxic precipitate when irrigating with CHX (15). There are some studies in the literature describing methods of removing the orange precipitate that accidentally forms (16,17). However, there is no clear information in the literature about whether MI and different irrigation activation devices completely remove the precipitate.

The aim of this study was to compare the efficacy of EDDY, PUI, and MI in the removal of orange precipitate from root canals. The null hypothesis is that there is no difference among the three techniques.

Materials and Methods

The study included 45 single-rooted anterior teeth, which were extracted for periodontal or orthodontic reasons. The residual tissue, bone, and calculus on the teeth were removed. The crowns of the teeth were removed with a diamond disk. The lengths of the root canals were measured with a 15-K file (Dentsply, Maillefer, Baillagues, Switzerland) until the tip of the instrument was visible from the apical foramen. The root canal lengths of all teeth were adjusted to 15 ± 1 mm. The teeth were then fixed into Eppendorf tubes (Eppendorf-Elkay, Shrewsbury, MA) with the aid of silicone (Optosil; Heraeus Kulzer, Hanau, Germany) to form a closed system similar to clinical conditions and to prevent solution from overflowing during irrigation.

The root canals were prepared with the ProTaper NEXT (X4; Dentsply, Maillefer, Switzerland) rotary system. Irrigation was performed with 2 ml of 5% NaOCl (Werax, Izmir, Turkey) with a 27-G needle (Scania-Dental AB, Knivsta, Sweden) during instrumentation. After instrumentation, 5 ml of 17% EDTA (Werax, İzmir, Turkey) was applied for 1 min, and then, 5 ml of 5% NaOCl was applied for 1 min. Finally, the root canals were irrigated with 5 ml of 2% CHX (Werax, Izmir, Turkey) for 1 min with a 27-G needle. The irrigation solutions were applied with in and out movements with the needle. Subsequently, root canals were dried with a paper point (Diadent, DiadentGroup International, Burbany, BC, Canada). Bucco-lingual grooves were created with a diamond disk, and the roots were then split into two halves with a chisel. The half of the root canal with the most orange precipitate was coded and evaluated. The coded halves were photographed at 16x magnification with dental operation microscopy (DOM) (Leica, M3, Germany). The images were transferred to the computer, and the area of the root canal surface that was covered with orange precipitate was calculated in mm2 using image analysis software (Image J vs 7; Wayne Rasband, NIH, MD, USA). A small portion of Super Glue (Scotch Super Glue Gel; 3 M, St. Paul, MN, USA) was applied to the halves to assemble the pieces and, the assembled pieces were placed back into Eppendorf tubes.

Removal process of orange-precipitate

The samples were randomly divided into three groups according to the irrigation activation system (n = 15).

Group1. EDDY. 25. A 28-mm polyamide tip with a 0.6 taper was adapted to the TA-200 (Micron, Tokyo, Japan) and operated at 6000Hz, which is the maximum speed setting. The tip was placed in the root canal 2 mm shorter than the working length and irrigated with 2.5 ml of distilled water followed by activation for 20 sec.

Group 2. PUI. A size 25 ultrasonic tip (Woodpecker, Japan) was inserted into the root canal 1 mm shorter than the working length, and the irrigation solution was activated with the ultrasonic device (Woodpecker, Japan) at four power settings. A volume of 2.5 ml of distilled water was administered to the root canal as three cycles of irrigation for 30 sec. An additional 2.5 ml of distilled water was introduced into the root canal and the procedure was repeated.

Group 3. MI. Irrigation was performed with a 27-G open-ended needle with distilled water. The injector was placed in the root canal 1 mm shorter than the working length and the root canals were irrigated by in-out movements.

A volume of 5 ml of distilled water was used in all groups. The roots were then dried with paper points. After the roots were separated again, the amount of residual parachloroaniline was visualized with a DOM and calculated. The percentage clearance was calculated with the following formula: (area of the precipitate formed in the root canal - area of the precipitate after removal) · 100/area of the precipitate formed in the root canal. After the removal procedures, two random samples from each group were prepared for scanning electron microscopy (SEM) analysis. The root halves were fixed to aluminum blades (Silverpaint; Agar Scientific Ltd., Stansted, Essex, United Kingdom) and dehydrated with ethanol solutions. The samples were coated and examined under 2000x magnification (Quanta 400 F Field Emission).

Statistical analysis

Shapiro Wilk test was used to determine whether the data was normally distributed. The results were statistically analyzed using the non-parametric Kruskal Wallis test with Statistics SPSS 22 software (IBM SPSS Inc., Armonk, NY, USA). A significance level of 0.05 was used for all statistical tests.

