

# Influence of the type of instrument used in passive ultrasonic irrigation on the smear layer removal capacity

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## ABSTRACT

**Introduction:** The aim of this study was to evaluate the smear layer removal ability of stainless steel and NiTi hand files as well as an orthodontic rectangular NiTi wire activated by an ultrasonic device. **Methods:** 50 palatal root canals of maxillary molars were preflared with a #35 LA Axxess bur at the cervical third and with Pro-Taper instrument, up to F4 instrument, within working length, at the apical third. The canals were irrigated with 1% sodium hypochlorite and divided into five groups for passive ultrasonic activation (PUI): GI = EDTA + 1 minute (PUI) with a stainless steel #15 K-file; GII = EDTA + 1 minute (PUI) with a NiTi #15 K-file; GIII = EDTA + 1 minute (PUI) with orthodontic NiTi 25 x 11 wire; GIV = EDTA for 3 minutes without PUI; GV = No EDTA and no PUI. Subsequently, each root was sectioned longitudinally and a hemisection was covered with a layer

of metal and analyzed by a scanning electron microscope. Images of the three thirds were taken, stipulating scores as follows: 0 = no layer of dentin debris, clean and open dentinal tubules; 1 = moderate dentin debris layer; 2 = thick layer of dentin debris covering the surface of the dentinal tubules. The data for each score were compared statistically. **Results:** Smear layer was observed in all three thirds. All groups using EDTA differed statistically ( $p < 0.05$ ) from the group without EDTA. There were no significant differences between the groups activated with ultrasound and the EDTA group without ultrasound. There were no significant differences ( $p < 0.05$ ) among the three instruments employed. **Conclusion:** The use of EDTA favored smear layer removal. Activation of EDTA for one minute, regardless of the instrument used, favored cleaner dentin walls.

**Keywords:** Smear layer. Root canal irrigants. Ultrasound.

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## Introduction

Endodontic treatment aims at eliminating microorganisms and pulp tissues, as well as at minimizing the amount of debris in the root canal system. In order to achieve this goal, root canals are decontaminated by mechanical instrumentation associated with irrigation and intracanal dressing; thus, avoiding contamination and reinfection of the treated area. In addition to removing pulp tissue, microorganisms, smear layer and/or dentin debris from the root canal system, the irrigation procedure also lubricates the walls of the canal to be instrumented.<sup>1</sup> Bacterial persistence and debris adhering to the root canal walls of endodontically treated teeth play an important role in the induction of recontamination and appearance of apical periodontitis. Bacteria can have access to root canal walls and organize as biofilms, thereby resisting treatment.<sup>2</sup>

After mechanical instrumentation, an irregular amorphous layer known as smear layer is formed on the root canal walls, blocking the entrances to dentinal tubules. Currently, irrigation with sodium hypochlorite (NaOCl) and a chelating agent, such as ethylenediaminetetraacetic acid (EDTA), is recommended to remove inorganic and organic components of smear layer. It has been reported that this layer is less significant in the apical region compared with the cervical and middle thirds of the root.<sup>3</sup> Irrigation efficiency depends on both mechanical action and the irrigant ability to dissolve the tissue,<sup>4</sup> but it has been observed that ultrasonic agitation greatly enhances the cleaning ability of irrigating agents.<sup>5</sup>

The use of ultrasound has been suggested to improve root canal irrigation. Passive ultrasonic irrigation (PUI) is the activation of an irrigant inside the root canal by means of an accessory, smooth tip, producing a sound flow and/or cavitation of any irrigating or chelating agent, thereby enhancing the cleaning effect. Furthermore, PUI causes the temperature of the irrigant to rise, which will increase the ability to dissolve tissues.<sup>1</sup> Although it has been demonstrated the efficacy of ultrasound at removing smear layer,<sup>6</sup> there is a lack of studies comparing the effect of different types of instruments to be subjected to PUI for smear layer removal.

Therefore, the aim of this study was to evaluate the ability of smear layer removal in the three thirds

of the root canal, when a NiTi orthodontic wire and stainless steel or NiTi files were used and irrigants were subjected to PUI inside the root canal. The hypothesis tested is that the type of instrument used in ultrasonic agitation does not affect smear layer cleaning ability.

