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ORIGINAL ARTICLE

Comparative evaluation of smear layer removal with Ultra-X device and XP-Endo Finisher file system: an ex-vivo study

ABSTRACT

Aim: *Chemo-mechanical debridement plays a crucial role in root canal treatment. Irrigant activation is the final step before obturation and it helps in effectively cleansing and disinfecting the complex root canal system. The current study aimed at comparing the smear layer removal after activation with Ultra-X and XP-Endo finisher (XPEF).*
Methodology: *Sixty extracted single-rooted second premolars were collected. The specimens were decoronated until 13mm standard length and were shaped using Protaper gold rotary files to size 40 under standard irrigation protocol. Following this, based on the final activation, the specimens were randomly allocated to: group 1: Conventional Needle Irrigation (CNI) (n=20); (Control group), group 2: Activation using Ultra X Ultrasonic device (PUI) (n=20); group 3: Activation using XPEF (n=20). Finally, the specimens were examined for smear and debris removal using scanning electron microscopy (SEM).*
Results: *Tested groups showed significant differences ($p<0.05$) in debris and smear layer removal when compared to control. However, no difference ($p>0.05$) was elicited between groups 2 and 3.*
Conclusion: *Both Ultra-X and XPEF devices showed comparable debris and smear layer removal.*

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Introduction

The root canals are shaped adequately by mechanical instrumentation and cleaned and disinfected appropriately by root canal irrigants (1). After the mechanical shaping with rotary Ni-Ti instruments, the actual irrigation process helps in effectively cleansing and flushing inorganic and organic tissue debris from the root canal space (2). Conventional needle irrigation (CNI) is a commonly and widely employed method of irrigant delivery while performing root canal therapy (3). According to previous research, the CNI is ineffective at removing debris and smear layer from canal complexities (4). As a result, clinicians are increasingly shifting towards machine-assisted irrigation activation techniques.

Literature also states the inefficiency of the irrigant activation devices in completely removing the smear layer and debris from the root canal system (5). There is also literature claiming the inefficiency of the instruments in achieving the three-dimensional wall contact with the root canal system (6). Even the recently claimed XP-Endo shapers could not achieve completely clean canals after usage (7). As far as the literature is concerned, the study results claim the inefficiency of minimal root canal shaping in obtaining adequate root canal debridement (8). Hence, the real benefit of the final activation protocol can be better investigated after conventional root canal shaping with appropriate instruments to appropriate sizes. So considering all these facts, in the current study, the efficacy of recently introduced and less investigated Ultra-X, an ultrasonic activation device, and XP Endo finisher (XPEF) in prepared single rooted premolars was compared. Although laboratory studies are still unclear on the efficacy of using XPEF on obtaining the canal cleanliness after root canal shaping (9), there is no literature comparing the efficacy of using Ultra-X with XPEF. Hence, the present study, assessed the superiority of these modalities after complete root canal shaping in terms of smear layer removal from root canals activated with Ultra X and XPEF.

Mathodology

The institutional ethical committee approval (RMC/ECO2/2023) for the current study was obtained from the university-affiliated hospital before the research commencement. The sample size for the current study was calculated based on the previous research (10). Based on the sample size calculation, a total sample of 57 was achieved at an effect size of 0.42 and power 80%. One sample in each group was increased to compensate for the sample loss, finally achieving a sample size of 20 per each group (1-β=80%, α=0.05). PRILE guidelines were followed for drafting the study (11).

Following this, 60 freshly extracted human mandibular second premolars were collected. The premolars were obtained from the oral surgery department. The teeth were rendered clean by rinsing under running tap water, and hard tissue deposits were removed using an ultrasonic scaler (Selector U2 Piezo Scaler, Apoza, Taiwan, China). The soft tissue deposits were removed by immersing the teeth in 3% NaOCl (Clorox, Household Cleaning Products of Egypt, Cairo, Egypt) for 20 minutes before being manually scaled. Finally, the teeth were radiographed, and the root curvatures were determined by applying the Schneider technique.

