



# Comparison of Apically Extruded Debris Associated with Different Irrigation Techniques after Removal of Intracanal Medicaments

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## Abstract

**AIM:** This study aimed to compare the effect of XP-endo Finisher file (XPF), passive ultrasonic irrigation (PUI) and conventional irrigation technique using side-vented needle (SVN) on the amount of apically extruded debris after the removal of calcium hydroxide Ca(OH)<sub>2</sub> and double antibiotic paste (DAP).

**MATERIALS AND METHODS:** Sixty extracted human mandibular premolars were used. After decoronation, all canals were prepared up to the ProTaper Next X4 file (Dentsply Maillefer, Ballaigues, Switzerland). After dryness, teeth were randomly assigned into two groups (n = 30) according to the Type of intracanal medication used; Ca(OH)<sub>2</sub> and DAP then incubated at 37°C and 100% humidity. After 1 week, samples in each group were randomly assigned to three subgroups (n = 10) according to the method used for medicament removal: XPF, PUI, and SVN. Debris extruded during the removal procedure were collected into pre-weighed Eppendorf tubes then left to dry in an incubator at 37°C for 15 days. The amount of extruded debris was assessed with an analytical balance and calculated by subtracting the initial weight from the final weight of the tube. Data were statistically analyzed using Kruskal–Wallis and Mann–Whitney U-test.

**RESULTS:** There was no statistically significant difference regarding the amount of apically extruded debris after using the three irrigation techniques in removal of both Ca(OH)<sub>2</sub> and DAP (p = 0.141, Effect size = 0.160) and (p = 0.237, Effect size = 0.073), respectively.

**CONCLUSIONS:** Neither XPF nor PUI increase the risk of intracanal medicament extrusion beyond the apex.

**Edited by:** Mirko Spiroski  
**Citation:** El-Din SN, Ali MM, Hassan R. Comparison of Apically Extruded Debris Associated with Different Irrigation Techniques after Removal of Intracanal Medicaments. Open Access Maced J Med Sci. 2021 Aug 20; 9(D):120-125. https://doi.org/10.3889/oamjms.2021.6094  
**Keywords:** Debris extrusion; Max i probe; Passive ultrasonic irrigation; XP-endo Finisher  
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**Received:** 28-Mar-2021  
**Revised:** 22-Apr-2021  
**Accepted:** 10-Aug-2021  
**Copyright:** © 2021 Shaimaa Nasr El-Din, Magdy M. Ali, Reham Hassan  
**Funding:** This research did not receive any financial support  
**Competing Interests:** The authors have declared that no competing interests exist  
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## Introduction

The main goal of successful root canal treatment is complete elimination of intracanal bacterial population. For this purpose, chemo-mechanical preparation is considered the first option to reduce the microorganism inhabitants including various instrumentation techniques and irrigation protocols. Considering the complexity of root canal morphology, none of the contemporary mechanical preparation techniques can result in bacteria-free root canal system [1]. On the contrary, there is accumulated evidence that significant percentage of the root canal wall is left untouched after mechanical instrumentation [2]. Therefore, additional chemical treatment including intracanal medications is required to disinfect the root canal system and to eliminate and/or decrease the bacteria loads which contribute to the healing of the affected periapical tissue [3], especially in cases where the chemo-mechanical preparation cannot alleviate the symptoms. With the advancement in the field of endodontics, newer antibacterial agents

are being tested such as nanoparticles [4]. However, the two mostly used intracanal medicaments (ICMs) are calcium hydroxide (Ca (OH)<sub>2</sub>) and antibiotic pastes.

Infections of the root canal system are polymicrobial in nature, with both aerobic and anaerobic bacterial species [5]. Thus, a single antibiotic may not be effective in the disinfection of root canals. The use of combination of antibiotics has been suggested to address the diverse flora encountered and decrease the possibility of the development of resistant bacterial strains [6]. The most widely used combination is triple antibiotic paste which consists of metronidazole, ciprofloxacin, and minocycline; this formulation was later modified by the removal of minocycline to avoid tooth discoloration forming double antibiotic paste (DAP) [7].

Intracanal medications should be removed prior to the obturation phase in conventional root canal therapy. The previous studies have shown that remnants of medicaments could directly result on discoloration of the teeth, decrease in root dentin micro-hardness, and act as a physical barrier along the sealer/dentin interface, which hinder the penetration of sealers into the dentinal tubules and negatively affects the quality

of the root filling and subsequently affect the treatment outcomes [8], [9].

