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# To evaluate the efficacy of XP endo finisher and passive ultrasonic irrigation for smear layer removal using scanning electron microscopy: An in vitro study

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**Abstract**
**Introduction**: This study aims to investigate the efficacy of XP endo finisher and passive ultrasonic irrigation for smear layer removal using scanning electron microscopy (SEM).
**Materials and method**: The root canals of 36 extracted single rooted mandibular premolars were selected for the study. All specimens were randomly distributed into the following 3 groups: Group I(Control): conventional irrigation by syringe Group II: passive ultrasonic irrigation (PUI) and, Group III: XP endo finisher. In all groups mechanical instrumentation was done with rotary files iRace. The specimens of all the 3 groups were grooved buccolingually along the entire length, with the help of a high- speed bur without perforating into the root canal space. The roots were then split carefully along the length of the groove and subjected to SEM evaluation.
**Results**: Within the limitation of this study, it can be concluded that XP endo finisher file (XP) was more effective in cleaning the apical area than passive ultrasonic irrigation (PUI) and conventional side vented needle irrigation (CI).

**Keywords:** smear layer, XP endo finisher, passive ultrasonic irrigation

## Introduction
The success of endodontic treatment depends significantly on the quality of cleaning and shaping the root canal system. However, adequate canal preparation, which involves mechanical (instrumentation) and chemical aspects (irrigation) is difficult to achieve due to the complex canal morphology [1]. The presence of smear layer and debris, especially in the apical portion of the canal, is of clinical significance because bacteria in combination with unfavorable local factors may cause endodontic failure [2]. Instrumentation using rotary NiTi instruments is relatively new approach in the preparation of root canals, but effective cleaning of a complex canal system still remains a challenge for dental practitioners [3]. Endodontic irrigants by their physical and chemical actions allow dissolution of smear layer on the canal walls and its partial removal [4]. Another means for smear layer removal include ultrasound or laser techniques [5]. It has been confirmed that the use of flexible microbrushes can reduce debris and remove smear layer from root canal walls [6].
Removal of smear layer from the canal walls before final obturation significantly increases sealer adhesion and reduces the incidence of microleakage along the canal walls [7]. However, none available technique provides complete and efficient removal of smear layer therefore, research is directed towards finding new resources and instruments to remove smear layer effectively. Passive ultrasonic irrigation is activation of the irrigant in the root canal using ultrasonically small files or smooth non – cutting wires following the completion of canal preparation [8]. The XP endo finisher file is a universal size 25 non -tapered nickel – titanium instrument. According to the manufacturer, it is made of a proprietary alloy that reacts at different temperature levels. When the file is cooled, it is straight (M phase); when it is exposed to body temperature, it changes its shape to the A- phase, which allows the instrument to expand reaching 6 mm in diameter or 100- fold of an equivalent size file when rotated.

The instrument has a semi – circular shape with a 3 mm diameter that is claimed to permit conversion into any canal shape and reach any canal irregularities [9].

This study aims to evaluate using SEM analysis the effectiveness of a new instrument XP endo finisher and passive ultrasonic irrigation system in cleaning root canal walls after instrumentation with iRace NiTi rotary instruments.

