



Research of the major methods and clinical outcomes of irrigation in endodontics: a systematic review

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Abstract

Introduction: In the context of endodontic treatment, mainly endodontic irrigation, endodontic therapy promotes the removal of debris from the pulp tissue, seeking cleaning and asepsis against various microorganisms. **Objective:** Carried out a systematic review of the main methods and clinical outcomes of irrigation in endodontics, presenting information on the effectiveness and biocompatibility on the dentin surface.

Methods: The present study followed by a systematic review (PRISMA). The search strategy was performed in the PubMed, Scielo, Cochrane Library, Web of Science and Scopus, and Google Scholar databases.

Results and Conclusion: The success of endodontic treatment depends on eradicating microbes (if present) from the root canal system and preventing reinfection. In research comparing the effectiveness of EDTA 17% maleic acid to 7%, and observed a greater effectiveness of maleic acid in removing the smear layer from the apical third of single-adicular human teeth. When compared to maleic acid, 5% of 17% EDTA proved to be equally effective. Irrigation with 70% ethanol showed a significantly higher percentage of clean root canal walls and greater depth of clean dentinal tubules when compared to irrigation with 2.5% sodium hypochlorite and 17% EDTA-T. The volume of irrigants and agitation act to reduce the microhardness of dentin in the root canal. The smallest reduction in hardness was found in the EDTA + NaOCl association, which can be explained by the fact that one substance has the power to neutralize the other. An alternative EDTA (EDTA - T) to the conventional one was studied and showed good results to remove the smear layer and a good antimicrobial action, but showed a greater potential to

generate inflammation than conventional 17% EDTA and 10% citric acid. Finally, one study showed that PUI with continuous irrigation and SAF were more effective than EndoVac and the conventional syringe in removing the drug Ca(OH)₂ from a standardized artificial groove in the apical part of the root canal.

Keywords: Endodontic irrigation. Techniques. Root irrigation channel. Efficiency. Dentin surface.

Introduction

In the context of endodontic treatment, mainly endodontic irrigation, endodontic therapy promotes the removal of debris from the pulp tissue, seeking cleaning and asepsis against several microorganisms [1]. Irrigation is the biomechanical preparation of the root canal, reaching places where instruments cannot, due to the complex anatomy of the root system [1].

In this scenario, there are several irrigation solutions designed for endodontic treatment [2,3]. In cases where the pulp is mortified and there is an infection, the irrigating solutions have the function of promoting asepsis, dissolving the necrotic tissue, and facilitating its removal, in addition to neutralizing the bacterial toxin [3]. In this context, ethylenediaminetetraacetic acid (EDTA) is generally used after endodontic instrumentation for its chelating action by which it removes the layer from the smear layer [4]. EDTA in endodontics was introduced in 1957 by Ostby, as a 15.5% aqueous solution at pH 7.3. This facilitates the atresia of the irrigating instrumentation channels, it has the ability to demineralize the dentin through stable calcium ions [4].

In this aspect, as EDTA is one of the most used

endodontic irrigants, it is important that the clinician is aware of the irrigator's properties. Added to this, calcium hydroxide, Ca(OH)₂ has important antimicrobial properties for endodontic treatment [5]. In addition, continuous passive ultrasonic irrigation (PUI) uses an ultrasound-activated file inside the root canal with a continuous irrigant provided by the handpiece. Studies have shown that the PUI was more effective in removing Ca(OH)₂ from the root canal walls than releasing the irrigant by positive pressure [5].

Based on these techniques, the present study carried out a systematic review of the main methods and clinical outcomes of irrigation in endodontics, presenting information on efficacy and biocompatibility on the dentin surface.

Methods

Study Design

The present study followed a systematic review model, following the rules of systematic review - PRISMA (Transparent reporting of systematic review and meta-analysis, access available in: <http://www.prisma-statement.org/>). The search strategy was performed in the PubMed, Scielo, Cochrane Library, Web of Science and Scopus, and Google Scholar databases, using scientific articles from 2004 to 2021.

