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Efficacy of Erythritol-Based Air-Polishing Compared with Conventional Mechanical Debridement in the Management of Peri-implant Mucositis: A Systematic Review and Meta-analysis of Clinical Outcomes

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ABSTRACT

Peri-implant mucositis is an inflammatory condition associated with biofilm accumulation around dental implants. Erythritol-based air-polishing has been proposed as a minimally invasive treatment approach. This study aimed to evaluate the clinical efficacy of erythritol-based air-polishing compared with conventional mechanical debridement in the management of peri-implant mucositis. PubMed/MEDLINE, Scopus, Web of Science, Embase, the Cochrane Library, and Google Scholar were searched for studies published between January 1, 2018, and October 31, 2026. Randomized and non-randomized controlled clinical studies comparing standalone or adjunctive erythritol air-polishing with conventional mechanical debridement were eligible. The primary outcome was bleeding on probing (BoP). Secondary outcomes included probing pocket depth, plaque indices, disease resolution, patient-reported discomfort, and adverse events. Risk of bias was assessed using RoB 2 or ROBINS-I, and evidence certainty was evaluated using GRADE. Meta-analysis was performed when data were sufficiently comparable; otherwise, a narrative synthesis was conducted. Three randomized controlled clinical trials involving 191 patients and 295 implants were included in the systematic review. The studies evaluated erythritol-based air-polishing (EAP) either as a standalone treatment or as an adjunct to conventional mechanical instrumentation, with follow-up periods ranging from 3 to 12 months. Both EAP and conventional mechanical debridement resulted in improvements in clinical parameters, including probing pocket depth (PPD), bleeding on probing (BoP), and plaque indices. However, no consistent statistically significant differences were observed between the treatment groups. Meta-analysis of two studies evaluating complete resolution of peri-implant mucositis showed no statistically significant superiority of EAP over conventional mechanical debridement (RR = 1.05; 95% CI: 0.94–1.16; I^2 = 0%). Erythritol-based air-polishing appears to be an effective and well-tolerated approach for biofilm removal in the management of peri-implant mucositis. However, current evidence does not demonstrate its statistical superiority over conventional mechanical debridement in achieving complete disease resolution. EAP may be considered an alternative or adjunctive treatment modality, although further well-designed randomized controlled trials with larger sample sizes and longer follow-up periods are needed to establish its comparative clinical effectiveness.

Keywords: Peri-implant mucositis, Erythritol, Air-polishing, Mechanical debridement, Bleeding on probing, Systematic review, Meta-analysis.

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Introduction

The increasing use of dental implants as a reliable treatment option for replacing missing teeth has highlighted the importance of maintaining the health of peri-implant tissues. Peri-implant mucositis is one of the most common biological complications associated with dental implants and is characterized by inflammation of the peri-implant soft tissues, bleeding on probing, and occasionally increased probing pocket depth, without progressive supporting bone loss. Given its potential association with the development of peri-implantitis if left inadequately controlled, early diagnosis and effective biofilm management are of considerable clinical importance(1).

The treatment of peri-implant mucositis primarily focuses on biofilm removal and the control of local factors contributing to inflammation(2). Conventional mechanical debridement using hand instruments or ultrasonic devices is widely employed for this purpose. However, limited access to certain implant surfaces, complex prosthetic designs, and concerns regarding potential alterations to implant surface characteristics may compromise the effectiveness of these approaches(3). Consequently, increasing attention has been directed toward alternative technologies that facilitate effective biofilm removal while minimizing potential damage to implant surfaces(1).

In this context, erythritol-based air-polishing has emerged as an alternative approach for peri-implant biofilm removal. This technology utilizes a combination of air, water, and fine erythritol powder particles to facilitate cleaning of implant surfaces, including anatomically challenging areas(2). The physical properties of erythritol and the availability of specially designed subgingival nozzles make this approach a promising option for the management of peri-implant mucositis. Nevertheless, its technical advantages do not necessarily translate into superior clinical outcomes compared with conventional mechanical debridement(4).

Although several clinical studies have investigated the application of erythritol-based air-polishing for peri-implant biofilm control, variations in study designs, treatment protocols, follow-up periods, and outcome assessment methods have made comparisons and interpretation of findings challenging(2). Furthermore, the potential superiority of this approach in improving clinical parameters, including bleeding on probing (BOP), plaque index (PI), and probing pocket depth (PPD), remains to be comprehensively established(5).

Therefore, the present study aims to conduct a systematic review and meta-analysis to compare the effectiveness of erythritol-based air-polishing with conventional mechanical debridement in the treatment of peri-implant mucositis. Additionally, clinical outcomes, treatment safety, and the sustainability of therapeutic effects across different follow-up periods will be evaluated to provide a comprehensive assessment of the available evidence and support evidence-based clinical decision-making.