Inclusion criteria

- Mandibular second premolars exhibiting single root with type I Vertucci canal configuration and closed apex.
- Teeth extracted for orthodontic or periodontal purposes from patients aged between 20 to 30 years.
- Canal curvature preferably less than 10 degrees

Exclusion criteria

- Teeth with surface cracks and extensive decay
- Teeth with resorption or calcifications
- Formerly endodontically-treated teeth

The teeth were preserved in 10% of formalin (El Fath, Cairo, Egypt) until use. Later the teeth were decoronated to a standard root length of 13 mm using a slow-speed diamond disc and water spray. The access cavity was refined if necessary using an Endo Z bur (Dentsply Maillefer, Switzerland) mounted onto a high-speed handpiece. The working length (WL) was approximated 1 mm short of the standardized root length (12 mm). The access cavity preparation and the WL determination procedure were performed by a postgraduate who was not aware of the protocol and not involved in the study. Later the instrumentation was performed by a single operator. He was instructed on the instrumentation and the specific irrigation protocols. The specimens were then prepared using Protaper gold Ni-Ti rotary files (Dentsply Maillefer, Ballaigues, Switzerland). The coronal root portion was enlarged using an orifice opener, and later the canals were prepared up to the F4 rotary instrument using the manufacturer's recommended torque and speed. 5 ml of 5.25% NaOCl (Parcan, Septodont, France) was used to irrigate the root canals between the instruments by placing a 30-gauge flexible polypropylene plastic side vented irrigation needle (Irriflex, PD, Switzerland), 1mm short of WL. The teeth were randomly assigned (www.random.org) to the operator by a head nurse. The specimens were assigned to three groups (n=20) depending on the final irrigation activation technique.

Group 1: Conventional Needle Irrigation (CNI) (n=20) (Control group, fig. 1-3).

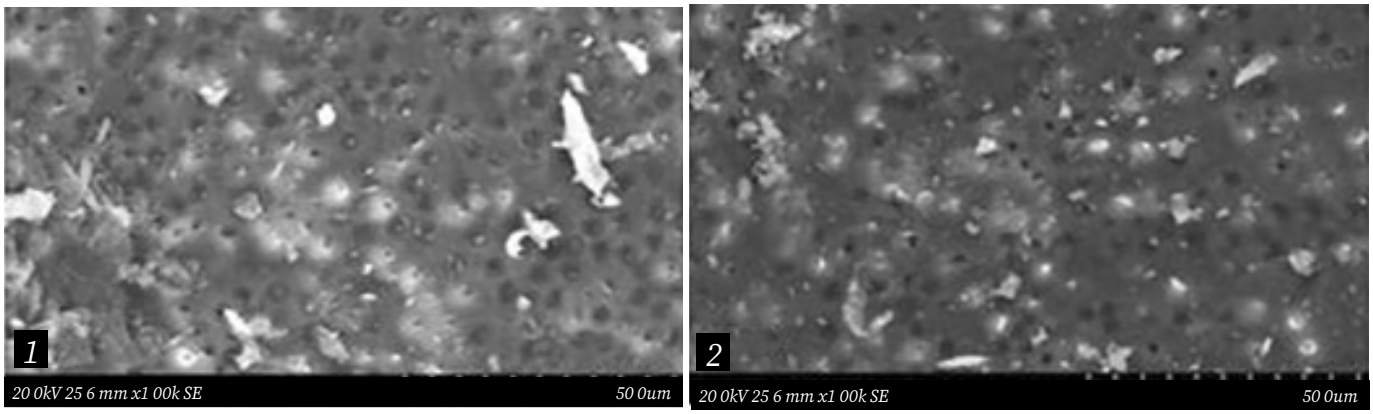
Group 2: Activation using Ultra X Ultrasonic device (PUI, fig. 4-6) (n=20).

Group 3: Activation using XPEF, fig. 7-9 (n=20).

CNI control group: The final root canal irrigation was completed with a volume of 20 ml of 5.25% warm NaOCl at 37 °C by inserting a side vented irrigation needle (Irriflex, PD, Switzerland), 1 mm away from the WL and slowly irrigating the solution using an in and out motion. After irrigation with warm 5.25% NaOCl, 5 ml of 17 % EDTA (MD Cleanser, MetaBiomed, South Korea) was irrigated slowly for 1 min. About 10 ml of normal saline was employed as an intermediate solution and a final rinse. The canals were rendered dry using absorbent paper points.

