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REVIEW

Use of air polishing for supra- and subgingival biofilm removal for treatment of residual periodontal pockets and supportive periodontal care: a systematic review

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Abstract

Aim To systematically review the literature to compare the efficacy of air polishing to hand or ultrasonic instrumentation to reduce periodontal inflammation during treatment of residual pockets or supportive periodontal care.

Methods Electronic searches were performed in five different databases, and two databases were used to capture the "grey literature partially." Clinical trials that compared the use of an air-polishing device to either conventional scaling and root planing (hand and/or ultrasonic instrumentation) or no treatment during periodontal therapy were included without restriction of year and publication status. The Joanna Briggs Institute instrument for clinical trials was used to appraise the studies critically. The results were submitted to qualitative descriptive analysis. The systematic review protocol was registered in PROSPERO (CRD420220156176).

Results Electronic searches found 1100 hits published between 2008 and 2019. Thirteen studies were included in the review, out of which four had a follow-up longer than 180 days. Results indicated no differences between the efficacy of air polishing and hand or ultrasonic instruments to reduce periodontal inflammation.

Conclusions Our findings suggest that there is no difference in the efficacy of air polishing and hand or ultrasonic instrumentation to control biofilm and reduce periodontal inflammation. However, these findings must be carefully interpreted owing to methodological issues, including a short follow-up, and a potential conflict of interest related to industry funding.

Clinical relevance Air polishing for biofilm control may be used as an alternative to hand and ultrasonic instrumentation to reduce periodontal inflammation during treatment of residual pockets or supportive periodontal care.

Keywords Periodontitis · Periodontal diseases · Therapeutics · Oral hygiene

Introduction

Periodontitis is a condition associated with the inflammatory destruction of the periodontium that ultimately leads to tooth loss. Periodontitis is clinically characterized by clinical attachment loss (CAL) and bleeding on probing (BOP) accompanied by increased probing pocket depth (PPD) and/or gingival recession [1]. The current paradigm poses that periodontitis results from a polymicrobial dysbiosis with keystone pathogens affecting the virulence of the entire biofilm community [2]. Thus, the inability of the host immune system to eliminate the biofilm insult leads to a complex chronic response with the destruction of bone and periodontal ligament attachment [2]. In addition, some conditions are associated with worsening the ability of the immune system to control the effect of biofilm, including tobacco smoking and diabetes mellitus [1].

The standard periodontitis treatment aims to restore the homeostasis of the immune system by mechanically reducing the microbial load to levels that are compatible with stability and health [3]. This is achieved by (1) professional mechanical

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biofilm control, (2) training the patient to maintain daily oral hygiene at an adequate level, and (3) performing supportive periodontal therapy to control the biofilm and avoid disease recurrence. Currently, there are several methods available for supra- and subgingival biofilm removal, including hand instruments, sonic and ultrasonic scalers, and air polishing therapy, of which hand instruments and ultrasonic scalers remain as the most commonly used tools for professional biofilm control [4]. However, both hand and ultrasonic instruments are time-consuming and technically demanding and often associated with patient discomfort and pain during and after treatment [5], including hypersensitivity caused by hard tissue loss when scaling the tooth surface [6].

More recently, air polishing devices have become a promising alternative to hand and ultrasonic scalers. An air-polishing device removes biofilm from the tooth surface by spraying compressed air containing water and abrasive particles [5], like glycine, trehalose, erythritol, and sodium bicarbonate. While reducing the clinical time and causing less discomfort and pain for the patients, air polishing devices remove only biofilm, whereas hand and ultrasonic instruments can remove both biofilm and dental calculus. Consequently, it has been suggested that air polishing could be used combined to hand instrumentation during initial periodontal therapy or alone during the treatment of residual pockets after initial therapy or supportive periodontal care. However, there is a gap to be filled in regarding the efficacy of air polishing devices in comparison to hand and ultrasonic instrumentation for the performance of periodontal therapy [7, 8].

