

Systematic Review

Efficacy of Removal of Calcium Hydroxide Medicament from Root Canals by Endoactivator and Endovac Irrigation Techniques: A Systematic Review of *In vitro* Studies

Abstract

Introduction: The aim of this systematic review was to systematically evaluate and summarize the outcomes of *in vitro* studies comparing Endoactivator irrigation and Endovac irrigation techniques for removing calcium hydroxide ($\text{Ca}(\text{OH})_2$) medicament from the root canals. **Materials and Methods:** The research question was developed according to the population, intervention, comparison, and outcome strategy. A computerized literature search was conducted in Medline, PubMed, Google Scholar, and Embase. A hand search of the reference lists of identified articles was performed to separate relevant articles. Two reviewers critically assessed the studies that fulfilled the inclusion criteria and processed. Evaluation of the risk of bias of the studies was performed independently by the two reviewers. **Results:** After study selection, 61 were assessed for eligibility. Of these, 13 met the inclusion criteria and were included in the systematic review. Since significant heterogeneity was found in the methodologies, it was not possible to conduct a meta-analysis. **Conclusions:** On the basis of available evidence, we determined that Endoactivator irrigation technique showed better performance in removing $\text{Ca}(\text{OH})_2$ intracanal medicaments from middle third and coronal third area of the root canals and Endovac irrigation technique showed better performance from the apical third area of the root canals. Due to the limitations, small sample sizes, and low number of included studies, further research is needed to confirm our results.

Keywords: Calcium hydroxide removal, Endoactivator, Endovac, irrigation technique, root canals

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Introduction

Rationale

The occurrence of microorganisms into the root canal system plays a major role for the development of pulpal and periapical diseases of the tooth, so the elimination or removal of this microorganisms from root canal systems is considered one of the main goal of endodontic treatments.^[1] The elimination of all microorganisms from the root canal system is accomplished by mechanical instrumentation supported by various irrigating solutions and placement of the different intracanal medicaments.^[2] Although cleaning and shaping of root canal by means of mechanical instrumentation have been shown to significantly reduce the number of bacteria in infected canals, complete disinfection of the root canal is difficult to achieve.^[3]

Calcium hydroxide ($\text{Ca}(\text{OH})_2$) has been widely used in endodontic treatment

as an intracanal medicament, due to its antimicrobial properties against the most of the endodontic microorganisms and its biological effects and also for their capacity to inactivate bacterial endotoxins.^[4] Removal of $\text{Ca}(\text{OH})_2$ medicament from root canals are necessary because the remnant of $\text{Ca}(\text{OH})_2$ on the canal walls will influence dentine bond strength and also harmfully affect the quality of root filling material.^[2] Therefore, it has to be completely removed before obturation of the root canals is suggested.^[5]

If $\text{Ca}(\text{OH})_2$ medicament is not removed from root canal, residues of $\text{Ca}(\text{OH})_2$ medicament can hamper the sealing ability of endodontic sealers which will obstruct the diffusion of root canal sealers into dentinal tubules.^[6] Different irrigation techniques have been in use to determine this problem. Clinically, most commonly used technique for removal of ($\text{Ca}(\text{OH})_2$) medicament is master apical file combined with numerous irrigation

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solutions.^[6] It has been reported that irrigation of root canals with sodium hypochlorite (NaOCl) irrigating solution and ethylenediaminetetraacetic acid (EDTA) irrigating solution achieved better results in removal of Ca(OH)₂ than NaOCl used alone.^[7] Numerous studies have also confirmed that it is difficult to remove Ca(OH)₂ completely from root canals using different irrigation solutions alone. Hence, to overcome this, new irrigation devices such as Endoactivator and Endovac were introduced.^[8]

The Endoactivator system (Dentsply Tulsa Dental Specialties, Tulsa, OK) was introduced as new sonically driven canal irrigation system comprises a portable handpiece and three types of disposable flexible polymer tips with different sizes. These different sized tips do not cut root dentin.^[1] Its design allows safe activation and the production of vigorous intracanal fluid agitation.^[3]

The Endovac system (Discus Dental, Culver City, CA) is one of the true apical negative pressure irrigation devices which are designed to deliver irrigation solutions to the apical end portion of the root canal systems and to suction out debris from the root canals.^[4] This system consists of a master suction tip, a macrocannula, and a microcannula that are connected to a vacuum line. Using this system, irrigation solutions are delivered into the pulp chamber with master suction tip.^[9]

Objectives

Need of the review

The evaluation of Endoactivator and Endovac irrigation technique in the removal of Ca(OH)₂ intracanal medicament from the root canals is essential to establish evidence-based guideline to improve clinical outcomes in endodontics. Previous studies have pointed out the removal efficacy of Endoactivator and Endovac irrigation technique individually. A systematic review has several purposes when the related articles had contradictory results to answer the questions that are not solved by the individual studies. However, no systematic review comparing the effectiveness of removal of Ca(OH)₂ medicament from root canals by Endoactivator and Endovac as an irrigation technique has been conducted.