Several techniques have been recommended for efficient removal of ICMS, irrigant agitation by passive ultrasonic irrigation (PUI) is the most commonly used method. PUI based on transmission of energy from an ultrasonically oscillating instrument to the irrigant inside the root canal [10].

Another instrument that can be used for agitation is the XP-endo Finisher (XPF: FKG, Dentaire SA, La Chaux-de-Fonds, Switzerland) which is made from a Max-wire alloy. XPF change from martensite phase at room temperature into austenite phase with a curved shape which is able to expand up to 6 mm in diameter to touch and clean highly complex morphologies and difficult to reach areas at body temperature [11].

Despite strict regulation of the working length (WL) during chemo-mechanical preparation, dentin chips, pulp tissue, microorganisms, and irrigants are eventually forced into the periapical tissues from the root canal. This is of concern, as the extrusion of these elements may trigger undesired consequences in the form of acute inflammatory response, post-instrumentation pain; inter appointment flare-up [12], and prolonged periapical healing time [13]. Therefore, in the procedure of root canal treatment, it is of prime importance to prevent debris extrusion. It could be suggested that various techniques used to remove ICMS could also result in debris extrusion.

In subcutaneous tissues, clinical concentrations of  $\text{Ca(OH)}_2$ , DAP can lead to a moderate inflammatory reaction and are cytotoxic to human dental pulp stem cells [7]. The complete removal of these drugs from the root canal with the lowest amount of debris extrusion during the removal is therefore an important step for the success of the treatment.

The ability of different irrigating solutions and activation techniques to remove ICMS have been previously studied [10], [11], [14], however up to the best of our knowledge; no study to date evaluated the weight of apically extruded debris produced by the removal procedure. Thus, the aim of this study was to compare the amount of apically extruded debris resulting from the removal of both  $\text{Ca(OH)}_2$  and DAP in the mature straight root canal with XPF, PUI, and side-vented needle (SVN). The null hypothesis was that there is no difference between different techniques used in the weight of apically extruded debris.

## Materials and Methods

### Sample size calculation

Based on the results of Gawdat and El Asfour [15], the mean values for conventional

syringe, PUI, and XPF groups were (0.006), (0.0009), and (0.0008), respectively. Using a standard deviation of 0.0002 within each group; the effect size (f) was found to be (0.62). Using alpha ( $\alpha$ ) level of (5%) and Beta ( $\beta$ ) level of (20%), that is, power = (80%); the minimum estimated sample size was (10) specimens per instrument in each group, giving a total of (60) specimens in both groups. Sample size calculation was performed using IBM® SPSS® SamplePower® Release 3.0.1.

### Sample selection

Ethical approval was obtained from the ethical committee, Faculty of Dentistry, Minia University, Egypt (Registration no 59/311). Sixty, straight, single-rooted human mandibular premolars, freshly extracted for orthodontic, or periodontal reasons were collected from the Department of Oral and Maxillofacial surgery, Faculty of dentistry, Minia University, Egypt. Teeth were disinfected by immersion in 5.2% sodium hypochlorite (NaOCl; Clorox, HC Egyptian Company, Cairo, Egypt) for 1 h. Soft tissues and calculus were removed mechanically from the root surfaces with a periodontal scaler. Teeth were examined under surgical operating microscope (Global Surgical Corp; USA) for caries, fractures, cracks, or resorptions. Buccolingual and mesiodistal radiographs were taken to evaluate the root canal anatomy and ensure the presence of single root canal. Teeth with curved canals, cracks, resorptive defects, or previous endodontic treatment were excluded from the study.

### Sample preparation

Decornation was done using a tapered diamond stone mounted on low-speed hand piece under water coolant to obtain a standardized root length of 15 mm. Root canal patency was checked and the WL was determined using K-files #15 (Dentsply Sirona, York, PA, USA) placed until it became visible at the apical foramen and subtracting 1 mm from that length of the file. Root canal preparation was performed using ProTaper Next rotary files (Dentsply Sirona, Ballaigues, Switzerland) in a crown-down fashion to the WL with an apical enlargement up to a file size  $\times 4$  (0.40/0.06) using an endodontic motor (X-Smart, Dentsply-Maillefer, Ballaigues, Switzerland) at 300 rpm and 2 Ncm torque according to the manufacturer's instructions. Root canals were irrigated with 2mL 5.25% NaOCl using a 30 gauge (G) SVN (Max-i-Probe, Dentsply, Rinn, IL, USA) at every instrument change. Final irrigation was completed using 5 mL 17% EDTA for 1 min and 5 mL 5.25% NaOCl for 1 min, followed by the final rinse with 5 mL distilled water. Finally, canals were dried using sterile paper points (Dentsply Maillefer, Ballaigues, Switzerland).

