Comparative evaluation of efficacy of different irrigation devices in removal of calcium hydroxide in teeth with simulated internal resorption cavities – An in vitro study

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Abstract

Aim: The aim of this in vitro study was to compare the efficacy of newly developed irrigation systems, i.e., XP-endo Finisher file (XP-endo), EndoActivator (EA), and Endo-Irrigator Plus (EI) with gold standard passive ultrasonic irrigation (PUI) tip and in removal of calcium hydroxide (CH) from single-rooted teeth with artificial simulated internal resorption cavities.

Materials and Methods: One hundred and twenty single-rooted mandibular premolars were decoronated and prepared using the ProTaper Gold system up to F5. Samples were buccolingually sectioned and resorption cavities were prepared. Twenty specimens were served as Group 1 – negative control. In the remaining specimens, CH was delivered and root halves were brought together. Twenty specimens were served as Group 2 – positive control. The remaining specimens were randomly divided into four experimental groups (n = 20), where NaOCl and EDTA were activated using PUI, XP-endo, EA, and EI for 1 min. The remnants of CH were scored and analyzed by employing Kruskal–Wallis H- and Mann–Whitney U-tests.

Results: PUI and XP-endo removed more CH than other devices (P < 0.05), showing no significant difference between them.

Conclusion: None of the tested systems were able to remove CH completely from resorption cavities. PUI and XP-endo were superior to other tested devices.

Keywords: Endo-Irrigator Plus; intracanal medicament; irrigation; XP-endo finisher

INTRODUCTION

The principal goal for a successful endodontic treatment is to remove vital and necrotic remnants of pulp tissues, microorganisms, and microbial toxins from the root canal system. As there are abundant studies of evidence ascertained that complete debridement of root canal through chemomechanical preparation, cleaning, and shaping is nearly impossible due to its intricate nature.[1-4] Therefore, the placement of calcium hydroxide (CH) as intracanal medication has been implemented to facilitate complete disinfection from the complex structures of the root canal.[1,2,5] Researchers have shown that remnants of CH on dentinal walls affect the penetration of sealers, increase apical leakage, and react chemically with obturating materials, thus interfering with their properties which cause compromising the quality of the seal provided by endodontic root filling materials. Therefore, the complete removal of CH from the root canal before obturation is recommended.[1,2,5] However, numerous

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studies reported the inability of manual irrigation with sodium hypochlorite (NaOCl) or other irrigants to remove intracanal dressings completely, therefore, a combination of antimicrobial action with tissue-dissolving solutions and mechanical activation of irrigant has been proposed to ensure the complete removal of intracanal medications.[1,2,6]

Several studies on mechanical activation of irrigant reported the efficacy of passive ultrasonic irrigation (PUI) as the gold standard for chemical irrigant activation. It removes more intracanal medicament, yet it is unable to remove complete CH.[7,9] Therefore, the present study deals with comparison of efficacy of following traditional and recently introduced devices for irrigation of CH from the root canal system.

PUI (Irrisafe, France) was introduced to increase the effectiveness of canal disinfection by agitating the irrigation solution previously placed inside the canal.[1,2,6,10,11] A new file system, XP-endo (FKG Dentaire, Switzerland), has been designed to follow any root canal preparation to reach and clean highly complex morphologies.[2,11-13] EA (Dentsply, Tulsa) is a sonically-driven canal irrigation system that effectively removes the smear layer and debris when used with demineralizing agents such as EDTA by producing vigorous intracanal fluid agitation.[1,2,11,14] Recently, EI (KDent, India) a novel irrigation delivery device based on the concept of continuous warm activated irrigation and evacuation system has been introduced.[15-17]

To date, studies evaluating these recently developed irrigation systems in removal of CH from resorption cavities are limited. Thus, the present study was conducted to evaluate the efficacy of these different irrigation devices in removal of CH in teeth with simulated internal resorption cavities.