Therefore, in the present review, the aim is to systematically evaluate the effectiveness of Ca(OH)₂ medicament removal from root canals by Endoactivator and Endovac irrigation techniques.

This systematic review was conducted in accordance with the guidelines of preferred items for systematic reviews and meta-analysis statement.^[10]

The research question was the following:

“Does Endoactivator irrigation technique remove more intracanal Ca(OH)₂ medicament than Endovac irrigation technique from the root canals?”

The population, intervention, comparison, and outcome (PICO) strategy was used for the structured review question is depicted in Table 1.

Materials and Methods

Eligibility criteria

Inclusion criteria for studies

Studies were selected for inclusion if they fulfilled all of the following criteria:

1. Full-text articles
2. Articles in English language
3. *In vitro* studies performed on extracted fully formed (mature) human teeth
4. Studies assessing the removal of Ca(OH)₂ materials placed as an intracanal medicament and evaluating the efficacy of removal of Ca(OH)₂ medicament from root canals by an irrigation device
5. Studies comparing Endoactivator irrigation technique with Endovac irrigation technique or studies comparing one of this two irrigation technique with any another irrigation techniques.

Exclusion criteria for studies

1. Studies which are failing to meet any of these inclusion criteria were excluded
2. Literature reviews
3. Studies which are similar in different search engines (Duplicate studies)
4. Articles in language other than English
5. Studies which are not relevant to the research question like studies which are assessed for smear layer removal from root canals or any other parameter (Irrelevant studies)
6. Studies which are assessed for other aspect than the Ca(OH)₂ removal.

Information sources

Literature search

A computerized literature search was conducted in Medline, PubMed and Google Scholar, and Embase for data published till March 2017 using the keywords such

Table 1: The population, intervention, comparison, and outcome strategy for the structured review question

Research question	Example
The population	Extracted fully formed (mature) human teeth
The intervention	Endoactivator irrigation technique
The comparison	Endovac irrigation technique
The outcome	Removal of Ca(OH) ₂ used as an intracanal medicament from root canals
The study design	<i>In vitro</i> studies examining the effects of Endoactivator irrigation by comparing it with Endovac irrigation technique

Ca(OH)₂: Calcium hydroxide

as Ca(OH)₂ removal, Endo-activator, Endovac, irrigation technique, root canals.

Data sources

Related articles, literature reviews that appeared in various search engines were evaluated and hand search of the reference lists of appropriate articles was also performed to identify relevant articles.

Search

The search strategy was the same for each electronic database. The search strategy used is depicted in Table 2.

Criteria for considering studies for this review

This systematic review included various studies that assessed the Endoactivator and Endovac irrigation techniques in terms of removal of Ca(OH)₂ medicament from root canals. The two reviewers assessed all of the full-text articles. Types of studies, types of populations, types of intervention, and types of outcome were specified as inclusion criteria using the PICO strategy, which enables an evidence-based approach.^[11]

Study selection

The articles were initially evaluated for relevance, on the basis of their titles and abstracts, by an observer independently. Possibly relevant studies were submitted to full-text evaluation. The full texts of the studies were obtained and reviewed for suitability.

Data collection process

Studies that fulfilled the inclusion criteria were processed for data extraction. The focus of this review was the Endoactivator and Endovac irrigation technique used for removal of Ca(OH)₂ intracanal medicament from root canals. The appraisal step was performed in a standardized manner using quality assessment checklists (PRISMA Guidelines, 2009) that included items such as study design and analysis and identified the deficiencies that might arise from bias.^[12] This step was performed by two independent reviewers for better reliability of the results. Any disagreements between the reviewers were resolved by discussion.