Results

Table 1 shows the removal capabilities of all groups. In all groups, parachloralanine residue was mostly observed in the roots. Although EDDY had a 100% cleaning efficiency in some samples during microscopic analysis, no statistically significant differences were found among the EDDY, PUI, and MI techniques according to the Kruskal Wallis test ($p>0.05$).

According to the SEM analysis, dentin tubules were obstructed in the regions where the parachloroaniline layer was present. In the EDDY group, the apical part of the root canal was covered with more orange precipitate, whereas the middle and coronal regions were covered with less precipitate, and the dentin tubules were mostly open. In the PUI and MI groups, the apical and middle parts of the root canals were covered with more orange precipitate, and the coronal parts were clearer for both irrrigation activation systems (Fig. 1).

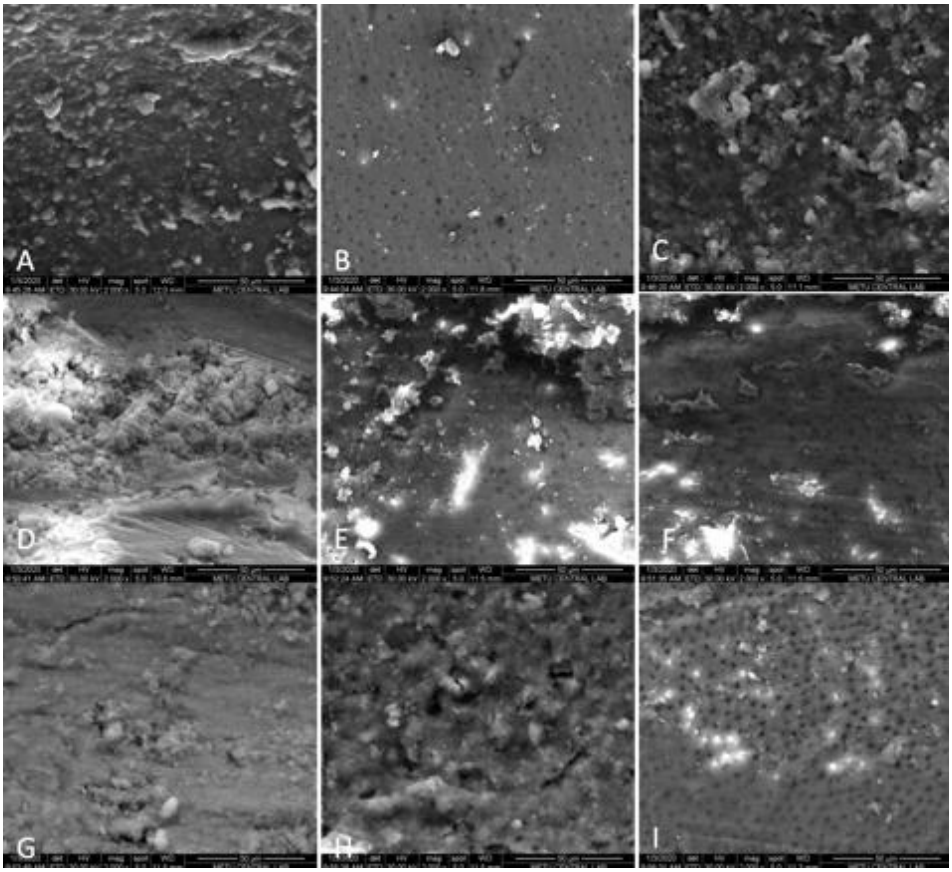

Figure 1. Scanning electron microscopy images of the apical, middle, and coronal part of the root surfaces (2000x). A) apical parts of the root canals EDDY, Group B) middle parts of the root canals EDDY group, C) coronal parts of the root canals EDDY group, D) apical parts of the root canal MI group, E) middle parts of the root canals MI group, F) coronal parts of the root canals MI group G) apical parts of the root canals PUI, Group H) middle parts of the root canals PUI group, I) coronal parts of the root canals PUI Group

Table 1. Removal capabilities of all groups.

Group	N	Percentage of cleaning effects
EDDY	15	28,13
PUI	15	22,37
Manual	15	18,50
Total	45	

Discussion

There are several studies in the literature on the removal of parachloroaniline formed by combined NaOCl and CHX (16,18). However, a study comparing these three techniques is not yet in the literature. According to the results of the current study, no statistically significant differences were found among the EDDY, PUI, and MI techniques in the removal of orange precipitate from root canals and the null hypothesis was accepted.

In the present study, distilled water was used to compare the effectiveness of irrigation activation devices in the removal of orange precipitate, as was done by Guneser et al. (16) Due to the biocompatibility of distilled water, the efficiency of the irrigation activation devices was observed to be better.

