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REVIEW ARTICLE

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MAJOR CONSIDERATIONS OF IRRIGATION METHODS IN ENDODONTICS: A SYSTEMATIC REVIEW

Hector Francisco Herrera Andrade[1], Sandy Carolina Andrade Cerón[2], Valeria MaribelLandeta Díaz[3], Idiberto José Zotarelli Filho*[4,5] and Oscar José Pires[4,5]

[1]Smile Odonto Clinic/Madrid y Lugo Quito –Ecuador; [2]UNACH-Consultorio Dental Andrade/Joaquina Galarza y Guadalupe Larriva Quito –Ecuador; [3] Dentalcord/ Quito-Ecuador; [4]University Center North Paulista (Unorp), Graduate in Dentistry, São José do Rio Preto – SP, Brazil; [5]Post Graduate and Continuing Education (Unipos), Postgraduate in dentistry, São José do Rio Preto SP, Brazil

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Corresponding author:
Idiberto José Zotarelli Filho,

ABSTRACT

Introduction: Endodontic therapy aims to remove debris from the pulp tissue resulting from the preparation of the root and microorganisms of the root canal system channels, seeking cleaning and complete antisepsis. Also, the drug calcium hydroxide, Ca (OH) and good antimicrobial properties against the majority of endodontic-2 are used in endodontic treatment as intracanal pathogens relevant in tactical terms. Sodium hypochlorite is an irritant solution widely used in chemotherapeutic treatment for a long time with great effectiveness. Gluconatechlorhexidine is a newer product but with excellent properties but there is still considerable controversy over which is the best product for the treatment of the channel. **Objective:** The objective of the present study was to systematically review the comparative literature to the different methods of endodontic irrigation, as well as to show the different clinical indications for use, in addition to bringing considerations of effectiveness, biocompatibility, and influencing the dentin surface of the solutions irrigation. **Major findings and conclusion:** The success of endodontic treatment depends on the eradication of microbes from the root canal system and the prevention of reinfection. The root canal is formed with manual and rotating instruments under constant irrigation to remove inflamed and necrotic tissue, microbes/biofilms, and other debris from the root space. There is no single irrigation solution that, by itself, sufficiently covers all the functions required of an irrigator. The ideal irrigation is based on the combined use of 2 different irrigation solutions, specific sequence, to obtain predictably the objectives of safe and effective irrigation. Traditionally, irrigantsare distributed in the space of the chest canal using syringes and metal needles of different sizes and designs. Clinical experience and research have shown, however, that this classic approach typically results in ineffective irrigation, especially in peripheral areas, such as canals, fins, and the most apical part of the main root canal. Therefore, many of the compounds used for irrigation have been chemically modified and several mechanical devices have been developed to improve irrigation penetration and efficiency.

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INTRODUCTION

Endodontic therapy aims to remove debris from the pulp tissue resulting from the preparation of the root and microorganisms of the root canal system channels, seeking cleaning and complete antisepsis (Bartols, 2020). Irrigation is one of the most important aspects of the biomechanical preparation of the root canal, since, by this procedure, the irrigating solution can reach places where the instruments cannot, due to the complex anatomy of the root system (Bartols, 2000). The arsenal of irrigation solutions designed for endodontic treatment and commercially available is broad. The choice of the correct solution depends on the combination of the properties of the solution associated with the effects to be obtained with irrigation, according to the clinical condition (Bartols, 2020 and Hsieh, 2020).

