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Irrigation solutions used in endodontic treatment. A scoping review

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Abstract
Introduction: The article has the medical importance in presenting ozone therapy, its application and benefits as a new irrigant in endodontic treatment.
Objective: To analyze the literature on ozone, sodium hypochlorite, ethyleneaminotetraacetic acid and chlorhexidine.
Methodology: A literature review was carried out by searching the Pubmed, Scopus an Google Scholar databases using the keywords: “ozone”, “therapy”, “dentistry”, “endodontics”, “sodium hypochlorite” “EDTA” “chlorhexidine”.
Results: Ozone has a powerful antioxidant capacity and outstanding antimicrobial properties and its toxicity, when properly administered, can be beneficial. Sodium hypochlorite helps to dissolve organic tissue giving cleanliness and disinfection of the root canal, high concentrations of NaOCl can irritate periapical tissues. Chlorhexidine is one of the main irrigants used in endodontic treatment, it is less cytotoxic to periapical tissues than NaOCl. EDTA benefits endodontic treatment by improving the seal of the obturation material. It is recommended in lower concentrations for clinical use to avoid cytotoxicity.
Conclusions: Ozone as a disinfectant and antioxidant agent, will have efficacy when handled with caution due to its intrinsic toxicity. Sodium hypochlorite stands out for its potent antibacterial activity, although its use in high concentrations can cause irritation. EDTA improves the seal of the filling material and demineralizes dentin, although it should be used in adequate concentrations to avoid excessive erosion. Chlorhexidine shows less cytotoxicity and greater regeneration compared to sodium hypochlorite.

Keywords: ozone, therapy, dentistry, endodontics, sodium hypochlorite, EDTA, chlorhexidine

Introduction
Successful root canal treatment hinges on three key factors: effectively filling the entire root canal system (three-dimensional obturation), completely eliminating bacteria from the infected pulp space (sterilization), and carefully shaping the root canal for proper filling (biomechanical preparation). While shaping the canals (instrumentation) is crucial, it alone cannot guarantee the complete removal of all bacteria from the root canal. [1]. Instrumentation and irrigation procedures using chemomechanical techniques are essential for root canal disinfection [2]. The aim of endodontic treatment with the aid of irrigants is to clean the infected pulp and periradicular tissues while preventing infection [3].
Ozone is a natural chemical compound composed of three oxygen atoms. It has the ability to absorb much of the ultraviolet energy emitted by the sun, making it one of the most important gases in the stratosphere [4]. The application of ozone in the medical field has been indicated for the prevention and treatment of various pathologies in dentistry [5]. A recent review reveals the lack of information about the application of ozone therapy in dentistry, which presents benefits for the treatment of the patient. This lack of data may lead to a lack of innovation in the dental field.

In this review it was analyzed the literature on the different types of irrigants used in endodontic treatment such as ozone, sodium hypochlorite, ethylenediaminetetraacetic acid and chlorhexidine, as well as their properties, antimicrobial activity, toxicity and contraindications.

Materials and Methods
Articles on the subject published through the PubMed, Scopus and Google Scholar databases were analyzed, with emphasis on the last 5 years. The quality of the articles was evaluated using guidelines, i.e., identification, review, choice and inclusion. The quality of the reviews was assessed using the measurement tool for evaluating systematic reviews. The search was performed using Boolean logical operators AND, OR and NOT; with the keywords: ozone, therapy, dentistry, endodontics, sodium hypochlorite, EDTA, chlorhexidine. The keywords were used individually, as well as each of them related to each other.

Results: Ozone
Properties: Ozone exhibits outstanding antioxidant capacity and possesses remarkable antimicrobial properties, in addition to other significant biological effects [6]. Ozone, also referred to as triatomic oxygen or trioxygen, is a molecule made up of three oxygen atoms. Found naturally in the Earth's stratosphere, it exists as a gas with concentrations fluctuating between 1 and 10 parts per million. This ozone layer is constantly being formed and broken down from ordinary molecular oxygen [7].
Ozone (O3) is a molecule made up of three oxygen atoms that readily dissolves in water. Its unique structure, with shifting electron arrangements, makes it inherently unstable. This instability makes it challenging to achieve and maintain high concentrations of ozone [8]. Application methods for ozone in oral tissues include the use of ozonated water, ozonated olive oil, and the delivery of oxygen/ozone gas directly [9]. Ozone, both in gas and liquid forms, possesses strong microbiological and metabolic properties, making it an effective disinfectant against a broad spectrum of microorganisms [10]. Research findings indicate that ozone does not cause significant harm to human oral epithelial cells, gingival fibroblasts, and periodontal cells, suggesting a degree of biocompatibility [11].