There are no previous studies in the literature that report complete removal of the orange precipitate that forms (16,18), and the present study supports the findings of other studies. In the current study, the EDDY irrigation activation device was able to remove more orange-precipitate from the root canals than the other groups, but there were no statistically significant differences among all of the irrigation activation devices. In contrast to the PUI system, the EDDY irrigation activation system has three strokes (VDW Dental-EDDY) as well as cavitation and acoustic streaming. EDDY operates at a high frequency with a three-dimensional motion, and the tip of EDDY is more flexible than the tips of the PUI system. Because of these differences, EDDY can be considered to clean root canals more effectively than PUI. Previous studies with EDDY have shown that it has better smear and debris removal efficiency (19), antibacterial activity (14), and organic tissue dissolution (20) than other irrigation activation devices. Donnermayer et al (11) showed that EDDY and PUI removed more calcium hydroxide from the root canals than MI, but there were no statistical differences among these techniques. According to the results of the current study, there were no differences among the three irrigation activation systems, which may be attributed to the difference in the quality of removed chemical substances, and the change in dentine penetration ability of the chemical orange precipitate.

Guneser et al. (16) found in their orange precipitate removal study that, MI was more effective than the Endoactivator, CanalBrush and PIPS systems. Even though MI was superior, orange precipitate was still observed in the samples. Therefore, intermediate irrigation was recommended to remove residual NaOCl when combined NaOCl and CHX irrigation solutions are used.

The design of this study was the same as some previous orange precipitate removal or calcium hydroxide removal study designs (11,16). The groove pattern in the tooth parts has advantages over models that investigate smooth artificial root canal walls (21,22). Smooth artificial root canals yield more standardized results, but the best method is to simulate the typical irregularities of root canals, such as original grooves with lateral canals and isthmuses. Intra-canal medications or by-products formed, such as orange precipitates, are more difficult to remove from these root canals, but this capability shows higher clinical success.

There are many studies in the literature in which the amount of residual intracanal medication or the amount of residual orange precipitate was scored (8,23). The scoring method is a subjective method that must be performed by at least two observers. To eliminate this limitation, a percentage calculation computer program was used in this study as an objective method.

In the present study, the amount of precipitate formed on the radicular dentin walls was examined under a DOM at 16x magnification. In similar studies 15x and, 10x magnifications were previously used (11,16). This magnification setting provided a two-dimensional view to effectively assess the amount of residual precipitate.

In the present study, the SEM images were similar to those in other studies, and showed that a precipitate formed after the NaOCl and CHX covered the root surfaces and occluded the dentin tubules (16,24). In this study, more open dentine tubules were found in the EDDY group than in the other groups. However, the main limitation of this study was that the amount of precipitate in the residual debris after the removal procedures was unknown. Future studies should evaluate the structure of the remaining debris, and the amount of residual orange-precipitate in the dentin tubules should be evaluated by more sensitive imaging methods, such as SEM or confocal laser scanning microscopy.

Conclusions

According to the results, some orange precipitates remained in the root canal walls after all irrigation activation procedures. Although some samples showed complete cleaning after use of the EDDY activation device, there were no statistically significant differences among MI, EDDY, and PUI.

Ethical Approval: Ethics committee approval was received for this study from Ankara Yıldırım Beyazıt University Ethics Committee in accordance the World Medical Association Declaration of Helsinki, with the approval number: 2019/458.

