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# Effectiveness of syringe, endo-activator and passive ultrasonic irrigation on smear layer removal and canal cleanliness - An In-Vitro stereomicroscopic evaluation

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## Abstract

**Aim:** To compare the effectiveness of syringe, Endo activator and passive ultrasonic irrigation methods in removing smear layer using stereomicroscope.

**Materials and Methods:** Forty-four extracted single-rooted human mandibular premolars were decoronated to a standardized length of 12 mm. Specimens were shaped up to F3 (Super Endo, super gold flex files) and irrigated with 17% EDTA. Teeth were divided into 4 groups (1control group [n = 10] and 3 test groups [n = 10]) according to the final irrigating devices (ie, sonic irrigation, passive ultrasonic irrigation [PUI], or manual irrigation). Root canals were then split longitudinally and observed under stereomicroscope. The presence of debris and a smear layer at coronal, middle and apical third was evaluated. Scores were analyzed by Kruskal-Wallis and Mann-Whitney U tests.

**Results:** Use of both the Endo Activator and PUI resulted in significantly better scores at all levels. The Endo Activator System (Dentsply Tulsa Dental Specialties, Tulsa, OK) was significantly more efficient than PUI and the control groups in removing the smear layer at the apical third. At coronal and middle thirds, Endo activator and PUI showed similar scores.

**Conclusion:** In our study Endo activator removed smear layer almost completely at the apical third. Sonic and ultrasonic irrigation resulted in better removal of the smear layer in all thirds of root canals than conventional irrigation.

**Keywords:** EDTA, PUI, Root Canal.

## Introduction

Success of root canal treatment depends on cleaning and shaping of root canals[1, 2]. Shaping of root canals creates a smear layer that consists of organic and inorganic substances, including fragments of odontoblastic processes, microorganisms, and necrotic materials [3, 4]. Presence of smear layer hampers the penetration of intracanal irrigants, disinfectants [5] and sealers [6] into the dentinal tubules, which might affect the root canal seal[7, 8]. To reduce the residual debris, necrotic tissue, and bacteria as well as the smear layer which is formed by the mechanical instrumentation of the root canal system, several irrigants have been used [5, 9]. Sodium hypochlorite (NaOCl) is used widely as an irrigant in endodontics[10]. For the efficient removal of the smear layer, EDTA, a calcium-chelating agent, has been recommended [4, 11]. To improve the debris removal, irrigating solutions should be in contact with root canals [9]. The syringe irrigation technique delivers irrigants not more than 0–1.1 mm beyond the needle tip [12]. This is not sufficient to clean the complex anatomy of the root canal system (lateral canals, isthmuses, fins, and accessory canals[13]. Exchange of irrigants might be hindered by a vapor lock which results in trapped air in the apical third of root canal which can also affect the debridement efficacy[14]. To increase the flow and distribution of irrigants within the root canal system [15], different devices for irrigation delivery have been proposed, especially at the apical third level. Endo Activator System (EA) (Dentsply Tulsa Dental Specialties, Tulsa, OK) is a sonically driven irrigant activation system, which is designed to produce vigorous intra-canal fluid agitation that has been shown to increase the efficacy of irrigation better than traditional needle irrigation [16]. It consists of portable hand-piece and three types of disposable flexible polymer tips of different sizes that do not cut root dentin. Weller et al described the use of PUI (passive ultrasonic irrigation)[17] in which stainless steel file is used to activate the irrigant in the canal [(18)]. PUI is able to disrupt the endodontic biofilm, helps in better penetration of irrigants throughout the root canal system[15, 18].

The aim of this study was to evaluate removal of smear layer and cleanliness of endodontic walls after using different irrigant activation systems.

## Materials and Methods

Root Canal Preparation Forty-four single-rooted mandibular premolars extracted for orthodontic purpose were collected. Inclusion criteria: Only teeth with intact and mature root apices and roots longer than 14 mm were selected. Exclusion criteria: caries, cracks, endodontic treatments, and restorations. Teeth with root canal curvatures greater than 20° or calcified root canals were excluded.

After the access cavity was prepared, a #10 K-file was inserted into the canal until the instrument tip was barely visible at the apical foramen. To standardize the root lengths to 12 mm, decoronating is done perpendicular to the long axis of the tooth by means of a high-speed, water-cooled diamond disc. Specimens were randomly divided into 4 groups: 1 control (n = 11) and 3 experimental groups (n = 11). Except for the negative control group, specimens were shaped to F3 (Super Endo, super gold flex files) according to the manufacturer's instructions until the F3 file reached the working length (WL). After each instrumentation, canals were rinsed with 3 mL 5.25% NaOCl (Chematek Spa, Rome, Italy). After each instrument, the apical patency was checked with #10 K-file. 17% EDTA (Chematek Spa) was used to irrigate each group and rinsed with 3 mL 5.25% NaOCl. Finally, 5.25% NaOCl was

activated/delivered with different methods. Irrigating solutions were delivered by means of a 27-G syringe needle inserted deeply at 1 mm short of the WL. All the specimens were then irrigated with distilled water which are then dried with sterile paper points.