Antimicrobial
Ozone, both in its gaseous and aqueous form, has proven to be an effective and reliable antimicrobial agent against bacteria, fungi, protozoa and viruses. Its oxidizing capacity leads to the destruction of cell walls and cytoplasmic membranes of bacteria and fungi [12]. The success of ozone disinfection was intricately linked to the chosen application method. Factors like the ozone concentration, treatment duration, the target bacterial species, and the use of supplementary disinfection techniques all played a crucial role in determining the overall performance [13]. Although no solution used as an irrigant for a contact time of 20 minutes has demonstrated an antimicrobial effect against E. faecalis [14].

Toxicity
Ozone, while a toxic gas, can offer significant therapeutic benefits when administered correctly by qualified medical professionals. Its potential is often overlooked due to prevailing misconceptions and a resistance to alternative therapies. Ozone therapy's effectiveness stems from its ability to trigger a chain reaction of beneficial compounds within the body, addressing various aspects of a disease simultaneously. This multifaceted approach can be particularly helpful in situations where conventional medicine may fall short [15]. While ozone possesses inherent toxicity, this property can be carefully managed. In fact, ozone can function as a bioregulator, exerting beneficial effects on various biological processes. To conclusively determine the therapeutic potential of ozone, rigorously controlled clinical investigations are essential [16].
Ozone is naturally present in the stratosphere and its application in gaseous or aqueous form shows efficacy as a disinfectant against a wide range of microorganisms. It has a powerful antioxidant capacity and outstanding antimicrobial properties. Its intrinsic toxicity has raised concern, although ozone therapy, when properly administered by medical experts, may be beneficial in conditions where traditional medicine appears limited.

Sodium hypochlorite (NaOCl)
Properties: NaOCl is an antibacterial and proteolytic agent that functions as a fantastic organic tissue solvent in addition to being a lubricant with a rapid onset of action. It is widely used as both an oxidizing agent and a hydrolyzing agent [3]. It can be used in various concentrations ranging from 0.5% to 5.25%, where the most commonly used is 2.5%. Higher concentrations may cause increased cytotoxicity and irritation of periapical tissue [17]. NaOCl appears to be one of the most common and cost-effective solutions for root canal irrigation [18].

Antimicrobial
Sodium hypochlorite has superior antimicrobial activity compared to several other irrigants; however, it does not eradicate biofilm volume, nor does it achieve complete bacterial kill, it was more effective than chlorhexidine in reducing microorganisms in one study [2], and among endodontists, almost 94 percent used sodium hypochlorite for irrigation [19].
Hypochlorite can eliminate 100 % of E. faecalis biofilms by presenting higher antimicrobial activity within the dentinal tubules [20].

Toxicity
NaOCl solutions, typically at a 5.25% concentration, are widely used in root canal treatments. This is because they effectively kill bacteria, help remove debris from the root canal during cleaning, dissolve organic matter, and have a broad range of antimicrobial activity. While NaOCl is highly effective at eliminating microbes, the optimal concentration for use in endodontic procedures remains unclear. The ideal concentration must strike a balance between its antibacterial power and its potential to damage healthy tissues. [21]. the use of NaOCl at high concentrations poses a risk of periapical tissue irritation and damage to the mineralized root canal wall [22]. Sodium hypochlorite is an antibacterial agent that helps to dissolve organic tissue giving cleanliness and disinfection of the root canal. Its antimicrobial activity is superior compared to other irrigants used and it is recommended to use it in a pure concentration of 5.25% to effectively eliminate microorganisms. In high concentrations it can irritate the periapical tissues and create hematomas or pain.

Ethylenediaminetetraacetic acid
Properties: Ethylenediaminetetraacetic acid (EDTA), a versatile compound, effectively binds to metals. This

polyaminocarboxylic acid, appearing as a colorless and water-soluble solid, utilizes four carboxylate and two amine groups for this binding process. EDTA finds extensive use in dissolving lime deposits [23]. The original recommendation was to use a 15% EDTA solution with a pH of 7.3. However, the most common type of EDTA solution available is neutralized and has a concentration of 17% [3]. EDTA, a common chelating agent in root canal treatments, binds to calcium in tooth structure (dentin). This action helps remove mineral components, primarily calcium ions, from the dentin surface. EDTA is employed in various concentrations and often combined with other agents during root canal procedures. The effectiveness of these chelating agents is influenced by several factors, including the length of the root canal, how deeply the agent penetrates the dentin, the dentin's hardness, the duration of its application, and the pH and concentration of the chelating solution [24].