Accordingly, this study aimed to systematically review the literature to compare the efficacy of air polishing devices to hand and ultrasonic instrumentation to reduce periodontal inflammation.

Methods

Protocol and registration

This systematic review was performed according to the list of PRISMA (Preferred Reporting Items for Systematic Reviews) recommendations [9] and the Cochrane guidelines [10]. The systematic review protocol was registered in the PROSPERO database under no. CRD420220156176.

Study design and eligibility criteria

This study was a systematic review based on a PICO strategy that aimed to answer the following review question: "Is air-polishing therapy as effective as hand or ultrasonic scaling to reduce periodontal inflammation among patients under periodontal therapy?", where

Population: patients under periodontal therapy;
Intervention: air polishing alone or air polishing as an adjunctive therapy;
Comparator: manual or ultrasonic scaling;
Outcome: main endpoint: probing pocket depth (PPD); secondary endpoints: bleeding on probing (BOP), clinical attachment level (CAL), and plaque index (PI).

Inclusion criteria comprised randomized controlled trials that compared the use of an air-polishing device to either conventional scaling and root planing (using hand instruments and/or ultrasonic devices) or no treatment during periodontal therapy (active phase or supportive therapy) without restriction of year and publication status. Exclusion criteria included studies not using an air-polishing device during periodontal therapy; studies on patients with a systemic commitment (pregnancy, diabetes); studies on dental implants; review articles; letters to the editor/editorials; books/book chapters; abstracts; as well as case reports and series.

Sources of information and search

Cochrane, Embase, PubMed (including MEDLINE), Scopus, and Web of Science databases were used as primary study sources. OpenGrey and ProQuest were used to capture the "grey literature partially." A manual search was also performed through a systematized analysis of the reference list of the eligible articles. All steps were performed to minimize selection and publication biases.

The MeSH (Medical Subject Headings), DeCS (Health Sciences Descriptors), and Emtree (Embase Subject Headings) resources were used to select appropriate search descriptors. The Boolean operators "AND" and "OR" were used to enhance the research strategy through several combinations (Appendix Table 5). The search strategy included the following descriptors: "Air-Powder," "Air polishing," "Air Abrasion," "Air Abrasion," "Dental," "Abrasive Powder," "Tooth Polishing," "Dental Polishing," "Periodontal," "Periodontitis," and "Periodontal Diseases." The bibliographic search ended in June 2020.

Study selection

All references were managed in EndNote X8 (Thomson Reuters, New York, NY, USA). Duplicate references were excluded. Before the assessment, reviewers were calibrated by discussing the eligibility criteria and examining 20% of the retrieved articles to estimate the level of agreement between both reviewers. Only when a kappa > 0.80 was achieved, the reviewers were allowed to start the study selection.

Titles, abstracts, and keywords were screened based on the inclusion and exclusion criteria by two reviewers

independently. Lists were compared, and in case of disagreement, a consensus was reached by discussion. Assessment of the full articles identified in the initial screening was performed by the same two reviewers. In addition to the electronic search, a hand search was performed in the reference list of all included studies by the same reviewers.

Data collection

After study selection, predefined data collection worksheets were employed for the assessment of each selected publication. The following data were elicited from the studies: identification (author, year, study location), sample characteristics (population, age), study design, periodontal data (definition, endpoints), characteristics of the therapy (active or supportive, frequency, follow-up), air polishing characteristics (machine, power), manual instrumentation (hand or ultrasound), adverse effects, secondary outcomes, primary results, and source of funding. Whenever necessary, the authors were contacted by e-mail to clarify potential doubts regarding the study methodology or results.

Risk of individual bias of the studies

The Joanna Briggs Institute (JBI) Critical Appraisal Tools for use in JBI Systematic Reviews for randomized clinical trials [11] was used to assess the risk of bias and the individual methodological quality of the selected studies. The same two reviewers assessed each domain independently regarding their potential risk of bias, as recommended by the PRISMA statement [9].

