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Major results of controlled clinical studies on the use of chlorhexidine in the success of endodontic treatment: a concise systematic review

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Abstract

Introduction: The efficacy of endodontic treatment is directly related to the elimination of bacteria. In the context of disinfection, sodium hypochlorite (NaOCl) and chlorhexidine digluconate (CHX) are recommended as irrigating solutions for the chemical-mechanical preparation of the root canal due to their broad-spectrum antimicrobial efficacy. **Objective:** This study aimed to develop a systematic review that addresses the main comparative clinical results of using chlorhexidine in the success of endodontic treatment. **Methods:** The systematic review rules of the PRISMA Platform were followed. The research was carried out from March to April 2025 in Scopus, Embase, PubMed, Science Direct, Scielo, and Google Scholar databases. The quality of the studies was based on the GRADE instrument and the risk of bias was analyzed according to the Cochrane instrument. **Results and Conclusion:** A total of 176 articles were found, 36 articles were evaluated in full and 11 were included and developed in this systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 27 studies with a high risk of bias and 33 studies that did not meet GRADE and AMSTAR-2. It was concluded that most randomized controlled clinical trials showed that chlorhexidine effectively reduces bacterial load, with greater reductions associated with successful outcomes. Chlorhexidine 2% is effective for clinical and radiographic success and for antimicrobial activity in primary teeth undergoing pulpectomy. Nonsurgical root canal retreatment using foraminal enlargement and 2% chlorhexidine gel demonstrated high success rates. A relatively favorable impact of chlorhexidine on post-endodontic pain was observed, with significant therapeutic implications.

Keywords: Endodontic treatment. Root canal. Chlorhexidine. Irrigating solutions. Disinfection.

Introduction

The effectiveness of endodontic treatment is directly related to the elimination of bacteria from the root canal system through disinfection protocols during chemomechanical preparation and obturation. Gutta-percha (GP) has been a widely used root canal filling material due to its favorable biocompatibility, cost-effectiveness, and wide clinical application [1,2].

Although GP cones are manufactured under aseptic conditions, they can become contaminated during storage. Incomplete disinfection of complex root canal systems and the use of infected obturation materials through cross-contamination increase the risk of persistent bacteria resulting in endodontic treatment failure, notably *Enterococcus faecalis*, *Candida albicans*, and *Staphylococcus aureus* [1-3].

The consortium between *C. albicans* and *E. faecalis* increases the virulence of endodontic biofilms, increasing the resistance of the biofilm against mechanical forces and chemical agents, as well as increasing periapical inflammation. The dysbiosis of the aforementioned pathogens can be directly related to systemic and metabolic diseases, such as diabetes, cardiovascular diseases (infectious endocarditis), and periodontitis [4,5].

In the context of disinfection, sodium hypochlorite (NaOCl) and chlorhexidine digluconate (CHX) are recommended as irrigating solutions for the chemical-mechanical preparation of the root canal due to their broad-spectrum antimicrobial efficacy, essential for

effective bacterial eradication and optimization of root canal disinfection [3-5].

Due to the antimicrobial action of these irrigating solutions, both solutions are used for the decontamination of the GP cone. NaOCl exhibits broad-spectrum antimicrobial activity against Gram-positive and Gram-negative bacteria by irreversibly oxidizing sulfhydryl groups in bacterial enzymes, disrupting membrane integrity, altering metabolism, and causing phospholipid degradation through its chlorine content and high pH [3].

CHX, on the other hand, exerts its bactericidal effect through other mechanisms, i.e., higher concentrations of CHX induce bactericidal activity, causing cytoplasmic precipitation or coagulation (protein cross-linking) and cell death. Studies have shown that lower concentrations of NaOCl are effective in disinfecting GP cones against E. faecalis with an immersion time of 10 minutes, while other findings have shown that neither NaOCl nor CHX was able to eliminate the pathogen within a 5-minute exposure period [1-3].