PUI Using Ultra X: To standardize the study conditions with the XPEF group, 10 ml of warm 5.25% NaOCl at 37°C was irrigated into the canal and ultrasonically activated by placing the tip of the Ultra X, 1 mm short of the WL for 30 seconds. The ultrasonic tip was moved in and out motion during irrigant activation. The canal was then irrigated with 10 ml warmed 5.25% NaOCl and activated for 30 seconds using the same technique. Following this, 5 ml of 17% EDTA was irrigated over 1 min slowly into the root canal and activated for 30 seconds by adopting the same method mentioned above. 10 ml of normal saline was used as an intermediate solution for final flushing. The total activation time was 90 seconds, and 20 ml of warmed 5.25% NaOCl and 5 ml of 17% EDTA were used intermittently to standardize the volume of NaOCl and EDTA used in the other groups. The canals were dried using absorbent paper points.

XPEF Group: The XPEF (size 25, taper 0.00) with an endomotor was used to clean the canals in this group with settings of 800 rpm and torque 1 Ncm. To simulate the clinical conditions in which the XPEF instrument is present in the austenitic phase with its unique sickle shape. The root canal was filled with 5.25% NaOCl to 37 °C. XPEF was operated as recommended by the manufacturers for the entire WL. The XPEF was used in a slow up-and-down motion for 30 seconds within the canal.



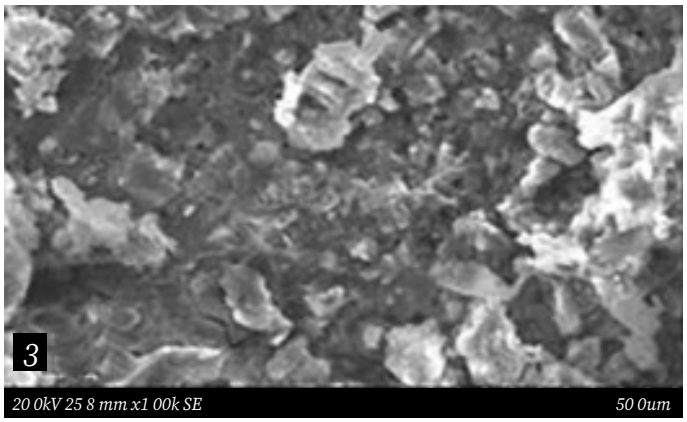


Figure 1-3
Depicting the coronal, middle and apical sections of control group.

The canal was then irrigated with 10 ml of warmed 5.25% NaOCl, and XPEF was activated for 30 seconds by adopting the same technique, followed by another 10 ml of warmed 5.25% NaOCl flush. Subsequently, about 5 ml of 17% EDTA was irrigated over 1 min slowly into the root canal and activated using XPEF. Again about 10ml of normal saline was used as an intermediate solution and final flush. The total activation time was 90 seconds, and 20 ml of warmed 5.25% NaOCl and 5 ml of 17% EDTA were used intermittently. Paper points were used to dry the canal.

Longitudinal grooves were carefully placed on the buccal and lingual root surfaces by not cutting through the canal. The roots were then separated with a chisel and mallet, and one-half was chosen for interpretation. The specimens were then sputtered with gold (K550X sputter coater, Quorum Technologies, Lewes, UK) and examined by Scanning Electron Microscopy (SEM) (Model Quanta, FEI, Eindhoven, Netherlands) at 30 kV and a magnification of 1000 X. The images were captured from the centre of about 11 mm (Coronal), 7mm (Middle), and 3 mm (Apical) from the apex (Figures 1, 2, 3). Two researchers evaluated the images, and the

Table 1

Samples scored according to the smear layer's presence or absence in the coronal, middle, and apical portions of the roots. Statistical significance among the different groups was reported.