The following criteria were evaluated: (Q.1)Was true randomization used for assignment of participants to treatment groups? (Q.2) Was allocation to treatment groups concealed? (Q.3) Were treatment groups similar at the baseline? (Q.4) Were participants blind to treatment assignment? (Q.5) Were those delivering treatment blind to treatment assignment? Q.6) Were outcomes assessors blind to treatment assignment? Q.7) Were treatment groups treated identically other than the intervention of interest? Q.8) Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analyzed? (Q.9) Were participants analyzed in the groups to which they were randomized? (Q.10) Were outcomes measured in the same way for treatment groups? (Q.11) Were outcomes measured in a reliable way? Q.12) Was appropriate statistical analysis used? (Q.13) Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial. In addition to the JBI instrument questions, we also assessed whether the study provided a sample size calculation based on previous studies and had a follow-up longer than 180 days.

Each study was categorized according to the percentage of positive answers to the questions corresponding to the assessment tool. The risk of bias was considered *High* when the study obtained up to 49% of "yes" answers, *Moderate* when the study obtained 50% to 69% of "yes" answers, and *Low* when the study reached more than 70% of "yes" scores.

Summary measures and syntheses of results

Initially, a descriptive analysis of all articles included in this systematic review was carried out. In addition to the descriptive analysis, we attempted to perform a meta-analysis to compare the effect of air polishing to conventional instrumentation on the primary (PPD) and secondary (BOP, CAL, PI) endpoints at different follow-up periods. However, due to the low number of studies with a follow-up longer than 180 days, we were not able to achieve at least three studies per type of treatment (singular use or adjunctive to manual or ultrasonic scaling), which, therefore, precluded the performance of a clinically relevant meta-analysis.

Results

Study selection

During the first phase of study selection, 1110 hits were found among the seven electronic databases. After removing duplicates, 733 articles remained for the analysis of titles and abstracts. Searches were updated in June 2020, but no new article fulfilled the inclusion criteria. Twenty studies were considered eligible for full-text analysis. At the full-text reading stage, one study was not found, whereas six studies did not meet the inclusion criteria and were, therefore, eliminated. Appendix Table 6 shows the studies excluded after full-text reading with the reasons for exclusion. The references of the 13 potentially eligible studies were evaluated carefully, and no additional article was selected. Finally, 13 studies were included for qualitative analysis. Figure 1 reproduces the process of search, identification, inclusion, and exclusion of articles.

Characteristics of eligible studies

The studies were published between the years of 2008 and 2019, and they were performed in Germany [4, 12], India [13], Sweden [14], Switzerland [6, 15, 16], South Korea [5], USA [17], Greece [18], Turkey [19], and China [20, 21]. Air polishing was compared to hand scaling in 10 studies [4–6, 15–21] and to ultrasonic scaling in three studies [12–14]. While eight studies evaluated the effect of air polishing to treat residual pockets after initial periodontal therapy, five studies [12, 15, 16, 18, 20] used it during supportive therapy. Ten studies compared the use of air polishing alone, while

