Introduction
Root canal treatment is indicated when the dental pulp is irreversibly inflamed or necrotic. In pulpal necrosis, the infection may progress from the coronal pulp to involve the apical third of the root canal system where 75% of the canal irregularities are present. These ramifications are unlikely to be debrided using mechanical instrumentation alone, thus the use of an intracanal medicament is advocated. For the purpose of disinfection, calcium hydroxide (Ca(OH)₂) is the medicament of choice owing to its superior antibacterial properties.

Ca(OH)₂ is mixed with different vehicles and is available in many formulations. One of them is Metapex (Meta Biomed, Korea), which is an oil-based paste. It is thought to have an added antibacterial advantage, which could be due to two reasons: the incorporation of 38% iodoform in its composition or the presence of viscous oil as a vehicle, which may prolong the action of the medicament. Conversely, the presence of oil is also a matter of concern because the oil-based dressing is very difficult to remove using conventional syringe irrigation.

Abstract
Objective: To evaluate the effectiveness of ethanol compared to citric acid in the removal of oil-based calcium hydroxide from the apical third of the root canal system using passive ultrasonic irrigation.

Method: The in vitro study was conducted from September to October 2021 at the dental clinics of the Aga Khan University Hospital, Karachi, and comprised single-rooted teeth that were selected from institutional bank of extracted teeth. They were randomly divided into group A having 70% ethanol + passive ultrasonic irrigation, group B 10% citric acid + passive ultrasonic irrigation, group C positive controls and group D negative controls. The specimens were sectioned at 1mm and 3mm from the apex and examined under a dental operating microscope. A single examiner scored the specimens on two different occasions. Data was analysed using SPSS 25.

Results: Of the 90 teeth, there were 40(44.4%) in each of the 2 experimental groups and 5(5.5%) in each of the 2 control groups. At 3mm apical sections, ethanol was significantly more effective in the removal of oil-based calcium hydroxide (p=0.01). However, at 1mm from the apex, there was no significant difference between the experimental groups (p=0.064). Intragroup comparison showed that for groups A and B, residual medicament at 1mm sections was significantly greater than at 3mm sections (p<0.001, p=0.003).

Conclusion: Neither irrigant showed complete removal at 1mm and 3mm from the apex. However, at 3mm apical sections, 70% ethanol was significantly more effective compared to 10% citric acid.

Keywords: Calcium hydroxide, Root canal medicament, Endodontics, Citric acid, Ethanol. (JPMA 74: 464; 2024)

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Complete removal of the intracanal medicament is necessary because it interferes with the bonding and seal of endodontic materials. Moreover, the solubility and dimensional instability of Ca(OH)₂ paste over time results in a compromised seal, thus jeopardising the endodontic treatment outcome. The residual Ca(OH)₂ paste may also affect the physical properties of the sealers, their bond strength to dentin, dentinal tubular penetration, and the filling of the lateral canals. This is particularly important in the apical third where a majority of canal irregularities are present, and the residual medicament might represent a path for bacterial infiltration.

Mechanical instrumentation of the root canal system combined with copious irrigation with sodium hypochlorite (NaOCl) and ethylenediaminetetraacetic acid (EDTA) is the most frequently used method for removing intracanal Ca(OH)₂. Apart from these, a variety of chemicals such as maleic acid, citric acid, and phosphoric acid have also been tested in the past for the removal of oil-based Ca(OH)₂. Of all these chemicals, citric acid has shown the most effective removal, but no attempt to date has been made to remove the oil-based dressing using ethanol as an irrigant. Besides these chemicals, various mechanical methods, like manual or rotary instrumentation, and sonic or ultrasonic activation, have also been tested as an adjunct to remove oil-based Ca(OH)₂ dressing. Passive ultrasonic...
irrigation (PUI) has proven to be more effective than others because of its streaming pattern within the canals.\textsuperscript{9}

Despite these advancements in irrigation techniques and using different types of irrigants, removing Ca(OH)\textsubscript{2} dressing from the apical third remains an endodontic challenge.\textsuperscript{11} Moreover, literature has reported that no currently available strategy can completely or predictably aid in its removal.\textsuperscript{12} Having said that, considering the importance of a tight apical seal, complete removal of medicament is indispensable. Therefore, the current study was planned to evaluate the effectiveness of ethanol compared to citric acid in the removal of oil-based Ca(OH)\textsubscript{2} from the apical third of canals using PUI. The null hypothesis tested was that there is no difference in the removal of oil-based Ca(OH)\textsubscript{2} dressing using ethanol and citric acid.

