http://jmscr.igmpublication.org/home/
ISSN (e)-2347-176x ISSN (p) 2455-0450
crossref DOI: https://dx.doi.org/10.18535/jmscr/v11i5.12

IGM Publication
Journal Of Medical Science And Clinical Research
An Official Publication Of IGM Publication

Original Article

A Cone beam CT Evaluation of the Efficacy of Essential Oils in removing Silicone Oil based Calcium hydroxide Intra canal medicament from the Root canal

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Abstract

Aim of this study is to find which among the given agents orange oil, eucalyptus oil and10% citric acid is better to remove silicone - oil based and aqueous based calcium hydroxide. Present study was performed on 60 human mandibular premolars extracted for orthodontic purpose. After decoronation of the crown instrumentation was done with sequential ProTaper Universal rotary files using crown down technique up to F4 on all specimen. Teeth were divided into two groups of 30 teeth each randomly. Half no of teeth filled with vitapex and half with ultracalXs. Vitapex and ultracalXs in teeth were retrieved with 10% citric acid, orange oil and eucalyptus oil along with passive ultrasonic agitation. Volumetric analysis was performed using CBCT

The results of the present study demonstrated that none of the agents tested were able to remove the oil based CH completely even though used along with passive ultrasonic activation. However aqueous CH was almost completely removed by all the three solvents used along with passive ultrasonic irrigation. The present study showed, citric acid to remove oil based CH better than orange oil and eucalyptus oil. Eucalyptus oil and orange oil were found to have comparable removal efficacy as that of 10% citric acid in removing both aqueous and oil based calcium hydroxide in this study. It is concluded that the efficacy of eucalyptus oil and orange oil were comparable with 10% citric acid in removing both aqueous and silicon oil based calcium hydroxide intra canal medicament. As 10% citric acid can produces dentinal erosion, orange oil and eucalyptus oil along with passive ultrasonic activations can be considered as an effective alternative to citric acid

Keywords: *Citric acid, ultra calXs, vitapex, orange oil, eucalyptus oil, ultrasonics, CBCT, CH (calcium hydroxide).*

Introduction

It has been established that microorganisms and their by-products are the primary cause of root canal infection. Root canal treatment aims to eliminate infection from root canal and protectthe tooth from further microbial invasion[1,2]. Successful endodontic therapy depends on a triad of proper access, thorough cleaning and shaping, and obturation of the root canal system. Cleaning and shaping is the most important step for successful root canal treatment and determines the success of all subsequent procedures[3].

Persistence of intra and extra radicular microbial infection is the primary cause of failure of primary endodontic therapy. Sothe primary aim of root canal treatment is the elimination of all the microbes from the root canal[4].Complete disinfection of the canals not possible with mechanical instrumentation and irrigation alone and may require multiple visits which demands the use of intracanal medicament.[5,6]

Calcium hydroxide (CH) is the most commonly used intracanal medicament. Calcium hydroxide has been shown to be an effective intracanal medicament during endodontic therapy. It is widely used as a root canal dressing between appointments. It has wide range of antimicrobial activity against common endodontic pathogens.[7] Other biologic properties of CH are tissue dissolution,[8] degradation of lipopolysaccharide[9] and inhibition of osteoclastic activity.[10]

Disinfecting efficacy mainly depends upon the availability of hydroxyl (OH^-) ions in solution which in turn depend on the vehicle in which CH is carried[11]. CH is used with vehicles such as aqueous, viscous and oil based. The physical and chemical properties of CH are affected by the type of vehicle used. Aqueous vehicles help in rapid release of calcium and hydroxyl ions, while oily vehicles prolong the ionic dissociation.[12]

CH medicament should be removed completely prior to obturation. Residual CH can negatively affect the sealing qualities of the root canal fillings[13]. Margelos et al reported that CH interacts with setting of zinc oxide eugenol (ZnOE) based sealers, makes them brittle and granular. It also increase the leakage after obturation[14]. It has been reported that residual CH influences the dentin bond strength,[15] hinder the bonding of resin based sealers to the root dentin.[16] Residual CH also found to markedly increase the apical leakage of root canal treated teeth[17]. So complete removal of CH from the root canal is recommended.