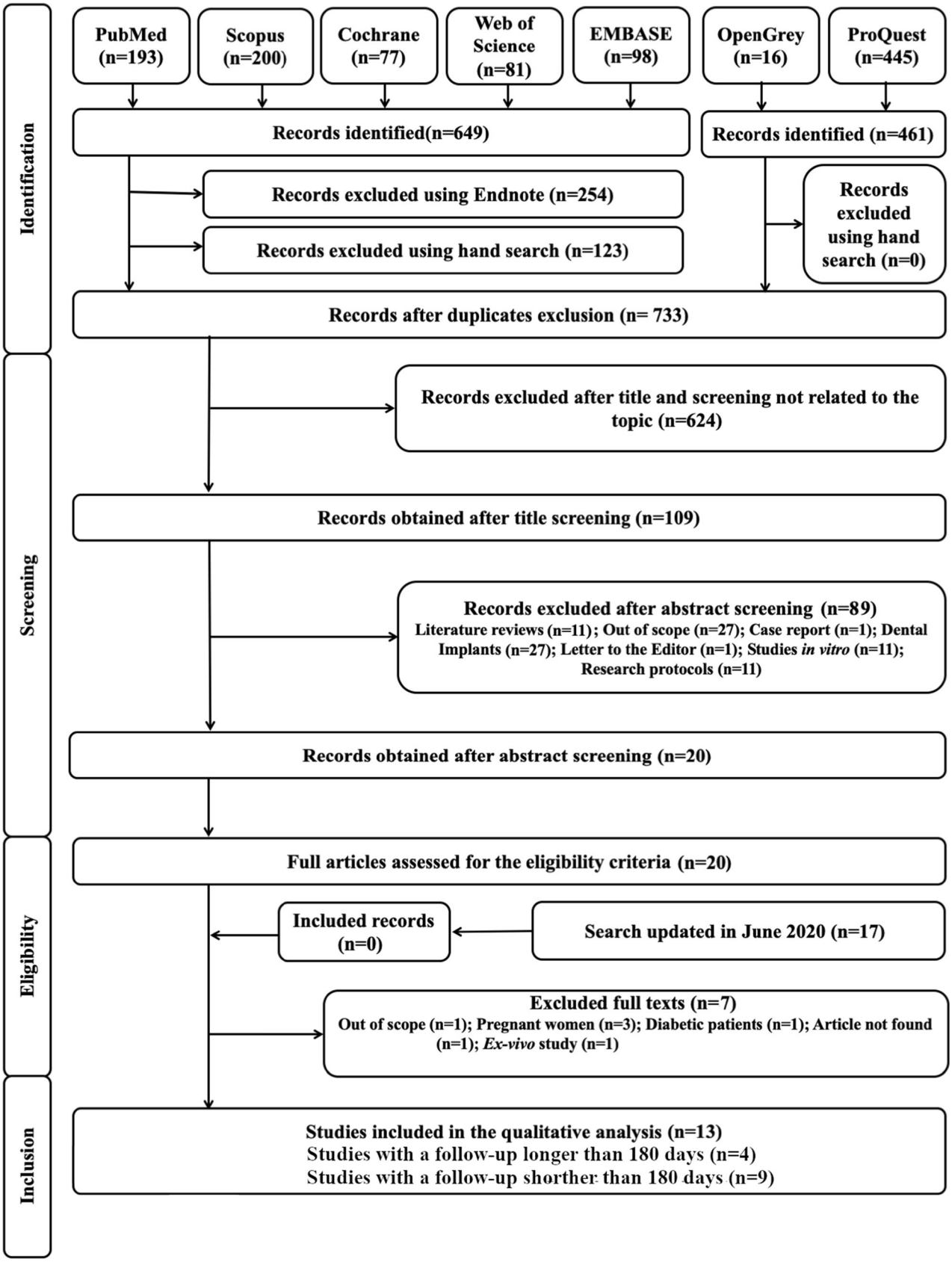

Fig. 1 Flow-chart of study selection

three studies [5, 19, 21] evaluated air polishing as an adjunctive to hand and ultrasonic instruments. Glycerin powder was used in 10 studies, while erythritol powder was used in two [5, 15], and trehalose powder in only one [12]. Nine studies used the air-polishing device for subgingival biofilm removal using a subgingival nozzle [5–7, 12, 14–16, 18, 21], whereas three studies did not provide information on the nozzle used for subgingival biofilm removal [4, 13, 19]. The remaining study used a supragingival nozzle to remove supragingival biofilm [20]. The average age ranged between 18 and 70 years among the group of patients. Only four studies had a follow-up up to or longer than 180 days [12, 16, 18, 21] (Table 1). All studies reported that they followed ethical criteria and applied terms of consent to all patients. Only one study [17] reported to follow the CONSORT guidelines. No study mentioned whether it was registered in clinical trial databases. Of the 13 studies, seven have been funded by the industry [4, 6, 12, 14–17]. More details are found in Table 1 for studies with a follow-up longer than 180 days and in Table 2 for the remaining studies.

