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# Comparison of the mechanical efficacy of sonic activated irrigation and passive ultrasonic irrigation for intracanal medicaments removal

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## ABSTRACT

### Comparison of the mechanical efficacy of sonic activated irrigation and passive ultrasonic irrigation for intracanal medicaments removal

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Objectives: This study compared the mechanical efficacy of sonic activated and passive ultrasonic irrigation for removing intracanal medicament from a simulated root canal under controlled conditions. Materials and Methods: Thirty simulated root canal in resin blocks were randomly divided into 3-groups. The canals were enlarged using ProTaper files and K3XF (#30/0.06). After cleaning and drying, canals were filled with Calcipex. Overfilled materials were wiped out and measured their weight to the unit of 1/10mg. After one week storage in 100% humidity 37℃ temperature, canals were irrigated using 20mL of saline with one of following methods according to the designated groups (n = 10). For group-NI, 30-gauge nickel-titanium irrigation needle was used. During irrigation with every 5mL, needle was moved in-and-out with 4-mm amplitudes. EndoActivator and ultrasonic tip were used for group-EA and group-UT respectively for 20 seconds after every 5mL irrigation using needle. Then the weight was measured again to calculate the weight of residual remnants. The data were analyzed by one-way ANOVA and Duncan's post-hoc test at a significance level of 95%. Results: The weight of the residual medicaments were 3.62±0.81 mg, 2.84±0.28 mg, and 2.73 ±0.90 mg for group-NI, -EA, and -UT, respectively. Group-EA and group-UT had no significant differences to remove intracanal medicament and left significantly less amount of paste than group-NI ($p < 0.05$). Conclusions: Under the controlled conditions of this study, the sonic activation and PUI have similar mechanical efficacy for removing intracanal medicament.

Key words : calcium hydroxide; EndoActivator; intracanal medicament; passive ultrasonic irrigation; sonic activation

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## Ⅰ. Introduction

There are many reasons of endodontic failure and the presence of microorganisms would be a primary reason for failure[1, 2]. To reduce the level of bacteria of the infected canal, intracanal medicaments are usually placed in the canal between appointments[3]. Irrigation with antimicro bial agents and placement of an intracanal medicament are regarded as clinical principles as much as mechanical instrumentation[4].

Calcium hydroxide(CH) has been widely accepted as the most frequently used intracanal medicament by virtue of its biocompatibility and good antimicrobial properties against the vast majority of endodontically relevant pathogens[3, 4]. When medicaments are used between visits, an arising concern is the extent to which all traces of the medicament can be removed from the canal, so as not to interfere with the placement, setting or polymerization of the materials used for the final root canal filling[5]. The CH residues in the root canal system influence dentine bond strength as well as penetration of sealers into dentinal tubules[6, 7]. Kim and Kim also found that residual CH in the canal might increase apical leakage after root canal obturation when zinc oxide-eugenol sealer is used[8]. The remnants could also react chemically with the sealer and affect the hermetic seal of the permanent root canal filling[5, 8].

Therefore, the complete and predictable removal of CH dressing before the root canal filling is critical and could be directly related to the outcome of treatment[9]. The efficacy of CH removal has been investigated for a range of products and techniques[9~14]. Typically, bulk of medicament pastes is removed mechanically by using an endodontic file, followed by several cycles of irrigation with sodium hypochlorite or ethylenediaminetetraacetic acid (EDTA)[4, 15]. Several studies have been performed to assess the efficacy of different techniques on the removal of intracanal dressings from the root canal, e.g. using rotary nickel-titanium instru ments, a patency file or different devices for the activation of intracanal solution to improve the mechanical flushing action of the irrigant[4, 10~13].

In various researches, they have compared the CH remnants by scanning electronic microscope (SEM) evaluation in a certain area, mainly in apical thirds or three areas of root canal with level differences[13, 14, 16]. In these methods, the limited inspection area may result in failure to reflect whole remnants and/or the removing activity because it is quite difficult to measure the thickness(or volume) of remnants. Further more, the numerical scoring using digit numbers

(0, 1, 2, etc.) may have big deviation on the examiners' decision. The anatomical condition of the canal wall in natural teeth may interfere with the exact comparison of the sole mechanical function of the instruments for CH removing.

Therefore, it would be valuable to compare the efficacy of CH removing without aforementioned methodological limitations. The present study compared the efficacy of sonic activation and passive ultrasonic irrigation for removing intracanal medicament from the simulated root canal in resin block under controlled condition using weight measurement method.

