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# EFFICACY OF XP-ENDO FINISHER, PASSIVE ULTRASONIC IRRIGATION, VIBRINGE AND CONVENTIONAL SYRINGE IRRIGATION ON DEBRIS REMOVAL IN OVAL ROOT CANALS: A COMPARATIVE STUDY

Shaimaa I. Gawdat* *and* Heba S.A. El-Asfouri*

## *ABSTRACT*

**Introduction**: The purpose of this study was to evaluate the efficacy of XP- Endo finisher (XP) (FKG Dentaire SA, La Chaux-de-Fonds, Switzerland) on removal of debris from coronal, middle and apical thirds of oval root canals in comparison to passive ultrasonic irrigation (PUI), vibringe (VB) and conventional syringe irrigation (CSI).

**Methods:** Eighty extracted single-rooted human mandibular premolars were used in this study. Specimens with a standardized length of 16 mm were mechanically prepared with Race (FKG Dentaire) till # 40/4%. Teeth were divided into 4 groups (n=20) according to the final irrigant activation protocol into the following groups: CSI, PUI, XP and VB. Root canals were then split longitudinally. Digital images were acquired to evaluate the amount of debris by using a digital camera mounted on a stereomicroscope at 25x magnification and transferred to the computer and scored in mm2 and recorded as a percentage of the overall canal surface area by using image analysis software. Debris percentage was analyzed by One-way ANOVA.

**Results:** The XP and PUI groups revealed significantly lower debris percentage than the other groups in the coronal, middle, and apical regions ($P \leq 0.05$). There was no statistically significant difference between XP and PUI. Regarding all systems the coronal third was cleaner than the apical thirds.

**Conclusions:** In our study, none of the activation systems completely removed the debris from the root canal walls; nevertheless, the XP and PUI showed the best results along all thirds in comparison to the other systems.

**KEY WORDS**: Oval canals, debris, XP- endo finisher, passive ultrasonic irrigation, vibringe, conventional syringe irrigation.

* Lecturer of Endodontics, Department of Endodontics, Faculty of Oral and Dental Medicine, Cairo University.

## INTRODUCTION

Efficient removal of vital, necrotic pulp tissue, microorganisms and their toxins is important to achieve successful root canal therapy[1-3]. Debridement of the root canal system is achieved through chemo-mechanical instrumentation [4,5]. Debris is defined as dentin chips and residual vital and necrotic pulp tissue loosely attached to the root canal wall that in most cases is infected, while smear layer is a surface film 1- to 2-$\mu$m thick formed after instrumentation, it is composed of organic and inorganic substances, including microorganisms and their by-products [6]. Penetration of root canal irrigants, intracanal medicaments as well as sealers into the dentinal tubules is hindered by the presence of debris and smear layer. [7,8].

The prevalence of oval root canals in human teeth was reported to be high [9]. Studies have indicated that no current instrumentation technique was able to completely clean dentin walls of the oval, long-oval, and flattened root canals and that un-instrumented recesses may remain [10-13].These areas may be colonized by biofilms, and their presence can lead to persistent apical periodontitis [14,15].

Therefore, chemical debridement through the use of irrigants is a necessary adjunct to mechanical instrumentation for killing microorganisms, flushing debris and removing the smear layer from the canal system [16,17]. Conventional syringe irrigation (CSI) with metal needles of variable tip designs have been routinely used. However, this technique was found to be inefficient, resulting in uncleaned areas left after irrigation due to complex root canal anatomy[18].

It was reported that the efficiency of irrigating solutions was limited when used in the apical area, especially for curved canals and even on single-rooted teeth [19-22]. Therefore, several irrigant activation regimens were introduced for the sake of improving the final irrigant flow and distribution in the apical third [23]. Passive ultrasonic irrigation (PUI), first described by Weller et al [24], used a stainless steel file to activate the irrigant in the canal, it has shown promising results in debris and smear layer removal [25-27].

The Vibringe System (VB) (Vibringe B. V. Corp, Amsterdam, Netherlands) is an irrigation device that combines manual delivery and sonic activation of the solution [28]. It is a cordless handpiece that fits in a disposable 10-mL Luer-Lock syringe which is compatible with all irrigation needles. This device operates at a low frequency (2-3 kHz), it uses sonic flow technology in combination with acoustic streaming [29,30].

The XP-Endo Finisher (XP) (FKG Dentaire, La Chaux-de-Fonds, Switzerland) is a size 25 nontapered instrument made of nickel-titanium (NiTi) MaxWire alloy (Martensite-Austenite Electropolish FleX). It is supposed to be used after any root canal instrumentation to accomplish an enhanced cleaning of the root canal highly complex morphologies and difficult-to-reach areas while conserving dentin. [31,32].