Antimicrobial

Neutral solutions of EDTA, at a concentration of 15-17 %, are effective in demineralizing dentin [25]. Dentin softens and loses minerals (demineralizes) more the longer it's exposed to acidic substances. In the lower part of the tooth root (apical third), a short (one-minute) treatment with 17% EDTA using ultrasound significantly improves cleaning. Additionally, using liquid EDTA during root canal procedures is generally advised [3]. These results suggest that 15% EDTA solution is more effective than saline as a root canal irrigant [26]. EDTA acts by dissolving the inorganic components of the smear layer, where it has been recommended for use in combination with 0.5-5.25% NaOCl to remove organic debris [27].

Toxicity

Studies have demonstrated that EDTA solutions ranging from 15% to 5% exhibit comparable levels of root canal wall erosion. In contrast, 1% EDTA solutions demonstrated limited erosive action. No significant variations in erosion patterns were observed across different areas of the root canal. To minimize excessive dentin loss, lower EDTA concentrations are generally recommended for clinical applications [28]. EDTA significantly decreases the microhardness of root dentin compared to intact controls [29]. Using as irrigant for 1, 3 and 5 minutes was equally effective in removing the smear layer from the canal walls of straight roots [30].

EDTA benefits endodontic treatment by improving the seal of the obturation material by the effective removal of dentin sludge, as well as it has been shown that dentin demineralization increases with the amount of time spent in contact with EDTA. A low concentration is recommended for clinical use to avoid excessive erosion of the canal dentin.

Chlorhexidine

Properties: Chlorhexidine has been a highly effective and widely used antiseptic in medicine for many years [31]. This potent germicide effectively reduces bacterial growth in the oral cavity. Oral rinses typically contain 0.1 to 0.2% water-based solutions, whereas root canal cleaning during root canal therapy utilizes a 2% concentration [3]. Chlorhexidine is a versatile antimicrobial agent that can be used throughout the root canal treatment process. It can be applied to disinfect the area before starting, used during the widening of the canal opening, help remove dead tissue before measuring the root canal's length, and assist in cleaning the canal itself. Chlorhexidine can be used alone or combined with other substances. It's seen as a good alternative to NaOCl because it effectively kills bacteria, its effects last for a significant period, and it helps prevent the root canal from becoming reinfected [32].

Antimicrobial

Chlorhexidine, a positively charged molecule, possesses broad-spectrum antimicrobial capabilities. This positive charge endows it with a distinctive characteristic known as substantivity [33]. Contrary to the characteristics of sodium hypochlorite, chlorhexidine results in less tissue irritation, although its effective role in disrupting polymicrobial biofilms and dissolving pulp tissue debris remains in doubt [32]. Although chlorhexidine is useful as a final irrigant, its use as a primary canal irrigant is not recommended because of its inability to dissolve necrotic debris [34]. Despite exhibiting comparable antibacterial efficacy, chlorhexidine and sodium hypochlorite possess distinct molecular mechanisms of action. This divergence in their modes of action renders them suitable for primary use as root canal irrigants [17]. These findings suggest that chlorhexidine and sodium hypochlorite are more effective than saline in eliminating bacteria from root canals, which may improve treatment outcomes and reduce the risk of post-treatment infection [35]. This substance effectively eliminates a broad spectrum of bacteria, encompassing both Gram-positive and Gram-negative types, regardless of their oxygen requirements (aerobic or anaerobic). It also demonstrates activity against yeasts, such as Candida albicans, and fungal organisms [36]. Chlorhexidine demonstrates antimicrobial action against a diverse array of microorganisms. This includes both Gram-positive and Gram-negative bacteria, encompassing both facultative and strict anaerobes, as well as aerobic bacteria. Additionally, it exhibits activity against yeasts, fungi, and certain viruses. However, it is important to note that chlorhexidine is ineffective against bacterial spores [31].

Toxicity

Chlorhexidine has been shown to be harmful to various types of human cells in laboratory studies. This damage isn't limited to a specific cell type. Research has demonstrated that chlorhexidine can negatively impact the health of several crucial cells found in the mouth, including those that make up the gums (gingival fibroblasts), the tissue that supports the teeth (periodontal ligament cells), the jawbone (alveolar bone cells), and the bone-forming cells (osteoblastic cells) [37]. Compared to 0.5% sodium hypochlorite, 1% chlorhexidine gluconate has demonstrated superior performance in both *in vivo* and *in vitro* experiments. It is less harmful, less irritating, and facilitates quicker tissue regeneration [38]. It has been described as a possible substitute for sodium hypochlorite during chemomechanical debridement in endodontic treatment; it is less cytotoxic to periapical tissues than NaOCl [2].