Materials and Methods

This systematic review and meta-analysis was conducted in accordance with the methodological recommendations of the Cochrane Handbook for Systematic Reviews of Interventions and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement(6). The review protocol was prepared before study selection and, where applicable, registered prospectively in the International Prospective Register of Systematic Reviews (PROSPERO). Any protocol amendments were documented and justified.

A systematic literature search was conducted to identify clinical studies published between January 1, 2018, and October 31, 2026. The following databases were searched: PubMed/MEDLINE, Scopus, Web of Science Core Collection, Embase, the Cochrane Library, and Google Scholar. The search strategies were adapted to the syntax and indexing systems of each database using controlled vocabulary, including Medical Subject Headings (MeSH) and Emtree terms where applicable, and free-text keywords. The core search strategy combined terms related to peri-implant mucositis and erythritol-based air-polishing. The principal search terms included "peri-implant mucositis," "periimplant mucositis," "erythritol," "erythritol powder," "air-polishing," "air polishing," and "air abrasion." Comparator-related terms were not mandatory search components to minimize the risk of missing relevant studies. The search was supplemented by screening the reference lists of included studies and relevant reviews. Google Scholar was used as a supplementary source, and the first 200 records sorted by relevance were screened. No language restrictions were applied during the initial search.

Eligible studies included randomized controlled trials (RCTs), including parallel-group and split-mouth designs, and non-randomized controlled clinical studies involving patients diagnosed with peri-implant mucositis. Studies were included if they evaluated erythritol-based air-polishing,

either as a standalone biofilm-removal procedure or as an adjunct to conventional mechanical instrumentation, and compared it with conventional ultrasonic and/or manual debridement using implant-compatible instruments. Studies reporting at least one relevant clinical or patient-reported outcome were considered eligible. Animal and in vitro studies, case reports, case series, reviews, editorials, uncontrolled studies, and studies exclusively investigating peri-implantitis without separately extractable mucositis data were excluded. Studies evaluating other air-polishing powders without a separately identifiable erythritol group were also excluded.

The intervention protocols were classified as standalone erythritol air-polishing or adjunctive erythritol air-polishing. Studies involving unequal co-interventions between treatment groups, such as the use of antiseptics in only one arm, were considered separately when appropriate to avoid inappropriate pooling. Multiple reports from the same clinical trial or patient cohort were linked and treated as a single study to prevent double-counting.

Study Selection, Data Extraction, and Outcomes

All retrieved records were imported into reference-management software, and duplicates were removed. Titles and abstracts were independently screened by two reviewers, followed by full-text assessment of potentially eligible articles. Disagreements were resolved through discussion or consultation with a third reviewer. The selection process was documented using the PRISMA 2020 flow diagram.

Data were independently extracted by two reviewers using a standardized extraction form. The extracted information included study characteristics, design, country, participant demographics, diagnostic criteria, sample size, intervention and comparator protocols, treatment devices, follow-up periods, clinical outcomes, patient-reported outcomes, adverse events, and available numerical data. Means, standard deviations, event counts, effect estimates, and 95% confidence intervals were extracted where reported. Missing or unclear data were addressed by contacting study authors where feasible.

The primary outcome was bleeding on probing (BoP), assessed as the between-group difference in change from baseline or as the proportion of bleeding-positive sites or implants at follow-up. Secondary outcomes included probing pocket depth (PPD), plaque or modified plaque indices, complete resolution of peri-implant mucositis, suppuration, patient-reported pain or discomfort, and treatment-related adverse events. Follow-up assessments were categorized as short-term (up to 3 months), intermediate-term (more than 3 to 6 months), and long-term (more than 6 months). Outcomes with different definitions or measurement scales were considered separately.

Statistical Analysis and Data Synthesis

A quantitative meta-analysis was performed when at least two studies provided sufficiently comparable data regarding the population, intervention, comparator, outcome definition, and follow-up period. For continuous outcomes, mean differences (MDs) with 95% confidence intervals (CIs) were calculated when the same measurement scale was used, whereas standardized mean differences (SMDs) were considered for outcomes measured using different scales. For dichotomous outcomes, risk ratios (RRs) with 95% CIs were calculated.