**Materials and Methods**

The in vitro study was conducted from September to October 2021 at the dental clinics of the Aga Khan University Hospital, Karachi, and comprised single-rooted teeth that were selected from the institutional bank of extracted teeth. After exemption was obtained from the institutional ethics review committee, the sample size was calculated using the World Health Organisation (WHO) calculator\textsuperscript{13} while taking mean percentage of Ca(OH)\textsubscript{2} removal from the apical third as 97.07% and 83% for citric acid and ethanol respectively\textsuperscript{10,13} and keeping the level of significance (α) 5% and power 80%.

The sample was raised using non-probability consecutive sampling technique. Single-rooted teeth with completed root formation and curvature <5 degrees, as determined by the schneider method, were included. Any samples with curved or multiple roots, previously filled teeth, and pre-existing cracks, caries, resorptions or calcifications were excluded.

All the teeth were cleaned to remove debris and soft tissue remnants. The teeth were disinfected with 5.25% NaOCl and stored in normal saline solution at room temperature. To standardise the length of specimens, the teeth were sectioned at 16mm from the apex. They were then mounted in wax blocks and a size 10K file was placed in the canal to check patency. The root canals were instrumented using Protaper Next rotary files (Dentsply, Sirona, United States) sequentially till X3 (30/07). Irrigation was performed with 3% NaOCL using a 3ml plastic syringe and a side-vented needle. Canals were dried with X3 paper points (Dentsply Maillefer, Sirona, United States).

The prepared specimens were filled with Metapex (Meta Biomed, South Korea) up to working length using lentulo spiral. Buccolingual and mesiodistal radiographs were taken to ensure the complete filling of canals. The root orifices were sealed with cotton and a temporary restorative material. The specimens were stored at 37°C and 100% humidity for 7 days (Figure 1).

![Figure 1: Specimen preparation and allocation into experimental groups on the basis of irrigation protocol. Barotrauma, but due to worsening airspace disease (f), the patient eventually expired on the 19th day of admission.](image1)

![Figure 2: Experimental groups A and B, positive control group C and negative control group D. The specimens after sectioning were evaluated under dental operating microscope (25.6x magnification).](image2)
After 7 days, the samples were coated with two coats of varnish, including the apical foramen, and were then fixed in silicone impression material (Aquasil, Dentsply, Sirona, United States) to create a closed system. After access was reopened, the specimens were randomly divided using a computer-generated randomisation sequence (RANDOM.ORG) on the basis of removal methods into experimental group A having 70% ethanol+PUI, experimental group B having 10% citric acid+PUI, group C positive controls and group D negative controls (Figure 2).

In group A, removal of Ca(OH)$_2$ paste was done with 6ml 70% ethanol divided into 3 applications of 2ml with each application ultrasonically activated for 1 minute. The activation was carried out using a size 15K file attached to a stainless steel endo file holder (E2, Guilin Woodpecker EMS, United Kingdom) with an ultrasonic unit (EMS Piezon Master 200, China) at a power setting of 10%. The file was activated inside the canal 2mm short of the working length, and was moved passively in an up-and-down manner to ensure that it does not bind with the canal walls. The excess chemical was removed with paper points after irrigation.

In group B, the same protocol as for group A was followed for Ca(OH)$_2$ removal with 10% citric acid.

In group C, the specimens were filled with Ca(OH)$_2$, but were not subjected to any removal protocol.

In group D, the specimens were instrumented but were not filled with Ca(OH)$_2$.

The specimens were sectioned with a diamond disk (Microdont, Brazil) at 1mm and 3mm from the apex. The sectioned samples were then examined under a dental operating microscope with 25.6x magnification (AM-4000, ALLTION, Guangxi, China), and the digital images were captured with a camera (Canon EOS 4000D). All clinical procedures were performed by the primary investigator, whereas the specimens were analysed by a co-investigator on two different occasions to ensure reliability. The investigator who scored the specimens was blinded to the study groups to eliminate bias.

