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The effect of Passive Ultrasonic Irrigation in Comparison with other Techniques on Removing Calcium Hydroxide from Root Canals: A Systematic Review

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ABSTRACT

Background and aim: Residues may remain in canal extensions and irregularities after removing the medication from root canals with a file. These residues can only have removed with irrigation. The present systematic review and meta-analysis investigated the effect of various irrigation methods on eliminating calcium hydroxide from root canals.

Material and methods: A preliminary analysis included 225 articles. Two reviewers investigated all the available abstracts and titles and determined whether they were associated with the cleaning effectiveness of a variety of irrigation systems in removing calcium hydroxide. The conducted search involved the years between 2013-18.

Results: The studies investigated lacked standardization concerning the irrigation method used or the measurement of outcomes; for instance, the volume or the concentration of the irrigation solution.

Conclusion: Although none of the methods examined could eliminate the calcium hydroxide dressing, activation methods resulted in better calcium hydroxide dressing removal compared to using a master apical file or syringe irrigation only.

1. Introduction

The presence of the microorganisms in root canals plays a vital part in developing periapical diseases[1]. Root canal therapy primarily conducted to create an environment where no residual organisms can survive. This can have achieved by eliminating as many bacteria as possible from root canal systems[2]. Many disinfection protocols include the use of intracanal medicaments[3]. Given the antimicrobial activities, the capacity for inactivating bacterial endotoxins, and the biological properties of calcium hydroxide, this substance is commonly used as an endodontic intra-canal medication[4] or a temporary medicament in root canal therapy. Calcium hydroxide confirmed as an antimicrobial medicament for more than 40 years, and some authors argue that maybe this is the best interappointment medicament of choice against residual microbiota[5]. The mechanism of action that can be sustained for a long time due to its high pH helps some authors to present the hypothesis of bacterial enzyme irreversible inactivation[6]. Three main mechanisms of action have found to destroy bacteria in endodontics; the first associated with the activity of calcium hydroxide based on its high pH, dissociation of ions, and the release of OH in water[7]. Second, the action of OH- which induces lipid peroxidation, resulting in the destruction of phospholipids in the microbial cell wall. The third mechanism associated with bacterial DNA that causes the two polynucleotide chains to break and lose genes. This process prevents DNA replication and inactivates the microorganism function. Calcium hydroxide detoxifies the endotoxin produced by the root canals ' microorganisms[8]. Materials containing Ca(OH)2 are water based on a thickener form of cellulose that makes removal from the root canals difficult.[9]. Calcium hydroxide can be eliminated from root canals using different methods[10]. Passive ultrasonic irrigation (PUI) found to be more effective in removing dentine debris from root canals than delivering the irritant with a syringe[11]. PUI based on placing and activating a small file at the core of a previously shaped root canal to generate cavitation and acoustic streaming[12]. PUI reported being more effective in eliminating the calcium hydroxide paste from the root canal walls compared to the syringe delivery of irrigants[13]. Also, agitation with the master apical file found to be more effective than the irrigant only techniques the procedure in terms of the removal of $Ca(OH)_2$ from the root canal[14]. A review of the literature suggests different methods for removing calcium hydroxide from root canals, including canal brush, PUI, rotary instrumentation and hand filing.[12, 15, 16, 19]

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Nevertheless, given the irregular canal structure, removing calcium hydroxide residues from the root canal walls is difficult[17]. This irregularity becomes more problematic in specific methods. Removal of remaining medication from the canals can only have achieved using a combination of irrigation solutions and devices[18, 19]. The present systematic review and meta-analysis examined the effect of a variety of irrigation systems on removing $Ca(OH)_2$ from root canals.

2. Material and methods

The search was conducted with no language limitations using irrigation, removal, calcium hydroxide, and root canal. The preliminary analysis involved 225 articles. Two reviewers investigated all the available abstracts and titles and determined whether they were associated with the cleaning efficiency of various irrigation systems on removing calcium hydroxide. The search was conducted between the years 2013 and 2018. Articles were automatically included in the subsequent analysis when the data obtained from the abstracts and the titles were inadequate for determining the paper's relevance. The excluded studies included 218 articles, and stricter exclusion criteria based on investigating the seven articles remaining (Table 1).

Eligibility criteria

1. Articles evaluating the removal of calcium hydroxide, which placed at the apical third of root canals as an intra-canal medicament
2. Papers that compared ultrasonically activated irrigation with other irrigation methods
3. Articles examining the cleaning effectiveness of irrigation devices
4. In-vitro studies and randomized controlled trials conducted on the extracted fully formed teeth.

The excluded studies comprised those out of the inclusion criteria as well as scanning electron microscopic studies. The remnants of calcium hydroxide are impossible to have discriminated from dentin debris. The smear layer is gave that energy dispersive X-ray spectroscopy shows calcium ions in both cases.

Table 1. Selected studies after review

	Study	Years
1	Kourti E et al (Kourti & Pantelidou 2017)[24]	2017
2	Kumar P et al(Kumar *et al.* 2017)[20]	2017
3	Wang Y et al (Wang *et al.* 2017)[21]	2017
4	Camargo CH (Camargo *et al.* 2016)[22]	2016
5	Alturaiki S et al(Alturaiki *et al.* 2015)[23]	2015
6	Capar ID et al(Capar *et al.* 2014)[25]	2014
7	Yücel AÇ et al (Yücel *et al.* 2011)[26]	2011

3. Results

The studies investigated were found to lack any standardization concerning the irrigation method used or the measurement of outcomes; for instance, different studies used five or ten ml of 2.5% NaOCl, or 5 ml of 5.25% NaOCl, or 0.5 ml, three ml and ten ml of 17% EDTA. Moreover, differences observed for different irrigation times. A study assessed results using an electron microscope, while other studies examined the outcomes under stereomicroscopes or utilizing micro-computed tomography scanning. Table 2 presents the features of the articles included.