Chlorhexidine is one of the most widely used main irrigants in endodontic treatment; it can be applied in all clinical phases as an antimicrobial agent, disinfectant, tissue removal, etc. It has been proven to be less cytotoxic when used at 1% and it is also less irritating and has a faster regeneration than sodium hypochlorite.

Conclusions

Ozone as a disinfectant and antioxidant agent will be effective as long as it is handled with caution due to its intrinsic toxicity. Sodium hypochlorite stands out for its potent antibacterial activity, although its use in high concentrations can cause irritation. EDTA improves the seal of the filling material and demineralizes dentin, although it should be used in adequate concentrations to avoid excessive erosion. Chlorhexidine shows less cytotoxicity and greater regeneration compared to sodium hypochlorite, especially when applied at 1%.

References

1. Naladkar K, Chandak M, Sarangi S, Agrawal P, Jidewar N, Suryawanshi T, *et al.* Breakthrough in the development of endodontic irrigants. Cureus. 2024 Aug 16;16(8):e66981.
2. Gonçalves LS, Rodrigues RC, Andrade Junior CV, Soares RG, Vettore MV. The effect of sodium hypochlorite and chlorhexidine as irrigant solutions for root canal disinfection: a systematic review of clinical trials. J Endod. 2016 Apr;42(4):527-532.
3. Ali A, Bhosale A, Pawar S, Kakti A, Bichpuriya A, Agwan MA. Current trends in root canal irrigation. Cureus. 2022 May 8;14(5):e24833.
4. El Meligy OA, Elemam NM, Talaat IM. Ozone therapy in medicine and dentistry: a review of the literature. Dent J (Basel). 2023 Aug 7;11(8):187.
5. Sen S, Sen S. Ozone therapy: a new vista in dentistry - integrated review. Med Gas Res. 2020 Oct-Dec;10(4):189-192.
6. Randi CJ, Heiderich CMC, Serrano RV, Morimoto S, de Moraes LOC, Campos L, Palma LF. Use of ozone therapy in implant dentistry: a systematic review. Oral Maxillofac Surg. 2024 Mar;28(1):39-49.
7. Grootveld M, Baysan A, Sidiiqui N, Sim J, Silwood C, Lynch E. History of the clinical applications of ozone. In: Lynch E, editor. Ozone: The revolution in dentistry. London: Quintessence Publishing Co.; 2004.
8. Smith NL, Wilson AL, Gandhi J, Vatsia S, Khan SA. Ozone therapy: an overview of pharmacodynamics, current research, and clinical utility. Med Gas Res. 2017 Oct 17;7(3):212-219.
9. Mohammadi Z, Shalavi S, Soltani MK, Asgary S. A review of the properties and applications of ozone in endodontics: an update. Iran Endod J. 2013 Spring;8(2):40-43.
10. Nagayoshi M, Kitamura C, Fukuizumi T, Nishihara T, Terashita M. Antimicrobial effect of ozonated water on bacteria invading dentinal tubules. J Endod. 2004 Nov;30(11):778-781.
11. Azarpazhooh A, Limeback H. The application of ozone in dentistry: a systematic review of the literature. J Dent. 2008 Feb;36(2):104-116.
12. Celiberti P, Pazera P, Lussi A. The impact of ozone treatment on enamel physical properties. Am J Dent. 2006 Feb;19(1):67-72.
13. Silva EJNL, Prado MC, Soares DN, Hecksher F, Martins JNR, Fidalgo TKS. The effect of ozone therapy in root canal disinfection: a systematic review. Int Endod J. 2020 Mar;53(3):317-332.
14. Estrela C, Estrela CR, Decurcio DA, Hollanda AC, Silva JA. Antimicrobial efficacy of ozonated water, gaseous ozone, sodium hypochlorite, and chlorhexidine in infected human root canals. Int Endod J. 2007 Feb;40(2):85-93.
15. Bocci V. Ozone as a bioregulator. Pharmacology and toxicology of ozone therapy today. J Biol Regul Homeost Agents. 1996 Apr-Sep;10(2-3):31-53.
16. Bocci V. Ozone as Janus: this controversial gas can be either toxic or medically useful. Mediators Inflamm. 2004 Feb;13(1):3-11.
17. Ruksakiet K, Hanák L, Farkas N, Hegyi P, Sadaeng W, Czumbel LM, *et al.* Antimicrobial efficacy of chlorhexidine and sodium hypochlorite in root canal disinfection: a systematic review and meta-analysis of randomized controlled trials. J Endod. 2020 Aug;46(8):1032-41.e7.
18. Gołąbek H, Borys KM, Kohli MR, Brus-Sawczuk K, Strużycka I. Chemical aspect of sodium hypochlorite activation in obtaining favorable outcomes of endodontic treatment: an in-vitro study. Adv Clin Exp Med. 2019 Oct;28(10):1311-1319.
19. Arias-Moliz MT, Ordinola-Zapata R, Baca P, Ruiz-Linares M, Ferrer-Luque CM. Antimicrobial activity of a sodium hypochlorite/etidronic acid irrigant solution. J Endod. 2014 Dec;40(12):1999-2002.
20. 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.
21. Poggio C, Arciola CR, Dagna A, Chiesa M, Sforza D, Visai L. Antimicrobial activity of sodium hypochlorite-based irrigating solutions. Int J Artif Organs. 2010 Sep;33(9):654-659.
22. Xu H, Ye Z, Zhang A, Lin F, Fu J, Fok ASL. Effects of concentration of sodium hypochlorite as an endodontic irrigant on the mechanical and structural properties of root dentine: A laboratory study. Int Endod J. 2022 Oct;55(10):1091-1102.
23. Mohammadi Z, Shalavi S, Jafarzadeh H. Ethylenediaminetetraacetic acid in endodontics. Eur J Dent. 2013 Sep;7(Suppl 1):S135-S142.
24. Calt S, Serper A. Time-dependent effects of EDTA on dentin structures. J Endod. 2002 Jan;28(1):17-19.
25. Teixeira CS, Felippe MC, Felippe WT. The effect of application time of EDTA and NaOCl on intracanal smear layer removal: an SEM analysis. Int Endod J. 2005 May;38(5):285-290.
26. Yoshida T, Shibata T, Shinohara T, Gomyo S, Sekine I. Clinical evaluation of the efficacy of EDTA solution as an endodontic irrigant. J Endod. 1995 Dec;21(12):592-593.
27. Hülsmann M, Heckendorff M, Lennon A. Chelating agents in root canal treatment: mode of action and indications for their use. Int Endod J. 2003 Dec;36(12):810-830.
28. Sen BH, Ertürk O, Pişkin B. The effect of different concentrations of EDTA on instrumented root canal walls. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009 Oct;108(4):622-627.
29. Aslantas EE, Buzoglu HD, Altundasar E, Serper A. Effect of EDTA, sodium hypochlorite, and chlorhexidine gluconate with or without surface modifiers on dentin microhardness. J Endod. 2014 Jun;40(6):876-879.
30. Teixeira CS, Felippe MC, Felippe WT. The effect of application time of EDTA and NaOCl on intracanal smear layer removal: an SEM analysis. Int Endod J. 2005 May;38(4):285-290.
31. Pałka Ł, Nowakowska-Toporowska A, Dalewski B. Is Chlorhexidine in Dentistry an Ally or a Foe? A Narrative Review. Healthcare (Basel). 2022 Apr 20;10(5):764.
32. Tonini R, Salvadori M, Audino E, Sauro S, Garo ML,