Descriptors (MeSH Terms)

The main MeSH Terms used were “*Endodontic irrigation. Techniques. Root irrigation channel. Efficiency. Dentin surface*”. For greater specification, the description “*Endodontic irrigation techniques*” for refinement was added during the searches, following the rules of the word PICOS (Patient; Intervention; Control; Outcomes; Study Design). The Cochrane Instrument was used to assess the risk of bias of the included studies.

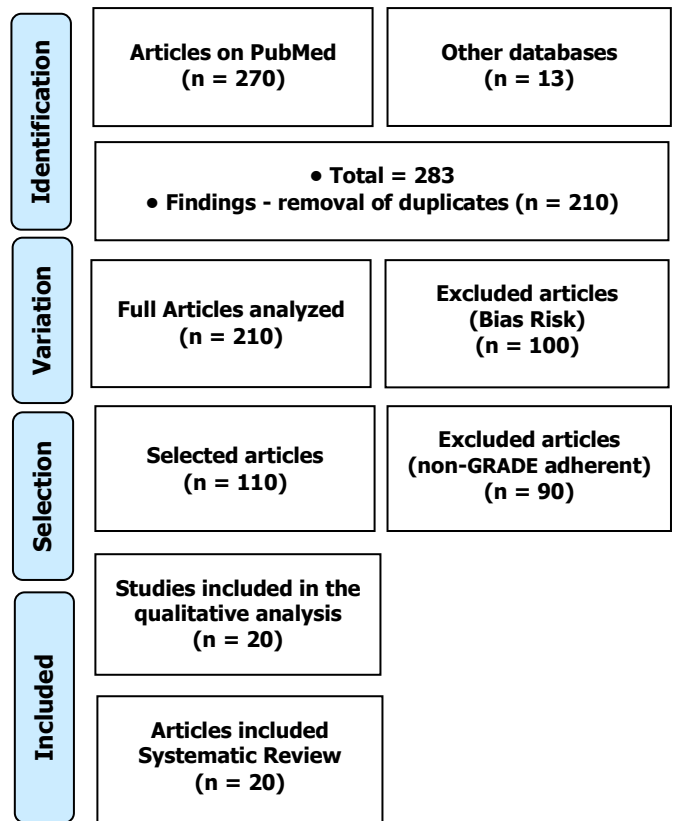
Results and Discussion

Summary of Findings

A total of 283 articles were found involving *endodontic irrigation, techniques and root irrigation channel*. Initially, the duplication of articles was excluded. After this process, the abstracts were evaluated and a new exclusion was performed, based on the elimination of articles with biases that could compromise the reliability of the results, according to the rules of the Cochrane instrument, as well as articles that presented low quality in their methodologies, according to the GRADE classification. A total of 110 articles were fully evaluated and 20 were included in this

study (Figure 1).

Figure 1. Flowchart showing the article selection process.



After this process, it was observed that the success of endodontic treatment depends on the eradication of microbes from the root canal system and the prevention of reinfection [1]. The root canal is formed with manual and rotary instruments under constant irrigation to remove inflamed and necrotic tissue, microbes/biofilms, and other debris from the root space [1]. The main purpose of instrumentation is to facilitate effective irrigation, disinfection, and filling. Several studies using advanced techniques, such as microcomputer tomography, have shown that proportionately large areas of the main wall of the root canal remain untouched by instruments, emphasizing the importance of chemical means to clean and disinfect all areas of the root canal [2].

There is no single irrigation solution that, by itself, sufficiently covers all the functions required of an irrigator [4]. Optimal irrigation is based on the combined use of 2 different irrigation solutions, specific sequence, to predictably achieve the goals of safe and effective irrigation. Traditionally, irrigants are distributed in the space of the chest canal using metal syringes and needles of different sizes and designs. Clinical experience and research have shown, however, that this classic approach typically results in ineffective irrigation, particularly in peripheral areas such as the canals, fins,

and the most apical part of the main root canal [5,6].