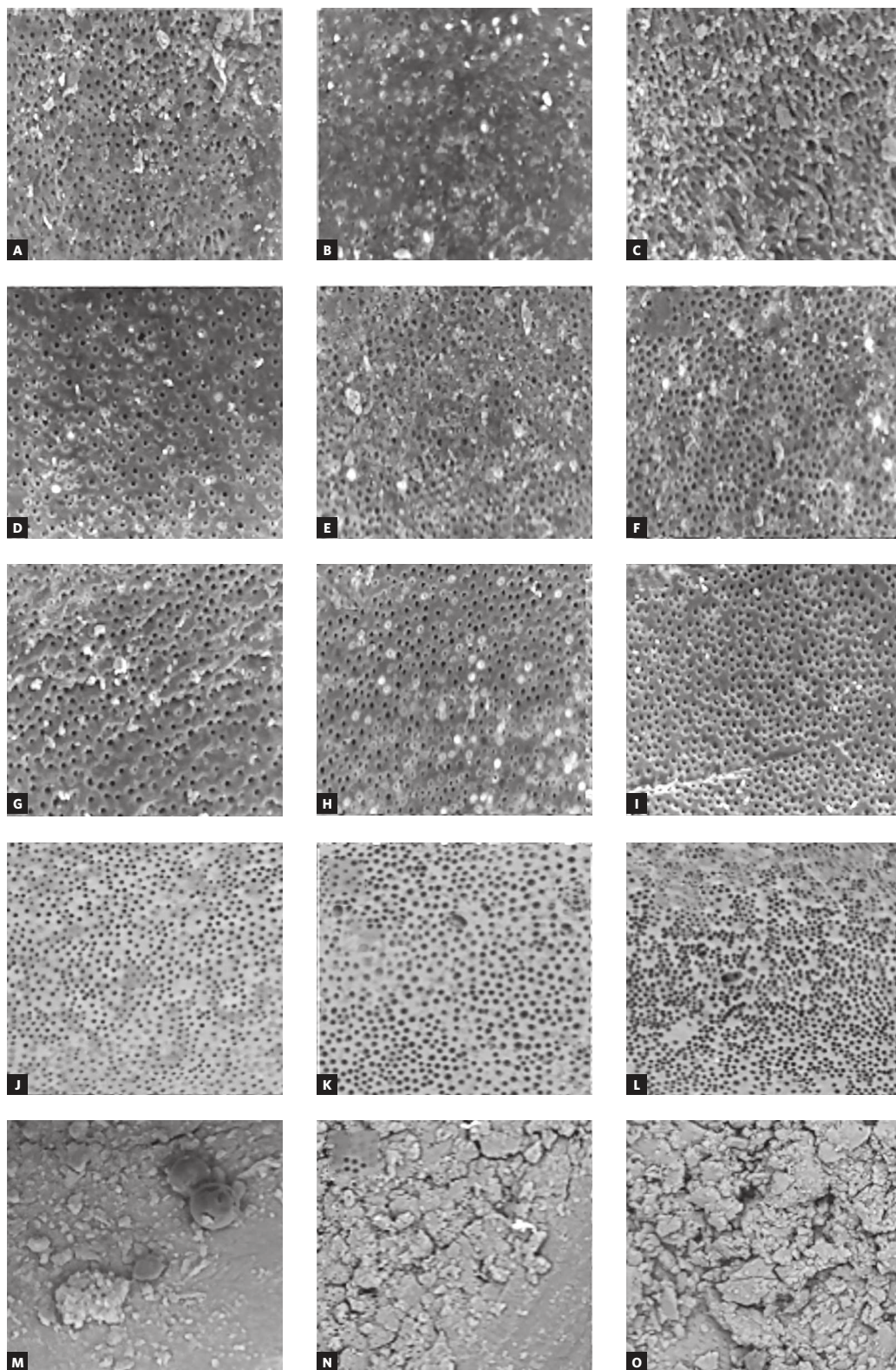
## Material and methods

A total of 50 straight palatal roots of extracted human maxillary molars were subjected to decoronation, so as 16 mm of root length were obtained and stored in saline solution after collection. Working length was established at 15 mm by inserting a stainless steel #10 K-file 1 mm short from the apical foramen. Roots were instrumented by means of the crown-down technique. The cervical portion of the root was preflared with a LA Axxess bur #35 (SybronEndo, Orange, CA, USA). Subsequently, middle and apical thirds were instrumented up to the working length by ProTaper Universal system (Dentsply, Maillefer, Ballaigues, Switzerland), up to F4 instrument (40.06) and at a constant speed of 300 rpm.

