Evaluation of the smear layer removal ability of passive ultrasonic irrigation

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Abstract

Background: The smear layer can prevent the penetration of intracanal medicaments into dentinal tubules and influence the adaptation of filling materials to canal walls. Passive ultrasonic irrigation is one of methods to removing smear layer. The purpose of this study is to compare the smear layer removal ability between Passive ultrasonic irrigation and Conventional needle irrigation. **Materials and Methods:** 30 extracted human premolar roots were selected and randomly divided into 2 groups (n=15) based on root canal irrigation methods with 17% EDTA solution: (1) Conventional needle irrigation, (2) Passive ultrasonic irrigation. The roots were prepared with Reciproc Blue 25 file and was removed smear layer by 2 different methods of irrigation. The study sample was then sectioned longitudinally with a diamond cutting disc, randomly selecting half of the root. After undergoing sample processing, the half roots were observed and evaluated for the presence of smear layer under a scanning electron microscope with a magnification of 1000 times according to Torabinejad (2003). **Results:** In both groups, mean of smear layer score in apical higher than that in cervical ($p>0.05$). There is no difference in mean of smear layer score between 2 groups at the apical, middle and cervical. **Conclusion:** Passive ultrasonic irrigation is as effective in removing smear layer as Conventional needle irrigation.

Keywords: *smear layer, passive ultrasonic irrigation.*

1. INTRODUCTION

Smear layer can prevent the penetration of intracanal medicaments into dentinal tubules and influence the adaptation of filling materials to canal walls [1]. Therefore, to achieve good endodontic treatment results, it is necessary to remove the smear layer.

To enhance the effectiveness of smear layer removing, many irrigation methods have been born and developed such as ultrasonic, sonic, laser, or XP-Endo Finisher file [2-4].

There are two forms of ultrasonic irrigation, including simultaneous ultrasonic irrigation with preparation and non-simultaneous ultrasonic irrigation, also known as Passive ultrasonic irrigation (PUI). PUI was first described by Weller et al [5]. The term "passive" refers to the fact that the instrument does not have a cutting effect during the manipulation of the tooth [6]. This method helps reduce the possibility of creating abnormal canal shapes during irrigation [7].

Currently, there have been many studies comparing the effectiveness of smear layer removal using different irrigation methods. According to the studies by Qiang Li and Mancini M., the results show that PUI is more effective in removing the smear layer than Conventional Needle Irrigation (CNI) [3, 4]. However, study by Machado R. showed that in the apical third, CNI have similar smear layer removal efficiency compared with the PUI while in the middle and cervical thirds, CNI removed more smear layer [2].

Therefore, in order to clarify the effectiveness of removing smear layer between 2 methods, we conducted a study: "Evaluation of the smear layer removal ability of Passive ultrasonic irrigation". The aim was to compare the smear layer removal capabilities of PUI and CNI, as observed through scanning electron microscopy.

2. MATERIALS AND METHODS

2.1. Research subjects: 30 roots of premolar mandible teeth taken from patients with indications for extraction in orthodontic treatment.

Selection criteria

- The tooth is intact with both the crown and root.
- No dental caries.
- No cracks or fractures.
- The tooth was extracted no more than 1 month before the study.
- The tooth has a single root canal.
- No signs of internal or external resorption, and no calcification of the root canal.
- The apical foramen is completely closed.

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- The root is relatively straight (the root curvature should not exceed 50° according to Schneider, 1971).

- All teeth are X-rayed with periapical films in both the buccal-lingual and mesio-distal views to examine the root canal system.

Exclusion criteria

- Tooth with abnormal root morphology.

- Tooth that have previously undergone endodontic treatment.

2.2. Study design: In vitro experimental study, carried out at the Preclinical Department of Odonto - Stomatology - Hue University of Medicine and Pharmacy and School of Biomedical Engineering - Vietnam National University - Ho Chi Minh City from September 2021 to September 2022.

2.3. Research methods

- Step 1: Biomechanical preparation

30 roots of premolars mandibular are standardized with a length of 15 mm. The working length (WL) was determined by inserting a K-type #15 instrument (Dentsply/Maillefer) until it could be visualized at the apical foramen, and subtracting 1 mm from this measurement. Simulation of the apical periodontal membrane using OpalDam Green gum protector (Ultradent Products, South Jordan, UT, USA). A #15 K-file was inserted before the layer was applied, to prevent the gingival barrier from entering the canal [3]. Preparing root canals with a Reciproc Blue R25 file (VDW, Munich, Germany) attached to the X Smart Plus endodontic machine (Dentsply Sirona, USA). The R25 file will be gradually moved down to the apex until WL is reached. During this procedure, the instrument was used in a reciprocating motion, with slight apical pressure and a slow in-and-out pecking motion, at an approximate amplitude of 3 mm. Each file was used for 5 canals. Root canal irrigation: insert a Elsodent 30G single sideport needle (France) into the canal with a length shorter than WL 1 mm. Irrigate with a total volume of 10 ml of 3% NaOCl solution for each canal during preparation [8]. Finally, the canals were further irrigated with 2 ml of distilled water to restrict the interaction between irrigant solutions [9].