Random-effects models were used when appropriate, with between-study variance estimated using the restricted maximum likelihood (REML) method where supported by the statistical software. Statistical heterogeneity was assessed using the Cochran Q test, the I^2 statistic, and τ^2. Separate analyses were planned for standalone erythritol air-polishing versus conventional mechanical debridement and adjunctive erythritol air-polishing plus conventional instrumentation versus conventional instrumentation alone. Subgroup and sensitivity analyses were considered where sufficient data were available. Funnel plots and statistical tests for small-study effects were considered only when at least 10 studies were available in a meta-analysis. When quantitative pooling was inappropriate because of clinical or methodological heterogeneity or insufficient data, a structured narrative synthesis was conducted. Studies with split-mouth or clustered designs were analyzed using appropriate paired or cluster-adjusted estimates whenever available.

Risk of Bias Assessment and Certainty of Evidence

The risk of bias was independently assessed by two reviewers. The Cochrane Risk of Bias 2 (RoB 2) tool was used for randomized controlled trials, while the Risk Of Bias In Non-randomized Studies of Interventions (ROBINS-I) tool was applied to eligible non-randomized controlled studies. Disagreements were resolved through discussion or consultation with a third reviewer. The assessments were used to inform the interpretation of the findings and sensitivity analyses(7).

The certainty of evidence for the primary and key secondary outcomes was evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach. Evidence was assessed across five domains: risk of bias, inconsistency, indirectness, imprecision, and publication bias. The certainty of evidence was classified as high, moderate, low, or very low. Summary of Findings tables were prepared using GRADEpro GDT or an equivalent tool.

Results

A total of 170 records were identified through database searches and other sources. After the removal of 34 duplicate records, 136 records underwent title and abstract screening. Of these, 126 were excluded because they were irrelevant to the review question or did not meet the predefined eligibility criteria. The full texts of the remaining 10 reports were assessed for eligibility, of which 7 were excluded because they did not meet the predefined inclusion criteria. Consequently, 3 reports remained eligible for inclusion in the systematic review Figure1. The characteristics and principal findings of the included studies are summarized in Table 1.

A total of three randomized controlled clinical trials conducted in China and Italy were included in this systematic review, comprising 191 patients and 295 implants. The included studies evaluated the clinical effectiveness of erythritol-based air-polishing (EAP), either alone or as an adjunct to conventional mechanical instrumentation, in the treatment of peri-implant mucositis. Follow-up periods ranged from 3 to 12 months. The assessed clinical parameters primarily included probing pocket depth (PPD), bleeding on probing (BoP), plaque and bleeding indices, and complete resolution of peri-implant mucositis. Overall, the findings indicated improvements in clinical parameters following treatment in both test and control groups. In the study by Sun et al. (2026), PPD decreased from 4.0 ± 0.5 mm to 3.4 ± 0.5 mm in the EAP group and from 3.8 ± 0.4 mm to 3.5 ± 0.4 mm in the ultrasonic debridement group at 3 months; however, the between-group difference was not statistically significant ($p = 0.250$). Similarly, Corbella et al. (2024) reported comparable clinical outcomes between groups, with 3-month healing rates of 96.7% (29/30 implants) in the erythritol air-polishing group and 92.5% (37/40 implants) in the control group, without a statistically significant difference ($p > 0.05$). In the study by Clementini (2023), complete disease resolution at 6 months was observed in 31% (19/62 implants) of the erythritol air-polishing group compared with 29% (17/58 implants) of the control group, with no statistically significant difference between groups ($p = 0.974$). Taken together, these findings suggest that erythritol-based air-polishing may be an effective treatment approach for peri-implant mucositis; however, its clinical superiority over conventional mechanical debridement has not been demonstrated Table ٢.

The meta-analysis using a random-effects model showed that the overall risk ratio (RR) for complete resolution of peri-implant mucositis in the erythritol-based air-polishing group compared with the control group was 1.05 (95% CI: 0.94–1.16). Since the 95% confidence interval included 1, the difference between the two groups was not statistically significant. Therefore, although the results numerically favored erythritol-based air-polishing, there was insufficient evidence to demonstrate its statistical superiority over conventional mechanical debridement. Furthermore, the I^2 value of 0% indicated no detectable statistical heterogeneity between the two studies included in this analysis(Table 3, Figure 1).

The study by Sun et al. (2026) was not included in this meta-analysis because it reported probing pocket depth (PPD) as its principal outcome, whereas the meta-analysis focused on the binary outcome of complete resolution of peri-implant mucositis. Since the outcomes reported by Sun et al. were not directly comparable with those of the other two studies, its findings were presented separately in the qualitative synthesis rather than being statistically pooled.