## Materials and Methods

- This in vitro study included 36 single-rooted teeth extracted for orthodontic or periodontal reasons. Prior to the experiment, teeth were stored in saline. All specimens of root length 14 mm were measured using digital vernier caliper and included in study. Access cavities in all teeth were prepared using high speed handpiece and diamond bur size 2 followed by an Endo Z bur. The occlusal surface of the crowns were then flattened by 2 mm to achieve a standardized reference point for determining the working length using #10 – size k – file. The apex of each tooth was covered with composite resin. All the teeth were instrumented using iRace rotary nickel titanium files using endomotor torque 1.5 Ncm and speed 600 rpm, as recommended by the manufacturer, with the sequence R1(size 15 taper 0.06), R2 (size 25 taper 0.04), R3 (size 30 taper 0.04). The canals were irrigated with 2 ml 5% NaOcl in between each file using a 30 gauge endodontic irrigating needle placed 1-2 mm of the working length and Irrigated with 2ml of saline.
- Teeth were randomly divided into three groups (n=12) according to the final irrigation technique
- Conventional irrigation (CI) (n=12) negative control group syringe irrigation.
- PUI (n=12) activation by ultra X
- XP (n=12) activation by XP- endo finisher
- GROUP 1- Irrigation was done using 6 ml 5%NaOCl by placing 30 gauge side vented irrigation needle till working length and depositing the solution slowly using an in and out motion for 60 seconds.
- GROUP 2- The root canal was filled with 5% NaOCl and the tip of the ultraX (PUI) was inserted into canal to the full working length and activated for 30 seconds. UltraX was moved in a slow up and down motion using power setting according to manufacturer's recommendations. Canals were flushed with NaOCl and activated again for 30 seconds with 3 ml of 5% NaOCl.
- GROUP 3 - The root canal was filled with 5% NaOCl XP endo finisher was used at 800 rpm and 1 Ncm up to full working length XP endo finisher was applied for 30 seconds within the canal in slow up and down motion. The canal was flushed with 3ml NaOCl again XP endo finisher was used till 30 seconda.
- Final irrigation was done with 17% EDTA for 1min followed by 5ml of distilled water. The canal was dried with sterile absorbent paper point.
- Prior to scanning the orifices of the teeth were sealed with teflon and the crowns were cut at the cementoenamel junction followed by removal of Teflon. The specimens of all the three groups were grooved buccolingually along the entire length, with the help of a #168-L high-speed bur, without perforating the root canal space. The roots were then split carefully along the length of the groove with an enamel chisel. One half of the split root was randomly selected, sputter coated, and subjected to SEM evaluation. Root samples were scanned at the cervical, middle, and apical root third levels using SEM at 5 kv and observed under ×2000. Qualitative assessment of smear layer on root canal walls was based on criteria given by Hulsmann *et al.*
- Grade 1 – no smear layer, dentinal tubules open
- Grade 2 – there is a small amount of smear layer, open some dentinal tubules
- Grade 3 – homogeneous smear layer covering canal walls, a few dentinal tubules open
- Grade 4 – complete canal wall covered with homogenous smear layer, dentinal tubules closed
- Grade 5 – ordinary homogeneous smear layer covering the entire canal walls.

The obtained results were analyzed using the Mann– Whitney U-test.

## Results

The average scores for the smear layer in a group where XP endo finisher was used were significantly lower than in the group where smear layer was removed with passive ultrasonic irrigation and conventional needle irrigation. In the coronal and middle thirds, when comparing between the XP and PUI, there was no significant difference between the percentages of patent dentinal tubules. In the apical area when comparing between XP and PUI separately, it was found that the canal activated with XP showed a higher percentage of patent dentinal tubules than PUI.