Various agents and techniques have been recommended for removing CH from root canals. The most commonly described technique is the shaping of the root canal using a master apical file and copious irrigation with ethylene diamine tetra acetic acid (EDTA) and sodium hypochlorite (NaOCl) at working length.[18] Several studies[19,20,21,22] have examined different intracanal irrigants such as saline, NaOCl, EDTA, and citric acid, along with combinations for removing CH. According to the results, EDTA and other acid solutions have been found more effective than NaOCl and saline[20,21]. However, none of them removed the CH from the dentin walls completely. These results showed that it is difficult to completely remove the CH using the irrigants alone. Therefore, combination of various irrigating agents and agitation techniques, have been employed to improve the efficacy. However, there is still no general consensus on the most effective technique.[23]

Recently, several other techniques have been recommended for more efficient elimination of CH medicament such as the use of vibratory file, canal brush, irrigation syringe, EndoVac, sonics, and passive ultrasonics. Of all these methods, passive ultrasonics has been found to produce cleaner canals [24]. Kenee et al also reported that passive ultrasonic irrigation (PUI) is better.[25]

Complete removal of CH prior to obturation poses a challenge to the clinician especially the silicon oil based CH systems. **Nandini** et al reported that oil based CH paste is more difficult to remove than aqueous based CH , because irrigation solution is incapable of penetrating the silicon oil layer[20]. Most commonly used solution for retrieving CH is chelating agents like EDTA,

recently organic acid chelators like maleic acid (MA) and citric acid also found to be more effective[26]. Most of organic compound are reported to have capability to dissolve silicon oil[27].Therefore their use as a possible irrigants solution to remove silicon oil based CH needs to be tested. Essential oils such as orange oil, and eucalyptus oil are organic solvents. They have been reported to be safe, biocompatible, and noncarcinogenic and have been mainly used for gutta percha removal[28,29,30]. There are as yet no studies that show the effectiveness of these solvents for removing CH intracanal medicament. So purpose of this study was to compare the effectiveness of orange oil, eucalyptus oil and citric acid in removing both aqueous and oil based CH intra canal medicament from the root canal.

Various methods have been used to measure the remaining CH residues in the root canal. These include stereomicroscopy, scanning electron microscopy (SEM) and spiral CT [20].Recently cone beam computed tomography (CBCT) has been found to be more superior than other methods as three dimensional volume measurements are possible without sectioning the specimen during the process. Hence it was decided to measure the CH residues in the present study using CBCT .[26]

Aims and Objectives

The aim of this study is to find which among the given agents orange oil, eucalyptus oil and10% citric acid is better to remove silicone - oil based and aqueous based CH and to compare the efficacy of orange oil, eucalyptus oil, and 10% citric acid in removing both aqueous based and silicone oil based CH intra canal medicament.

Materials and Methods

60 Human mandibular premolars extracted for orthodontic purpose with straight roots and single canal were selected. Fractured teeth, carious teeth, restored or cracked teeth, teeth with calcified canals, teeth with curved roots (root canal curvature of more than 10^0) were excluded. Teeth were stored in normal saline that was changed daily until sufficient number of teeth were collected. Using a low speed hand piece with a double sided diamond disk, the specimens were decrowned. Decoronation of the crown was done at 16 mm from the apex to (figure 1) standardize the length of the roots, the working length was determined by subtracting 1mm from the length at which a 15 k file tip extruded apically.

Figure 1 -Decoronated Teeth

Instrumentation was done with sequential ProTaper Universal rotary files (Dentsply-Mailiefer, Ballaigues, Switzerland) using crown down technique up to F4(tip diameter of taper 0.06) . During the preparation root canals were irrigated with 2 ml of 5.25% NaOCl solution after each instrumentation. Paper points were used for drying the canal. Teeth were divided into two groups of 30 teeth each randomly.