## Ⅱ. Materials and methods

Thirty simulated root canals in resin blocks (Dentsply Maillefer, Ballaigues, Switzerland) were randomly divided into 3 groups(n = 10) according to the irrigation methods. The canals were enlarged by using nickel-titanium rotary files with ProTaper(Dentsply Maillefer) of sizes S1, S2, F1, F2 and followed by K3XF(Sybron Endo, Glendora, CA, USA) to size #30/0.06 taper. Canals were cleaned thoroughly and dried for one week in room temperature. Then the canals were filled with Calcipex(Nippon Shika Yakuhin Co., Shimonoseki, Japan). After over filled materials were wiped out, the filled canals were weighed in the unit of 1/10 mg using micro-balance(Discovery; OHAUS, Parsippany, NJ, USA). Then canal blocks were stored in 100% humidity 37℃ for one week. After one week storage, canals were irrigated using 20 mL of saline with one of the following methods according to the designated groups(Fig. 1).

Needle irrigation(group-NI): 30-gauge nickel-titanium notched open-end needle(NiTi Super-Flex; SybronEndo) was used. After every 5 mL of irrigation procedure, needle was moved with in-and-out motion of 4-mm amplitudes in a speed of approximately 120 times per 50 seconds. The tip was inserted 2 mm short of the working length. EndoActivator(Dentsply Maillefer, Santa Barbara, CA, USA)(group-EA) and ultrasonic irrigation tip(DH tip; EP dent, Seoul, Korea)(group-UT): They were used for 20 seconds after every 5 mL irrigation, respectively. EndoActivator was set at maximum power(166 Hz) and medium tip(red; #25/0.04 taper) was attached for sonic vibration. The tip was inserted 2 mm short

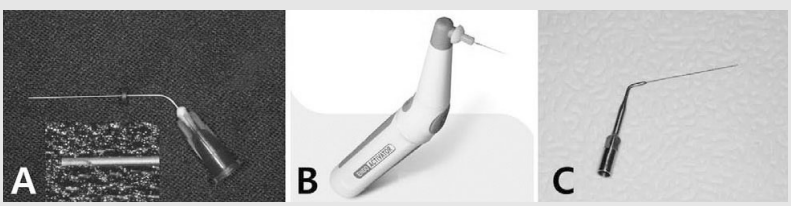


Fig. 1. Instruments used in this study for canal irrigation. A. 30-gauge nickel-titanium notched open-end needle (NiTi Super-Flex; SybronEndo), B. EndoActivator (Dentsply Maillefer), C. ultrasonic irrigation tip (DH tip; EP dent).

of the working length and activated. Ultrasonic vibration was delivered with the ultrasonic tip(DH tip) using an ultrasonic handpiece (Shinhung, Seoul, Korea) mounted on dental unit chair. The tip was inserted 2 mm short of the working length and passively activated by using a minimal power setting consistently, according to manufacturer's recommendation.

Then the canal blocks were dried in room temperature without using paper point for preserving the medicament residue. After three days for sufficient natural evaporation to remove the residual saline, the weight measured again to calculate the weight change. The data were analyzed by one-way ANOVA and Duncan's post-hoc test at a significance level of 95%.

## Ⅲ. Results

The pre- and post- irrigation weight of resin blocks for each groups were shown in Table 1. The weight of the residual medicament in the tested groups were 3.62 ± 0.81 mg, 2.84 ± 0.28 mg, and 2.73 ± 0.90 mg for group-NI, -EA, and -UT, respectively. Group-EA and group-UT had no significant differences to remove intracanal medicament and left significantly less amount of CH paste than group-NI($p < 0.05$).

## Ⅳ. Discussion

The complex anatomy of the root canal system (lateral canals, isthmuses, fins and accessory canals) not only prevents the penetration of irrigants and medicaments into mechanically untouched space but also interfere with the removal of medicaments from the canals.1 The advent of sonic, ultrasonic and laser instruments has led to many investigations looking into their potential for the energizing of irrigants and removing the medicaments[1, 10, 11, 13, 17].

Conventional syringe irrigation method has been a standard procedure, in spite of an insufficiency in the apical part of the root canal[18]. Therefore, to overcome this limitation, other systems have been introduced and the activation of the irrigant should be considered as a solution because it results in cleaner areas when compared with conventional irrigation, increases tissue dissolution, and significantly

Table 1 The weight (unit; mg) of pre- and post-irrigated resin block of simulated canal and medicament residue (mean ± standard deviation)

| Method \ Weight | Pre-irrigation | Post-irrigation | Medicament Residue |
|---|---|---|---|
| Syringe needle | 3461.28 ± 16.97 | 3426.00 ± 15.62 | 3.62 ± 0.81[a] |
| EndoActivator | 3467.16 ± 9.91 | 3430.32 ± 10.07 | 2.84 ± 0.28[b] |
| Ultrasonic tip | 3459.16 ± 9.94 | 3421.04 ± 10.25 | 2.73 ± 0.90[b] |

a,b; Groups with different superscript showed significantly different ability to remove calcium hydroxide medicaments ($p < 0.05$).

reduces the number of bacteria present inside the root canal system[1, 4, 9~12, 19~22].