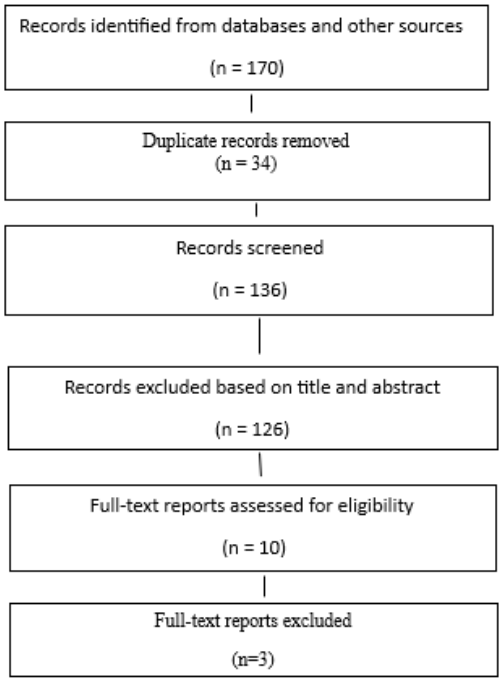


Figure 1 :PRISMA flow diagram of study identification, screening, eligibility assessment, and inclusion.

Table 1. Characteristics of the included randomized controlled trials evaluating erythritol-based air-polishing for the treatment of peri-implant mucositis

Study (Author, Year	Country	Design	Sample size (patients/implants)	Test group	Control group	Follow-up	Outcomes assessed
Sun et al., 2026(5)	China	Single-blind Randomized Controlled Clinical Trial (RCT)	36 patients / 36 implants (18 test, 18 control; one implant per patient)	Erythritol air-polishing (EAP), with oral hygiene instructions and implant crown polishing	Ultrasonic debridement (US), with oral hygiene instructions and implant crown polishing	Baseline, 1 month, and 3 months	Peri-implant Probing Pocket Depth (PPD), Modified Plaque Index (mPLI), Bleeding on Probing (BOP), Suppuration on Probing (SoP), Visual Analogue Scale (VAS) for pain, and proportion of sites with PPD ≥4 mm
Corbella et al., 2024(2)	Italy	Randomized Controlled Clinical Trial (RCT)	80 implants (40 test, 40 control); approximately 23 patients	Subgingival and supragingival biofilm removal using erythritol powder air-polishing, with ultrasonic instrumentation if needed	Full-mouth ultrasonic and manual instrumentation, combined with 1% chlorhexidine gel	1 week, 1, 3, 6, and 12 months	Bleeding Index (BI), Plaque Index (PI), Peri-implant Probing Depth (PPD), peri-implant tissue level, Patient-Reported Outcome Measures (PROMs), and incidence of peri-implantitis
Clementini, 2023(3)	Italy	Single-center, single-masked (blinded examiner), parallel-group, three-arm randomized controlled clinical trial (RCT), with a 6-month follow-up.	75 patients and 179 implants. Control group: 25 patients, 58 implants Erythritol air-polishing group: 25 patients, 62 implants Er:YAG laser group: 25 patients, 59 implants	Submarginal instrumentation using titanium curettes followed by adjunctive erythritol powder air-polishing (AIR-FLOW Powder PERIO; EMS).	Submarginal mechanical instrumentation using titanium curettes alone, without adjunctive treatment.	6 months; clinical assessments were performed at baseline and at 1, 3, and 6 months after treatment.	- Primary outcome: Bleeding on probing (BoP) reduction. - Secondary outcomes: Probing pocket depth (PPD) changes and complete disease resolution (absence of BoP at all six implant sites). - Additional clinical parameters: Plaque index (PI), full-mouth plaque score (FMPS), full-mouth bleeding score (FMBS), and keratinized mucosa width (KMW).

Table 2. Clinical outcomes of erythritol-based air-polishing compared with conventional mechanical debridement in the treatment of peri-implant mucositis

Study (Author, Year)	Outcome	Assessment time	Test group (Baseline)	Test group (Follow-up)	Control group (Baseline)	Control group (Follow-up)	Between-group difference	Statistical significance
Sun et al., 2026	Peri-implant Probing Depth (PPD, mm)	Baseline, 1 month, 3 months	4.0 ± 0.5 mm	3.4 ± 0.5 mm (3 months)	3.8 ± 0.4 mm	3.5 ± 0.4 mm (3 months)	−0.1 mm (3.4 vs. 3.5 mm)	p = 0.250 (Not statistically significant)
Corbella et al., 2024(2)	Bleeding Index (BI); complete resolution of peri-implant mucositis (absence of bleeding on probing)	Baseline, 1 week, 1 month, 3 months (primary endpoint), 6 months, and 12 months	BI: 0.67 ± 0.55	BI at 3 months: 0.44 ± 0.38; Change from baseline (ΔBI): −0.22 ± 0.66	BI: 0.74 ± 0.63	BI at 3 months: 0.37 ± 0.32; Change from baseline (ΔBI): −0.33 ± 0.68	Healing rate at 3 months: Test group 96.7% (29/30 implants) vs. Control group 92.5% (37/40 implants). The absolute difference was 4.2 percentage points in favor of the test group.	p > 0.05
Clementini, 2023(3)	Complete disease resolution (absence of BoP)	6 months	19/62 implants (31%)	-	17/58 implants (29%)	-	−1.28 percentage points (Erythritol − Control)	p = 0.974