Given this, the present study developed a systematic review to address the main comparative clinical results of the use of chlorhexidine in the success of endodontic treatment.

Methods

Study Design

This study followed the international systematic review model, following the PRISMA (preferred reporting items for systematic reviews and meta-analysis) rules. Available at: http://www.prisma-statement.org/?AspxAutoDetectCookieSupport=1. It was accessed on: 05/12/2025. The AMSTAR-2 (Assessing the methodological quality of systematic reviews) methodological quality standards were also followed. Available at: https://amstar.ca/. It was accessed on: 05/12/2025.

Data Sources and Search Strategy

The literature search process was carried out from March to April 2025 and developed based on Web of Science, Scopus, Embase, PubMed, Lilacs, Ebsco, Scielo, and Google Scholar, covering scientific articles from various periods to the present day. The descriptors (DeCS/MeSH Terms. Available on: https://decs.bvsalud.org/) were used: *"Endodontic treatment. Root canal. Chlorhexidine. Irrigating solutions. Disinfection"*, and using the Boolean "and" between MeSH terms and "or" between historical findings.

Study Quality and Risk of Bias

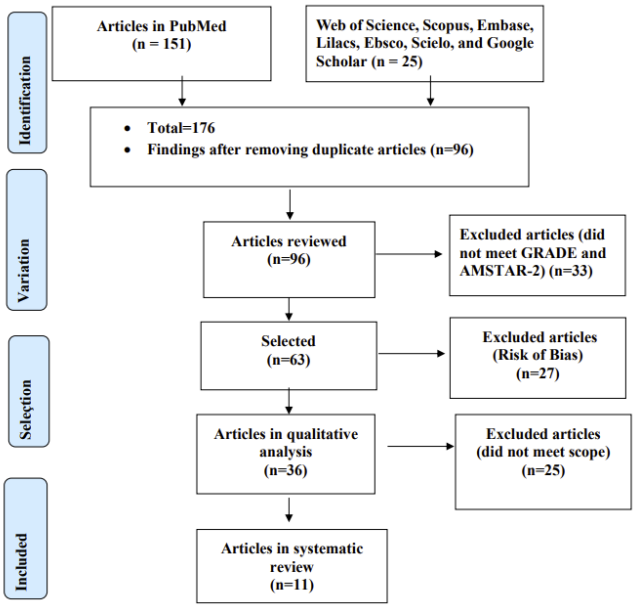
The quality was classified as high, moderate, low, or very low regarding the risk of bias, clarity of comparisons, precision, and consistency of analyses. The most evident emphasis was on systematic review articles or meta-analysis of randomized clinical trials, followed by randomized clinical trials. Low quality of evidence was attributed to case reports, editorials, and brief communications, according to the GRADE instrument. The risk of bias was analyzed according to the Cochrane instrument by analyzing the Funnel Plot graph (Sample size versus Effect size), using Cohen's d test.

Results and Discussion

Summary of Findings

A total of 176 articles were found. Initially, duplicate articles were excluded. After this process, the abstracts were evaluated, and a new exclusion was performed, removing the articles that did not include the topic of this article, resulting in 96 articles. A total of 36 articles were evaluated in full, and 11 were included and developed in the present systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 27 studies with high risk of bias and 33 studies that did not meet GRADE and AMSTAR-2, according to Figure 1.

Figure 1. Selection of the articles.

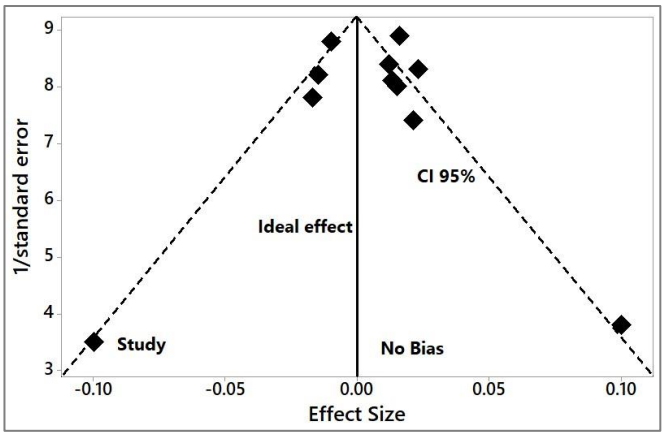


Source: Own Authorship.