Up to the date of this research, there was no studies assessing the debridement efficacy of XP-Endo finisher files in oval canals. The aim of this study was to evaluate the effectiveness of the XP-Endo finisher file on debris removal from oval root canals in comparison to PUI, vibringe and CSI. The null hypothesis was that there was no difference between the examined irrigant activation methods regarding root canal cleanliness.

## MATERIALS AND METHODS

### Selection of the teeth

A total of eighty extracted human single-rooted mandibular premolars were selected. The inclusion criteria were premolars with one root canal and one apical foramen, with canal curvature between 0º and 10º, determined using Schneider's technique[33]. Radiographs were taken from both buccolingual and mesiodistal directions for the confirmation of presence of single patent canal. Premolars with

calcifications, fractured roots and open apices were excluded. The root ends were inspected under magnification (20x) to verify closed apices and the absence of root resorption or visible cracks. The premolars were cleaned mechanically of debris, soft tissue remnants and calculus and stored in distilled water until required.

Endodontic access cavities were prepared by Endo Access Bur( Dentsply Maillefer, Ballaigues, Switzerland) in a high-speed handpiece. The crowns were ground with a high-speed bur (KG Sorensen, Barueri, SP, Brazil) under copious water spray, until equal tooth lengths with an average of 16mm were created

The working length (WL) was determined by placing a #15 K-file (Mani, Inc., Utsunomiya, Japan) until it was just visible at the apical foramen, from which, 1 mm was subtracted to determine the WL. The WL of each sample was recorded. The apex was sealed with sticky wax to avoid the escape of irrigant solutions through the apex to simulate in vivo situations [34].

**Specimen preparation**

A single operator instrumented the canals of all specimens, using Race (FKG Dentaire) rotary files with 800 rpm and 1.5 N cm, in the following sequence: coronal flaring with file 40/10%, and apical preparation to a size 40/4% taper using a crown-down technique. The following sequence was used; 20/4%, 25/4%, 30/4%, 35/4% and 40/4% to the full working length. Irrigation with 2.6% sodium hypochlorite (NaOCl) using 30-gauge needle (PPH, CERKAMED, Stalowa Wola, Poland) after every file use was carried out. Apical patency was maintained by passing size # 15 file to WL after the use of each file.

**Final irrigation procedures**

After biomechanical preparation, the teeth were divided into 4 groups ( n=20) according to the final flush irrigation protocol as follows:

***Group 1: CSI***

Irrigation with 5 ml of 2.6% NaOCL over 60 seconds was applied as a final flush with a hand-held syringe and a 30 gauge (G) side vented needle (PPH, CERKAMED, Stalowa Wola, Poland). The irrigation needle was placed 1 mm short of the WL and the needle was constantly pulsed 1-2 mm in the apical to coronal direction during irrigation.

***Group 2: PUI***

5 ml of 2.6% NaOCL was delivered inside the root canal using conventional syringe and 30G side vented needle placed 1 mm from the WL. PUI was performed using a Satalec P5 Newtron ultrasonic system and an IrriSafe tip size 25,.00 taper file (Acteon Group, Merignac, France satalec) in 6$^{th}$ power setting. The IrriSafe tip was inserted into the canal 1 mm short of the WL, and the irrigant was ultrasonically activated for 60 s. The file was kept as centered as possible to minimize contact with the canal walls, as any contact with the canal wall could dampen the oscillatory motion of the file.

***Group 3: XP***

5 ml of 2.6% NaOCL was delivered inside the root canal using conventional syringe and 30G side vented needle placed 1 mm from the WL. The XP-endo finisher file was then used with a torque controlled motor (X-Smart, Dentsply Sirona, Ballaigues, Switzerland) operated at 800 rpm and the torque was set to 1 Ncm, according to the manufacturer's instructions. The WL was fixed using the plastic tube to adjust the rubber stopper, and the file was cooled inside the tube using a cold spray (Endo-Ice, Whaledent, Mahwah, NJ, USA). The XP-endo file was then inserted 1mm short of WL, the canal/access cavity was filled with irrigant and the finisher was operated for 60 s using slow and gentle 7–8 mm lengthwise in-and-out movements.

***Group 4 : VB***

Irrigant was delivered and sonically activated via the Vibringe System by using 30G side vented needle. The irrigation needle was placed 1 mm short of the predetermined working length.