### Sample grouping

Samples were randomly divided into two equal experimental groups using a random group allocation online software (<https://www.randomizer.org>) according to the type of ICM used with either  $\text{Ca}(\text{OH})_2$  or DAP ( $n = 30$ ).

### Preparation of the ICMs

In Group A;  $\text{Ca}(\text{OH})_2$  paste (UltraCal<sup>®</sup>; Ultradent, South Jordan, UT, USA) was placed using a Navitip 29G tip (Ultradent, South Jordan, UT, USA) starting 1 mm shorter than WL then moved coronally until the paste was visible at the canal orifice.

In Group B; DAP was prepared by grinding an equal number of tablets of 500 mg metronidazole (Flagyl; Aventis, Cairo, Egypt) and 500 mg ciprofloxacin (Ciprofar; pharco, Alexandria, Egypt). The powder (1:1) was then mixed with distilled water. The paste was applied to the canal spaces with 3 cm plastic syringe.

In both groups, excess material extruded from the apex was wiped off with moist cotton, cotton pellets were placed over the canal orifices, and a temporary sealing material (Cavit G; 3M ESPE, Seefeld, Germany) was used to seal the access cavities. Then, all samples were stored at 37°C in 100% relative humidity for 1 week.

### Debris extrusion collection

The experimental model described by Myers and Montgomery in 1991 [16] was used in this study. The stoppers of Eppendorf tubes were removed, and tubes were numbered and weighed using an analytical balance (Adam Equipment Co. Ltd, MK10 0BD. UK) with an accuracy of  $10^{-4}$  g. Three consecutive weights were obtained for each tube, and the mean value was considered to be its initial weight (W1). A hole was created with a heated instrument in the center of the rubber stopper of each tube, and then each tooth was inserted under pressure into the rubber stopper and fixed at the cemento-enamel junction using cyanoacrylate glue. A 27G needle was placed alongside the cover as a drainage cannula to equalize the internal and external air pressure. Next, each unit including the stopper, tooth and needle, was fixed to its Eppendorf tube. The tubes were fitted into vials to hold the device during preparation. The operator was blinded from seeing the root apex during the removal procedure by covering the vial with aluminum foil. In each group, samples were randomly divided into three equal subgroups ( $n = 10$ ) as follows;

#### Subgroup I; (XPF)

The specimens were rinsed with 10 mL distilled water using a 30G SVN (Maxi-i-probe, Dentsply, Rinn,

IL, USA) placed 1 mm from the WL with a flow rate of approximately 5 mL/min. XPF file (size 25, 0.00 taper) (FKG, LaChaux-de-faund, Switzerland) was used with an endodontic motor (X-Smart, Dentsply-Maillefer, Ballaigues, Switzerland) at 800 rpm and 1 Ncm torque according to the manufacturer's instructions [17]. The file was inserted 1 mm shorter than the WL which was adjusted using the plastic tube to fix the rubber stopper. The canal was filled with irrigant and the finisher was operated for 60 s using slow and gentle 7–8 mm lengthwise in-and-out movements. Each file was used for one canal in order to prevent interfering with the debris extrusion results.

#### Subgroup II; (PUI)

Using IrriSafe ultrasonic tip (size 25, 0.00 taper) (Acteon, France) mounted on an ultrasonic system (Newtron P5; Satelec, Acteon group, France) in an endo power setting at the 5<sup>th</sup> power. The root canal of each specimen was rinsed with 10 mL distilled water using 30G SVN (Max-i-Probe, Dentsply, Rinn, IL, USA) placed 1 mm from the WL with a flow rate of approximately 5 mL/min. Then, the IrriSafe tip was inserted into the canal 1 mm short of the WL, and the irrigant was ultrasonically activated for 20 s. This sequence was repeated 2 more times; the tip 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 tip by Jiang *et al.* [18]. Each tip was used for one canal to prevent interfering with the debris extrusion results.

#### Subgroup III; (SVN)

Root canals were rinsed with 10 mL distilled water using a 5 mL disposable plastic syringe and 30G SVN (Max-i-Probe, Dentsply, Rinn, IL, USA). The needle was inserted passively up to 1 mm short of the WL with a flow rate of approximately 5 mL/min. During irrigation, the needle was constantly moved up and down within the apical third.