During instrumentation, 1 mL of 2.5% sodium hypochlorite (NaOCl) (Rioquímica, São José do Rio Preto, São Paulo, Brazil) was used to irrigate the canal at each change of instrument. After shaping, the canals were irrigated with 3 mL of 2.5% NaOCl. Subsequently, the teeth were randomly divided into three experimental groups (n = 10) and two control groups (n = 5), according to the final irrigation, with passive ultrasonic irrigation (PUI), as follows: GI = EDTA + 1 minute (PUI) with a stainless steel #15 K-file; GII = EDTA + 1 minute (PUI) with a NiTi #15 K-file; GIII = EDTA + 1 minute (PUI) with orthodontic NiTi 25 x 11 wire; GIV = EDTA for 3 minutes without PUI; GV = no EDTA and no PUI. All files were attached to Jet Four Sonic Plus ultrasonic device (Gnatus, Ribeirão Preto, São Paulo, Brazil) with an insert n. A-120 (Gnatus, Ribeirão Preto, São Paulo, Brazil). The power used was 20%, and the instrument was kept in the center of the canal, avoiding contact of the instrument with root canal walls, 1 mm short from the working length. Oscillation of the file was performed mesiodistally.

After these procedures, all groups were given a final flush with 4 mL of saline solution and the canals were dried with absorbent paper points.

The roots were vertically sectioned by means of a low-speed saw (Isomet, Buhler, Ltd. Lake Bluff, NY, USA) at 200 rpm, under continuous water cooling



**Figure 1.** Representative SEM images of smear layer removal. All images represent, from left to right, the apical, middle and cervical portion of the root canal, respectively. **A, B, C)** stainless steel files; **D, E, F)** NiTi files; **G, H, I)** NiTi orthodontic wire; **J, K, L)** EDTA group without PUI. These groups show adequate smear layer removal in all root thirds. Finally, figures **M, N, O)** the group in which EDTA was not used, showed a significant amount of smear layer blocking the entrance of dentinal tubules. Original magnification: 500x.

to prevent frictional heat, so as to expose the inner part of the canal, with two grooves in buccolingual direction along the root surface, taking the best of two halves for analysis. The samples were dried, mounted on circular metal bases (stubs), coated with a layer of metal and analyzed by a scanning electron microscope (SEM) (Aspex Express, Fei company, Eindhoven, Netherlands). The samples were analyzed under magnification of 500x, and images corresponding to the most representative portion in the apical, middle and cervical thirds were selected. To analyze the presence or absence of smear layer, a grid containing 100 squares was mounted over the image, and the number of squares that had the following scores corresponding to the amount of smear layer were counted: 0 = no layer of dentin debris, clean and open tubules; 1 = moderate layer of dentin debris; 2 = thick layer of dentin debris covering the surface of dentinal tubules.

Data were recorded as the percentage of squares in each image with each score. Data for each score were compared by means of Kruskal-Wallis test for global comparison and Dunn's test for individual comparisons. The level of significance was set at 5%.

## Results

The median as well as minimum and maximum percentage of each score assigned to the cleaning of cervical, middle and apical thirds of each group are shown in Table 1. The cervical third presented with the lowest percentage of smear layer, although without significant differences ( $p > 0.05$ ) relative to the middle and apical thirds. In general, stainless steel files presented a slight improvement in cleaning ability, regardless of the thirds analyzed, but without significant differences ( $p > 0.05$ ) among instruments. All groups that used EDTA, with and without ultrasonic agitation, differed from the group without EDTA in both scores 0 and 2. There were no statistically significant differences ( $p > 0.05$ ) between groups with ultrasonic agitation and the group with EDTA without agitation.

When controls IV and V were analyzed without the use of ultrasound, there was statistically significant difference ( $p < 0.05$ ) in all thirds.

## Discussion

The smear layer produced during root canal instrumentation has organic and inorganic substances

**Table 1.** Median, minimum and maximum percentages of each score assigned to the cleaning of cervical, middle and apical thirds of each group studied.