The irrigant flow rate was standardized in all techniques of approximately 5 ml/ min

Then all root canals received a final rinse with 5ml of distilled water.

**Cleaning efficacy assessment**

The canals were dried with paper points, and two longitudinal grooves were prepared on the buccal and lingual surfaces of each root with a diamond disk under dry conditions, preserving the inner layer of dentin around the canal, and then the roots were split using a chisel. Twenty roots in each group were sectioned into 2 halves; For each specimen, the half enclosing the most visible part of the apex was selected and the other half was discarded thus, 20 samples were obtained from each group. Every half was divided into coronal, middle and apical thirds.

**Stereomicroscopic evaluation**

Digital images were acquired to evaluate the amount of debris by using a digital camera mounted on a stereomicroscope (Ziess technival 2, Germany) at 25x magnification and transferred to the computer. It was scored in $mm^2$ and recorded as a percentage of the overall canal surface area by using image analysis software (Image J version 1.49. NIH, USA).

**Statistical analysis**

The mean and standard deviation values were calculated for each group in each test. Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests and showed parametric (normal) distribution. One-way ANOVA followed by Tukey post hoc test was used to compare between more than two non-related samples. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

**RESULTS**

Statistical analysis of the tested groups exhibited varying amounts of remaining debris along coronal, middle and apical root canal thirds (fig. 1). Regardless of the activation protocol used, the mean percentage of debris in the apical third was higher than coronal third. The mean and standard deviation values of percentage of remaining debris are presented in (table 1).

XP and PUI showed the least amount of remaining debris with no statistical significant difference between them (p=0.038). CSI showed the highest percentage of remaining debris with statistical significant difference between it and all other groups ($p \leq 0.001$). Vibringe on the other hand was better than CSI (p=0.038) but less efficient than PUI and XP, ($P=0.003$)($p \leq 0.001$) respectively.

For the coronal third, XP and PUI eliminated more debris than CSI ($p \leq 0.001$), and vibringe (p=0.004),(p=0.045) respectively. CSI showing the highest mean percentage value of debris (9.62±1.69), while the least mean percentage value of debris was found in (XP) (2.93 ± 0.95). For the middle third, the highest mean percentage value of debris was found in CSI (13.57 ± 2.24), while the least mean percentage value of debris was found in XP (4.86±1.10) with a statistical significant difference between them ($p \leq 0.001$). As for the apical third, XP and PUI also showed the least amount of debris with no statistical difference between them (p=0.073), also there was no significant difference between CSI and VB groups (p=0.104) ( fig. 2 ).

TABLE (1) The mean, standard deviation (SD) of percentage values of remaining debris. (One-way ANOVA)

| Thirds | Irrigation systems | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | CSI | | PUI | | XP | | VB | |
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| **Coronal** | 9.62 [a] | 1.69 | 3.97 [a] | 1.60 | 2.93 [a] | 0.95 | 6.39 [a] | 1.69 |
| **Middle** | 13.57 [b] | 2.24 | 6.73 [b] | 1.36 | 4.86 [b] | 1.10 | 11.27 [b] | 2.13 |
| **Apical** | 17.57 [c] | 1.86 | 9.74 [c] | 1.12 | 6.26 [b] | 1.56 | 14.33 [b] | 2.67 |
| **P-value** | ≤0.001* | | ≤0.001* | | 0.001* | | ≤0.001* | |