Risk of individual bias of the studies

Two eligible studies [12, 17] had low risk of bias, while eight studies [5, 6, 13, 14, 16, 18–20] had a moderate risk of bias, and three a high risk of bias [4, 15, 21]. Of the studies with a follow-up longer than 180 days, one had a low risk of bias [12], two a moderate risk [16, 18], while one had a high risk of bias [21]. Table 3 shows detailed information on the risk of bias assessment among the studies. Items 1 and 2 were considered unclear when tossing a coin was used as the randomization method. In item 4, none of the studies informed about the participants blinding. All studies were marked as "no" in item 5 because they did not blind the operators. Item 6 was considered "unclear" when no information about blinding the clinical assessor was provided. In item 9, all 13 studies were marked as "no" because they reported neither participant dropout nor provided intention to treat analysis. Item 13 was considered as "unclear" because the articles did not follow a guideline to fulfill the RCT designs and did not mention any specific method to do so. Additionally, seven studies did not provide a sample size calculation based on results from previous findings, and the vast majority (nine studies) did not have a follow-up longer than 180 days.

Synthesis of results

Table 4 displays the main clinical findings of the studies included in the review. Eleven studies evaluated probing pocket depth [4, 5, 12, 14–21] (Appendix Table 7), while five studies evaluated clinical attachment level [5, 12, 15, 19, 21] (Appendix Table 8). Eight articles measured plaque index [4, 13, 15–20] (Appendix Table 9). Finally, bleeding on probing was measured by 11 studies [4–6, 12, 14–17, 19–21] (Appendix Table 10).

For the primary endpoint of this study, PPD data, four studies with a follow-up longer than 180 days [12, 16, 18, 21] provided a comparison between air polishing and hand and ultrasonic instruments. Three studies used air polishing alone to treat residual periodontal pockets (PPD ≥ 4 mm) during supportive therapy [12, 16, 18], while one study used air polishing as an adjunctive therapy to hand instrumentation during initial periodontal therapy [21]. Three studies indicated that air polishing achieved similar PPD results to hand instrumentation after 180 days [12, 16, 21], while one study showed greater improvement of PDD among participants treated with hand instrumentation [18] (Table 4).

As displayed in Table 4, no differences were observed between manual or ultrasonic scaling and air polishing for any of the secondary clinical parameters evaluated (BOP, CAL, PI), irrespective of the evaluation time.

In addition to the clinical parameters, seven studies performed microbiological analyses [5–7, 14, 16, 18, 20], seven evaluated patient's comfort [5–7, 12, 14–16], and three carried out efficacy analysis on clinical professional time [6, 15, 18], whereas VSC level was evaluated in one study [19], and GCF volume and cytokines in another [21]. Regarding the microbiological analyses VSC level and GCF volume, air polishing had similar results than manual or ultrasonic scaling did; however, it showed better results regarding the patients' comfort and the time spent by the professional (Table 4). Finally, 12 studies did not observe any adverse effect related to the use of air polishing, while one study did not report information about it [19] (Table 4).

Discussion

This systematic review aimed to evaluate the efficacy of air polishing compared to manual and ultrasonic scaling for reduction of periodontal inflammation. Our findings suggest no differences between the efficacy of air polishing and manual or ultrasonic instruments to reduce probing pocket depth (PPD) during treatment of residual periodontal pockets or supportive periodontal care. Similar results were also observed for the secondary endpoints, namely, BOP, CAL and PI. In addition, air polishing seems to be safe, more comfortable for patients, and to reduce the length of the clinical appointment.

