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Original Research

Comparison of the effect of two irrigation techniques and rootcanal preparation size on sodium hypochlorite penetration into root canal dentinal tubules

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ABSTRACT:
Objective: This study aims to compare the effects of conventional syringe irrigation (CSI) and passive ultrasonic irrigation (PUI) on the penetration of sodium hypochlorite (NaOCl) solutions into root canal dentinal tubules at different levels of the root canal. **Materials and Methods:** 200 extracted first mandibular premolars of 18 to 30-year-old patients were decoronated 13mmfrom the root apices and separated into two groups according to apical preparation sizes (APS) 25 and 40. Photomicrographs were taken of all three cross-sections of each tooth under a stereomicroscope. **Results:** No penetration was found at the apical level in the CSI25, CSI40, and PUI25 groups. **Conclusions:** Within the limitations of this study, irrigation techniques and APS affect the penetration depth of NaOCl into the root canal dentinal tubules. In terms of irrigation techniques, the penetration was deepest when PUI was used, followed by CSI. In terms of APS, NaOCl penetrated deeper intoAPS40 than APS25.
Keywords: Debris, Root canal irrigation, Canal disinfection, sodium hypochlorite

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INTRODUCTION

The removal of both necrotic and vital pulp substrates and microorganisms and their toxins from the root canal system is the basis for a successful endodontic treatment.[1]It has been shown that endodontic lesions do not develop in the absence of bacteria.[2]Primary infections of the endodontic space are mainly caused by obligate anaerobic species,[3] while the most responsible one for endodontic failure is Enterococcus faecalis.[4]

Cleaning and shaping of the root canal system are the main components of successful root canal treatment.[5] Cleaning is directly influenced by proper removal of debris and smear layer. Hence, irrigation is an essential part of root canal debridement to ensure cleaning in areas that were not touched by mechanical instrumentation.[6,7] These irrigants must have direct contact with the entire canal wall for effective action. During conventional needle irrigation, replenishment and fluid exchange only extend shortly beyond the tip of the irrigating needle.[8]Thecleanliness of the apical third is determined by apical preparation size (APS) and irrigation protocol. APS affects the insertion distance of the needle tip, the dynamics of irrigation flow, and the disinfecting effect of irrigation.[9]An increase in the APS significantly improved root canal disinfection.[10]

Sodium hypochlorite solution (NaOCl) is commonly used as a root canal irrigant because of its antimicrobialactivity and tissue dissolution ability.[11]A previous studyshowed that a 6% NaOClsolution could penetrate 300 μminto dentinal tubules at 45°C with 20 minutes of exposure. The irrigation techniques could affect the penetration efficacy of NaOCl.[12] Various root canal irrigation techniques have been used in endodontic treatment, conventional syringe irrigation (CSI).

This study aimed to compare the effect of two different irrigation techniques and two different APSs

on the penetration depth of NaOCl into the root canal dentinal tubules.

MATERIALS AND METHODS

200 permanent mandibular first premolar teeth that were extracted from 18 to 30 year-old patients during orthodontic treatment with a single root canal and no previous root canal treatment were used in this study. Radiographs of the teeth were taken in both the mesiodistal and buccolingual aspects to confirm a single root canal. Teeth with root lengths shorter than 13 mm, restoration, caries, cracks, fractures, or immature apexes were excluded. *e samples were stored in 0.1% thymol immediately after extraction until use.

The teeth were decoronated by a carborundum disc13mm from root apices. A size 10 stainless steel k-file (VDW GmbH, Munich, Germany) was used to achieve apical patency, and a size 15 stainless steel k-file (VDW GmbH, Munich, Germany) established a working length 1mm shorter from the apical foramen. If a size 15 stainless steel k-file was loose at the apical foramen, the root was excluded.

The samples were divided into two groups according to APS (n = 200). Each tooth was instrumented with Mtwo rotary files (VDW GmbH, Munich, Germany). Group 1 (APS =25, n = 100), the root canals were prepared to size 25. Group 2 (APS = 25, n = 100), the root canals were prepared to size 40.

The instrumented canal was irrigated with 2 ml of 2.5% NaOCl solution for 30 sec. The irrigant was delivered via a 27- gauge, open-ended needle (Nipro, Ayutthaya, Thailand) by placing the tip 3mmshort of the working length after each file change. Final irrigation was performed with 5 ml of 17% ethylenediaminetetraacetic acid (EDTA) for 1 minute, and the canal was flushed with 5 ml of distilled water and dried with three pieces of paper points. The root apex was sealed with composite resin to create a closed system.

The root canals were stained by submerging in crystal violet at room temperature for 72 hours. Crystal violet was renewed every 12 hours. Then, the root canals were washed with 20mL of distilled water. The irrigation techniques were performed as follows:

(i) CSI: the irrigant was applied with a 27-gauge, openended needle. The needle tip was placed 3mm shorter than the working length, and the canals were irrigated by using 6mL of 2.5% NaOCl for 120 sec.

(ii) PUI: the irrigant was applied with a 27-gauge, openended needle. The irrigation needle was inserted 3mm shorter from the working length, and the canal was irrigated with 2mL of 2.5% NaOCl for 20 sec. then, theirrigant was activated with an ultrasonic file size of 20 (IRRI 20; Irri-safeTM, Acteon®, Merignac, France) by insertion 3mm shorter than the working length for 30 sec, followed by 2mL with the CSI technique for 20 sec, PUI for 30 sec, and 2mL with CSI for 20 sec. The total volume of irrigantwas 6 mL, and the total time of irrigation was 120 sec.