Group A-Vitapex was injected into the root canal until material extruded through the apex.

Group B -.UltracalXs paste was injected into the canal until it extruded through the apex.

Teeth were held in wet sponge during placement of CH formulations. Excess material was wiped off with moist cotton. Access cavities were temporarily sealed with cotton pellet and IRM and teeth were stored at 37°C and 100% relative humidity for 7 days in an incubator. The teeth were mounted in a modeling wax for the purpose of CBCT (figure 2). Fifteen teeth were arranged in one U shaped occlusal rim. Pre retrieval CBCT imaging for all the samples were done and volume of medicament inside the canal was estimate (figure 3,4).

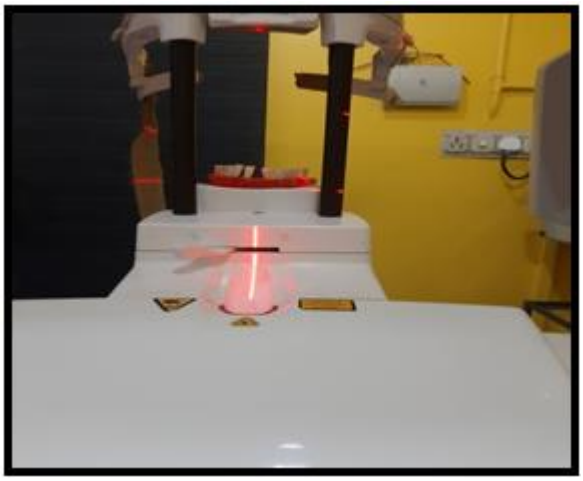


Figure 2 Arrangement of teeth in occlusal rim for CBCT volumetric analysis

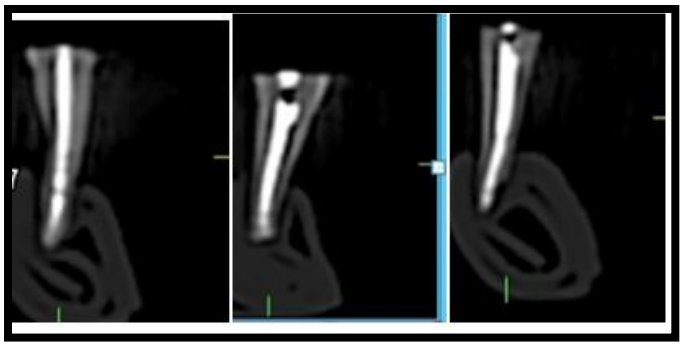


Figure 3 CBCT images of teeth filled with vitapex

Figure 4 CBCT images of teeth filled with UltracalXs

Teeth in each group were further divided into three subgroups of 10 teeth each based on the irrigant used. After the removal of the temporary fillings, a size 15# K file was introduced to the working length to loosen the CH and to create space for an irrigation needle (30-G; NaviTip; Ultradent, South Jordan, UT). The irrigation needle was placed 1 mm short of the working length without binding.

Group A1 –retrieved vitapex with 1ml of 10% citric acid + ultrasonic agitation for 3minute + final rinse with 2 ml saline

Group A2- retrieved vitapex with 1 ml of orange oil + ultrasonic agitation for 3 minute + final rinse with 2 ml saline

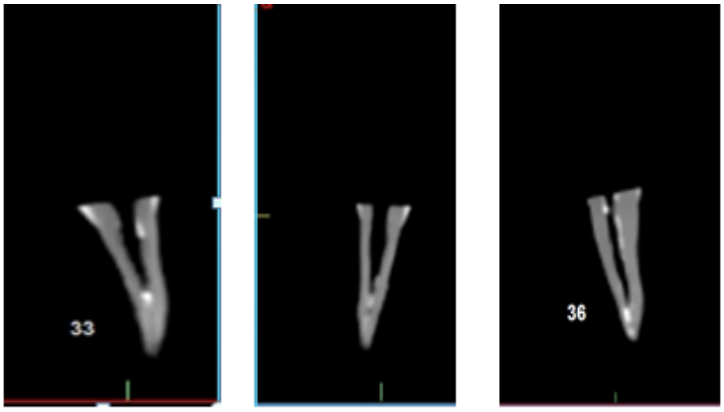
Group A3 –retrieved vitapex with 1 ml of eucalyptus oil + ultrasonic agitation for 3minute + final rinse with 2 ml saline