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 (Hsieh, 2020). 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 (Gambin, 2020). EDTA in endodontics was introduced in 1957 by Ostby, in the form of a 15.5% aqueous solution and pH7.3. This facilitates the atresia of irrigating instrumentation channels, can demineralize dentin using stable calcium ions (Gambin, 2020). EDTA is one of the most widely used endodontic irrigators and the clinician must become aware of the irrigator's properties. Also, the drug calcium hydroxide, Ca(OH) and with good antimicrobial properties against most endodontic-2 are used in the treatmentof endodontic as intracanalpathogens relevant in tactical terms (Brignardello-Petersen, 2020). Research shows that the remaining Ca(OH)2 in the dentin walls can affect the penetration of sealers in dentinal tubules and increase apical leakage. Therefore, it is recommended to completely remove the Ca(OH)2 placed inside the root canal before filling the root system (Brignardello-Petersen, 2020). Thus, the most frequently described method for removing Ca(OH)2 is the instrumentation of the root canal with a main apical file at the working length and the abundant irrigation of sodium hypochlorite (NaOCl) and EDTA. Previous studies have investigated the effectiveness of removing Ca(OH)2 with different irrigation devices and systems (Keine, 2019) Continuous passive ultrasonic irrigation (IUP) uses an ultrasound-activated file inside the root canal with a continuous irrigator provided by the handpiece. Studies have shown that IUP was more effective in removing Ca(OH)2 from the walls of the root canal than the release of irrigant by positive pressure (Keine, 2019).

The EndoVac system (Discus Dental, Culver City, CA) is an apical negative pressure (ANP) irrigation device designed to provide irrigation solutions for the apical portion of the canal system and to suck up debris. The EndoVac system ANP effectively cleans dentinal surfaces. ANP irrigation with sufficient volume and flow removes the smear layers and displaces debris (Keine, 2019). Also, the self-adjusting filing system (SAF) (Re-Dent-Nova, Raanana, Israel) adapts to the three-dimensional shape of the root canal to allow continuous irrigation during the preparation and activation of vibrating irrigators. The SAF system is operated by vibrating a slightly abrasive lattice in an in and out movement to remove dentin (Qing, 2006). SAF is more effective at removing dentine debris from the canalroot than rotary instrumentation. However, whether the SAF can remove the drug Ca(OH)2 from the root canal wall is not known (Qing, 2006). The objective of the present study was to make a systematic review of the comparative literature to the different methods of endodontic irrigation, as well as to show the different clinical indications of use, besides bringing considerations of efficacy, biocompatibility, and influencing the dentin surface of the irrigation solutions.

METHODS

For the selection of scientific papers, a detailed search strategy was carried out for the Medline (Pubmed), Scielo, Bireme, Google Scholar, and Cochrane databases in the years 1989 - 2019, in addition to books and magazines related to the theme. The inclusion and exclusion criteria were: systematic review studies, meta-analysis, controlled and randomized cases, non-randomized clinical cases, and opinion articles, which addressed the term endodontic irrigation. The data were analyzed, correlated for the discussion of the results highlighted in the literature.

MeSH Terms: The main descriptors (MeSH Terms) used were “Endodontic irrigation. Root canal irrigation. Different methods. Clinical studies”. For further specifications, the description “endodontic irrigation” for refinement was added during the research, following the rules of the systematic review-PRISMA (Transparent reporting of systematic reviews and meta-analysis-https: //www.prisma-statement.org/).

Series of Articles and Eligibility: One-fifty hundred (150) articles were found involving minimally invasive surgery, traumatic surgery, endodontics, implantology, extraction. Initially, the duplication of articles was excluded. After this process, abstracts were evaluated and a new exclusion was performed, removing articles that did not include endodontics). A total of 65 articles were evaluated in full and 37 were included and discussed in the present study (Figure 1).

Selection of studies and risk of bias in each study: Two independent reviewers (1 and 2) carried out research and study selection. Data extraction was performed by reviewer 1 and completely reviewed by reviewer 2. A third investigator decided on some conflicting points and made the final decision to choose the articles. Only studies reported in Portuguese and English were evaluated. The Cochrane Instrument was adopted to assess the quality of the included studies.

Risk of bias: Considering the Cochrane tool for risk of bias, the overall assessment resulted in 5 studies with a high risk of bias and 3 studies with uncertain risk. The domains that presented the highest risk of bias were related to the number of participants in each study addressed, and the uncertain risk was related to the literary consensus on the effectiveness of the applications of minimally invasive techniques in endodontics and/or surgeries for dental implants. Also, the funding source was absent in 4 studies and 3 studies did not disclose information about the conflict of interest statement.