Salgarello S. Irrigating solutions and activation methods used in clinical endodontics: a systematic review. Front Oral Health. 2022 Jan 31;3:838043.
33. Mohammadi Z, Abbott PV. The properties and applications of chlorhexidine in endodontics. Int Endod J. 2009 Apr;42(4):288-302.
34. Mohammadi Z, Jafarzadeh H, Shalavi S. Antimicrobial efficacy of chlorhexidine as a root canal irrigant: a literature review. J Oral Sci. 2014 Jun;56(2):99-103.
35. Jeansonne MJ, White RR. A comparison of 2.0% chlorhexidine gluconate and 5.25% sodium hypochlorite as antimicrobial endodontic irrigants. J Endod. 1994 Jun;20(6):276-278.
36. Farhad Mollashahi N, Saberi E, Karkehabadi H. Evaluation of cytotoxic effects of various endodontic irrigation solutions on the survival of stem cell of human apical papilla. Iran Endod J. 2016 Fall;11(4):293-297.
37. Omar N, Abdelraouf RM, Hamdy TM. Effect of different root canal irrigants on push-out bond strength of two novel root-end filling materials. BMC Oral Health. 2023 Apr 2;23(1):193.
38. Onçağ O, Hoşgör M, Hilmioğlu S, Zekioğlu O, Eronat C, Burhanoğlu D. Comparison of antibacterial and toxic effects of various root canal irrigants. Int Endod J. 2003 Jun;36(6):423-432.

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