Group B1- retrieved UltracalXs paste with 1ml of 10% citric acid + ultrasonic agitation for 3 minute + final rinse with 2 ml saline

Group B2- retrieved UltracalXs paste with 1 ml of orange oil + ultrasonic agitation for 3minute + final rinse with 2 ml saline

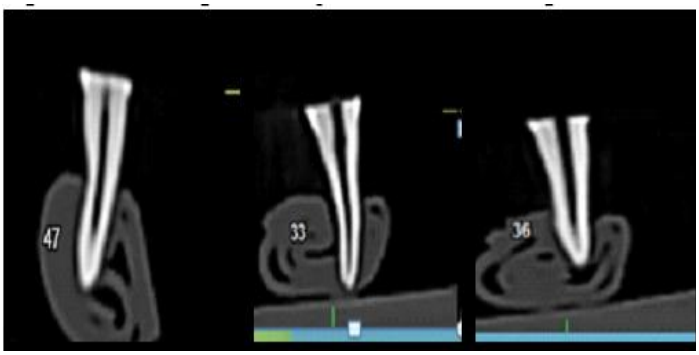
Group B3- retrieved UltracalXs paste with 1 ml of eucalyptus oil + ultrasonic agitation for 3 minute + final rinse with 2 ml saline

Ultrasonic agitation was performed with a Satelec ultrasonic endodontic tip K15 Sonofile (Dentsply, Tulsa, OK, USA) in endodontic mode of ultrasonic unit. (Woodpecker Uds – P ultrasonic scaler). A second CBCT imaging was done and the volume of remaining material in each tooth was estimated as before.



Citric acid orange oil eucalyptus oil

Figure 5 CBCT images of teeth specimen after retrieval of vitapex with



Citric acid **orange oil** **eucalyptus oil**

Figure 6 CBCT image of teeth specimen after retrieving ultracalXs with

Statistical Analysis

Calculation of CH volume in each specimen was analysed using Planmeca Romexis 3.2.0.R software (Planmeca India) by the bucket tool. Volume of calcium hydroxide was expressed in cubic mm.(figure 7)

The removal efficiency was calculated using the formula - [(a-b) 100/a]

a- Volume of the material packed in the root canal

b- volume of material remaining after retrieval

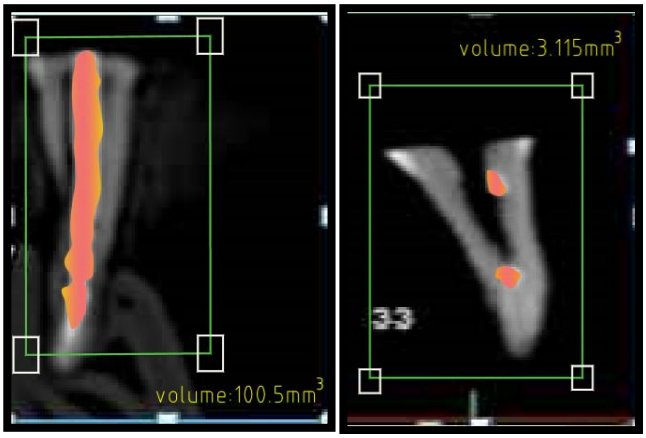


Figure 7 Images of Calculating the volume of calcium hydroxide

Observations and Results

The data was analysed using SSPS software. The mean for all the groups was calculated along with a standard deviation and subjected to statistical analysis using Kruskal-Wallis test followed by intergroup comparison using MannWhitney U-test. Results showed that aqueous CH was almost completely removed by all the three agents. The removal efficacy was 99.1%, 99.19% and 99.19% for citric acid ,orange oil and eucalyptus oil respectively. But there were no significant difference between the groups.