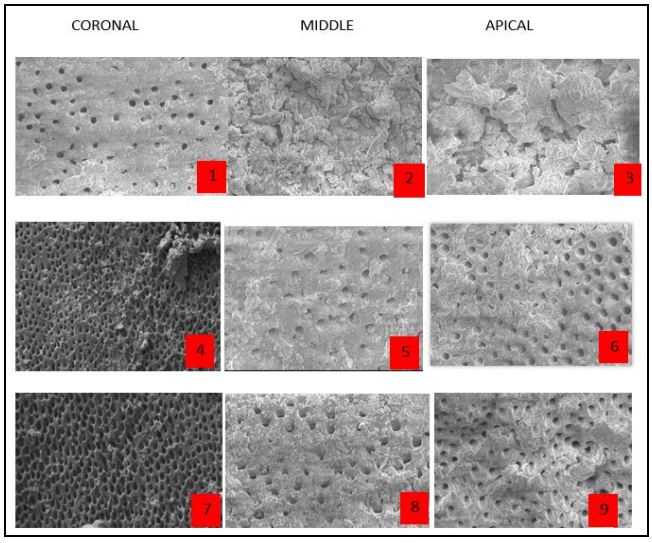
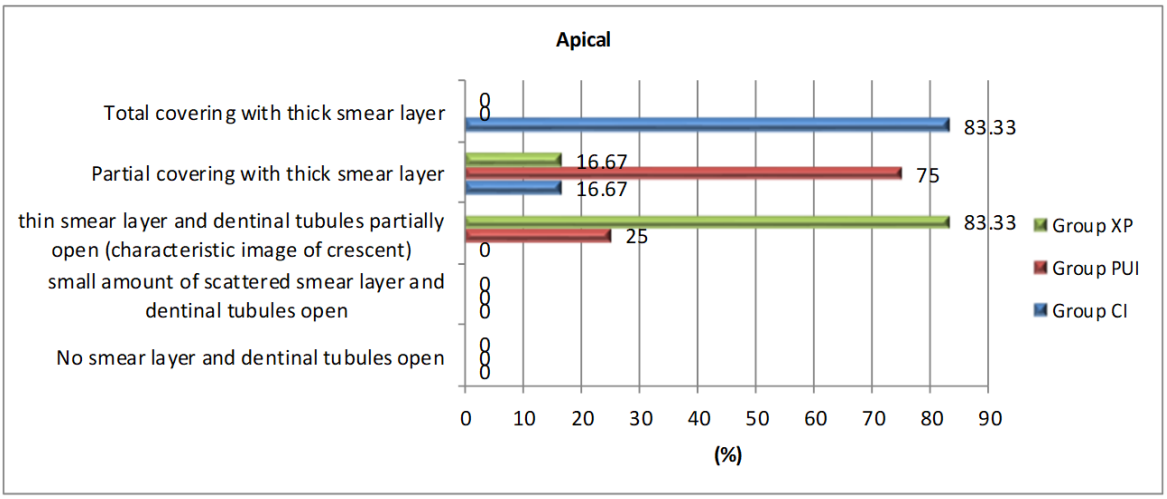



**Fig 1:** 1, 2, 3 are the images of conventional needle irrigation group at coronal, middle and apical 4, 5, 6 are the images of passive ultrasonic sonic activation group at coronal, middle and apical 7, 8, 9 are the images of XP endo finisher group at coronal, middle and apical. SEM image at 2000X showing the canal surface where dentinal tubules were either opened or covered by debris in all groups.

**Table 1:** Shows percentage of smear layer present in apical section of the root canal in all three groups.
Chi square test shows statistical significant difference between Group CI with group PUI and Group XP with p value (P<0.001).

| APICAL | Group CI | Group PUI | Group XP |
|---|---|---|---|
| No smear layer and dentinal tubules open | 0 | 0 | 0 |
| small amount of scattered smear layer and dentinal tubules open | 0 | 0 | 0 |
| thin smear layer and dentinal tubules partially open (characteristic image of crescent) | 0(0%) | 3(25%) | 10(83.33%) |
| Partial covering with thick smear layer | 2(16.67%) | 9(75%) | 2(16.67%) |
| Total covering with thick smear layer | 10(83.33%) | 0(0%) | 0(0%) |

| Groups | APICAL | |
|---|---|---|
| | Chi square value | Significance |
| Group CI vs Group PUI | 17.45 | P<0.001 |
| Group CI vs Group XP | 20.00 | P<0.001 |
| Group XP vs Group PUI | 8.22 | P=0.016 |