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References

1. Byström A, Sundqvist G. Bacteriologic evaluation of the efficacy of mechanical root canal instrumentation in endodontic therapy. Scand J Dent Res 1981;89:321-8. (Crossref)
2. Prado M, Gusman H, Gomes BP, Simao RA. Scanning electron microscopic investigation of the effectiveness of phosphoric acid in smear layer removal when compared with EDTA and citric acid. J Endod 2011;37:255-8. (Crossref)
3. Zehnder M (2006). Root canal irrigants. J Endod 2006;32:389-98. (Crossref)
4. Kuruvilla JR, Kamath MP. Antimicrobial activity of 2.5% sodium hypochlorite and 0.2% chlorhexidine gluconate separately and combined, as endodontic irrigants. J Endod 1998;24: 472-476. (Crossref)
5. Basrani BR, Manek S, Sodhi RN, et al. Interaction between sodium hypochlorite and chlorhexidine gluconate. J Endod 2007 ;33: 966-9. (Crossref)
6. Akisue E, Tomita VS, Gavini G, Poli de Figueiredo JA. Effect of the combination of sodium hypochlorite and chlorhexidine on dentinal permeability and scanning electron microscopy precipitate observation. J Endod 2010;36:847–50. (Crossref)
7. Kolosowski KP, Sodhi RN, Kishen A, Basrani BR. Qualitative analyses of precipitate formation on the surface and in the tubules of dentin irrigated with sodium hypochlorite and a final rinse of chlorhexidine or Qmix. J Endod 2014;40:2036-40. (Crossref)
8. Arslan H, Uygun AD, Keskin A, Karataş E, Seçkin F, Yıldırım A. Evaluation of orange-brown precipitate formed in root canals after irrigation with chlorhexidine and Qmix and spectroscopic analyses of precipitate produced by a mixture of chlorhexidine/NaOCl and Qmix/NaOCl. Int Endod J 2015;48:1199-1203. (Crossref)
9. Bolles JA, He J, Svoboda KK, Schneiderman E, Glickman GN. Comparison of Vibringe, Endoactivator and needle irrigation on sealer penetration in extracted human teeth. J Endod 2013;39:708-711. (Crossref)
10. Akman M, Akbulut MB, Aydınbelge HA, Belli S. Comparison of different irrigation activation regimens and conventional irrigation techniques for the removal of modified triple antibiotic paste from root canals. J Endod 2015;41:720-724. (Crossref)
11. Donnermayer D, Wyrsch H, Bürklein S, Schafer E. Removal of calcium hydroxide from artificial grooves in straight root canals: Sonic activation using EDDY versus passive ultrasonic irrigation and XPendo Finisher. J Endod 2019;45:322-326. (Crossref)
12. Van der Sluis LW, Versluis M, Wu MK, Wesselink PR. Passive ultrasonic irrigation of the root canal: a review of the literature. Int Endod J 2007;40:415-426. (Crossref)
13. Haupt F, Meinel M, Gunawardana A, Hülsmann M. Effectiveness of different activated irrigation techniques on debris and smear layer removal from curved root canals: a SEM evaluation. Aust Endod J 2020;46:40-46. (Crossref)
14. Neuhaus KW, Liebi M, Stauffacher S, Eick S, Lussi A. Antibacterial efficacy of a new sonic irrigation device for root canal disinfection. J Endod 2016;42:1799-1803. (Crossref)
15. Gomes BP, Vianna ME, Zaia AA, Almeida JF, Souza-Filho FJ, Ferraz CC. Chlorhexidine in Endodontics. Braz Dent J 2013;24: 89-102. (Crossref)
16. Guneser MB, Dincer AN, Arslan D. Comparison of conventional syringe, canalbrush, endoactivator, photon-induced photoacoustic streaming, and manual instrumentation in removing orange-brown precipitate: an in vitro study. Photomed Laser Surg 2017;35:311-316. (Crossref)
17. Metri M, Hegde S, Dinesh K, Indiresha HN, Nagaraj S, Bhandi SH. Comparative evaluation of two final irrigation techniques for the removal of precipitate formed by the interaction between sodium hypochlorite and chlorhexidine. J Contemp Dent Pract 2015;16:850–853. (Crossref)
18. Chabbra N, Gangaramani S, Singbal KP, Desai K, Gupta K. Efficacy of various solutions in preventing orange-brown precipitate formed during alternate use of sodium hypochlorite and chlorhexidine: An in vitro study. J Cons Dent 2018;21:428-432. (Crossref)
19. Urban K, Donnermeyer D, Schafer E, et al. Canal cleanliness using different irrigation activation systems: a SEM evaluation. Clin Oral Investig 2017;21:2681-2687. (Crossref)
20. Conde AJ, Estevez R, Lorono G, et al. Effect of sonic and ultrasonic avtivation on organic tissue dissolution from simulated grooves in root canals using sodium hypochlorite and EDTA. Int Endod J 2017;50:976-982. (Crossref)
21. Kenee DM, Allemang JD, Johnson JD, et al. A quantitative assessment of efficacy of various calcium hydroxide removal techniques. J Endod 2006;32:563-5. (Crossref)
22. Capar ID, Ozcan E, Arslan H, et al. Effect of different final irrigation methods on the removal of calcium hydroxide from an artificial standardized groove in the apical third of root canals. J Endod 2014;40: 451–4. (Crossref)
23. Ince Yusufoglu S, Ozcelik M, Arı Aydınbelge H. Evaluation of different file systems on the removal of calcium hydroxide paste from the root canals. Selcuk Dent J 2015;3:122-129. (Crossref)
24. Bui TB, Baumgartner JC, Mitchell JC. Evalution of the interaction between sodium hypochlorite and chlorhexidine gluconate and its effect on root dentin. J Endod 2008;34:181-185. (Crossref)