Table 3. Meta-analysis of the Effect of Erythritol-Based Air-Polishing on Complete Resolution of Peri-Implant Mucositis Using a Random-Effects Model

Study	RR	CI for RR	Weight (%)
Clementini et al. (2023)	1.05	0.60–1.81	3.9
Corbella et al. (2024)	1.05	0.94–1.17	96.1
Overall effect	1.05	0.94–1.16	100

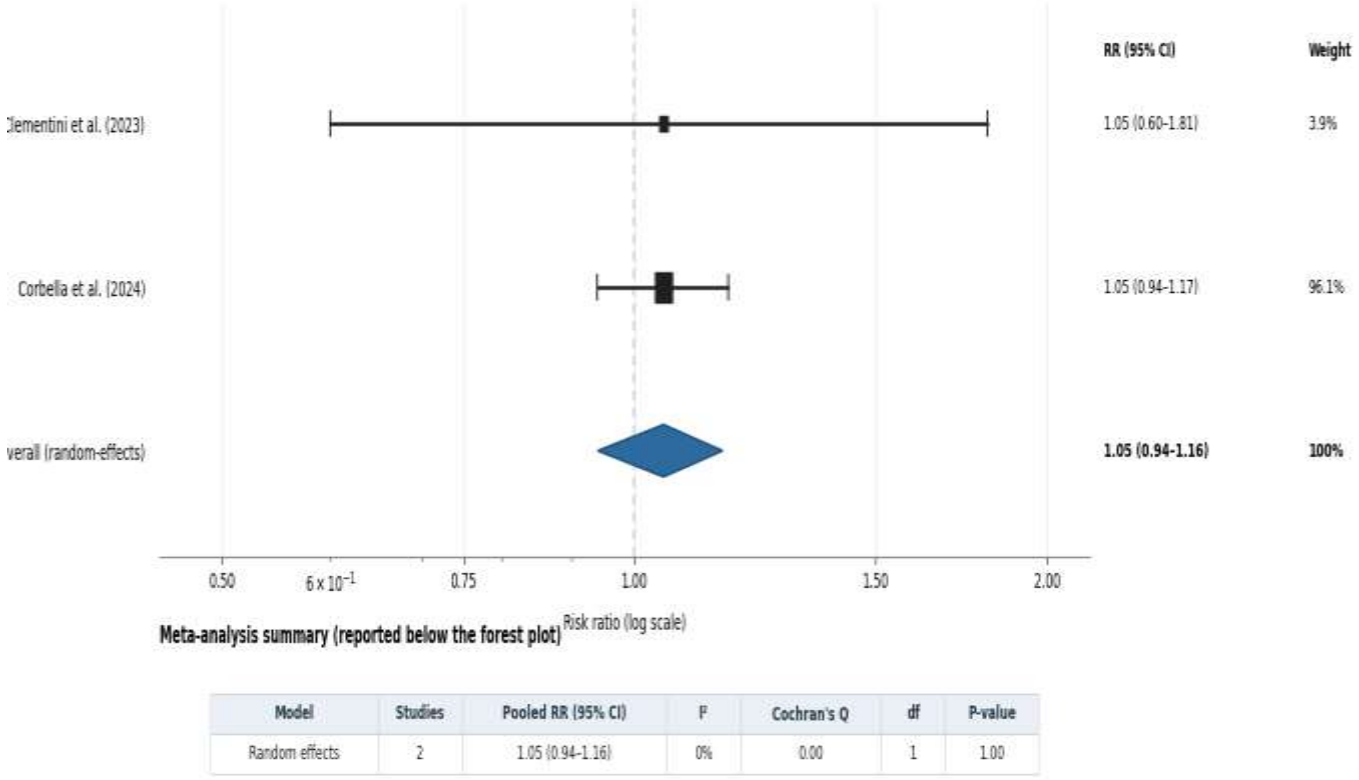


Figure 2. Forest plot of the pooled risk ratio (RR) for complete resolution of peri-implant mucositis following erythritol-based air-polishing compared with conventional mechanical debridement using a random-effects model.