The trial sample sizes varied in terms of the number of teeth involved in the experimental group, ranging from seven to eighty-eight. The studies included found to possess a moderate total risk of bias. The methods used in these studies were different in terms of the blinding of the teeth, the gauge of the needle used in syringe irrigation, irrigation time, the placement of the irrigation needle and the ultrasonic file, the type of the teeth and ultrasonic tip, the power, and type of the ultrasonic device.

Table 2. Summary of the characteristics of the studies

Study	Sample size	Type of the teeth	Type of intervention	Type of calcium hydroxide	Irrigation method	Evaluation method	Quality score
(Kourti & Pantelidou 2017)[24]	N= 84	single-rooted teeth	30-gauge slot-tipped needle, ultrasonic irrigation system, erbium-doped yttrium aluminum garnet laser and EndoVac system	powder mixed with saline	5 ml 5% NaOCl 5 ml 17% EDTA	electronic microscope	Moderate
(Kumar *et al.* 2017)[20]	N= 42	single-rooted mandibular first premolars	Endo Activator, EndoVac, ultrasonic irrigation with Endo-U-File, F-file, and Maxi-Probe needle	powder	2 ml 5.25% NaOCl Final Rinse: 5 ml 17% EDTA 5 ml 5.25% NaOCl	--------	Moderate
(Wang *et al.*	N= 20	simulated	protocol 5 mL of irrigant and	distilled water	10% citric acid,	Micro-computed	Moderate

2017)[21]		curved	following two operating periods, different techniques and final rinse were performed, 30-gauge NaviTip (Ultradent) needle		2.5% NaOCl, i	tomography scanning	
(Camargo *et al.* 2016)[22]	N=50	single-rooted human teeth	master apical file, foraminal debridement, and 5 mL of saline solution applied with the NaviTip irrigation needle. ultrasonic	powder	0.5 ml 17% EDTA 5 ml saline solution 5 mL of citric acid	stereoscopic microscope and scanning electron microscope	Moderate
(Alturaiki *et al.* 2015)[23]	N= 40	single-rooted teeth	master apical file, EndoVac, EndoActivatorand systems	powder	3 ml 18% EDTA and 3 ml 1% NaOCl	scanning electron microscope	Moderate
(Capar *et al.* 2014)[25]	N= 88	single-rooted teeth	conventional syringe irrigation, continuous passive ultrasonic irrigation (PUI), EndoVac irrigation, and SAF irrigation	Premixed	10 ml 17% EDTA 10 ml 2.5% NaOCl	Stereo microscope	Moderate
(Yücel *et al.* 2011)[26]	N=47	single-rooted teeth	30-gauge slot-tipped needle, EndoVac system and ProUltra® PiezoFlow™ ultrasonic irrigation system	Premixed	5 ml of 5.25% NaOCl 5 ml of 17% EDTA	electron microscopic images	Moderate

4. Discussion

Removing intra-canal medicaments from canal systems is crucial for achieving a good seal and the adherence of root canal filling substances to the root canal walls[27]. In the study of Kourti E et al[24], no difference reported between the syringe irrigation, ultrasonic irrigation system, Er: YAG laser, and EndoVac system in the apical third. For the remaining two-thirds of the root canals, Er: YAG laser improved the calcium hydroxide removal compared to conventional techniques, even though none of the techniques achieved complete calcium hydroxide removal from every third tooth. The energy, width, and frequency of the pulse, as well as irradiation time and the fiber tip position, significantly affected the laser's cleaning efficiency. The fiber tip that placed close to the groove, a longer irradiation time, a shorter pulse width, higher pulse energy, and to a lesser extent, a higher pulse frequency yielded better debris scores. However, the shape and diameter of the fiber tip did not exert statistically significant effects on the obtained results [28]. Kumar P et al.[20] reported that EndoVac, EndoActivator, PUI, and F-file presented better results than a conventional side-vented needle. Wang et al.[21] reported that EndoActivator or PUI was more useful to remove residual Ca(OH)2 in a curved root canal system than using the master apical file. Camargo et al.[22] also stated that using the master apical file to remove the intracanal dressing showed the worst results in terms of canal cleanliness. Çapar ID et al.[25] found that using the SAF system in conjunction with EDTA and NaOCl improved the elimination of calcium hydroxide compared to using only NaOCl irrigation with the SAF. The SAF and continuous PUI exerted higher effects on eliminating the calcium hydroxide medicament from artificial standardized grooves in the apical part of root canals compared to conventional syringe irrigation and EndoVac. According to Yücel AÇ et al.[26], the minimum scale values, i.e., the cleanest canals, are associated with the EndoVac and PiezoFlow groups, although these groups were not statistically different. The conventional irrigation group presented significantly higher debris scores ($P<0.05$). Moreover, although the traditional needle irrigation was inefficient in removing calcium hydroxide from root canal systems, irrigation with EndoVac and PiezoFlow™ ultrasonic irrigation systems improved the elimination of intracanal medicaments and the cleaning of the root canal walls. Using a master apical file or syringe irrigation only, are not sufficient to remove the calcium hydroxide dressing from the root canal walls.

5. Conclusion

Although none of the methods examined could eliminate the calcium hydroxide dressing, activation methods resulted in better calcium hydroxide dressing removal compared to using a master apical file or syringe irrigation only.

Conflict of Interest

The authors declared that there is no conflict of interest.

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