Score	Control				XPEF (XP Endo Finisher)				Ultra X (PUI)			
	Coronal	Middle	Apical	P-value	Coronal	Middle	Apical	P-value	Coronal	Middle	Apical	P-value
1	7	0	0	0.041*	15	15	11	0.001*	15	13	5	0.002*
2	8	8	3		0	0	4		0	2	10	
3	0	7	12		0	0	0		0	0	0	
Total	15	15	15		15	15	15		15	15	15	

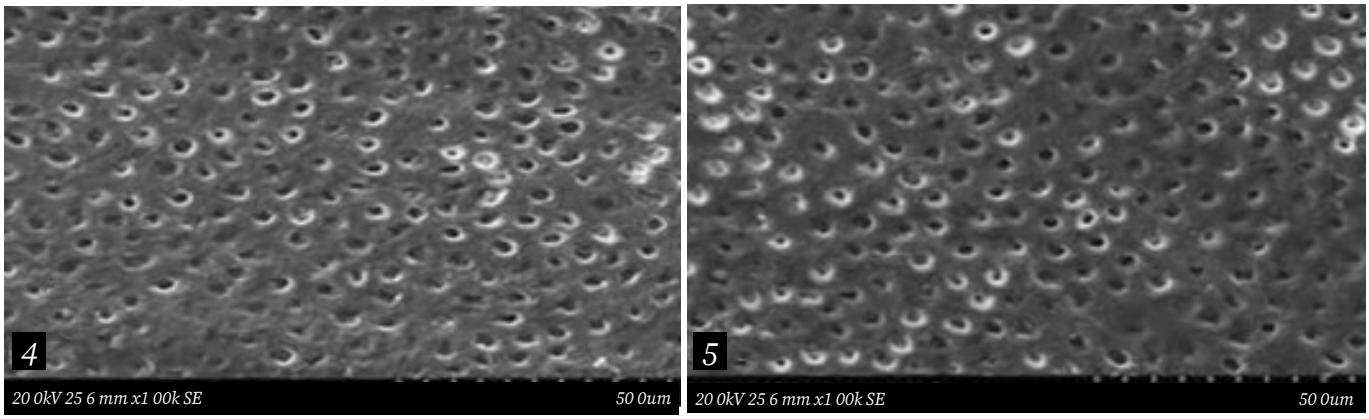


Figure 4-6
Depicting the coronal, middle and apical sections of XPFE group.

scoring was done. The specimens were scored according to the smear layer's presence or absence from the root canals' coronal, middle, and apical portions using the Torabinejad et al. criteria (12) as follows:
1. No to minimal smear layer, all tubules were clean and open;
2. Moderate smear layer: No smear layer on the root canal surface, but tubules with debris;
3. Heavy smear layer on the root canal surface and tubules.
The resulting scores were tabulated, and statistical analysis was performed.

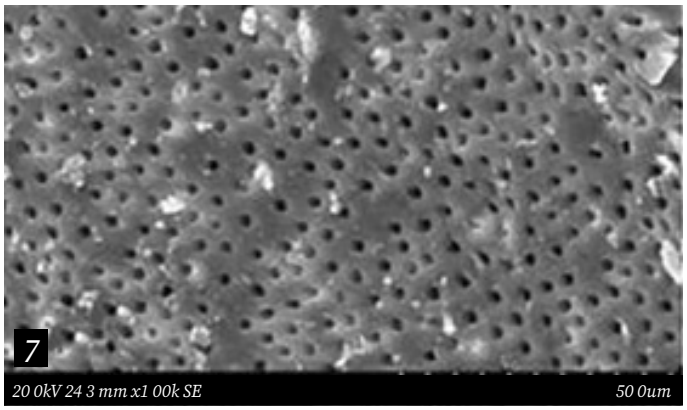
Statistical analysis
The obtained data were analysed using the chi-square test in SPSS software version 22.00. Statistical significance was set at p=0.05.

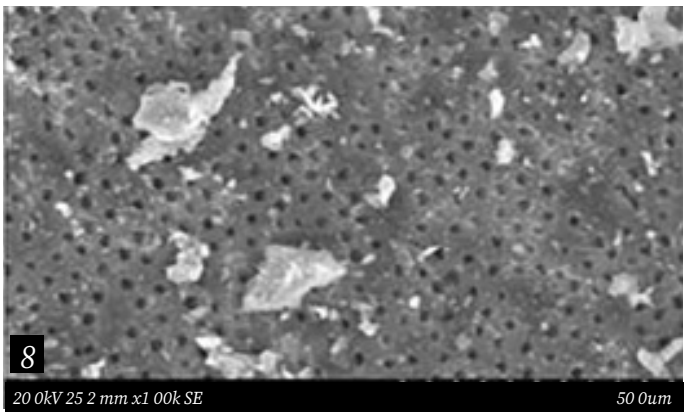
Results

The results of smear layer removal were tabulated in Table 1. A significant difference in the smear layer and debris removal was observed ($p<0.05$) among test groups when compared to control. However, no significant difference ($p>0.05$) between the experimental groups (group 2 and 3) was observed.