- Step 2: Smear layer removal: The teeth were randomly divided into 2 groups (n=15) according to the protocol for smear layer removal that was used.

+ Group 1 (n=15) (Conventional needle irrigation) (CNI): The root canals were filled with 2.5 mL of 17% EDTA using a Elsodent 30G single sideport needle (France) calibrated to reach 1 mm short of the WL.

+ Group 2 (n=15) (Passive ultrasonic irrigation) (PUI): The root canals were filled with 2.5 mL of 17% EDTA using a Elsodent 30G single sideport needle (France) calibrated to reach 1 mm short of the WL. PUI was performed with Irrisonic E1 (Helse, Santa Rosa de Viterbo, Brazil) attached to the P5 Booster (Satelec, France) according to the manufacturer's instructions (energy level 4, insert into the canal with a length shorter than WL 1 mm, avoiding the instrument touching the canal wall for 20 seconds).

In each group, the solution used was renewed and/or activated for 3 cycles of 20 seconds each, totaling an irrigation/activation time of 1 minutes. The canals were then irrigated with 2 mL of distilled water, and dried with 3 absorbent paper points (R25, Reciproc, VDW).

- Step 3: Analysis by SEM

The R25 obturator cone insert into canal with full WL (to prevent debris from falling onto the root canal wall during cutting). Cut along the root in the mesial and distal direction with a diamond disc. Replacing the disc after each cut. Then, using an enamel chisel between the two halves of the tooth root and rotate it slightly, separating the tooth root into two halves, randomly selecting one half of the root. Dehydrate the samples before SEM reading according to the following procedure: soak the half roots in 30% ethanol for 10 min, 50% for 20 min, 90% for 30 min, 100% for 30 min. Samples after dehydration were fixed on round metal plates with Carbon glue and coated on the surface with a 30 nm thick gold layer. On each half root, the smear layer was observed under SEM (JSM-IT100 InTouchScopeTM, Japan) with 1000x magnification at 3 positions: apical third, middle third and cervical third. The technician takes the observed images. Three observers were trained on how to assess participation. Each observer observes and evaluates over 135 images. Evaluation of the presence of smear layer according to the Torabinejad M. scale [10]:

1: No smear layer. No smear layer on the surface of the root canals; all tubules were clean and open.

2: Moderate smear layer. No smear layer on the surface of root canal, but tubules contained debris.

3: Heavy smear layer. Smear layer covered the root canal surface and the tubules.

2.4. Data analysis

Data was statistically analyzed using SPSS software ver 20.0. Calculate the mean and standard deviation of the measured values.

+ Compare 2 groups that are related by Wilcoxon test, the test is used with 95% confidence.

+ Compare 2 independent groups by Mann - Whitney's U test, the test is used with 95% confidence.

3. RESULTS

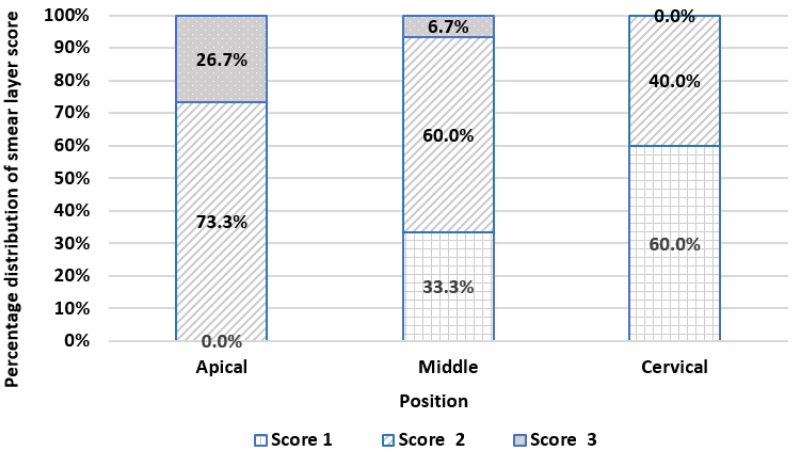

Chart 1. Distribution of smear layer scores at the apical, middle and cervical of group 1 (CNI) (n=15)

Table 1. Mean of smear layer score of apical, middle, cervical of group 1 (CNI) (n=15)

Position \ Value	Mean ± SD	Median	p
Apical (1)	2.27 ± 0.46	2	$p_{(1-2)} = 0.011$
Middle (2)	1.73 ± 0.59	2	$p_{(1-3)} = 0.002$
Cervical (3)	1.4 ± 0.51	1	$p_{(2-3)} = 0.059$

Wilcoxon test, the test is used with 95% confidence.