Figure 2 presents the results of the risk of bias of the studies using the Funnel Plot, showing the calculation of the Effect Size (Magnitude of the difference) using Cohen's Test (d). The sample size was determined indirectly by the inverse of the standard

error (1/Standard Error). This graph showed symmetrical behavior, not suggesting a significant risk of bias, both among studies with small sample size (lower precision) that are shown at the base of the graph and in studies with large sample size that are shown in the upper region.

Figure 2. The symmetrical funnel plot suggests no risk of bias among the studies with small sample size that are shown at the bottom of the graph. High confidence and high recommendation studies are shown above the graph (NTotal = 11 studies evaluated in full in the systematic review).



Source: Own Authorship.

Clinical Findings

Chlorhexidine digluconate (CHX) is widely recognized for its antimicrobial properties and potential use as an irrigant in endodontic treatment [1,5]. A study evaluated the efficacy of CHX in cleaning the root canal system in pediatric endodontic treatment. The results indicate that 2% CHX demonstrates good antibacterial efficacy. The minimum irrigation volume when using CHX is 2 mL per root canal, which ensures optimal efficacy in bacterial elimination and improves treatment outcomes [6].

A randomized clinical trial compared the clinical and radiographic success rates of indirect pulp treatment in primary molars using mineral trioxide aggregate (MTA) with and without 2% CHX. Eighty primary molars in 40 subjects aged four to eight years were randomly allocated so that each subject had one tooth treated with MTA and CHX and the other tooth treated with MTA alone. Follow-up was performed at 12 months to evaluate the teeth clinically and radiographically. At follow-up, one tooth in each group had failed. After clinical and radiographic evaluations, the overall success rate for both groups was 97% [7].

Another randomized controlled clinical trial evaluated the antimicrobial activity and clinical and radiographic outcomes of pulpectomy in primary teeth using 1% sodium hypochlorite (NaOCl) or 2% CHX as irrigants. Groups 1% NaOCl (n=20) and 2% CHX (n = 20). For 1% NaOCl, the following clinical and radiographic success rates were observed: 7 days (93%/80%); 30 days, 3 and 6 months (100%). For 2% CHX: 7 days (73%/53%); 30 days (93%); 3 months (100%/93%); 6 months (100%) ($p>0.05$). 1% NaOCl and 2% CHX effectively reduced the total number of microorganisms ($p<0.05$), but not *Streptococcus mutans* ($p>0.05$). In the qPCR analysis, the solutions promoted a reduction in the total number of bacteria and *Streptococcus mutans*, with no difference between the times and groups ($p>0.05$) [8].

Also, a randomized clinical study evaluated the effect of calcium hydroxide (CH) and 2% CHD as intracanal medicaments and their impact on bacterial load and regenerative endodontic results. Bacterial samples from 41 patients who participated in this clinical trial comparing CH and CHD. A total of 123 microbial samples were analyzed by real-time quantitative polymerase chain reaction (qPCR). Bacterial loads were assessed at three-time points: before root canal disinfection (S1), after root canal disinfection (S2), and after intracanal dressing (S3). Significant reductions in bacterial load were observed after root canal disinfection (S2) in the CH and CHD subgroups, regardless of treatment outcome. Further reductions after intracanal dressing (S3) occurred exclusively in successful cases. Both CH and CHD effectively reduced bacterial load, particularly of *E. faecalis* [9].