In this sense, the removal of the smear layer generated during the instrumentation of the root canal walls is an essential condition for the best antimicrobial efficacy of the irrigation solution in the dentinal tubules, in addition to improving the obturator sealing capacity [7]. The smear layer removal power by the EDTA chelator makes it one of the most used in root canal irrigation. This is generally used as the gold standard for smear layer removal in comparative research studies comparing the effectiveness of EDTA 17% maleic acid to 7% and observed greater effectiveness of maleic acid in removing the smear layer from apical third of single-rooted human teeth. When compared to maleic acid, 5% of 17% EDTA proved to be equally effective [8].

Furthermore, a study evaluated the cleaning of the walls of the root canal and dentinal tubules after an attempt to remove the calcium hydroxide dressing with different irrigating solutions and the use of non-activated irrigation or PUI. Irrigation with 70% ethanol showed a significantly higher percentage of clean root canal walls and greater depth of clean dentinal tubules when compared to irrigation with 2.5% sodium hypochlorite and 17% EDTA-T for both irrigation methods ($p < 0.05$). No differences were observed between the non-activated or PUI irrigation protocols [9].

In addition, a study analyzed the effect of the volume of endodontic irrigants used in different techniques of activation of final irrigation on the microhardness of root canal dentin. A reduction in root canal dentin microhardness was observed with all endodontic irrigation techniques tested. EndoVac and combined irrigation techniques showed maximum reduction in root canal dentin microhardness in all thirds of the root canal. Therefore, the volume of irrigants and the agitation act to reduce the microhardness of the root canal dentin. The total volume of irrigants to cause maximum reduction was 25 mL, beyond which neither volume nor agitation affected root canal dentin microhardness [10,11].

In mixed biofilms developed in situ in the oral cavity, Ordinola-Zapata et al. (2012) [12] evaluated the effectiveness of irrigation agents commonly used in endodontics and found that sodium hypochlorite was the most effective for biofilm dissolution and exhaustion. But, EDTA was not effective for this purpose and had a role compared to saline. Low efficacy of EDTA results was found in another study where we compared EDTA to Qmix, 0.2% cetrimide, 2% chlorhexidine and EDTA, antimicrobial activity, and also substantively. However, some contradict these findings. There is one study that shows almost no potential for disruption of the biofilm structure; however, a high antimicrobial potential of

EDTA, reaching levels similar to those of sodium hypochlorite when used at pH 12 and 50 mmol/L, affecting the membrane integrity of the 24-hour biofilm *E. faecalis*, *L. paracasei* and *S. anginosus*.

Furthermore, EDTA also has antifungal activity against *Candida albicans*, which is a fungus commonly associated with endodontic failures. The evaluation of the antifungal effect of EDTA to ethylene glycol-tetraacetic acid, titanium tetrafluoride, sodium fluoride, nystatin, ketoconazole, EDTA and titanium tetrafluoride showed better antifungal activity [11]. This study corroborates another previous study that compared the inhibition of halo EDTA to various antifungal agents and sodium hypochlorite and EDTA with more satisfactory results [12].

An alternative EDTA (EDTA - T) to the conventional one was studied and showed good results to remove the smear layer and a good antimicrobial action, but showed a greater potential to generate inflammation than conventional 17% EDTA and 10% citric acid [13]. Even when compared to light-sensitized personnel, FotoSan EDTA showed similar cytotoxic action, showing a biocompatible material and similar to other decontamination methods used.

Also, studies have shown that, in addition to removing microorganisms, dissolved organic and inorganic matter, irrigators are capable of damaging the dentin microstructure, leading to changes in the organic material/inorganic surface [14]. The type and intensity of these alterations in the proportion of dentin components depend on the irrigation solution used and can influence the quality of adhesion of sealants and cements used for intraradicular cementation.

Another study evaluated the effects of QMix EDTA Chlorhexidine + EDTA + NaOCl and maleic acid on root dentin microhardness. In this study, the authors found that maleic acid has a high dentin hardness-reducing ability compared to the other groups. The smallest reduction in hardness was found in the EDTA + NaOCl association, which can be explained by the fact that one substance has the power to neutralize the other [15].