The irrigants temperature, flow rate, volume, and activation time were standardized for all groups. Rubber stoppers were placed on the XPF, IrriSafe ultrasonic tip, and the needle at the required length to ensure length control. In all groups, saline solution was warmed to 37°C before use to allow the XPF to work optimally at the austenite phase.

### Assessment of debris extrusion

On completion of the intracanal removal procedure, the stoppers, needles, and teeth were gently removed from their tubes and vials, then the debris adhered to the root surface were collected by washing off the apex with 1 mL of distilled water into the tube. Eppendorf tubes were stored in an incubator at 37°C

for 15 days to evaporate the moisture before weighing the dried debris. Weighing procedure was carried out again using the same balance and three consecutive weights were obtained for each tube, followed by calculating the mean. These measurements considered to be the weight of the tube plus the debris (W2). The dried weight of the extruded debris was calculated by subtracting the weight of the empty tube from that of the tube containing debris (W2-W1).

All root canals were prepared, by the same experienced operator (S.N) to reduce inter-operator variability, while measurements were done by an examiner who was blinded to the study groups (R.H).

### Statistical analysis

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov–Smirnov and Shapiro–Wilk tests). All data showed non-normal (non-parametric) distribution. Data were presented as median, range, mean and standard deviation (SD) values. Mann–Whitney U-test was used to compare between the two materials with each technique. Kruskal–Wallis test was used to compare between the three irrigation techniques. Dunn’s test was used for pair-wise comparisons when Kruskal–Wallis test is significant. The significance level was set at  $p \leq 0.05$ . Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.

## Results

Figure 1 shows the median and range values of the amount of apically extruded debris of the

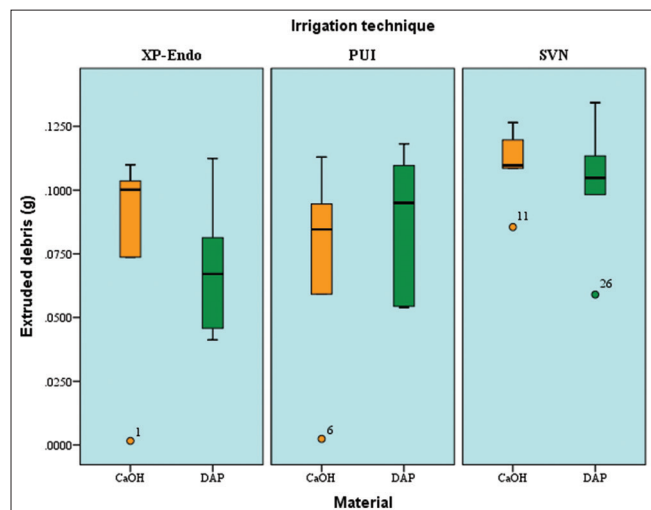


Figure 1: Box plot representing median and range values for the amounts of apically extruded debris in medicaments (circles represent outliers)

two materials; there was no statistically significant difference regarding to the amount of apically extruded debris between the two medicaments using XPF, PUI, and SVN ( $p = 0.602$ , Effect size = 0.335). As regard  $\text{Ca(OH)}_2$  and DAP group; in each group there was no statistically significant difference in the amounts of apically extruded debris after using the three irrigation techniques ( $P$ -value = 0.141, Effect size = 0.160) and ( $p = 0.237$ , Effect size = 0.073), respectively (Table 1).

**Table 1: Descriptive statistics and results of Kruskal–Wallis test for comparison between apical extruded debris after using the three irrigation techniques**

Irrigation technique	$\text{Ca(OH)}_2$		DAP	
	Median (range)	Mean (SD)	Median (range)	Mean (SD)
XPF	0.1002 (0.0016–0.1099)	0.0778 (0.0448)	0.0671 (0.0413–0.1124)	0.0696 (0.0289)
PUI	0.0846 (0.0024–0.1130)	0.0707 (0.0429)	0.095 (0.054–0.1181)	0.0862 (0.0304)
SVN	0.1097 (0.0855–0.1265)	0.11 (0.0156)	0.1048 (0.059–0.1343)	0.102 (0.0276)
$p$	0.141		0.237	
Effect size (Eta Squared)	0.160		0.073	

non-significant ( $p > 0.05$ ). XPF: XP-endo Finisher file, PUI: Passive ultrasonic irrigation, SVN: Side-vented needle,  $\text{Ca(OH)}_2$ : calcium hydroxide, DAP: Double antibiotic paste, SD: Standard deviation.