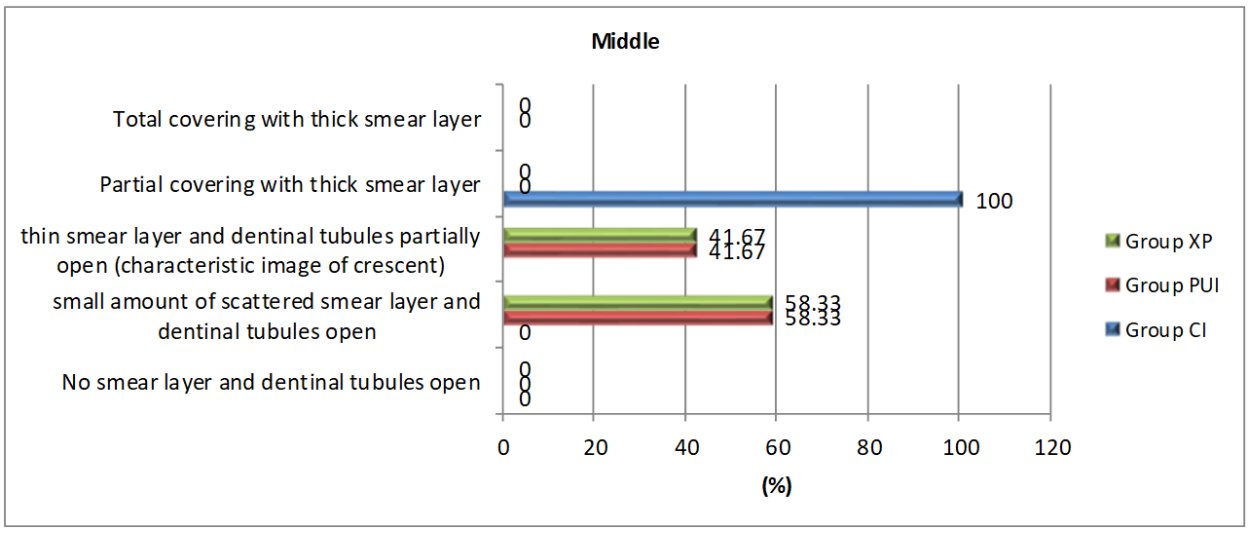



**Graph 1:** Shows percentage of smear layer present in apical section of the root canal with Group XP, Group PUI and Group CI.

**Table 2:** Shows percentage of smear layer present in middle section of the root canal in all three groups.
Chi square test shows statistical significant difference between Group CI with group PUI and Group XP with p value (P<0.001).

| Middle | Group CI | Group PUI | Group XP |
|---|---|---|---|
| No smear layer and dentinal tubules open | 0(0%) | 0(0%) | 0(0%) |
| small amount of scattered smear layer and dentinal tubules open | 0(0%) | 7(58.33%) | 7(58.33%) |
| thin smear layer and dentinal tubules partially open (characteristic image of crescent) | 0(0%) | 5(41.67%) | 5(41.67%) |
| Partial covering with thick smear layer | 12(100%) | 0(0%) | 0(0%) |
| Total covering with thick smear layer | 0(0%) | 0(0%) | 0(0%) |

| Groups | MIDDLE | |
|---|---|---|
| | Chi square value | Significance |
| Group CI vs Group PUI | 24 | P<0.001 |
| Group CI vs Group XP | 24 | P<0.001 |
| Group XP vs Group PUI | | |