Results

Study selection

The combined search through the electronic databases and hand searching resulted in a total of 104 articles. Out of which, 61 articles were eligible for inclusion on the basis of their titles and abstracts. The other 43 articles were rejected as they were found to be irrelevant to the topic or they did not fulfill the inclusion criteria. Out of 61 articles, 48 articles were excluded as they did not fulfill the inclusion criteria and a total of 13 articles submitted to full-text evaluation fulfilled the inclusion criteria and articles were finally selected for the review. The PRISMA checklist flow diagrams of the included studies are presented as flowchart form [Figure 1].

Study characteristics

The authors of all studies that are included in this review reported random assignment in their study reports. No standardization was found among the studies regarding the irrigation methods used for the outcome measurements. For example, researchers in some studies used 10 ml 2.5% NaOCl^[2,5,7,13,14], whereas few other researchers used 1 ml 0.5% NaOCl^[1] and 10 ml 0.5% NaOCl.^[4] In several other studies, the authors have also used 2 ml 3% NaOCl, 5 ml 5.25% NaOCl,^[3,15] 2 ml 1% NaOCl^[16] and 5 ml 3% NaOCl.^[9] In some studies, the researchers used 3 ml 18% EDTA^[1] and 1 ml 17% EDTA^[7] whereas other studies used 5 ml 17% EDTA.^[3,5,8,9,15,16] In addition, differences were also found in irrigation times for the removal of Ca(OH)₂ medicaments from the root canals. Researchers in 8 studies evaluated outcomes using scanning electron microscopy,^[1-4,6,13-15] whereas researchers in 5 studies evaluated outcomes under a stereomicroscope.^[5,7-9,16]

Risk of bias in included studies

In 6 studies,^[2,4,9,14-16] the evaluator assessing the outcomes was blinded to the allocation groups. The sample sizes of the included studies were varied, with a range of 10–25 teeth in each experimental group. The overall risk of bias of the included studies was moderate. Two studies had a low methodological quality score of 3^[7,8] and another had a low methodological quality score of 4.^[2] Five studies had a moderate methodological quality score of 5;^[1,3,5,6,13] the rest of the studies had a moderate methodological quality score

Table 2: Example of the search strategy (Medline, PubMed, Google Scholar, Embase databases)

Search strategy	Results
Example of the search strategy for PubMed database	
Endoactivator	77
“therapeutic irrigation” OR “therapeutic” AND “irrigation” OR “therapeutic irrigation” OR “irrigation”	33,211
Endovac	109
“calcium hydroxide” OR “calcium” AND “hydroxide” OR “calcium hydroxide	6789
#1 AND#2 AND#3 AND#4	5
Example of the search strategy for Google Scholar, Medline , Embase databases	
Endoactivator, Endovac, irrigation technique, calcium hydroxide removal, root canals	99
Filter: Publication date till 2017	

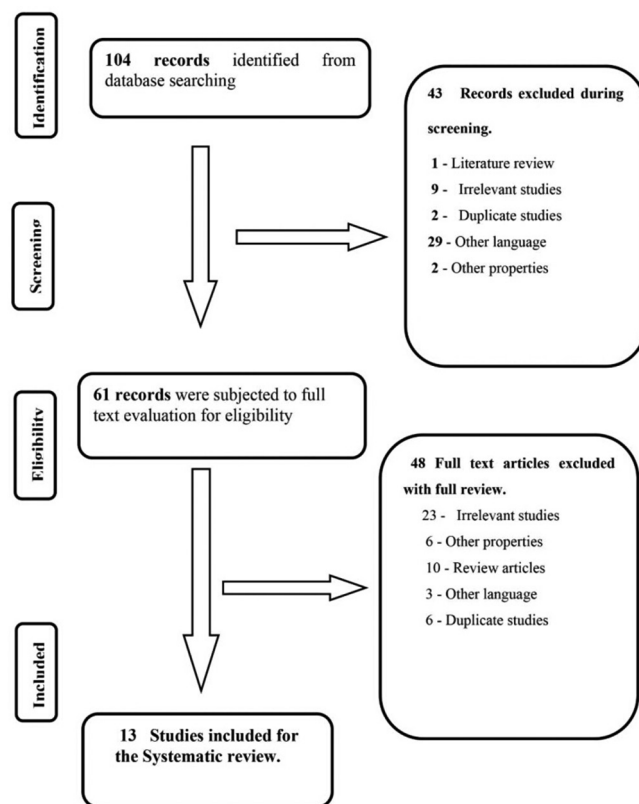


Figure 1: A flowchart of the systematic review process

of 6 [Table 3].^[4,9,14-16] Blinding of the participants was not possible because of the nature of the studies.