Also, the combination of EDTA and NaOCl as a final rinse had no important effect in removing $\text{Ca}(\text{OH})_2$ residues from dentin walls [16]. The differences between the studies may be originated from the use of SAF for removal of $\text{Ca}(\text{OH})_2$. Previous studies used a standardized artificial groove design in the $\text{Ca}(\text{OH})_2$ drug removal assessments. In addition, this model allows you to standardize the size and location of the grooves and the amounts of medication used before irrigation. A disadvantage of this standardized artificial groove design is that it does not represent the complexity of a natural root canal system.

Thus, one study showed that PUI with continuous

irrigation and SAF were more effective than EndoVac and the conventional syringe in removing the drug Ca(OH)₂ from a standardized artificial groove in the apical part of the root canal. Similar to these findings, several previous studies showed that drug Ca(OH)₂ removal was superior to PUI compared with conventional syringe irrigation and sonic irrigation [11,12,15]. The higher speed of the irrigating flow generated by the PUI may explain its efficiency in removing Ca(OH)₂ from root canals. The efficiency of the PUI is also improved with the replacement of fresh irrigators [17-20].

Conclusion

The success of endodontic treatment depends on eradicating microbes from the root canal system and preventing reinfection. In research comparing the effectiveness of EDTA 17% maleic acid to 7%, and observed a greater effectiveness of maleic acid in removing the smear layer from the apical third of single-adicular human teeth. When compared to maleic acid, 5% of 17% EDTA proved to be equally effective. Irrigation with 70% ethanol showed a significantly higher percentage of clean root canal walls and greater depth of clean dentinal tubules when compared to irrigation with 2.5% sodium hypochlorite and 17% EDTA-T. The volume of irrigants and agitation act to reduce the microhardness of dentin in the root canal. The smallest reduction in hardness was found in the EDTA + NaOCl association, which can be explained by the fact that one substance has the power to neutralize the other. An alternative EDTA (EDTA - T) to the conventional one was studied and showed good results to remove the smear layer and a good antimicrobial action, but showed a greater potential to generate inflammation than conventional 17% EDTA and 10% citric acid. Finally, one study showed that PUI with continuous irrigation and SAF were more effective than EndoVac and the conventional syringe in removing the drug Ca(OH)₂ from a standardized artificial groove in the apical part of the root canal.

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Data sharing statement

No additional data are available.

Conflict of interest

The authors declare no conflict of interest.

Similarity check

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References

1. Wright PP, Cooper C, Kahler B, Walsh LJ. Multiple assessment methodologies in determining the antibiofilm actions of sodium hypochlorite mixed with clodronate or etidronate in endodontic irrigation. *J Microbiol Methods*. 2021 Jan;180:106107. doi: 10.1016/j.mimet.2020.106107. Epub 2020 Nov 21. PMID: 33227309.
2. Bartols A, Bormann C, Werner L, Schienle M, Walther W, Dörfer CE. A retrospective assessment of different endodontic treatment protocols. *PeerJ*. 2020 Jan 30;8:e8495. doi: 10.7717/peerj.8495. eCollection 2020.
3. Hsieh SC, Teng NC, Chu CC, Chu YT, Chen CH, Chang LY, Hsu CY, Huang CS, Hsiao GY, Yang JC. The Antibacterial Efficacy and In Vivo Toxicity of Sodium Hypochlorite and Electrolyzed Oxidizing (EO) Water-Based Endodontic Irrigating Solutions. *Materials (Basel)*. 2020 Jan 7;13(2). pii: E260. doi: 10.3390/ma13020260.
4. Gambin DJ, Leal LO, Farina AP, Souza MA, Cecchin D. Antimicrobial activity of glycolic acid as a final irrigant solution for root canal preparation. *Gen Dent*. 2020 Jan-Feb;68(1):41-44.
5. Brignardello-Petersen R. There may be no differences in periapical healing between passive ultrasonic irrigation and nonactivated irrigation when undergoing endodontic treatment. *J Am Dent Assoc*. 2020 Feb;151(2):e14. doi: 10.1016/j.adaj.2019.08.019. Epub 2019 Dec 10.
6. Keine KC, Kuga MC, Coaguila-Llerena H, Palma-Dibb RG, Faria G. Peracetic acid as a single endodontic irrigant: effects on microhardness, roughness and erosion of root canal dentin. *Microsc Res Tech*. 2019 Dec 13. doi: 10.1002/jemt.23424.
7. Qing Y, Akita Y, Kawano S, Kawazu S, Yoshida T, Sekine I. Cleaning efficacy and dentin microhardness after root canal irrigation with a strong acid electrolytic water. *Journal of endodontics*, 2006, 32, 1102-6.
8. Haapasalo M, Shen Y, Wang Z, Gao Y. Irrigation in endodontics. *Br Dent J*. 2014; 216 (6): 299-