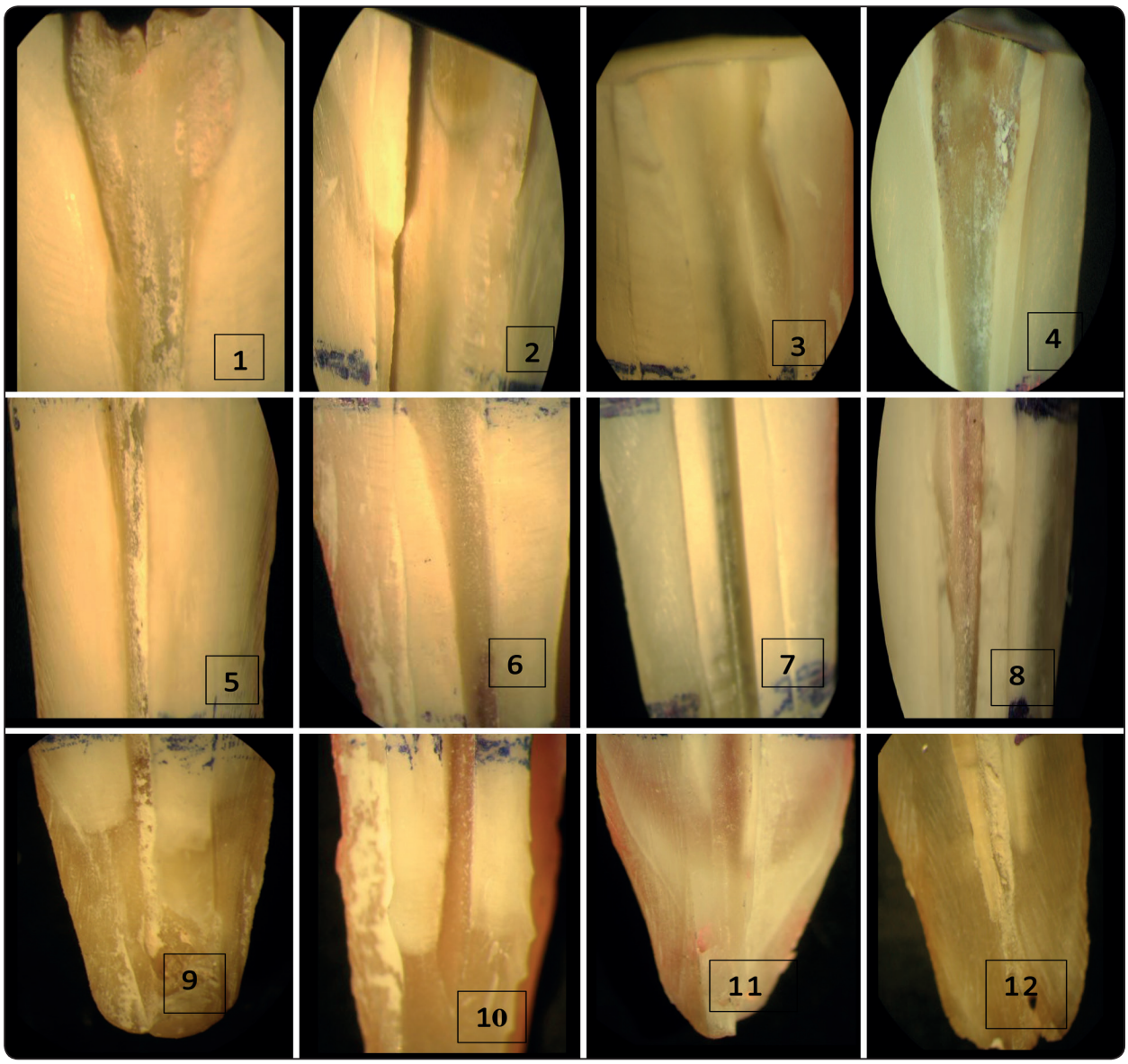


Fig. (1) Representative stereomicroscopic images of A) CSI represented by figures 1) coronal, 5) middle,9) apical thirds showing an increased amount of adherent debris on the root canal walls, B) PUI represented by figures, 2) coronal, 6) middle, 10) apical thirds, c) XP represented by figures , 3) coronal, 7) middle, 11) apical thirds showing decreased amount of adherent debris, D) vibringe represented by figures, 4) coronal, 8)middle, 12) apical thirds.

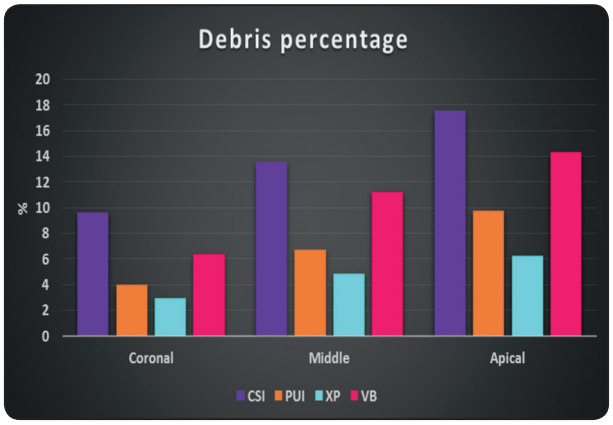


Fig. (2) Bar chart representing mean percentage debris in coronal, middle and apical thirds among various irrigant activation protocols

## DISCUSSION

One of the primary goals of endodntic therapy is the prevention or treatment of apical periodontitis[4]. Complex root canal anatomy presents an ideal location for harboring debris and micoorganisms, complicating complete debridement of the root canal system. [35]. Up to date, no single irrigation solution or technique has been found to achieve complete root canal cleanliness. A general agreement exists about the benefits of using irrigant activation at the end of the canal preparation [23]. Therefore this study was conducted to evaluate the effectiveness of the XP-endo Finisher file in removing debris from oval root canals after instrumentation in comparison to PUI and CSI. Results showed that XP and PUI removed more debris compared with the other irrigant activation techniques, therefore, the null hypothesis that there was no difference between various irrigant activation techniques was rejected.