Oil based calcium hydroxide was not completely removed by all the three agents.10% Citric acid, orange oil, and eucalyptus oil removed 96.1%,95.86% and 95.28 % of oil based calcium hydroxide respectively. Citric acid removed oil based CH better than orange oil and eucalyptus oil .There were no significant difference between groups

Independent t test was used to compare the residual CH. For all the three irrigants, the difference in residual CH left in the aqueous and silicone based groups were statistically significant which meant that percentage of residual CH was more in vitapex group than UltracalXs group by all the three irrigants. None of the techniques removed the CH dressing completely. Remnants of medicament were found in all experimental groups regardless of the removal technique or CH vehicle.

Table 1

Type of Calcium hydroxide	Irrigant	N	Mean	Std. Deviation
Vitapex	Citric acid	10	96.1000	.98545
	Orange oil	10	95.8600	.87203
	Eucalyptus oil	10	95.2800	1.13314
UltracalXs	Citric acid	10	99.1022	.08468
	Orange oil	10	99.1900	.28371
	Eucalyptus oil	10	99.1980	.11458

Table 1 shows the mean percentage of CH removed following irrigation with all the three irrigants.

Kruskal-Wallis Test

Table 2: Comparison of removal efficacy of different irrigants in vitapex

Type of Calcium hydroxide	Irrigant	N	Mean Rank	chi square	p value
Vitapex	Citric acid	10	18.15	3.090	0.213
	Orange oil	10	16.75		
	Eucalyptus oil	10	11.60		

Table 3: Comparison of removal efficacy of different irrigants in ultracal XS.

Type of Calcium hydroxide	Irrigant	N	Mean Rank	chi square	p value
UltracalXs	Citric acid	10	12.20	3.543	0.170
	Orange oil	10	14.80		
	Eucalyptus oil	10	19.50		