LITERARY REVIEW AND DISCUSSION

The success of endodontic treatment depends on the eradication of microbes (if present) from the root canal system and the prevention of reinfection (Bartols, 2020). The root canal is formed with manual and rotating instruments under constant irrigation to remove inflamed and necrotic tissue, microbes/biofilms, and other debris from the root space (Bartols, 2020). The main purpose of instrumentation is to facilitate effective irrigation, disinfection, and filling. Several studies using advanced techniques, such as microcomputing tomography, have shown that proportionally large areas of the main root canal wall remain untouched by the instruments, emphasizing the importance of chemical means to clean and disinfect all areas of the root canal (Keine, 2019). There is no single irrigation solution that, by itself, sufficiently covers all the functions required of an irrigator (Gambin, 2012). The ideal irrigation is based on the combined use of 2 different irrigation solutions, specific sequence, to obtain predictably the objectives of safe and effective irrigation.

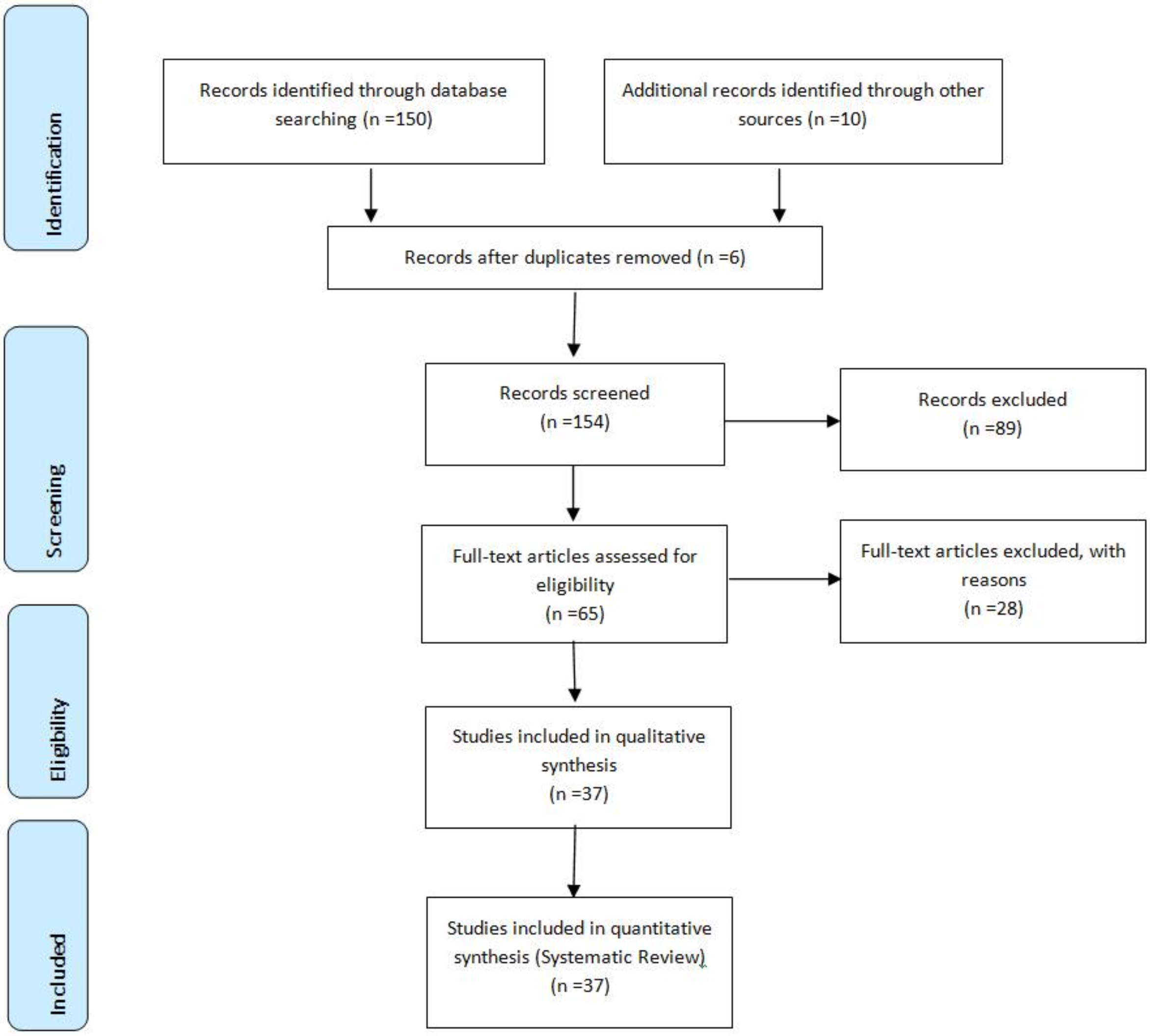

Figure 1. Flowchart

Traditionally, irrigators are distributed in the space of the chest canal using syringes and metal needles of different sizes and designs. Clinical experience and research have shown, however, that this classic approach typically results in ineffective irrigation, especially in peripheral areas, such as canals, fins, and the most apical part of the main root canal (Brignardello-Petersen, 2019). Therefore, many of the compounds used for irrigation have been chemically modified and several mechanical devices have been developed to improve irrigation penetration and efficiency (Brignardello-Petersen, 2019 and Keine, 2019). 