Besides, a randomized, crossover clinical trial compared the antiplaque and antigingivitis efficacy of 0.12% CHX and 5% *Malva sylvestris*. Forty-four participants were enrolled in two phases, each comprising three stages with variations in the mouthwash solution used. During the study, participants refrained from mechanical plaque removal for seven days. On the first day, they received whole-mouth prophylaxis and oral health assessment. After three days, gingival inflammation assessment and prophylaxis were performed in the contralateral quadrants. The results showed no statistically significant differences between the *Malva sylvestris* and CHX groups regarding inflammation and plaque formation. However, CHX demonstrated a significantly greater mean reduction (7th to 4th day) in gingival inflammation compared to Malva ($p = 0.02$) (0.01 ± 0.19 and 0.00 ± 0.19, respectively). In addition, participants using CHX reported a more pleasant taste and considered a greater perception of plaque control ($p < 0.05$) [10].

A randomized study analyzed the efficacy of different endodontic irrigants used in the technique of lesion sterilization and tissue repair. Forty children aged between 4 and 8 years, with at least one primary molar with irreversible pulpitis/pulp necrosis and indication for

pulpectomy, were included. The participants were randomly divided into three test groups (Groups A, B, and C) and one control group (Group D). The pulp floor was irrigated with different endodontic irrigants in each group: Group A - propolis 20%, Group B - sodium hypochlorite 2%, Group C - chlorhexidine gluconate 2%, and Group D (control) - saline solution. Alternate 3-Mix (triple antibiotic paste containing metronidazole, ciprofloxacin, and amoxicillin) was then applied over the pulp floor and the teeth were restored with glass ionomer cement, followed by a stainless steel crown. Clinical success was achieved in all treated teeth, with the results showing statistical significance ($p<0.05$). Furthermore, Group C (2% chlorhexidine gluconate) showed the best clinical results [11].

A retrospective cohort study evaluated the efficacy of nonsurgical root canal retreatment using 2% chlorhexidine gel and foraminal widening techniques, with the aim of assessing whether these approaches improve periapical healing outcomes and success rates compared with traditional techniques. A total of 120 teeth diagnosed with persistent apical periodontitis were evaluated, and 80 patients underwent nonsurgical root canal retreatment. The mean follow-up period was 30 months. Under flexible criteria, 92.50% (n=111) of the teeth were categorized as successful and 7.5% (n = 9) as unsuccessful. Non-surgical root canal retreatment using foraminal enlargement and 2% chlorhexidine gel has demonstrated high success rates [12].

A meta-analysis study evaluated the overall impact of chlorhexidine, when used as an endodontic irrigant/medication, on post-filling pain after endodontic treatment by applying Bayesian meta-analysis methods. A random-effects Bayesian meta-analysis model demonstrated a relatively favorable impact of chlorhexidine on post-endodontic pain, which has significant therapeutic significance [13].

Finally, a randomized clinical trial evaluated the healing of mandibular molar teeth with large periapical lesions after a single-visit root canal treatment using 2% CHX as the final irrigant, comparing the results with a two-visit conventional root canal treatment as a control group. During the 48-month follow-up, 86 teeth (44 in the 1-visit group and 42 in the 2-visit group) were examined. There were no significant differences between the two groups in radiographic healing rates (1-visit group: 91% and 2-visit group: 88%) ($p>0.05$) [14].

Conclusion

It was concluded that most randomized controlled clinical trials have shown that chlorhexidine effectively reduces bacterial load, with greater reductions associated with successful outcomes. Chlorhexidine 2% is effective for clinical and radiographic success and antimicrobial activity in primary teeth undergoing pulpectomy. Nonsurgical root canal retreatment using foraminal enlargement and 2% chlorhexidine gel has demonstrated high success rates. A relatively favorable impact of chlorhexidine on post-endodontic pain was observed, with significant therapeutic implications.

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Conflict of Interest

The authors declare no conflict of interest.

Similarity Check

It was applied by Ithenticate®.

Application of Artificial Intelligence (AI)

Not applicable.

Peer Review Process

It was performed.

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