Discussion

The findings confirm that the Endoactivator irrigation technique showed better performance in removing Ca(OH)₂ intracanal medicament from middle third and coronal third area and Endovac irrigation technique from apical-third area of the root canals. The most commonly used intracanal medicament is Ca(OH)₂ because it is effective against the majority of endodontic pathogens.^[2] In included studies, various methods have been used to investigate the amount of Ca(OH)₂ residue on the root canal walls such as digital radiographs, conventional radiographs, stereomicroscope, and scanning electron microscopy. In this review, different researchers have discussed about which irrigation techniques to be used for complete removal of Ca(OH)₂ intracanal medicament from the root canals.

Out of 13 studies, 3 studies proposed that Endoactivator system is better than Endovac in removing Ca(OH)₂ medicament from the coronal and middle parts. Alturaiki *et al.* stated that Endoactivator system showed better results in removing Ca(OH)₂ medicament from the coronal, middle, and apical parts of root canals than the Endovac system. The efficiency in eliminating Ca(OH)₂ from root canals by the EndoActivator in combination with irrigation may be caused by its primary function, to produce vigorous

intracanal fluid agitation through acoustic streaming and cavitations. It improves the penetration, circulation, and flow of irrigant into the more inaccessible sites of the root canals.^[1] Further, Al-Garni *et al.* reported that agitation of Endoactivator system combined with NaOCl and EDTA irrigating solutions improved Ca(OH)₂ removal only in the coronal-third area.^[3] Khaleel *et al.* concluded that Endoactivator irrigation technique was more effective in removing Ca(OH)₂ medicament from coronal third, middle third, and apical third of the root canals. The EndoActivator is performed in the coronal part but removed significantly more in the apical part. A possible explanation is that the oscillation amplitude of the sonically activated irrigation needle is higher at the tip than the attached end.^[7]

While rest of the 3 studies concluded that Endovac system is better than Endoactivator in removing Ca(OH)₂ from apical third of the root canals. Turker *et al.* stated that Endovac system showed significantly better in removing Ca(OH)₂ from apical third of the root canals. The effectiveness of Endovac on removal of Ca(OH)₂ from apical third is related to its better mechanical flushing action and vacuum aspiration effect. Moreover, the orifices of the microcannula may provide a portal of exit for Ca(OH)₂, resulting in effective removal from apical third of the root canal.^[2] Ahmetoglu *et al.* stated that Endovac system offers the safe and effective cleaning of Ca(OH)₂ in the apical area of the root canal.^[4] Later, Yücel *et al.* concluded that Endovac irrigation systems improved removal of Ca(OH)₂ from the coronal third, middle third, and apical third resulting in cleaner root canal walls.^[15]

Two of 13 studies proposed that Endoactivator and Endovac are comparable.^[13,14] Dabhi *et al.* stated that Endoactivator and Endovac irrigation techniques performed better in removing Ca(OH)₂ medicaments from coronal third, middle third, and apical third of the root canals but more effective at the apical area due to the design and working properties of these systems like suction out debris and vigorous agitation of irrigant.^[13] Later, Faria *et al.* in his study demonstrated that the rotary instrument combined with Endoactivator and Endovac were more efficiently remove Ca(OH)₂ from middle third and apical third of the root canals.^[14] Summary of 13 studies evidence is summarized in Table 4.

Out of 5 studies, 2 studies reported that a significant problem in using the Endovac system is blockage of the holes of the microcannula. Thus, it may be a contributing factor for the failure to completely remove Ca(OH)₂.^[9] Blockage of the holes of the microcannula may influence the sucking effect of the microcannula and result in insufficient Ca(OH)₂ removal.^[5] While rest of the 3 studies concluded that Endoactivator did not clean the apical third or the isthmus areas successfully, even when their tips were placed close to the root apex. Trapped air in the apical area creates a vapor lock and block, which prevents fluid

