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Disinfection Capability of Three Cleaning Techniques for Orthodontic Clear Aligners Maintenance - Systematic Review and Meta-Analysis

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ADMINISTRATIVE INFORMATION

Support - No hemos tenido ningún apoyo.

Review Stage at time of this submission - Completed but not published.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 11 June 2025 and was last updated on 11 June 2025.

INTRODUCTION

Review question / Objective The primary objective of this meta-analysis is to evaluate and compare the antimicrobial efficacy of four disinfection techniques: (1) mechanical brushing, (2) immersion in 2% chlorhexidine for 2 hours, (3) exposure to O₃/O₂ gas for 72 hours, and (4) ZnO + PVDF piezoelectric nanocoatings.

Condition being studied The use of removable clear aligners has gained substantial popularity in orthodontic treatment, offering a discrete and aesthetic alternative to fixed appliances. These devices are typically worn for approximately 22 hours of daily use to achieve effective tooth movements, which results in prolonged and direct exposure to the dynamic oral environment. Their removability facilitates oral hygiene and dietary freedom, distinguishing them from conventional braces. However, this advantage is counterbalanced by a significant drawback: the

susceptibility of clear aligners to bacterial colonization and biofilm accumulation.

METHODS

Participant or population Patients treated with orthodontic clear aligners using mechanical brushing, ZnO+PVDF piezoelectric coating, O₃/O₂ gas 72h or Clorexidina 2% (2h) cleaning techniques for maintenance.

Intervention Use of chemical disinfectants (e.g., chlorhexidine, hydrogen peroxide, nanoparticles, ozonated solutions) and the methods used to evaluate their efficacy.

Comparator Microbial decolonization, measured directly (e.g., CFU count) or indirectly (e.g., optical density, turbidity, SEM analysis).

Study designs to be included Randomized controlled trials, prospective or retrospective

studies, case series, case reports, and laboratory-based experimental studies.

Eligibility criteria The inclusion criteria were as follows: experimental trials (ETs) were included in the database. Publications related to orthodontic clear aligners using mechanical brushing, ZnO+PVDF piezoelectric coating, O₃/O₂ gas 72h or Clorexidina 2% (2h) cleaning techniques for maintenance were included. Studies were not restricted by language or year of publication. The exclusion criteria were as follows: systematic literature reviews, prospective and retrospective randomized clinical trials, clinical cases, and editorials. Moreover, studies that did not provide information related to the disinfection capability of orthodontic clear aligners using mechanical brushing, ZnO+PVDF piezoelectric coating, O₃/O₂ gas 72h or Clorexidina 2% (2h) cleaning techniques for maintenance or presented a sample size smaller than the established were rejected. The following data were recorded: author, year, title journal, sample size (n), and disinfection capability of orthodontic clear aligners using mechanical brushing, ZnO+PVDF piezoelectric coating, O₃/O₂ gas 72h or Clorexidina 2% (2h) cleaning techniques for maintenance. The results obtained from studies that analyzed the disinfection capability of orthodontic clear aligners using mechanical brushing, ZnO+PVDF piezoelectric coating, O₃/O₂ gas 72h or Clorexidina 2% (2h) cleaning techniques for maintenance were included.

Information sources PubMed, ScienceDirect, Springer Nature, and Google Scholar.

Main outcome(s) Current evidence shows general agreement on variability of brushing efficacy. Outcomes has been noted due to factors such as brushing duration, applied pressure, and toothbrush type.

Quality assessment / Risk of bias analysis The risk of bias in the studies included in the review was independently assessed by two authors (Á.Z.-M. and J.M.M.-C.) using the Jadad scale, a tool for evaluating the methodological quality of clinical trials. This scale comprises five items assessing randomization, blinding of both researchers and participants, and the reporting of withdrawals and dropouts, with a total score ranging from 0 to 5. Scores below 3 are indicative of low methodological quality. Inter-rater agreement was evaluated using Cohen's Kappa coefficient.

Strategy of data synthesis A subgroup meta-analysis using a random-effects model and the

inverse variance method was used to estimate the effect size as the difference in standardized means (Hedges' g) for the bacterial count variable measured on different scales, comparing different mechanical and chemical techniques versus the control. To interpret Hedges' g, the Cohen scale was used, indicating a g 0.8 as a significant effect. The search assessed all literature published internationally up to May 2025. Nine medical subject headings (MeSH) or free-text terms were included in the search: "orthodontic appliance"; "clear aligner"; "thermoplastic retainer"; "disinfection"; "cleaning"; "antimicrobial activity"; "biofilm"; "plaque control"; and "color stability". Three Boolean operators were applied ("OR", "AND", and "NOT"). These search terms were applied as follows: [("orthodontic appliance") OR ("clear aligner") OR ("thermoplastic retainer")] AND [("disinfection") OR ("cleaning") OR ("antimicrobial activity") OR ("biofilm") OR ("plaque control")] AND [("chlorhexidine") OR ("ozone sterilization") OR ("ZnO+PVDF coating") OR ("SEM analysis") OR ("color stability")].

Subgroup analysis Not performed due the small sample size.

Sensitivity analysis Was performed using the one study remove.

Country(ies) involved Spain, France.

Keywords Orthodontics; Clear Aligners; Disinfection; Cleaning Techniques, Mechanical disinfection, Chemical Disinfection, Biofilm Reduction, Bacterial Removal, Antimicrobial Activity.

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