Discussion

The current study results showed no significant difference in irrigants activation using PUI Using Ultra X or XPEF. However, both the experimental groups have shown to be better at removing the smear and debris than the CNI group. A previous systematic review literature including laboratory studies showed unclear evidence on the superiority of PUI compared to the XPEF (9), corroborating the results obtained by the present study. Although in the current study the canals were enlarged to size 40 and 0.06 taper, the recent research data on XP endo shaper usage proved no improvement in canal cleanliness on increasing the apical width to the specified sizes as the present study employed (13). The specimens' apical size of 40 and 0.06 taper was choosen according to previous literature as an acceptable master apical file size and taper in obtaining better root canal debridement (14). In addition, warmed 5.25% NaOCL at a temperature of 37 °C as a primary irrigant for the final activation protocol was used, considering the improved flexibility and change in allow transitions of XPEF at body temperatures (15, 16). On the contrary, previous study results reported the efficiency of 60 °C heated NaOCL in conjunc-





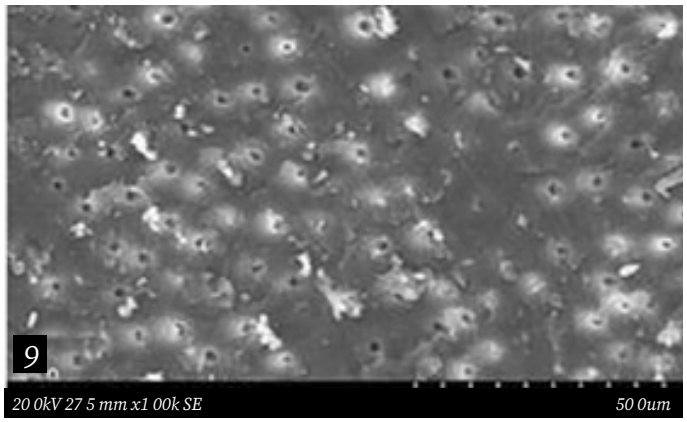


Figure 7-9
Depicting the coronal, middle and apical sections of PUI group.

tion with 17% EDTA to be effective in the removal of the smear layer, even without the activation (17). The results were even more efficient when the intracanal heating of NaOCL was done (18-20). However, heated NaOCL at 37 °C might be efficient in removing smear layer and debris without causing negative effects on the periapical surrounding tissues.

In the present study the volume, concentration, and irrigation protocol were similar in all groups except for the final activation system; moreover, a single operator performed the entire protocol to avoid any procedure or operator-related bias. However, some limitations should be stressed as the inclusion of single-rooted teeth. The real benefit of these devices would have better been evaluated when the curved and multirooted teeth were considered. Furthermore, shaping the teeth to size 40 would have caused a better smear layer removal not fully assessing the real-time benefit of using an activation system. Therefore, future studies should be better focused on these limitations and evaluate the device efficacy in minimal shapes and contracted access designs (21).

Conclusion

Within the limitation of the present ex-vivo study, it can be concluded that both Ultra-X and XPEF were equally effective in smear layer and debris removal in single-rooted mandibular second premolars.

Clinical Relevance

Clinicians currently have various rotary file systems and irrigant activation devices to choose for a routine endodontic practice. However, none of the available to date has proven to be efficient in completely removing the smear layer and the debris. The recently introduced XPEF has 3-dimensional canal wall contacts with better smear removal. Hence, in the present study we compared its debris and smear removal efficacy with the Ultra-X. Our results showed similar efficacy on using both the systems. The present study is clinically relevant as it compared a newer 3-dimensional file system with a popular and widely followed passive ultrasonic irrigation system.

Conflict of Interest

None.

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