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 effectiveness of the irrigation solution in the dentinal tubules, in addition to improving the sealing ability of the obturator (Qing, 2006). The smear layer removal power by the EDTA chelator makes it one of the most used in the irrigation of root canals. This is generally used as the gold standard for the removal of the smear layer in comparative studies conducted in research comparing the effectiveness of EDTA 17% maleic acid to 7% and noted greater effectiveness of maleic acid in removing the smear layer from the apical third of uniradicular human teeth (Haapasalo, 2014). When compared to maleic acid, 5% EDTA 17% proved to be equally effective (Haapasalo, 2014). In a recent study that evaluated the removal of the smear layer in SEM for various irrigation agents (EDTA, apple cider vinegar, 5% maleic acid, acetic acid, and distilled water as a control), EDTA promoted the best results, proving to be the most effective solution (Soares, 2011). Another work, noting the removal of the smear layer with an SEM evaluation, was carried out by Cehreli et al. (2013). This work, carried out in vivo, promoted the instrumentation and irrigation channels with 5.25% NaOCl or 17% EDTA or MTAD Biopure and were extracted immediately. And among these irrigation solutions, EDTA showed significantly better results at the expense of greater dentin erosion (Cehreli, 2013). In a study by Zia et al. (2014) performed on extracted teeth, EDTA equivalence to MTAD Biopure can be observed, being more efficient than brine. Another study compared three different formulations of QMix with EDTA and found better effectiveness of QMix in removing the smear layer in the apical third and equivalence between the results of the solutions in the middle and cervical thirds, showing a viable alternative to EDTA for the end of irrigation (Sahar-Helft, 2013). The alternative would be to use the EDTA gel, which proved to be as effective as the liquid in the same concentrations and conditions of use (Sahar-Helft, 2013).