In the present study, the canals were prepared to a size #40 master apical file, which have been shown to produce superior canal debridement than smaller size apical preparations[36]. NaOCL have been used in this study as it is the most commonly used endodontic irrigant due to its bactericidal and tissue dissolution abilities [37]. Additionally, no chelating agent or intracanal aspiration of irrigant solution was used to avoid the introduction of confounding factors [38].

ImageJ software was used in the present study to evaluate debris percentage. The software is widely used in medical imaging and analysis due to its ability to perform various functions, such particle analyses as well as the capability of converting data to quantitative measures [39].

Syringe irrigation is the basic method for root canal irrigation; but it was found to be inefficient, especially in the apical third of the root canal [40]. The CSI method delivers solutions no further than 0–1.1 mm beyond the needle tip [41]. Debridement efficacy can also be affected by vapor lock that results in trapped air in the apical third which hinder irrigant exchange[42]. CSI showed the worst results regarding debris removal in comparison to the other irrigant activation systems, and that is in agreement with many studies [6,43]. Although a size 30-guage needle was used which is equivalent to a size 30 file allowing it to reach the apical most part of the canal, the apical third was the least effectively cleaned part of the root canal as has been shown by many previous studies [44, 45].

Vibringe was more effective than CSI, but on the other hand was less effective than PUI and XP. In previous studies, ultrasonic irrigation has been demonstrated to be more effective in debris removal compared with sonic activation [26,28,46,], which could be due to the higher driving frequency of ultrasound (30 kHz) in comparison to the sonic device (150 Hz).

PUI and XP-endo Finisher files resulted in more effective debris removal in comparison to CSI and vibringe at all evaluated root levels. This comes in agreement with many studies which stated that PUI was found to be an efficient aid in debris removal and better canal cleanliness [23,38,47,48,49]. PUI-activated irrigation efficiency has been attributed to acoustic microwaves, cavitation as well as heat generation, favouring the removal of dentinal debris [50] .

Results for the XP-Endo Finisher files were promising because its performance was comparable with PUI, a widely used irrigant activation method. This could be attributed to its mettalurgy, at room temperature the instrument is straight in its martensite phase, but at body temperature it changes to the austenite phase and develops a spoon shape; when rotated and moved up and down in the canal, this shape as well as the helical movement of the instrument allowed it to reach previously untouched areas of the canal walls and shake the irrigant solution [31]. In a study by Azim et al, they found that XP- endo finisher appears to be stronger than photon induced photoacoustic streaming and endoactivator in disinfecting the main root canal space and up to 50 mm deep into the dentinal tubules. [51]. In another study by Leoni et al, PUI technique and XP-endo Finisher instrument were associated with significantly lower levels of accumulated hard tissue debris compared with conventional irrigation and the modified self-adjusting file system protocol in mesial root canals of mandibular molars [38]. Alves et al, found that XP-Endo Finisher caused a significant reduction in the bacterial counts after chemomechanical preparation in comparison to PUI.[52].

However, the use of ultrasoniclly activated file has the potential for continued cutting of the canal walls leading to canal deviation, apical zipping, root perforations especially when being used within a curved canal during irrigation [53].This could be an added advantage to XP as it is supposed to be conservative on the dentin as claimed by the manufacturer [31,32].

The results revealed that the coronal thirds were significantly cleaner than the apical thirds irrespective of the irrigation method used. This finding is in agreement with previous studies [54, 55, 56]. This could be attributed to the larger diameter in the coronal area, exposing dentin to larger volume of irrigants which facilitates debris removal [57].

The manufacturer proposed only 1–minute operation time, which represented a restriction on the operator, as this time was not enough to result in complete cleanliness of the root canals. Attempts to test longer operation periods of XP should be carried out to see if it results in better canal cleanliness.

## CONCLUSIONS

Within the limitations of this study, it can be concluded that irrigation of oval root canals using XP-endo Finisher and PUI methods seems to be more effective in the removal of debris compared with other irrigant activation devices. None of the tested irrigation methods in this study resulted in complete root canal debridement. Root canal cleanliness was noticeably improved in the coronal than in the apical root canal region.

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