	Apical			Middle			Cervical		
	0	1	2	0	1	2	0	1	2
<b>Group I: stainless steel</b>	20 (38.0–0.0)	38 (53.0–21.0)	41.9 (111.0–65.0)	25.2 (47.0–2.0)	38.9 (66.0–26.0)	35.8 (70.0–17.0)	28 (43.0–1.0)	42.5 (75.0–28.0)	28.4 (59.0–18.0)
<b>Group II: NiTi</b>	31.3 (66.0–0.0)	51.5 (77.0–24.0)	17 (40.0–3.0)	28.2 (69.0–1.0)	56.2 (77.0–24.0)	15.2 (36.0–1.0)	36.6 (79.0–1.0)	44.2 (59.0–20.0)	22.6 (60.0–1.0)
<b>Group III: orthodontic wire</b>	29.6 (76.0–0.0)	48.1 (68.0–15.0)	22.6 (34.0–9.0)	25.1 (68.0–0.0)	49.6 (73.0–24.0)	25.3 (52.0–8.0)	36.2 (90.0–0.0)	41 (79.0–6.0)	21.7 (50.0–1.0)
<b>Group IV: EDTA</b>	40.4 (86.0–9.0)	33.4 (51.0–10.0)	26 (50.0–4.0)	54 (71.0–37.0)	29.4 (48.0–10.0)	16.4 (25.0–9.0)	67.2 (76.0–55.0)	21.4 (32.0–15.0)	11.4 (19.0–8.0)
<b>Group V: no EDTA</b>	0 (0.0–0.0)	2 (6.0–0.0)	98 (100.0–94.0)	4.2 (18.0–0.0)	2 (6.0–0.0)	83.6 (95.0–52.0)	1.8 (8.0–0.0)	5.4 (14.0–0.0)	92.8 (100.0–78.0)

in its composition; that is, in addition to dentin and predentin, it has pulp remnants, odontoblast processes and, in cases of infected root canals, microorganisms.<sup>7</sup> The presence of smear layer hinders effective penetration of antimicrobial agents and sealer; thus, compromising antiseptics of the root canal and adaptation between the filling material and root canal walls.<sup>8</sup>

The apical third of the root canal is more difficult to clean, possibly due to its narrower dimensions, which can effectively prevent the penetration of irrigating solutions, resulting in limited contact of solutions with the root canal surfaces.<sup>6</sup>

This study compared activation of EDTA through ultrasound by means of three different instruments. All instruments yielded satisfactory results on the permeability of dentinal tubules in the apical, middle and cervical thirds of the root canal, proving their ability to remove most of dentin debris. The null hypothesis was accepted, as the type of instrument attached to the ultrasound device did not influence smear layer removal.

The results of SEM showed that EDTA can efficiently remove smear layer from all root thirds, while NaOCl used alone during irrigation, without EDTA as a final irrigating agent, was not able to remove smear layer from the root canal. Some authors<sup>9-12</sup> showed that irrigation with EDTA is effective in removing the smear layer. According to Van Der Luis et al,<sup>1</sup> the use of ultrasound has been suggested to improve root canal irrigation. Less debris and smear layer were observed in the apical region than in the cervical portion,<sup>1</sup> thereby corroborating the results of the present study.

Ultrasound promotes oscillation of instruments attached to the ultrasonic device, thereby causing

acoustic micromotion, which helps the irrigant to reach inaccessible regions. Furthermore, ultrasound promotes transient cavitation of the liquid, generating shock waves and increasing shear stress on the surface of the root canals, for instance, the apical third which is particularly difficult to clean due to root canal complex morphology.<sup>13</sup>

When the groups subjected to ultrasonic agitation were compared to the EDTA group without ultrasonic agitation, there was no statistically significant difference ( $p > 0.05$ ). These results corroborate the findings of a previous study.<sup>14</sup> EDTA likely promotes satisfactory smear layer removal on the root canal wall, even without PUI. Nevertheless, PUI would produce a more significant effect in cases of complexities inside the root canal, as noted by other authors.<sup>1,15</sup> However, Sabins et al<sup>14</sup> found that passive ultrasonic agitation produces significantly cleaner canals than passive sonic agitation for 30 to 60 seconds.<sup>14</sup>

## Conclusion

There was no statistical difference in terms of cleaning effect among the three types of instruments used for PUI associated with EDTA within the root canal. PUI did not enhance smear layer removal from root canal walls when compared to the EDTA group without PUI. The use of EDTA with and without ultrasonic activation favored smear layer removal compared to the group in which no EDTA was used. EDTA ultrasonic activation for one minute, regardless of the instrument used, favored cleaner walls.

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