Antimicrobialaction: As it is well used in the endodontic irrigator, EDTA has studied its antimicrobial properties, as is usually the final irrigating treatment. Bryce et al. (2009) conducted a study to verify the antimicrobial action of irrigating agents on biofilms of microorganisms isolated from root canals. The authors observed low antimicrobial efficacy of EDTA in biofilm, especially when compared to sodium hypochlorite. Also, EDTA, which conditions dentin to allow an increase in the number of connected microorganisms, as well as resistance to adhesion (Bryce, 2009) and compared to other types of irrigation, has low retention power in reinfection or activity residual is low, which can only be improved with the addition of auxiliaries in a composition (Bryce, 2009). In mixed biofilms developed in situ in the oral cavity, Ordinola-Zapata et al. (2012) evaluated the efficacy of irrigation agents commonly used in endodontics and found that sodium hypochlorite was the most effective for dissolving and depleting biofilm. But EDTA was not effective for that purpose and had a stake compared to saline. Low efficacy of EDTA results was found in another study in which we compared EDTA to Qmix, 0.2% cetrimide, 2% chlorhexidine and EDTA, antimicrobial activity,and alsosubtantivity (Ordinola-Zapata, 2012). However, some contradict these findings. There is a study that shows almost no potential for disruption of the biofilm structure; however, a high antimicrobial potential for EDTA, reaching levels similar to sodium hypochlorite when used at pH 12 and 50 mmol/L, affecting the integrity of the biofilm membrane 24 hours E. faecalis, L. paracasei and S. anginosus (Ordinola-Zapata, 2012). EDTA also has antifungal activity against Candida albicans, which is a fungus commonly associated with endodontic failure. The evaluation of the antifungal effect of EDTA to tilenoglycol-tetraacetic acid, titanium tetrafluoride, sodium fluoride, nystatin, ketoconazole, EDTA and titanium tetrafluoride showed better antifungal activity (Ordinola-Zapata, 2012). This study corroborates another previous study that compared the inhibition of the halo EDTA with several antifungals and sodium hypochlorite and EDTA with more satisfactory results (Zhang, 2010). One way to improve the antimicrobial action of EDTA would be the association with cetrimide. Ferrer-Luque et al. (2010) found that EDTA associated with the same 15% cetrimide, compared to maleic acid, has a lower antimicrobial activity. Also, EDTA has a low potential to prevent the recolonization of the root canal and, therefore, can associate another irrigating solution to it, to improve the substantivity of the action of the final irrigant. One of the viable options studied is the addition of cetrimide EDTA with promising results (Ferrer-Luque, 2012).

Biocompatibility: Chandrasekhar et al (2013) injected 0.1 ml of various solutions into the mice's back and found that EDTA had toxicity similar to QMix and less toxic when compared to 3% NaOCl, and more toxic than the physiological solution. In a more recent study, Prado et al (2015) compared the cytotoxicity of 17% EDTA compared to 37% phosphoric acid, 10% citric acid, 5.25% NaOCl and 2% chlorhexidine. In this study, it is possible to observe a lower cytotoxicity of EDTA and citric acid, when compared with other tested substances, presenting a good biocompatibility of EDTA. An alternative EDTA (EDTA - T) to the conventional one has been studied and has shown good results to remove the smear layer and a good antimicrobial action, but has demonstrated a greater potential to generate inflammation than conventional EDTA 17% and citric acid 10% (Østby, 1957). Even when compared to personnel sensitized by light, FotoSan EDTA showed a similar cytotoxic action, showing a biocompatible material and similar to other decontamination methods used (Østby, 1957).

Dentin changes: Studies have shown that, in addition to the removal of microorganisms, dissolved organic and inorganic matter, irrigators can damage the dentin microstructure, leading to changes in the organic material/inorganic surface (Wang, 1957). The type and intensity of these changes in the proportion of dentinal components depend on the irrigation solution used and may influence the quality of adhesion of sealants and cements used for intraradicular cementation (Shahravan, 2007). Another study evaluated the effects of QMix EDTA Chlorhexidine + EDTA + NaOCl and maleic acid on the root dentin microhardness. In this study, the authors found that maleic acid has a high capacity to reduce dentin hardness compared to the other groups. The lowest reduction in hardness was found in the association EDTA + NaOCl, which can be explained by the fact that one substance has the power to neutralize the other (Chávez de Paz, 2010). Still, another study examined the effect of the final irrigation protocols (17% EDTA, Biopure MTAD and Smear ClearQMiX) on dentine root canal hardness and erosion. All irrigating agents promoted a reduction in dentin hardness and EDTA promoted erosion of dentinal tubules. When compared to alternative chelating agents, such as 2.25% peracetic acid, which demonstrated good antimicrobial power, EDTA 17 % shows a similar erosion of power in the dentinal walls (Ates, 2010). Ballal et al (2013), (Ballal, 2009). Evaluated the influence of irrigants (EDTA, 2.5% NaOCl, maleic acid and 7% QMix) on the wetting of two cements (AH Plus and ThermaSeal) on intra-root dentin. QMix proved to be the most favored irrigator than the wetting of cements in the root canal dentin, which promoted better adherence and sealing of the obturator. As Aranda-Garcia et al 2013 studied the influence of three different irrigating adhesives (QMix, EDTA and Smear Clear) of a cement epoxy resin, not checking the interference of the adhesiveness of these materials on the root canal wall.