Discussion and Conclusion

Peri-implant mucositis is a biofilm-induced inflammatory condition characterized by inflammation of the peri-implant soft tissues without progressive loss of supporting bone beyond initial physiological remodeling. Effective management of this condition is essential to prevent its

progression to peri-implantitis and maintain long-term implant survival. Mechanical disruption and removal of the bacterial biofilm, together with improvement of individual oral hygiene practices, remain the fundamental components of peri-implant mucositis therapy. However, the optimal instrumentation method for removing biofilm while minimizing damage to implant surfaces remains a subject of ongoing investigation. In this context, erythritol-based air-polishing (EAP) has attracted increasing attention as a minimally invasive approach for professional biofilm removal around dental implants.

The present systematic review and meta-analysis evaluated the clinical effectiveness of erythritol-based air-polishing compared with conventional mechanical debridement in patients with peri-implant mucositis. Three randomized controlled clinical trials involving 191 patients and 295 implants were included. Overall, the findings demonstrated that both erythritol-based air-polishing and conventional mechanical instrumentation were associated with improvements in clinical inflammatory parameters. However, the pooled analysis did not demonstrate a statistically significant superiority of erythritol-based air-polishing in achieving complete resolution of peri-implant mucositis (RR = 1.05; 95% CI: 0.94–1.16). The absence of statistically significant heterogeneity (I^2 = 0%) suggests consistency in the direction and magnitude of the results of the two studies included in the quantitative synthesis. Nevertheless, these findings should be interpreted cautiously because the relatively small number of included trials limits the precision and generalizability of the pooled estimate.

The results of the present analysis are consistent with the findings reported by Corbella et al. (2024), who compared erythritol powder air-polishing with conventional ultrasonic and manual instrumentation combined with chlorhexidine gel. Their randomized clinical trial demonstrated favorable clinical outcomes in both treatment groups over a 12-month observation period. Although the erythritol group demonstrated a numerically higher success rate at the 3-month assessment, the difference between treatment modalities was not statistically significant. Furthermore, patient-reported outcomes were generally comparable, with a more favorable taste perception reported in the erythritol group. These observations suggest that erythritol-based air-polishing may represent a clinically acceptable alternative to conventional instrumentation, particularly when the primary objective is biofilm removal while avoiding unnecessary mechanical trauma to peri-implant tissues(2) .

A further comparison can be made with the randomized controlled trial conducted by Clementini et al. (2023), which investigated the adjunctive use of erythritol powder air-polishing and Er:YAG laser following submarginal instrumentation. In this three-arm clinical trial, all treatment groups showed significant improvements in bleeding on probing (BoP) and probing pocket depth (PPD) throughout the follow-up period. Nevertheless, no statistically significant differences were detected between the groups. Complete disease resolution was achieved in approximately 29%–31% of implants, indicating that the addition of erythritol air-polishing did not provide a clinically meaningful advantage over conventional submarginal instrumentation alone. Interestingly, the authors identified several clinical factors associated with treatment success, including baseline PPD below 4 mm, the presence of vestibular keratinized mucosa, and a supramucosal restorative margin. These findings are particularly relevant because they indicate that the anatomical and prosthetic characteristics of the implant site may influence treatment outcomes independently of the biofilm-removal technique employed (3).

The findings of the present meta-analysis are also supported by the systematic review conducted by Verket et al. (2023), which evaluated mechanical and physical approaches for the nonsurgical management of peri-implant mucositis. The authors reported that several treatment modalities, including ultrasonic instrumentation, curettes, laser therapy, and air-polishing, were associated with reductions in BoP. However, the available randomized clinical trials did not demonstrate clear superiority of one mechanical or physical treatment modality over another. In particular, the addition of air-polishing to conventional mechanical instrumentation did not consistently produce additional clinical benefits. This observation is in agreement with the present findings and suggests that the effectiveness of peri-implant mucositis treatment may depend more on adequate biofilm disruption, patient adherence to oral hygiene recommendations, and regular supportive maintenance than on the selection of a particular professional instrumentation device (8).

From a biological and clinical perspective, erythritol-based air-polishing offers several potential advantages. Erythritol is a low-molecular-weight sugar alcohol that is water-soluble and can be delivered as a fine powder through specialized air-polishing devices. The combination of air, water, and erythritol particles facilitates the mechanical disruption and removal of supramucosal and submucosal

biofilm deposits. Compared with conventional metal instruments, this technique may allow access to anatomically complex peri-implant areas, including implant threads and irregular restorative contours. Furthermore, the use of low-abrasive powders and specially designed periodontal nozzles may reduce the risk of undesirable surface alterations when appropriate operating parameters are maintained. Nevertheless, these theoretical and technical advantages should not automatically be interpreted as evidence of superior clinical effectiveness. The results of the present review indicate that improved access and potentially less traumatic instrumentation do not necessarily translate into higher rates of complete disease resolution.