Table 3: Quality of the included studies

	Alturaiki S <i>et al.</i> , 2015	Turker S <i>et al.</i> , 2013	Al-Garni <i>et al.</i> , 2014	Ahmetoglu F <i>et al.</i> , 2013	Capar I <i>et al.</i> , 2014	Li <i>et al.</i> , 2015	Khaleel H <i>et al.</i> , 2013	Arsilan H <i>et al.</i> , 2014	Topcuoglu H <i>et al.</i> , 2015	Dabhi M <i>et al.</i> , 2016	Faria G <i>et al.</i> , 2014	Yucel A <i>et al.</i> , 2011	Pabel AK <i>et al.</i> , 2017
Was the assignment to treatment groups truly random?	0	0	0	0	0	0	0	0	0	0	0	0	0
Were participants blinded to treatment allocation?	0	0	0	0	0	0	0	0	0	0	0	0	0
Was allocation to treatment groups concealed from the allocator?	0	0	0	0	0	0	0	0	0	0	0	0	0
Were the outcomes of people who withdrew described and included in the analysis?	0	0	0	0	0	0	0	0	0	0	0	0	0
Were those assessing the outcomes blind to the treatment allocation?	0	1	0	1	0	0	0	0	1	0	1	1	1
Were control and treatment groups comparable at entry?	1	1	1	1	1	1	1	1	1	1	1	1	1
Were groups treated identically other than for the named interventions?	1	1	1	1	1	1	1	1	1	1	1	1	1
Were outcomes measured in the same way for all groups?	1	0	1	1	1	1	0	0	1	1	1	1	1
Were outcomes measured in a reliable way?	1	0	1	1	1	1	0	0	1	1	1	1	1
Was appropriate statistical analysis used?	1	1	1	1	1	1	1	1	1	1	1	1	1
Total	5	4	5	6	5	5	3	3	6	5	6	6	6

No and unclear: 0 point. Yes: 1 point (low methodologic quality: 1-2-3-4 points; moderate methodologic quality: 5-6-7 points; high methodologic quality: 8-9-10 points)^[(10)]

Table 4: Summaries of the characteristics of the studies

Study	Sample size (n)	Type of the teeth	Type of intervention	Type of calcium hydroxide	Placement method of calcium hydroxide score	Verification of calcium hydroxide placement	Irrigation method	Evaluation method
Alturaiki S <i>et al.</i> , 2015	70	Single-rooted teeth	Conventional irrigation Endoactivator Ultrasonic irrigation Endovac	Paste form	Lentulospiral	Radiographs	1 ml 0.5% NaOCl, 3 ml 18% EDTA	Scanning electron microscopy
Turker S <i>et al.</i> , 2013	60	Mandibular canine	Conventional irrigation Canal brush irrigation Endovac Sonic agitation (SAF)	N/A	Lentulospiral	N/A	Conventional irrigation, Endovac, Sonic agitation (SAF) 10 ml of 2.5% NaOCl Canal brush irrigation: 5 ml of 2.5% NaOCl	Scanning electron microscopy
Al-Garni <i>et al.</i> , 2014	44	Single-rooted mandibular premolars	Hand file irrigation Endoactivator	Premixed solution	Lentulo spiral	Radiographs	5 ml of 5.25% NaOCl, 5 ml of 17% EDTA	Scanning electron microscopy
Ahmetoglu F <i>et al.</i> , 2013	30	mandibular premolars	Endovac PUI Needle irrigation	Paste form	Master apical file	Radiographs	10 ml of 5% NaOCl	Scanning electron microscopy
Capar I <i>et al.</i> , 2014	88	Single-rooted mandibular premolars	SAF Endovac PUI	N/A	N/A	Digital photograph	10 ml of 2.5% NaOCl, 17% EDTA for 2 min	Stereomicroscope
Li <i>et al.</i> , 2015	24	Maxillary first premolars	Needle irrigation Endoactivator Ultrasonic irrigation PIPS irrigation	Premixed injectable	Lentulo spiral	N/A	2 ml of 3% NaOCl, for 60 s	Scanning electron microscopy
Khaleel H <i>et al.</i> , 2013	45	Single-rooted teeth	Needle irrigation Protaper file Endoactivator Ultrasonic irrigation	Powder and distilled water	Lentulo spiral	Radiographs	5 ml of 2.5% NaOCl, 1 ml of 17% EDTA	Stereomicroscope
Arslan H <i>et al.</i> , 2014	48	Single-rooted mandibular premolars	Needle irrigation PIPS irrigation Ultrasonic irrigation Endoactivator	Powder and distilled water	N/A	N/A	5 ml of 17% EDTA	Stereomicroscope
Topcuoglu H <i>et al.</i> , 2015	100	Single-rooted teeth	Conventional irrigation Canal brush irrigation PUI SAF Endoactivator Endovac	Powder and distilled water	Lentulo spiral	N/A	5 ml of 3% NaOCl, 5 ml of 17% EDTA for 2 min	Stereomicroscope

Contd...