Elnaghy (2014) (Elnaghy, 2014) conducted a study that evaluated the influence of various irrigations on the adhesion of sealants, biodentin and MTA. The author found that QMix did not influence the adhesion of the materials and obtained results similar to those of EDTA and NaOCl. Another study by Elnaghy (2014) to assess the influence of EDTA associated with chlorhexidine on the adhesion of fiberglass pins cemented with resin cement in the root canal and showed that QMix and EDTA associated with chlorhexidine provided the best adhesion results. There are contradictory results in the literature on the need to remove Ca(OH)2 (Kirchhoff, 2014; Kuruvilla, 2015; Hasheminia, 2012; Cehreli, 2013 and Zia, 2014). However, it is well established that residual Ca(OH)2 must be removed because it influences the bonding and sealing of endodontic materials (Bryce, 2009). The use of the SAF system with the combination of EDTA and NaOCl improved Ca(OH)2 removal. Thus, the combination of EDTA and NaOCl as a final rinse had no important role in removing Ca(OH)2 residues from the dentin walls (Kishen, 2008). The differences between the studies may be stemmed from the use of SAF to remove Ca(OH)2. Previous studies used a standardized artificial groove design in assessments of Ca(OH)2 removal. Also, this model allows to standardize the size and location of the grooves and the quantities 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 (Kishen, 2008). Thus, a study showed that IUP with continuous irrigation and SAF were more effective than EndoVac and the conventional syringe in removing the Ca(OH)2 drug from a standardized artificial groove in the apical part of the root canal. Similar to these findings, several previous studies have shown that removal of the drug

Ca(OH)2 was superior to IUP compared to irrigation with conventional syringe and sonic irrigation (Ferrer-Luque, 2010, & 2012; Ordinola-Zapata, 2012 and Zhang, 2010). The higher speed of the irrigating flow generated by the IUP may explain its efficiency in removing Ca(OH)2 from the root canals. IUP's efficiency is also improved by replacing fresh irrigators (Ates, 2005; Chandrasekhar, 2013; ZaccaroScelza, 2010 and Gambarini, 2011). The same study also revealed that there was no significant difference between syringe irrigation and EndoVac. However, in contrast to our Ycelel et al reported that the EndoVac system is superior to conventional irrigation needles in removing the Ca (OH)2 medication. Therefore, this study was created to simulate non-instrumented instruments channel extensions in the apical half. This may explain the conflict results. Still, blocking the microcannula orifices is a concern.

It can be assumed that the removal of the drug Ca(OH)2 can influence the suction effect of the microcannula and result in insufficient removal of Ca(OH)2. The SAF system improved the removal of gutta-percha from the root canal. However, there are no data available in the literature on the effect of APS on the removal of the drug Ca(OH)2 (Doğan, 2001; Prado, 2015; Panighi, 1992; Perdigao, 2001 and Kara Tuncer, 2015). The artificial furrow model was created in the apical part of the root canal to simulate uninstructed extensions of the canal (Aranda-Garcia, 2013). Studies report that the removal of the drug Ca (OH)2 from the apical part of the root canal wall is very difficult (2013). After the removal of the Ca(OH)2 drug from the main canal, the remnants may remain in canal extensions or irregularities (Elnaghy, 2014 and Elnaghy, 2014).

CONCLUSION

Irrigation plays a fundamental role in the success of endodontic treatment. Although hypochlorite is the most important irrigating solution, no irrigator can perform all the tasks required by irrigation. A detailed understanding of the mode of action of various solutions is important for optimal irrigation. New developments, such as CFD and mechanical devices, will help promote safe and effective irrigation. Within the limitations of this study, the use of the SAF system with the combination of EDTA and NaOCl improved the removal of Ca(OH)2. PUI and SAF were more effective in removing Ca(OH) 2 from the lateral grooves in the apical parts of the root canal than EndoVac and conventional syringe irrigation systems.

Competing Interests: The authors no have competing interests.

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