In previous researches for the functional comparison, the passive ultrasonic irrigation (PUI) method was revealed to have superior abilities to remove the CH medicaments from the root canals[9~12]. The combination of passive ultrasonic activation for CH removal results in significantly lower amounts of remnants in the canal compared with sonic irrigation[11]. The PUI activation was also significantly more efficient for debris removal than sonic irrigant activation[20, 22, 23]. However, in some in-vitro tests the sonic activation methods and PUI were reported to have similar ability of irrigant penetration, and resulted in better cleaning in the apical third of curved root canals than syringe irrigation method[17, 24].

Aforementioned results were controversial whether the technique of PUI was better than the sonic activation or not. These in-vitro study methods may have some limitations such as anatomical variation of natural extracted teeth and canals, limited inspecting area(not all the canal wall), and erroneous scoring. Methodolo gically, the way of comparing methods may be debatable because their scoring methods depen ding on the visual inspection and localized area for SEM evaluation may have deviated results[13, 16, 23]. On the contrary to the SEM method which enables the inspection and evaluation only localized areas, the photographic method may evaluate whole root canal surface from apical to coronal. However, this method neither evaluates the thickness of the remnants. In a study using micro-CT evaluation method, only some of the axial sections were used for scoring and then have same limitation[9].

The simulated root canals used in this study were quite remote from clinical reality, however it could reduce the anatomical limitation and chemical effects from root canals / dentin and irrigants. And we could weigh exactly(accuracy to the unit of 1/10 mg) the amount of medicament remnant and therefore it was possible to compare the efficacies of sonic activation and PUI by weighing the medicament remnant.

The results in the present study showed that the PUI method and sonic activation have statisti cally similar in regard to removal of the CH paste from the root canal. This result is coincident with the results from de Gregorio et al. and Blank-Gonçalves et al[17, 24]. However, it was different from Jiang et al. and Al-Jadaa et al. who reported the ultrasonic activated irrigation was better than the sonic irrigation[20, 23]. These differences may result from the different experimental conditions as fore-described.

Conventional needle irrigation alone showed significantly less penetration of the irrigant into the lateral canals and was limited to the level of penetration of the needle[17]. When using positive-pressure irrigation only, irrigant replacement was limited to 1 to 1.5 mm apical to the needle tip. The sonic and ultrasonic activation has different mechanism of action each other, which generate different frequency and intensity. Nevertheless, they resulted in the enhanced irrigant replenish ment at the apical third, breaking the vapor lock and moving the solutions apically and laterally[17].

EndoActivator, a species of sonic-activated devices, were introduced to improve the irrigation phase[19] and has been shown to better irrigate in comparison with traditional needle irrigation alone[17]. EndoActivator has polymer-based tips that do not damage the canal wall, instead of metal alloys for generating ultra sound[20, 25]. It uses sonic wave(low frequency than ultrasound) resulting in less extrusion of debris than ultrasound[11].

The fact that ultrasonic activation removed significantly more dentin debris than the sonic activation substantiates the study of Sabins et al[26]. A possible explanation is that the driving frequency of ultrasound(30 kHz) is higher than that of the sonic device(160-190 Hz). Because the root canal is enlarged enough to permit a small file can move freely, the vibrations of the file enable acoustic streaming and transferring their energy to the irrigant inside the canal. Similar to these findings, several previous studies showed that the medicament removal was superior with PUI compared with conventional syringe irrigation and sonic irrigation.10-13 PUI is also able to disrupt the endodontic biofilm, facilitating better penetration of irrigants inside the root canal walls[19].

The CH remnants could also influence the penetration of sealers into dentinal tubules, markedly compromising the quality of the seal provided by the root filling[7, 8]. The residual volumes of CH depending on the removal technique was reported ranging from 3% to 20%, predominantly in the apical region[12, 27~29]. Although the present study has a limitation on evaluating a specific area along with other previous studies, it could possible to measure the weight of remnants in the whole canal spaces.

The CH remnants left in the root canal can result in a thicker non-homogeneous appearance of root canal sealers, and also result in a reduction of flow or working time due to chemical reaction with the sealer[8, 30]. Prior to root filling, hence, intracanal CH material should be removed thoroughly[30].

The effectiveness of the CH removal may depend on several factors not only anatomical variation and irrigation methods such as apical preparation size, taper, penetration depth of the irrigation needle, and irrigant volume, but also the chemical and physical properties of medica ments such as flow rate and solubility[16, 31~33]. Therefore, it would be valuable to evaluate using various intracanal medicaments.

Bearing in mind the limitations of this study, the results in the present study show that none of the irrigation techniques could guarantee 100% removal of all medicaments[15]. The sonic acti vated and ultrasonic activated irrigation techniques showed similar efficiency for removing intracanal medicaments. Clinicians need to follow the manufacturers' instruction to remove the intracanal medicaments efficiently by using these techniques.

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