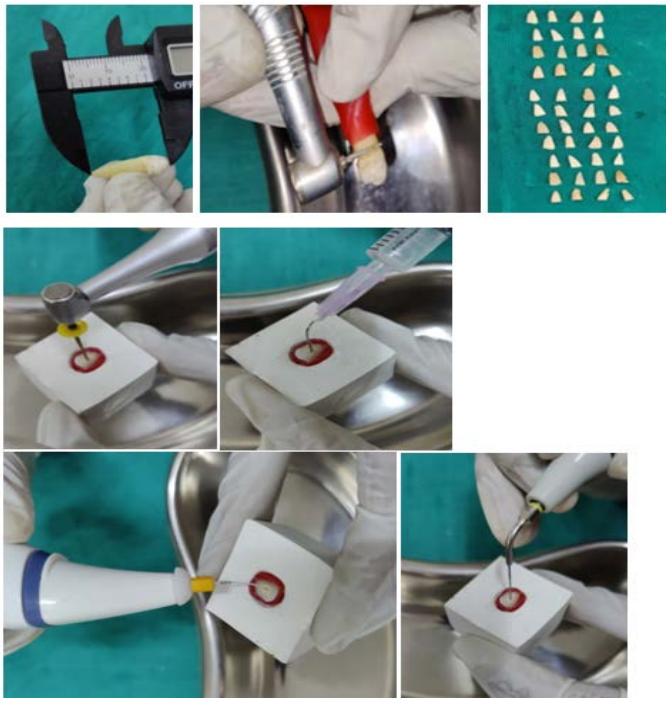
**Specimen Preparation**

Stereomicroscopy was used to evaluate the removal of smear layer from the root canals. All the roots were grooved longitudinally on the external surface with a diamond disc without penetration into the root canals, to fracture the root into two halves. The roots were then split into halves with a chisel with a F3 gutta-percha cone in the root canal to limit tooth fragments covering endodontic canal walls. For each root, the half containing the most visible part of the endodontic wall was used. The specimens were desiccated, and viewed with stereomicroscopy. Five photographs for each tooth were taken in the same positions inside the canal (apical, middle and coronal thirds) at 3 different magnifications (300, 1,000, and 3,000).

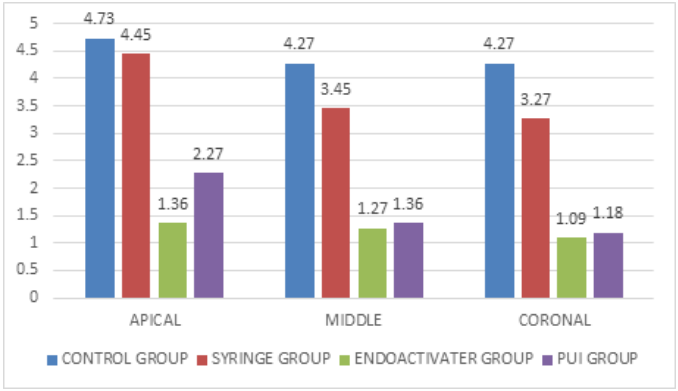
**Stereomicroscopic Evaluation**

Cleanliness was evaluated by micrographs taken at apical, middle and coronal thirds at a 1,000X magnification. Cleanliness was evaluated according to a 5-score index system which was given by Hulsmann et al [(22)], which measured the presence, quantity, and distribution of the smear layer as follows: score 1 = no smear layer, score 2 = small amount of smear layer, score 3 = homogenous smear layer covering the root canal wall, score 4 = complete root canal wall covered by a homogenous smear layer, and score 5 = heavy nonhomogeneous smear layer covering the complete root canal wall. Kruskal-Wallis and Mann-Whitney U tests were used for data analysis.

Figure 1:



Graph 1:




Graph 2:

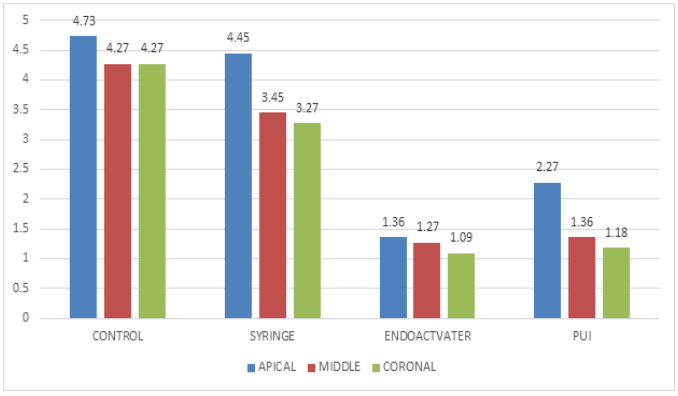
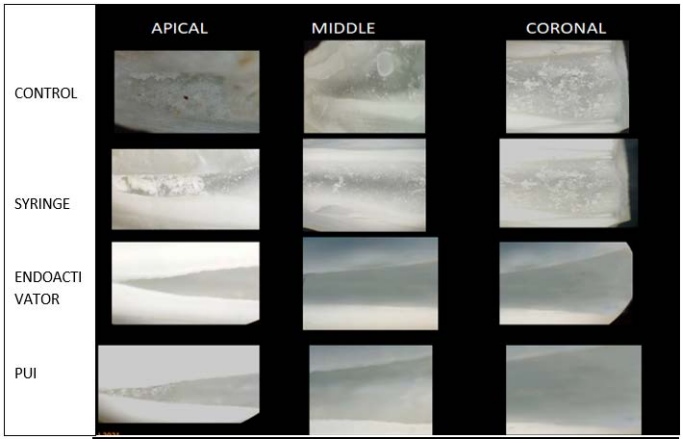


Figure 2:




On analysis of the stereomicroscopic photographs, cleanliness was evaluated, and the results are given as the mean score. At apical third, the dentin surface was covered by heavy coherent deposits of smear layer and debris with irregular shapes and sizes in all groups, except for the group which was irrigated with the Endo activator. The Endo activator group was the only group that at apical third showed the root canal to be cleaner than in the other groups; the mean score was significantly reduced (1.36) when compared with the other groups. At middle third, the EA and PUI showed statistically significant differences when compared with the syringe and control groups (1.27 and 1.36respectively). When the samples were irrigated with NaOCl and activated with Endo activator, the effect of NaOCl on the dentinal surface was improved, and some of the dentinal tubules were partially opened, with some removal of the smear layer. At coronal third, the EA, and PUI showed statistically significant reductions of debris when compared with the syringe and control groups. Moreover, all groups showed better smear layer removal at coronal third than apical third.

**Discussion**

The aim of this study was to evaluate the effectiveness of different irrigating systems in removing the smear layer from endodontic walls at apical, middle and coronal thirds. An in vitro closed-end canal model was used because it simulates in vivo conditions such as gas entrapment in the root canal and periodontal ligament[14]. Smear layer removal is usually achieved by irrigants which are capable of dissolving both organic and inorganic components [17, 23]. 17% EDTA followed by 1%–6% of NaOCl is commonly recommended [4, 11]. However, there is no consensus on volume [18, 24], time of application [15, 25], or activation method [26, 27] of irrigating solutions. Recently, to increase the flow and distribution, different irrigation delivery and activation systems have been proposed[16]. In our study, to increase volume exchange of irrigants at the WL, groups were shaped to a Pro Taper F3 (apical size .30, taper 6%)[28]. For improved irrigant delivery at the apical third level, apical patency was confirmed[29] after each instrumentation. Analyses of the 3 distances from the apex showed that the EA performed significantly better than the other groups at apical third. Similar results were described by Rodig et al [30], who showed greater smear layer removal was achieved when the EA was used rather than ultrasonic agitation. These results are in contrast to those from a recent study by Uroz-Torres D et al reporting no significant improvement of smear layer removal with the EA [31]. These findings can be because of the lower volume of irrigant used (ie, 1 mL 17% EDTA and 3 mL 4% NaOCl) compared with the present study in which 17% EDTA and 5.25% NaOCl were used for longer times and at higher volumes. Ultrasonics showed poor results in the apical third, which is in agreement with Gu LS et al[15], possibly because of the reduced time of activation and the contact between the ultrasonic file and the canal walls[32]. Conversely, other studies Alacam T, Cameron JA [33, 34 have] shown that the activation of different concentrations (3% and 5%) of NaOCl with PUI for a longer period i.e 3 to 5 minutes is sufficient to

remove the smear layer completely. Chopra S et al showed that ultrasonic activation is not efficient in removing the smear layer in straight root canals when using 17% EDTA [27]. In our study, PUI showed better ability to remove the smear layer at coronal and middle than apical third. These findings are confirmed by a recent study reporting better results with the manual activation than with PUI and passive irrigation [35]. In our study, the difference of smear layer removal at middle third between PUI and EA was not statistically significant, but both devices performed significantly better than the control and syringe groups.

The limitation of the study is that stereomicroscope has low magnification power as compared to that of SEM.

**Conclusion**

- The problem of smear layer is yet a controversy.
- However, if it is to be removed, based on the results of this study, the activation of 17% EDTA with Endo activator is a viable technique for removal of the smear layer from the root canal walls.

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