Another important consideration is the distinction between the use of erythritol air-polishing as a standalone treatment and its application as an adjunct to conventional mechanical instrumentation. These two treatment strategies should not be considered interchangeable. In the standalone approach, erythritol air-polishing is primarily used to remove the peri-implant biofilm, whereas in the adjunctive approach, conventional submarginal instrumentation is performed first, followed by additional biofilm removal using erythritol powder. The trial by Sun et al. (2026) directly compared erythritol air-polishing with ultrasonic debridement and demonstrated significant improvements in PPD, modified plaque index, and BoP in both groups after three months. Although the erythritol group showed a numerically greater reduction in PPD, the overall between-group differences were not statistically significant. However, the proportion of sites with PPD of at least 4 mm was significantly lower in the erythritol group at the three-month assessment. This finding may indicate a potential benefit of erythritol air-polishing in the management of deeper peri-implant sites, although the short follow-up period and relatively small sample size prevent definitive conclusions regarding its clinical superiority (5).

The distinction between standalone and adjunctive treatment is particularly important when interpreting the results of the present meta-analysis. The study by Corbella et al. compared different treatment protocols, including erythritol-based biofilm removal with ultrasonic instrumentation when required and conventional mechanical instrumentation combined with chlorhexidine gel. In contrast, Clementini et al. evaluated erythritol air-polishing as an adjunct following conventional submarginal instrumentation. Therefore, the observed treatment effects may reflect differences in the overall therapeutic protocols rather than the isolated effect of erythritol powder itself. Moreover, the use of chlorhexidine exclusively in the control group of the Corbella trial introduces an additional co-intervention that should be considered when interpreting the comparative findings. For this reason, separate analyses of standalone and adjunctive treatment protocols are clinically and methodologically justified(2).

The broader evidence also supports this interpretation. A systematic review and meta-analysis by the authors evaluating air-polishing in peri-implant diseases reported that air-polishing produced clinical improvements comparable to ultrasonic instrumentation in terms of BoP and PPD reduction in patients with peri-implant mucositis. However, no consistent evidence of superiority was identified. Although that review included studies investigating different air-polishing powders and both peri-implant mucositis and peri-implantitis, its findings provide additional support for the use of air-polishing as an alternative biofilm-removal approach rather than a definitively superior therapeutic intervention(9).

An important contribution to the interpretation of these findings comes from the 2025 joint consensus report of the American Academy of Periodontology (AAP) and the Academy of Osseointegration (AO). This consensus emphasizes that peri-implant mucositis should primarily be managed through an etiology-based approach involving nonsurgical debridement with implant-compatible instruments, including titanium curettes, ultrasonic devices, and air-abrasion systems. The recommendations also highlight the importance of identifying and controlling local and systemic risk factors, including inadequate plaque control, a history of periodontitis, smoking, uncontrolled diabetes, and unfavorable prosthetic conditions. Consequently, erythritol-based air-polishing should be regarded as one of several acceptable approaches for professional biofilm removal rather than a replacement for comprehensive peri-implant disease management(10).

More recently, Brunello et al. (2026) published a systematic review evaluating the effectiveness of nonsurgical treatment approaches for peri-implant mucositis. Their review included 21 studies, comprising 19 randomized controlled trials and two non-randomized controlled studies, with a total of 1,068 patients. The authors reported that different nonsurgical treatment approaches, including mechanical instrumentation, ultrasonic devices, air-polishing, lasers, and antimicrobial adjuncts, generally resulted in improvements in BoP. However, complete resolution of peri-implant mucositis was achieved only in a proportion of treated implants or patients, and the available

evidence did not establish a clear superiority of one treatment approach. Importantly, the authors highlighted considerable methodological heterogeneity, inconsistent outcome definitions, and the limited reporting of patient-reported outcomes. These observations closely correspond to the findings of the present review and reinforce the need for adequately powered clinical trials with standardized diagnostic criteria and longer follow-up periods(11).

The pooled risk ratio obtained in the present meta-analysis deserves particular consideration. The estimated RR of 1.05 indicates that the probability of complete disease resolution was approximately 5% higher in the erythritol group than in the conventional treatment group. However, the 95% confidence interval (0.94–1.16) included the null value of 1, indicating that the observed difference was not statistically significant. Therefore, the numerical advantage observed in favor of erythritol-based air-polishing should not be interpreted as proof of therapeutic superiority. Equally important, the absence of a statistically significant difference does not establish that the two interventions are equivalent. Demonstrating equivalence or non-inferiority requires appropriately designed clinical trials with predefined clinical margins and sufficient statistical power. Furthermore, the I^2 value of 0% suggests that no statistical heterogeneity was detected between the two pooled studies; however, this finding should be interpreted cautiously because heterogeneity tests have limited power when only two studies are included. Clinical differences in treatment protocols, follow-up periods, outcome definitions, and co-interventions may still be present despite the absence of measurable statistical heterogeneity.