MATERIALS AND METHODS

One hundred and twenty freshly extracted, noncarious, intact, single rooted having single canal human premolars were selected for this study. To obtain a standardized root length, all samples were decoronated at 12-mm length from the apex using sterile diamond disks (DFS mi, Germany) [Figure 1a]. Patency of root canals was established and pulp tissue was extirpated by inserting #10 K-file (Dentsply Maillefer, Ballaigues, Switzerland). Working length (WL) was determined by introducing #15 K-file was introduced into canals to loosen CH, which created a space for irrigation needle and were filled with 5% NaOCl and randomly divided into four groups as follows (n = 20). In Group 3 – For activation 15/0.02 PUI tips (Irrisafe, Satelec, Acteon Group, France) were mounted on a piezoelectric ultrasonic unit (EMS) with power setting at 6. The tip was placed 1 mm short of WL without touching canal walls, enabling it to vibrate freely for 1 min [Figure 1g]. In Group 4 – XP-endo file was used as recommended by the manufacturer. This was inserted into root canals at a speed of 800 rpm and maximum torque of 1 N.cm using torque-limited electric motor for 1 min with amplitude of 6–7 mm to full WL [Figure 1h]. In Group 5 – EA was used with medium tip size 25/0.04 taper was inserted into root canals 2-mm short of the WL and activated for 1 min at 10,000 cpm [Figure 1i]. In Group 6 – EI was used for the placement and activation of 5% warm NaOCl by heated up to 50°C, which was placed into root canals with the help of positive pressure tips for coronal one-third and negative pressure tips for the apical area. Irrigation was accompanied by simultaneous evacuation for 1 min [Figure 1j]. Finally, specimens were irrigated with 2 ml of normal saline, 2 ml of 5% NaOCl, 2 ml of 17% EDTA, and 2 ml of normal saline, respectively. The root halves were taken out from mold and separated. Images of internal resorption cavities were taken by digital DSLR camera of 1:1 macro lens and were scored according to the following classification [Table 1].[18]
Shapiro–Wilk test was used for normality and scores revealed that data were not normally distributed. Therefore, a nonparametric test has been used for further analysis. An alternative test to ANOVA, Kruskal–Wallis H-test was used to allow comparison of more than two independent groups. The test showed that there was a statistically significant difference among the tested group in CH removal at \( P = 0.05 \). For intergroup comparisons, Mann–Whitney U-test was employed.

**RESULTS**

Mann–Whitney U-test results revealed that scores of positive and negative control groups were significantly different from all tested groups \( (P < 0.05) \). None of the tested groups were able to remove complete CH paste from simulated internal resorption cavities. PUI and XP-endo file showed superior and effective results as compared to all other experimental groups. EndoActivator (EA) showed similar results to XP-endo but significant difference with PUI whereas Endo-Irrigator Plus (EI) showed the least amount of CH removal at \( P < 0.05 \) [Table 2].

**DISCUSSION**

The main challenge in internal root resorption (IRR) cases is treating the irregularity of the resorptive cavity. Recent stats disclosed that 35% of premolars and molars root canal complexities retained necrotic pulp tissues and debris after instrumentation due to lesser contact to root walls. To date, CH is the material of choice for disinfection of root canal complexities, but before obturation CH should be removed completely. Several authors found that the complete CH removal using master apical files and conventional irrigation systems is ineffective.\[1,2,4-9,11\]

Nowadays to increase the efficacy of canal irrigation, activation of irrigants is done using ultrasonic or sonic tips and finisher files to remove more CH from IRR cavities. In this study, effective irrigation of PUI, XP-endo, EA, and EI was compared and results showed that PUI removed significantly more CH than EA and EI [Table 1]. Surprisingly, XP-endo scores were not significantly different from PUI and both removed a larger quantity of CH from artificial IRR cavities. As consistent with previous research, results from this study also indicated that none of the proposed techniques removed 100% of CH from artificial IRR cavities.\[1,2,7-9,14,19-21\] Although to facilitate scoring without bias, cavities were made by no. 2 round diamond bur to standardize dimensions, location of resorption cavities, and quantity of medicament used.\[22,23\]

Based on the results of this study [Figure 3], PUI and XP-endo were able to remove complete CH in 55% of specimens, where IRR cavities were free of any debris which was significantly higher than EA (25%) and EI (5%). Several

### Table 1: Scores corresponding to calcium hydroxide remnants filled in the cavity

| Score | Occupation of the cavity with CH remnants | Refer figure |
|-------|------------------------------------------|-------------|
| 0     | Free of CH debris                        | Figure 2a   |
| 1     | Less than half was filled with CH debris | Figure 2b   |
| 2     | More than half was filled with debris    | Figure 2c   |
| 3     | Completely filled with debris            | Figure 2d   |