All specimens were irrigated with distilled water (2 mL) and dried with three pieces of paper point, then sectioned perpendicular to the long axis of the root by a carborundumdisc at 3mm from apex to represent an apical level, 6mm from apex to represent the middle level, and 10mm fromapex to represent a coronal level.

The penetration of NaOCl into the dentinal wall of the root canal presented as the bleached area of crystal violet. In the positive control group, the bleached depth of crystal violet was observed to be more than four-fifths of the thickness of the root canal wall. In the negative control group, the dark purple color of crystal violet was present throughout the thickness of the root canal wall.

STATISTICAL ANALYSIS

The data were analyzed using SPSS 24.0 for Windows (SPSS Inc., Chicago, IL). The Kolmogorov– Smirnov test and Levene's test were used to test the normality and homogeneity of variants of each experimental group, respectively. The penetration depth was normally distributed. However, homogeneity of variance was not achieved, so differences in the penetration depth between each irrigation technique and root level were compared by Welch's ANOVA, and then, multiple comparisons were performed by Dunnett's T3. *e significance level was set at 0.05.

RESULTS

Table 1: The penetration depth of sodium hypochlorite into the dentinal wall of the root canal. Means sharing the same superscript are not significantly different from each other ($p \geq 0.05$)

Techniques	Preparation size	Root canal level	Penetration depth (mean ± SD)
CSI	25	Coronal	699.44 ± 91.44^{a}
		Middle	36.31 ± 14.30^{i}
		Apical	0
	40	Coronal	805.43 ± 67.54^{a}
		Middle	$230.64 \pm 32.77^{c,d}$
		Apical	0
PUI	25	Coronal	651.40 ± 138.02^{b}
		Middle	$110.62 \pm 11.88^{g,h}$
		Apical	0
		Coronal	685.07 ± 44.78^{b}

	40	Middle Apical	304.72 ± 93.43^{c} $180.87 \pm 97.36^{d, f}$

The penetration depth of each group is shown in Table 1. The highest penetration depth was at the coronal level of the CSI40 group. No penetration was observed at the apical level in the CSI25, CSI40, and PUI25 groups. At the coronal level, the penetration depth was not different between the APS of each irrigation technique. At the middle and apical levels, there was a statistically significantdifference in penetration depth between APSs, as size 40 penetrated deeper than size 25 in all irrigation techniques ($p < 0.05$), except at the apical level of the CSI group.

DISCUSSION

In the case of infected root canals, the removal of debris and smear layer and hence, in the case of infected root canals, most of the microorganisms from the root canal system is still one of the most important objectives during treatment of infected root canals.[4]The variability of root canal anatomy with its recesses and isthmi is challenging, and despite of the invention and implementation of new endodontic instruments, often more than 50% of the root canal areas remained untouched by mechanical instrumentation alone.[13] Additionally, packing of debris into canal irregularities by reciprocating and/or rotary instrumentation has been described.[14] Most importantly, irrigation and especially activation of irrigation solutions are crucial for further improvement of canal cleanliness and disinfection of the entire root canal system.

The reduction of bacteria in the root canal system to levels that are compatible with periapical tissue healing significantly affects the outcome of root canal treatment.[15] NaOCl is the main disinfectant solution used in root canal treatment. This study aimed to compare the efficiency of CSI, PUI, and different APS on the penetration of NaOCl solutions into root canal dentinal tubules at different levels of the root canal. The penetration was determined by the bleached area of crystal violet in the dentinal tubules.In terms of the root canal level, the coronal level of the root canal had the greatest penetration depth of NaOCl in all groups because the coronal level had the largest diameter and highest density of dentinal tubules. The diameters of the dentinal tubules were 4.32 ± 1.00, 3.75 ± 1.48, and 1.73 ± 0.93 μm in the coronal, middle, and apical portions of the root, respectively.[16,17] The penetration at the coronal level between APS25 and APS40 for each irrigation technique was no different because of the similar size of the root canal at the coronal level in both groups.

In contrast with other studies, this study used 27G needles with an outer diameter of 0.41 mm, and the smallest size of the prepared root canal was 25.06 tapers. The diameter of the prepared root canal was 25.06 at 2 and 3mm short working lengths of 0.37mm and 0.43 mm, respectively. Then, the needle tip could be freely inserted deepest at 3mm from the working length. Because of the limitation of the needle tip and canal preparation size, the positions of the needle tip and activator tips were set at a working length of 3mm in all groups. In addition, the flowability of the irrigant was limited at the apical level of the small preparation size root canal.[18-20]

Previous studies have shown that CSI cannot eradicate air bubbles, but sonic activation can be considered an effective method for vapor lock reduction.[21]A previous study found that the small APS impeded the penetration of irrigants at the apical level due to diminished contact between irrigants and canal walls.[22] The insertion depth of the syringe needle irrigation depends on the size and morphology of the canal.[23] The large APS enhances the flow of irrigants at the apical level.[24]

Each irrigation technique has different characteristics of fluid dynamics. A previous study on the irrigation dynamics of different irrigation techniques found that PUI has maximum velocity and high intensity of turbulence flow at the apical portion.[25]PUI has more maximum wall shear stress than CSI, which supports the result of this study that PUI has more penetration depth of NaOCl than CSI when the canal was APS 40. However, the canal size of APS 25could limit the effectiveness of the ultrasonic tip to generate acoustic streaming and cavitation because the tip may contact the root canal wall during activation.[26]

CONCLUSION

Within the limitations of this study, irrigation techniques and APS affect the penetration depth of NaOCl into root canal dentinal tubules. In terms of irrigation techniques, thepenetration was deepest when EDDY was used, followed by PUI and CSI. In terms of APS, NaOCl penetrated deeper into APS40 than APS25.

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