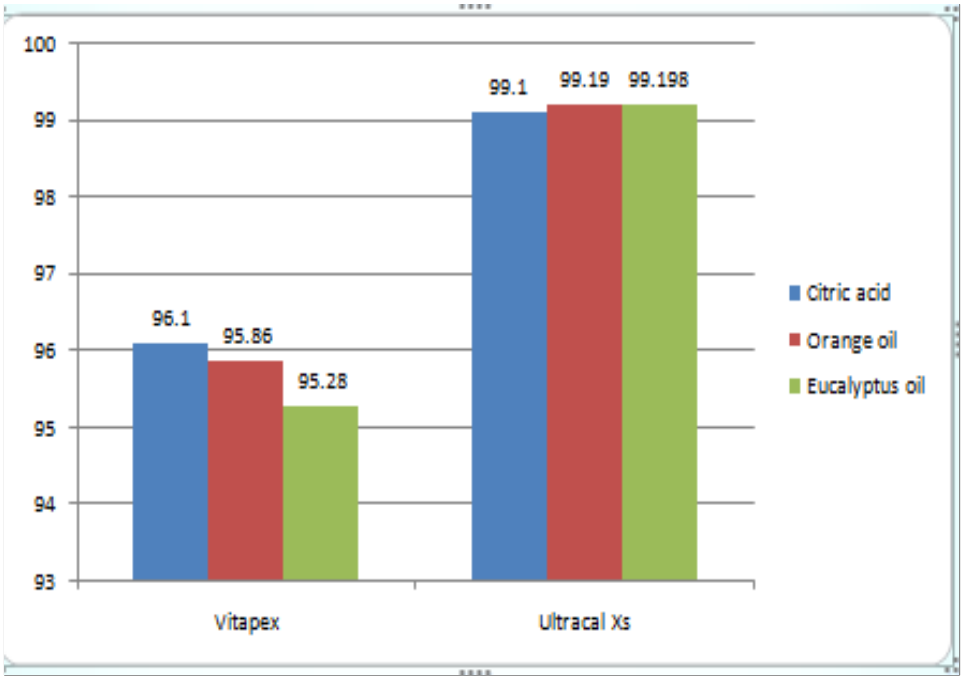


Figure 8: Removal efficacy using different irrigants

Discussion

The main cause of failure of primary endodontic therapy is the persistence of intra and extra radicular microbial infection.[4] Complete disinfection of the canal is not possible with mechanical instrumentation and irrigation alone and may require multiple visits which demands the use of intracanal medicaments[5, 6]. The main goal of intracanal medication is to eliminate bacteria in the root canal, prevent bacterial proliferation between appointments, and act as a physicochemical barrier, preventing root canal

reinfection and nutrient supply to the remaining bacteria.[31]

Calcium hydroxide is the most commonly used intracanal medication due to its effective antimicrobial activity. The possible mechanism of action of is related to its basic pH, which converts the acidic pH of periapical tissues to a more basic environment.[32] CH paste used as intracanal medicament in endodontics is composed of the calcium hydroxide powder, a vehicle and a radio pacifier. The medicament vehicle plays an important role in the overall disinfection process because it determines the velocity of ionic dissociation causing the paste to be solubilized and resorbed at various rates by the periapical tissues and from within the root canal. Mainly three types of vehicles are used- Aqueous, viscous and oil based vehicles.

Oil type vehicle may remain within the root canal for longer than the pastes containing aqueous or viscous vehicles. [12]A classic study by **Lambrianids et al (1999)[33]** have shown that it is not the concentration of calcium hydroxide but it is the vehicle contained in the CH used which affected the retention of CH. So two different type, oil type and aqueous type vehicle is used in this study which is silicone oil and water based vehicle..

After fulfilling its purpose, prior to obturation, removal of the medicament is mandatory as its remnants may block the apical area and also affect the viscosity, working time, integrity, dentin tubule penetration and adhesion of root canal sealers.[34] Residual CH will adversely affect the success of root canal treatment. The combination of CH and sealer presumably affects their physical properties and apical sealing ability (Hosoya et al.2004)[35]. The use of CH paste as an intra canal medication between sessions can reduce canal permeability by promoting formation of calcium carbonate particles and interfering with the sealing ability of endodontic sealer. It has been reported that residual CH on the root canal walls interacts with ZnOE based sealers and produce calcium eugenolate (Margelos et al. 1997).[14] Intracanal calcium hydroxide material should therefore be removed as much as possible prior to root canal filling (Hosoya et al. 2004)[35]

The aim of the present study was to find which among the given experimental agent was better in removing silicone - oil based and aqueous based CH intra canal medicament from the root canal.

In the present study, Vitapex was the commercially available silicone oil based CH used and UltracalXs, as the aqueous based CH. 10% citric acid, eucalyptus oil and orange oil was used as the solvents to remove CH.

The results of the present study demonstrated that none of the agents tested were able to remove the oil based CH completely even though used along with PUI. 10% Citric acid, orange oil, and eucalyptus oil removed 96.1%, 95.86% and 95.28 % of oil based CH respectively. However aqueous CH was almost completely removed by all the three solvents used along with PUI. The removal efficacy was 99.1%, 99.19% and 99.19% for citric acid, orange oil and eucalyptus oil respectively.

This was in accordance with study by **Nandini** [20] et al (2006) who compared efficacy of two chelators 17% EDTA and 10% citric acid in removing aqueous and silicone oil based CH. Similar result was found by **RemyaReghu**[26]et al (2017) who compared efficacy of three chelators – 17% EDTA, 20% citric acid and 0.2% chitosan. Both the authors used ultrasonic agitation as in the present study.