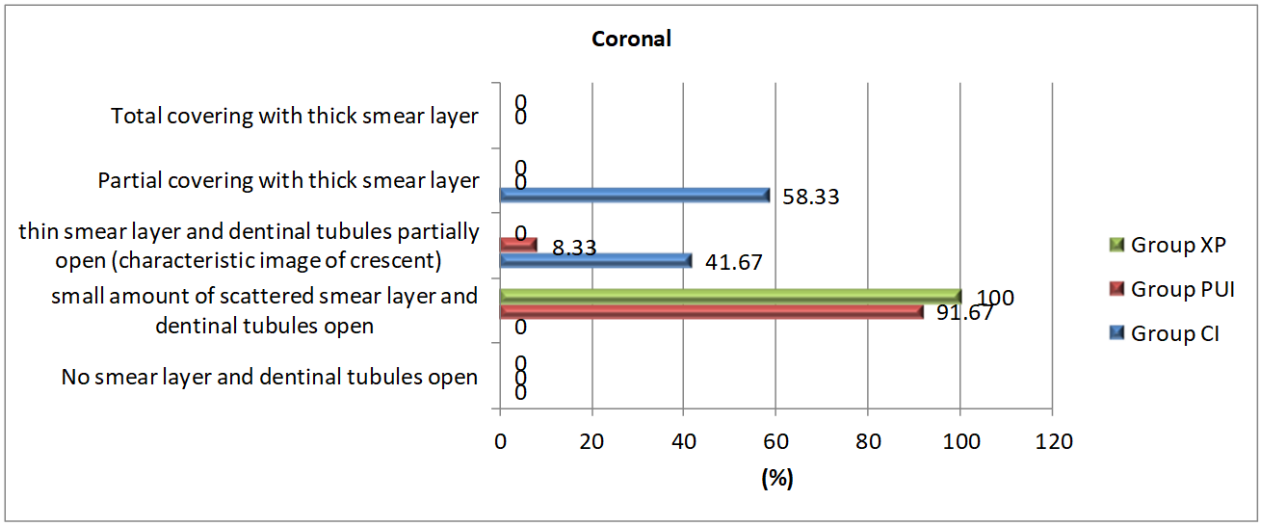



**Graph 2:** Shows percentage of smear layer present in middle section of the root canal with Group XP, Group PUI and Group CI.

**Table 3:** Shows percentage of smear layer present in coronal section of the root canal in all three groups.
Chi square test shows statistical significant difference between Group CI with group PUI and Group XP with p value (P<0.001).

| Coronal | Group CI | Group PUI | Group XP |
|---|---|---|---|
| No smear layer and dentinal tubules open | 0(0%) | 0(0%) | 0(0%) |
| small amount of scattered smear layer and dentinal tubules open | 0(0%) | 11(91.67%) | 12(100%) |
| thin smear layer and dentinal tubules partially open (characteristic image of crescent) | 5(41.67%) | 1(8.33%) | 0(0%) |
| Partial covering with thick smear layer | 7(58.33%) | 0(0%) | 0(0%) |
| Total covering with thick smear layer | 0(0%) | 0(0%) | 0(0%) |

| Groups | CORONAL | |
|---|---|---|
| | Chi square value | Significance |
| Group CI vs Group PUI | 20.66 | P<0.001 |
| Group CI vs Group XP | 24 | P<0.001 |
| Group XP vs Group PUI | 1.04 | P=0.59 NS |




**Graph 3:** Shows percentage of smear layer present in coronal section of the root canal with Group XP, Group PUI and Group CI.

## Discussion

Removal of smear layer that forms along the walls during instrumentation is an important clinical parameter for the success of endodontic treatment [10]. The aim of the study was to compare the effectiveness of XP endo finisher and passive ultrasonic irrigation. Extracted human mandibular teeth commonly have a type I vertucci canal configuration [11]. When compared with the other groups, conventional side vented needle irrigation showed a significantly lower percentage of patent dentinal tubules. This result was anticipated because no activation method was used to enhance the removal of the smear layer. A combined strategy of both chemical and mechanical methods should be used. The results showed a significantly more efficient removal of the smear layer from the root canal walls after using XP endo finisher. The use of this instrument resulted in more efficient cleaning of the canal system and considerably less smear layer at apical area. In the coronal and middle thirds, when comparing between the XP endo finisher and passive ultrasonic irrigation, there was no significant difference between the percentages of patent dentinal tubules [12]. This may be due to fact that the passive ultrasonic instrument might have not been able to vibrate freely in the apical third due to the narrowness of the canal. On the other hand XP endo finisher does not depend on vibration; it depends on mechanical scraping and rotation. XP endo finisher has a sickle shape with a 3mm arc at the apical part of an instrument, which may have allowed for more contact with the canal walls [13]. However, Bao *et al.* and Hamdan *et al.* found that the XP endo finisher was more effective in removing calcium hydroxide paste and bacteria from the canal in the apical area than passive ultrasonic irrigation.

## Conclusion

Within the limitation of this study, it can be concluded that no activation technique completely eliminated the smear layer. The XP endo finisher was more effective in cleaning the apical area than passive ultrasonic irrigation and conventional side vented needle irrigation.

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