- In group 1 (CNI), mean of smear layer score in apical higher than that in middle and cervical.

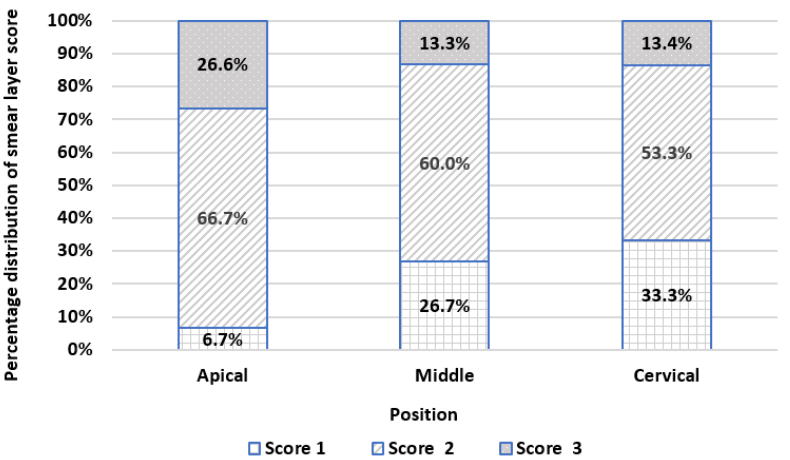

Chart 2. Distribution of smear layer scores at the apical, middle and cervical of group 2 (PUI) (n=15)

Table 2. Mean of smear layer score of apical, middle, cervical of group 2 (PUI) (n=15)

Position \ Value	Mean ± SD	Median	p
Apical (1)	2.2 ± 0.56	2	$p_{(1-2)} = 0.059$
Middle (2)	1.87 ± 0.64	2	$p_{(1-3)} = 0.034$
Cervical (3)	1.8 ± 0.68	2	$p_{(2-3)} = 0.655$

Wilcoxon test, the test is used with 95% confidence.

- In group 2 (PUI), mean of smear layer score in apical higher than that in cervical.

Table 3. Mean of smear layer score of apical, middle, cervical of 2 groups

Group \ Position	Apical (Mean ± SD)	Middle (Mean ± SD)	Cervical (Mean ± SD)
Group 1 (n=15)	2.27 ± 0.46	1.73 ± 0.59	1.4 ± 0.51
Group 2 (n=15)	2.20 ± 0.56	1.87 ± 0.64	1.8 ± 0.68
p	0.775	0.567	0.394

Mann - Whitney's U test, the test is used with 95% confidence.

- There is no difference in mean of smear layer score between 2 groups at the apical, middle and cervical.

4. DISCUSSION

The results from Table 1 show that in group 1 (CNI), the score of smear layer in the apical third was higher than that in the middle and the cervical thirds. This can be explained by the "vapor lock" effect (formed by a closed end at the end of the apical third and the further apical approach, the narrower the root canal diameter becomes, this prevent the circulation of irrigant solutions) [11]. Gulabivala also explained that it is not possible to clean the apical because of the lack of penetration of the needle tip and the formation of a "stagnation plane" below the needle tip [12].

In group 2, the score of smear layer at the apical third was higher than that of the cervical third. Our results are quite consistent with the study of Qiang Li [4].

The results from Table 3 also show that at the apical third, the smear layer removal efficiency of CNI and PUI is the same. According to the study of Machado, it was shown that in the apical third, the amount of smear layer residue in the canal of the 2 methods was not statistically significant [2]. The author also explained that the reason for this was that the constriction of the canal in the apical third prevented the circulation of irrigant and chelating solution, leading to a decrease in the removal efficiency of dentin. For ultrasonic and sonic irrigation methods, it must be ensured that the instrument does not touch the root canal wall during irrigation [2]. However, our results are not consistent with the conclusions of Matos. According to this author's study, at the apical third, the canal irrigation with 17% EDTA solution combined with PUI removed smear layer better than CNI [13]. The author interpreted this result as the existence of a "vapor lock" effect in the CNI method. Meanwhile, PUI is able to eliminate this effect, improving the efficiency of the irrigant [14].

Although there is no difference in the ability to remove smear layer compared to CNI, PUI offers a unique advantage. PUI improved the disinfection of root canals after chemomechanical procedures by reducing bacterial levels [15]. Acording to Quang Li, confocal laser scanning microscopy revealed that PUI achieved the greatest bacterial inhibition depth in the coronal, middle and apical thirds of the canal [4]. More extensive studies on a larger scale are needed to clarify the role of PUI in endodontic irrigation.

5. CONCLUSION

Passive Ultrasonic Irrigation is as effective in removing smear layer as Conventional needle irrigation.

Our study was conducted on premolar mandible teeth with a single root canal, following strict selection criteria. However, there are still morphological differences in the root canals among the selected samples, which is one of the limitations of the study.

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