The criterion defined in literature was used to score the specimens for residual medicament in the apical sections as: Ca(OH)$_2$ completely removed=0, Ca(OH)$_2$ in >50% of the canal=2, Ca(OH)$_2$ in >50% of the canal=3 (Figure 3).

The scores for the specimens at 1mm and 3mm from the apex were recorded in a customised proforma.

Data was analysed using SPSS 25. The intra-examiner reliability was determined using the intraclass correlation coefficient (ICC). Shapiro-Wilk test was used to assess normality of data distribution. Mann-Whitney U test was applied to compare the effectiveness of medicament removal between the experimental groups at 3mm and 1mm sections. For intragroup comparison, Wilcoxon sign rank test was used. P<0.05 was considered significant.

### Results

ICC for intra-examiner reliability was 0.89 (95% confidence interval: 0.85-0.92) showing ‘good’ to ‘excellent’ reliability (p<0.001).

Of the 90 teeth, there were 40(44.4%) in each of the 2 experimental groups and 5(5.5%) in each of the 2 control groups. At 3mm apical sections, ethanol was significantly more effective in the removal of oil-based calcium hydroxide (p=0.01). However, at 1mm from the apex, there was no significant difference between the experimental groups (p=0.064) (Table 1).

Intragroup comparison showed that for groups A and B, residual medicament at 1mm sections was significantly greater than at 3mm sections (p<0.001, p=0.003) (Table 2).

<table>
<thead>
<tr>
<th>Apical cross-section</th>
<th>Median (IQR) 70% ethanol</th>
<th>Median (IQR) 10% citric acid</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>3mm from apex (n=40)</td>
<td>1 (0-2)</td>
<td>2 (1-3)</td>
<td>0.010*</td>
</tr>
<tr>
<td>1mm from apex (n=40)</td>
<td>3 (1-3)</td>
<td>3 (2-3)</td>
<td>0.064</td>
</tr>
</tbody>
</table>

IQR: Interquartile range; *Mann-Whitney U test; *p-value <0.05
Discussion

The apical third of the root canal system has the most complex anatomy owing to the presence of irregularities in the form of apical deltas, ramifications and lateral canals.\(^2\) The presence of Ca(OH)\(_2\) remnants in these complexities compromises the fluid-tight seal necessary for successful endodontic treatment.\(^8\) Therefore, the current study focussed on the apical third of the root canal system.

The current findings were in line with Dias et al. who used ethanol to remove water-based Ca(OH)\(_2\) dressing.\(^10\) However, the current study, to the best of our knowledge, is the first to use ethanol as an irrigant to remove oil-based Ca(OH)\(_2\) dressing. Since there was no head-to-head comparison for ethanol and citric acid, therefore the present study aimed at assessing the effectiveness of ethanol compared to citric acid, using PUI in the removal of oil-based Ca(OH)\(_2\) from the apical third of canals.

The results revealed that neither ethanol nor citric acid was able to completely remove the oil-based Ca(OH)\(_2\) from the apical third of the root canal system. Nevertheless, ethanol was significantly more effective in the removal at 3mm compared to citric acid, using PUI in the removal of oil-based Ca(OH)\(_2\) from the apical third of canals.

The current study has limitations as it lacked a group with standard NaOCl and EDTA irrigation protocol, as utilised in previous studies.\(^14,22\) Moreover, curved and multi-rooted teeth were not taken into consideration where removal of intracanal medicament might present a great challenge due to anatomical constraints.

On the basis of current findings, the oil-based Ca(OH)\(_2\) dressing should be used with caution as it is difficult to remove, and the residual medicament might result in a compromised endodontic outcome. Likewise, more dynamic methods of irrigation should be tested in conjunction with ethanol for the complete removal of oil-based Ca(OH)\(_2\) paste.

Conclusion

Neither ethanol nor citric acid completely removed oil-based Ca(OH)\(_2\) from the apical third of the root canal system. However, 70% ethanol was significantly more effective in the removal of medicament at 3mm apical sections compared to 10% citric acid.

Disclaimer: None.

Conflicts of Interest: None.
Comparative evaluation of ethanol versus citric acid in removal of oil-based calcium ……

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References


Author Contribution:

NN and FU: Study conception and design; data analysis and interpretation, final approval.

NN: Data acquisition and drafting

FU: Critical revision

Both the authors agree to be accountable for all aspects of the work.