Eucalyptus oil and orange oil were found to have comparable removal efficacy as that of 10% citric acid in removing both aqueous and oil based CH in this study.All the three agents seem to be significantly better in removing aqueous based CH than oil based CH **(p value- 0.00)**

Intracanal CH is usually removed from the root canal by use of copious manual irrigation with either NaOCl combined with hand instrumentation and a final rinse with EDTA. However, these techniques are inefficient to completely eliminate CH.[26] The chelating agents that have been used include EDTA, citric acid, MA, PAA , chitosan and other agents like MTAD, tetra clean,

etiodronicacid. In addition, several techniques also have been used like hand file, rotary file, canal brush, irrigation syringe, endovac, sonics, and PUI. [13,24,25,36]

Lee et al. (2004) stated that the cleaning efficacy of an irrigation technique depends not only on mechanical agitation and volume of the irrigation solution but also on the chemical activity of the irrigant.[37]

Nandini[20] et al (2006) reported that oil based calcium hydroxide intra canal medicaments are difficult to remove because irrigation solution is incapable of penetrating the silicone oil layer. Silicone oil is a term generally used to describe group of hydrophobic polymeric and monomeric compounds constituted of silicon –oxygen bonds named as organosiloxane.[38] Silicone oil have been found to be soluble in hydrocarbon solvents like toluene, xylene etc.[27] Orange oil containing 90% d-limonene & eucalyptus oil having 1, 8-cineole as its main constituent, are two essential oils mainly used in endodontics for softening gutta percha. They are also found to dissolve most endodontic sealers. They have been reported to be safe, non carcinogenic, biocompatible and useful for the purpose[39]. As essential oils are organic compounds silicone oil may be miscible in essential oils and hence these two agents were taken as our experimental solvents.

In the present study, regardless of the vehicle used, residual CH was found mostly in the apical third of the canals ,which was also similar to that seen in the study by **Nandini**[20] et al(2006). EDTA is the most commonly used chelating agent for calcium hydroxide removal but studies have shown it to be more erosive on the dentin as compared to other chelating agents. Moreover 17% EDTA was found to be inferior to 10% citric acid in removing silicone oil based CH.[20] Citric acid is a strong chelator and is found to be efficient in removing intra canal CH.[21] Citric acid is a biological and organic acid with sufficient tissue compatibility.[40,41] Moreover citric acid is inexpensive and effective on anaerobic microorganisms[42]. Hence 10% citric acid was used in this study.

The present study showed citric acid to remove oil based CH better than orange oil and eucalyptus oil. This is in agreement with study by **Nandini**[20] **et** al (2006) in the case of citric acid.Citric acid not only penetrates silicone oil, it is also a strong chelating agent and has shown to be efficient in removing intra canal CH[20,21]. This might be related to the formation of complexes between citric acid and calcium .[43]But in the **aqueous group**, citric acid seemed to be slightly less efficacious when compared to orange oil and eucalyptus oil, though it was not statistically significant. This finding was in accordance with **Remyareghu**[26] et al

Citric acid has been found to be an ineffective chelator at neutral pH. The highly alkaline pH of calcium hydroxide raises citric acid pH towards neutrality so it will limit the effectiveness of citric acid in calcium hydroxide removal[44]. This could be the reason for its lower performance in aqueous group.

There is no gold standard recommendation as to the optimal time period of chelating agents. To minimize destructive effects on dentin reported by some re-searchers, we opted for a low volume (1 mL) of chelating agents for an application time of 3mts.

In the present study PUI was used along with all the solvents. Among the various techniques used, PUI was found to be superior. **Van der sluis**[24]and **Wiseman**[45]**etal** also reported ultrasonic to be better for CH removal.PUI used along with the irrigants play an important role in CH removal. During PUI, acoustic micro streaming and cavitation occur, which cause a specific streaming pattern within the root canal from the apical to the coronal. Because of this micro streaming, more debris can be removed even from remote places in the root canal[24]. Since PUI is done with small size file in an enlarged canal space, the file is moving freely allowing the irrigant to penetrate all regions of root canal space,. Due to active streaming of

irrigant, its potential to contact a greater surface area of the canal wall is enhanced.[26]

Various methods have been employed to measure the remaining CH residues in the root canal. In previous studies, the amount of CH in the canal was calculated by measuring the surface area of the residues on the canal walls in terms of mm^2 [25,33] ,by using a scoring method[21,24], by using a scanning electron microscopy [46]or volumetric analysis by spiral CT [20]. Recently, CBCT has been used and was found to be superior.