CH: Calcium hydroxide
authors explained that during PUI, acoustic microstreaming and cavitation can cause a streaming pattern within the root canal from apical to coronal, which removes CH more effectively\cite{1,2,6,7-9,11,14,19-21} as compared with sonic (EA) and syringe delivery (EI) system. Therefore, similar to previous studies,\cite{1,2,6,7-9} this study also concluded that PUI possesses a great aptitude for clearing remote areas. For adequate acoustic flow and cavitation effect, proper enlargement of the root canal was required therefore canals were instrumented until F4, which promotes greater penetration of irrigation solution.\cite{1,2,19} Moreover, various authors showed its inability to remove complete CH from IRR due to its excessive turbulence production in the root canal, results in retention of debris and inability of irrigant to penetrate into eccentric areas. It is possible that it pushes more debris into narrow isthmus regions.\cite{15-17} Kenee et al.\cite{23} reported that longitudinal sectioning might more precisely allow for measurement of complete canal area and facilitate scoring. For exact reapproximation of root halves, individual molds were created for each specimen and stored at 37°C and 100% humidity which represent the natural environment of the oral cavity, so does in the present study also.

The new XP-endio Finisher file (XP-endio) tested in this study removes CH as effective as PUI, as manufacturer claims that this is a potential tool to clean highly complex morphologies and inaccessible irregularities that are otherwise impossible to reach with standard instruments. This enhanced effect may be attributed to its flexible and spoon-shaped structure, which creates irrigant streaming powerful enough to dislodge CH. It can expand up to 6 mm in diameter, and thus is claimed to allow mechanical cleaning. The file design is based on shape-memory principles of NiTi alloy; it was straight in M-phase (30°C) and changes its molecular memory to a spoon-like shape in A-phase when exposed to canal temperature, which allows the file to contract and expand according to root canal anatomy. XP-endio showed superior performance in removal of CH, double antibiotic paste, smear layer, debris, or biofilm from a curved root canal in previous studies.\cite{20} On the other hand, Wigler et al.\cite{21} reported that manufacturer claims of the file reaching irregularities of root canal anatomy were not fulfilled due to 1-min operation time which was not sufficient for irrigant activation.

EA results do not show any significant difference with XP-endio, it is a sonically driven device and it was designed to improve the irrigation phase by energizing irrigants with a flexible, noncutting polymer tip. The effectiveness of irrigation could depend on both mechanical flushing action and chemical ability to dissolve tissue. The velocity produced by sonic irrigation has been reported below the threshold required to create cavitation that might be attributed to its inability to remove CH from IRR cavities.\cite{1,2,11,14,20}

In the present study, EI showed the least amount of removal of CH from IRR cavities at $P < 0.05$ level [Table 1]. As a result of several studies, EI shows better results than PUI in removing biofilms and pulp tissues from isthmus areas, but in this study, it shows significantly lesser results than any other group in removing CH. Since this device was only delivering the warm irrigant for activation, it was inefficient in removing CH from inaccessible areas.\cite{15-17}

According to the results of this study, advanced irrigation devices such as PUI and XP-endio were more effective than traditional methods in removal of CH from inaccessible areas of the root canal system which affects the prognosis of root canal treatment.

**CONCLUSION**

Within the limitations of the study, it was concluded that none of the irrigation techniques were able to remove CH completely from artificial internal resorption cavities. Here, PUI was superior to all other irrigation devices and XP-endio removed CH as effectively as PUI, but superior to EA and EI plus.

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Table 2: U and P values after intergroup comparison using Mann-Whitney U-test, which shows significant differences between experimental groups

| Groups     | $U_1$ | $U_2$ | Lowest value among $U_1$ and $U_2$ | P (α = 0.05) | Significance (lowest value = 127) |
|------------|-------|-------|-----------------------------------|--------------|----------------------------------|
| PUI-XP     | 184   | 216   | 184                               | 0.5303       | Nonsignificant                   |
| PUI-EA     | 116   | 284   | 116                               | 0.0192       | Significant                      |
| PUI-EI     | 93.4  | 342.6 | 93.4                              | 0.0004       | Significant                      |
| XP-EA      | 140   | 260   | 140                               | 0.0689       | Nonsignificant                   |
| XP-EI      | 106.8 | 287.2 | 106                               | 0.0137       | Significant                      |
| EA-EI      | 172   | 228   | 172                               | 0.3005       | Nonsignificant                   |

PUI: Passive ultrasonic irrigation, EA: EndoActivator, EI: Endo-Irrigator

Figure 3: Percentage of CH removal in samples per score in each group: NC, PC, PUI, XP-endo, EA, and EI

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Conflicts of interest

There are no conflicts of interest.

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