- 303.
9. Dias-Junior LCL, Castro RF, Fernandes AD, Guerreiro MYR, Silva EJNL, Brandão JMDS. Final Endodontic Irrigation with 70% Ethanol Enhanced Calcium Hydroxide Removal from the Apical Third. *J Endod.* 2021 Jan;47(1):105-111. doi: 10.1016/j.joen.2020.09.017. Epub 2020 Oct 9. PMID: 33045271.
 10. Arul B, Suresh N, Sivarajan R, Natanasabapathy V. Influence of volume of endodontic irrigants used in different irrigation techniques on root canal dentin microhardness. *Indian J Dent Res.* 2021 Apr-Jun;32(2):230-235. doi: 10.4103/ijdr.IJDR_709_18. PMID: 34810395.
 11. Ferrer-Luque CM, Arias-Moliz MT, González-Rodríguez MP, Baca P. Antimicrobial activity of maleic acid and combinations of cetrimide with chelating agents against *Enterococcus faecalis* biofilm. *J Endod.* 2010 Oct;36(10):1673-5.
 12. Ordinola-Zapata R, Bramante CM, Cavenago B, Graeff MS, Gomes de Moraes I, Marciano M, Duarte MA. Antimicrobial effect of endodontic solutions used as final irrigants on a dentine biofilm model. *IntEndod J.* 2012 Feb;45(2):162-8.
 13. Soares JN, Goldberg F. *Endodontia - Técnicas e fundamentos.* 2 ed. Artmed: Porto Alegre; 2011.
 14. Sahar-Helft S, Stabholtz A, Moshonov J, Gutkin V, Redenski I, Steinberg D. Effect of Er:YAG laser-activated irrigation solution on *Enterococcus Faecalis* biofilm in an ex-vivo root canal model. *Photomed Laser Surg.* 2013 Jul;31(7):334-41.
 15. Zhang K, Kim YK, Cadenaro M et al. (2010) Effects of different exposure times and concentrations of sodium hypochlorite/ethylenediaminetetraacetic acid on the structural integrity of mineralized dentin. *Journal of endodontics* 36, 105-9.
 16. Kishen A, Sum CP, Mathew S, Lim CT. Influence of irrigation regimens on the adherence of *Enterococcus faecalis* to root canal dentin. *J Endod.* 2008 julho; 34 (7): 850-4.
 17. Ates M, Akdeniz BG, Sen BH. The effect of calcium chelating or binding agents on *Candida albicans*. *Oral Surg Oral Med Oral Pathol Oral RadiolEndod.* 2005 Nov;100(5):626-30.
 18. Chandrasekhar V, Amulya V, Rani VS, Prakash TJ, Ranjani AS, Gayathri Ch. Evaluation of biocompatibility of a new root canal irrigant Q Mix™ 2 in 1- An in vivo study. *J Conserv Dent.* 2013 Jan;16(1):36-40.
 19. ZaccaroScelza MF, da Silva Pierro VS, Chagas MA, da Silva LE, Scelza P. Evaluation of inflammatory response of EDTA, EDTA-T, and citric acid in animal model. *J Endod.* 2010 Mar;36(3):515-9.
 20. Gambarini G, Plotino G, Grande NM, Nocca G, Lupi A, Giardina B, De Luca M, Testarelli L. In vitro evaluation of the cytotoxicity of FotoSan™ light-activated disinfection on human fibroblasts. *Med SciMonit.* 2011 Feb 25;17(3):MT21-5.