In a study by Pradeepkumar[47]et al it has been stated that volume analysis provides accurate result than surface area measurement. They pointed out that though most studies used scanning electron microscopy as the method of analysis, the accuracy of this method can be questioned. There was a possibility of bias as the entire root canal wall will not be imaged. And also, the method was destructive. With CBCT, three dimensional volume measurements are possible without sectioning the specimens, during the process. Hence, it is a more accurate and faster method. Advantages of CBCT over spiral CT include a lower radiation dose, a shorter acquisition time and reduced cost.So in the present study, CBCT was used for volumetric assessment of the root canal.

The important finding in the present study is that the CH removal efficacy of eucalyptus oil and orange oil are comparable to that of citric acid in both aqueous and oil based CH. Although there are only limited studies on the use of orange oil and eucalyptus oil on the removal efficacy of intracanal medicaments, various studies were conducted by several authors on the dissolving efficacy of eucalyptus oil and orange oil on various endodontic sealers. **Martos J[48] et al 2006, Martos J [49] et al 2011, Shafer [50]et al 2002** gave favourable results for these oils in removing various endodontic sealers including CH based sealers. **Bayram [51]et al 2015** showed eucalyptol to be least effective.

Eucalyptus oil is the distilled oil obtained from the leaves of plant named Eucalyptus globules Its major constituent is 1,8-cineole. It exhibits antibacterial and anti-inflammatory properties. Orange oil, an extract of the peel of sweet orange fruit (Citrus sinensis) is an efficient alternative to potentially toxic solvents. Sweet orange oil consists of approximately 90% D-limonene. There is no evidence for its carcinogenicity or genotoxicity[52]. Further, orange oil is less cytotoxic and more biocompatible than eucalyptol and chloroform.[53,54]

It has been reported that, prolonged exposure to strong chelators such as citric acid or EDTA may weaken root dentin. Observations by Edeniz et al suggested that canal irrigation with chelator solutions can lead to structural changes, as evidenced by reduction of dentin microhardness and augmentation in surface roughness.[55] Effect of etiodronate, a weak chelator was studied by **S J Chokkattu et al (2017)[44]** in the CH removal efficacy and was found to be superior to citric acid and EDTA. But because of high acidity, etiodronate was also found to produce dentinal erosion in SEM. Similarly 0.2% chitosan which performed better than 17% EDTA in removal of oil based CH also was shown to reduce dentinal microhardness.[56,57] PAA, a strong disinfectant which is also found to remove CH was also found to reduce micro hardness of dentin.[58]

Hence solvents like Orange oil and Eucalyptus oil having comparable efficacy as that of citric acid in CH removal would be beneficial as they do not cause any detrimental effect on the root canal dentin. However more questions need to be answered as to the extent to which these solvents have any effect on root canal dentin. Eucalyptus oil and orange oil along with PUI prove to be a promising alternative for removal of aqueous and oil based CH from the root canal.

Conclusion

Under the experimental conditions of the study it was concluded that the vehicle present in CH intra canal medicament determines the efficacy of its removal from root canal. 10% Citric acid orange oil and eucalyptus oil removed aqueous CH

significantly better than silicone oil based calcium hydroxide which was more difficult to remove from root canal.

Aqueous based CH was almost completely removed by all the three irrigants. Although not significant, citric acid was found to perform slightly better than orange oil and eucalyptus oil in removing silicone oil based calcium hydroxide and slightly lower in removing aqueous CH preparations. Regardless of the vehicle used in the present study, remnants were found mainly in the apical region of the root canal

The efficacy of eucalyptus oil and orange oil were comparable with 10% citric acid in removing both aqueous and silicone oil based CH intra canal medicament. As 10% citric acid can produces dentinal erosion, orange oil and eucalyptus oil along with passive ultrasonic activations can be considered as an effective alternative to citric acid

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