## Discussion

Every effort should be made to reduce the apical extrusion of debris, bacteria, and irrigants beyond the apex as it could result in undesirable consequences such as induction of inflammation and inter-appointment flare-ups [12], [19] in addition to postoperative pain, and delayed periapical healing where the incidence of these complications is reported to range between 1.4% and 16% [20].

Apical extrusion of debris and irrigants was found to be influenced by many factors such as; root canal anatomy, instrument size, type, canal preparation technique, apical enlargement, apical stop, irrigation solutions, techniques, and devices, in addition to canal curvature and the presence of more than one canal [21], [22], [23]. Therefore, only single rooted teeth with straight canal were used in this study in a trial to eliminate variables which might interfere with the results. In addition, mature teeth were only included; ruling out teeth with incomplete root growth where dentin mineralization is less intense than mature teeth, making them more susceptible to wear, leading to increased extrusion [12]. The length of root canals was standardized by sectioning the crowns in a trial to homogenize the amount of ICM placed in all teeth.

Shuping *et al.* [24] showed that placement of  $\text{Ca(OH)}_2$  for at least 1 week rendered 92.5% of canals bacteria free. Removal procedure in the current study was performed after 1 week to simulate the clinical situation. Changes in surface properties and deterioration of the mechanical properties of root canal dentin were previously demonstrated when endodontic medicaments were used for long-term periods [25].

Distilled water was used as an irrigant in the present study to highlight the potential effect of the activation techniques merely and to avoid the possible crystallization of NaOCl, which could change the weight of the apically extruded debris and compromise the reliability of the results [26].

The extrusion of irrigants is affected by the depth of needle tip placement. The further the needle is positioned coronally, the less apical pressure is developed, but the irrigant exchange becomes less efficient [27]. For standardization purpose, the needle was placed 1 mm short of the WL in all groups, needle binding into the root canal walls was avoided to prevent pushing material into the periapex.

One of the limitations of the present study was the inability to simulate the intracanal temperature, while the XPF instruments can only function properly at body temperature (austenitic phase) [17]; however, placing the teeth in hot water bath as mentioned in other studies such as Hamdan *et al.* [28] would have an impact on the solubility of the ICMs plus disturbing the debris extrusion results. To overcome this limitation, distilled water used as irrigant was preheated to 37°C to mimic body temperature.

Result showed that, all irrigation techniques used were associated with some level of apically extruded debris without significant differences between them (Figure 1), ( $p = 0.141$ , Effect size = 0.160) and ( $p = 0.237$ , Effect size = 0.073) in both  $\text{Ca}(\text{OH})_2$  and DAP, respectively, thus the null hypothesis was accepted. This was in line with a previous study by Dos Reis *et al.* [29] who showed no significant difference in the irrigant extrusion between no agitation group, ultrasonic agitation with Irrisonic, ultrasonic agitation with Irrisonic Power, mechanical agitation with Easy Clean and the XPF. On the other side, a study conducted by Gummadi *et al.* [22] concluded that during instrumentation; conventional irrigation extruded significantly more debris apically compared to PUI. This could be explained as open-ended needles generate positive pressures in excess of central venous pressure, as stated by Khan *et al.* [30]. Also Boutsoukis *et al.* concluded that, during open-ended needle irrigation there is an increased pressure at the apical foramen indicating increased risk of extrusion toward the periapical tissue [27].

SVN showed the highest amount of apically extruded debris relative to XPF and PUI for both ICMs. The results are in line with a study by Tambe *et al.* [31] and Dos Reis *et al.* [29]. Even with closed-end needles extrusion may occur, as the root canal cross-section is not perfectly circular thus, irrigant access to the apical area might not be completely blocked by the needle tip Pshima *et al.* [32].

Both XPF and PUI caused less debris extrusion than the SVN, the lack of conicity of both instrument and its use in back and forth movements in the canal allow the irrigant to be pushed in coronal direction, which may

have minimized its pattern of apical extrusion Keskin *et al.* [33]. Moreover, instruments with a lower taper probably favor lower volumes of apical extrusion as they provide a larger area of debris escapement space in the coronal direction which is the case with XPF and PUI [29].

## Conclusions

XPF or PUI did not increase the risk of ICM extrusion beyond the apex. Further clinical trials on the post-operative pain incidence after the removal of ICMs using different activation techniques are required.

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