Another clinically relevant finding concerns the relatively low rates of complete disease resolution reported in the included studies. In the trial by Clementini et al., complete resolution was achieved in approximately 31% of implants treated with erythritol air-polishing and 29% of implants receiving conventional instrumentation alone. These findings suggest that reductions in inflammatory parameters do not necessarily correspond to complete elimination of clinical signs of mucositis. Peri-implant inflammation is influenced by several interacting factors, including the quality of patient-performed plaque control, implant positioning, restoration contour, accessibility for interdental cleaning, soft-tissue phenotype, and the presence of residual submucosal deposits. Therefore, professional debridement should be considered an essential component of treatment but not a substitute for patient education, modification of local predisposing factors, and continuous supportive peri-implant care.

Patient-reported outcomes and treatment safety should also be considered when comparing different instrumentation methods. The study by Sun et al. (2026)(5) reported low pain scores in both treatment groups and no treatment-related adverse events. Similarly, Corbella et al. (2024)(2) found generally comparable patient-reported outcomes, although the erythritol group reported a more favorable taste perception. These observations suggest that erythritol air-polishing may be a well-tolerated treatment option. Nevertheless, the relatively limited number of studies reporting patient-centered outcomes prevents a comprehensive assessment of differences in postoperative discomfort, treatment satisfaction, and patient preference. Future randomized clinical trials should therefore incorporate standardized patient-reported outcome measures alongside conventional clinical parameters.

From a clinical standpoint, the findings of this review support the use of erythritol-based air-polishing as a potentially useful alternative for professional biofilm removal in the management of peri-implant mucositis. Its application may be particularly appropriate in situations where access to complex implant surfaces is challenging or where clinicians aim to minimize unnecessary mechanical instrumentation. However, treatment selection should be individualized according to implant morphology, prosthetic design, peri-implant tissue characteristics, patient preference, and clinician experience. Regardless of the instrumentation technique, reinforcement of oral hygiene practices and regular supportive peri-implant maintenance remain essential for achieving long-term stability. The 2025 AO/AAP consensus report also emphasizes the importance of continued maintenance following treatment, with more frequent monitoring for patients with a history of peri-implant mucositis(10) .

Several limitations of the present systematic review should be acknowledged. First, only three randomized controlled clinical trials fulfilled the eligibility criteria, resulting in a relatively limited evidence base. Second, the included studies differed in their intervention protocols, particularly regarding the use of erythritol air-polishing as a standalone intervention or as an adjunct to conventional instrumentation. Third, differences in diagnostic criteria and definitions of treatment success may have affected the comparability of the reported outcomes. Fourth, the follow-up periods ranged from three to twelve months, limiting the ability to assess the long-term stability of clinical

improvements. Fifth, some studies included multiple implants per patient, potentially introducing clustering effects if the statistical analyses did not adequately account for the correlation between implants within the same individual. Finally, the inclusion of only two studies in the quantitative synthesis substantially limits the interpretation of statistical heterogeneity, publication bias, and the precision of the pooled estimate.

Future investigations should focus on adequately powered multicenter randomized controlled trials comparing standalone erythritol air-polishing with conventional mechanical debridement using standardized treatment protocols. Studies should also distinguish clearly between patient-level and implant-level outcomes and account for the clustered nature of implant data. In addition, standardized definitions of complete disease resolution, consistent BoP and PPD measurement protocols, and longer follow-up periods of at least 12–24 months are recommended. Further research should investigate whether specific clinical characteristics, such as baseline pocket depth, keratinized mucosa width, implant surface characteristics, and prosthetic restoration design, modify the response to erythritol-based air-polishing. The inclusion of microbiological assessments and patient-reported outcomes would also provide a more comprehensive understanding of its therapeutic value.

Overall, the available evidence indicates that erythritol-based air-polishing is an effective and generally well-tolerated approach for professional biofilm removal in patients with peri-implant mucositis. Nevertheless, the present meta-analysis did not demonstrate statistically significant superiority over conventional mechanical debridement in achieving complete disease resolution. Therefore, erythritol-based air-polishing may be considered a viable alternative or, in selected clinical situations, an adjunctive treatment modality; however, its routine use as a superior treatment strategy cannot currently be recommended on the basis of the available evidence.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

Not applicable.

Authors' Contributions

All authors equally contributed to this study.

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Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

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