Table 4: Contd...

Study	Sample size (n)	Type of the teeth	Type of intervention	Type of calcium hydroxide	Placement method of calcium hydroxide score	Verification of calcium hydroxide placement	Irrigation method	Evaluation method
Dabhi M <i>et al.</i> , 2016	60	Maxillary anteriors	Side-vented needle Endoactivator Endovac	Premixed injectable (metapex)	N/A	N/A	5 ml of 2.5% NaOCl for 30 s	Scanning electron microscopy
Faria G <i>et al.</i> , 2014	66	Canines	Conventional irrigation PUI Endovac Endoactivator	Paste form	Lentulo spiral	Radiographs	5 ml of 2.5% NaOCl for 30 s	Scanning electron microscopy
Yucel A <i>et al.</i> , 2011	47	Single-rooted teeth	Side-vented needle Endovac Proultra piezoflow	Powder and saline solution	Lentulo spiral	Radiographs	5 ml of 5.25% NaOCl, 5 ml of 17% EDTA for 90 s, 30 s, 1 min	Scanning electron microscopy
Pabel AK <i>et al.</i> , 2017	110	Single-rooted teeth Central and lateral maxillary incisors, canines, premolars	PUI RinsEndo Endoactivator Motor-driven plastic brush (CanalBrush) Manual irrigation with syringe	Premixed injectable (calxyl)	N/A	Digital photograph	2 ml 1% NaOCl, 5 ml 17% EDTA	Stereomicroscope

EDTA: Ethylenediaminetetraacetic acid; SAF: Self-adjusting file; NaOCl: sodium hypochlorite; PUI: Passive ultrasonic irrigation; PIPS: Photon-induced photoacoustic streaming; N/A: Not available

movement and exchange. It cannot create adequate fluid movement to suck air from the apical region. Furthermore, the needle delivers irrigants no further than 1 mm beyond the needle tip, and therefore, the apical third is inaccessible for flushing. It also delivers insufficient volume of irrigants to the apical area and lacking cavitation, resulted in low efficiency of Ca(OH)₂ removal.^[6] The ineffectiveness of it could result from its inability to create cavitation.^[8] A potential benefit could be its noninvasive mode of action but it is not effectively remove Ca(OH)₂ medicament from coronal and apical groove of root canals when compared to other irrigation techniques.^[16]

Limitations

This review had certain limitations. In that, the first limitation was the complexities of the different methodologies used in the different studies assessed. Different types of Ca(OH)₂, irrigation times, irrigation solutions, and their concentration and outcome measurements were used in the studies assessed. Hence, it was not possible to conduct a meta-analysis. The second limitation was that the results of the included studies were derived from *in vitro* studies. But, however, the clinical trials such as randomized controlled trials give more accurate results.

The third limitation was that all of the included studies described randomized allocation of all groups but none

of the studies described the randomization methods. Furthermore, some of the studies performed blinding and some studies not performed blinding. Hence, this has increased the risk of bias.

The different evaluation methodologies used in the included studies made comparisons difficult amongst the studies because of a lack of uniformity in the evaluative criteria for the assessment of removal of Ca(OH)₂ from root canals. There was no standardization of placement of Ca(OH)₂, removal of Ca(OH)₂, or evaluation methods. The fourth limitation of the review was the small size of the studies evaluated. Studies with larger sample sizes would have led to results that are more accurate.

Conclusions

The review did not find enough evidence for the superiority of Endoactivator and Endovac irrigation techniques investigated because of conflicted, limited, and methodological differences between the studies evaluated. These differences may have led to conflicting evidence in some comparisons. Due to the methodological differences between the studies evaluated, further research is required to produce definitive results. Within the limitation of this systematic review, the current evidence indicates that Endoactivator irrigation technique showed better performance in removing Ca(OH)₂ intracanal medicament

from middle third and coronal third area of the root canals and Endovac irrigation technique from the apical third area of the root canals. However, none of the irrigation techniques removed Ca(OH)₂ intracanal medicament completely from the root canals.

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Conflicts of interest

There are no conflicts of interest.

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