Prior to further discussions, let us examine the limitations and strengths of our review. The main limitation of this review relates to the lack of a standard protocol for air polishing, which included the use of different powders, among others. Additionally, none of the included studies had a follow-up longer than 1 year, a methodological issue that should be overcome in future studies, as there is a common relapse in RCT's on periodontal therapy after the first year of treatment

Table 1 Summary of the main characteristics and results of the eligible studies with a follow-up of up to and longer than 180 days

Author, year	Country	Sample and age	Study design	Follow-up	Powder type	Use	Biofilm removal, equipment, and nozzle	Clinical application	Application mode	Funding
Müller et al. 2014 [16]	Switzerland	50* (G1: 25 e G2: 25) Age: n.r.	Blinded clinical trial	90, 180, 270, and 365 days	GPAP	Singular	Subgingival biofilm removal with EMS Air Flow Master using a subgingival nozzle.	SPT PPD ≥ 4 mm	Test sites were treated for 5 s.	EMS Electro Medical System, Nyon, Switzerland
Kargas et al. 2015 [18]	Greece	21* (G1: 21 e G2: 21) Age: n.r.	Blinded clinical trial split-mouth	30, 90, and 180 days	GPAP	Singular	Subgingival biofilm removal with EMS Air Flow Master using a subgingival nozzle.	SPT PPD ≥ 4 mm	Test sites were treated for 5 s.	No funding was provided by the industry
Tsang et al. 2018 [21]	China	27* (G1: 27 e G2: 27) Age: 18-65 years old	Blinded clinical trial split-mouth	180 days	GPAP	Adjunctive to hand and ultrasonic instruments	Subgingival biofilm removal with hand and ultrasonic instruments and EMS Air Flow Master using a subgingival nozzle.	Initial therapy with PPD ≥ 5 mm	Test sites were treated with manual scaling and after with air polishing for 5 s.	The University of Hong Kong
Kruse et al. 2019 [12]	Germany	52* (G1: 52 e G2: 52) Age: n.r.	Blinded clinical trial split-mouth	90 and 180 days	Trehalose powder	Singular	Subgingival biofilm removal with EMS Air Flow Master using a subgingival nozzle.	SPT PPD ≥ 5 mm or PPD = 5 mm with BOP	Test sites were treated for 5 s.	Orochemie, part of the Dürr Dental Group (Bietigheim-Bissingen, Germany)

Abbreviations: *n.r.* not reported, *G1* control group, *G2* test group, *GPAP* glycerin powder air polish, *BOP* bleeding on probing, *PPD* probing pocket depth, *SPT* supportive periodontal therapy

*Gender not specified

Table 2 Summary of the main characteristics and results of the eligible studies with a follow-up of up shorter than 180 days.

Author, year	Country	Sample and age	Study design	Follow-up	Powder type	Use	Biofilm removal, equipment and nozzle	Clinical application	Application mode	Funding
Petersilka et al. 2008 [4]	Germany	10* (G1: 5 e G2: 5) Age: n.r.	Double-blinded clinical trial	14 days	GPAP	Singular	Supra- and subgingival biofilm removal with EMS Air Flow S1. No information about the nozzle used.	Residual pockets after initial therapy PPD ≥ 5 mm	The main powder-water jet was directed into the buccal or lingual aspect of the periodontal pocket at an angle of 60°–90° to the root surface for 5 s per tooth.	3M Espe
Möene et al. 2010 [6]	Switzerland	50* (G1: 25 e G2: 25) Age: 18-70 years old	Blinded clinical trial	7 days	GPAP	Singular	Subgingival biofilm removal with EMS Air Flow Master using a subgingival nozzle.	Residual pockets after initial therapy PPD ≥ 5 mm	The nozzle was attached to an air-polishing hand piece. The nozzle design induced a pressure drop in the jet spray of up to 1 bar, reducing the effective working pressure. The recommended instrumentation time was limited to 5 s.	EMS Electro Medical System, Nyon, Switzerland
Wennström et al. 2011 [14]	Sweden	20* (G1: 40 e G2: 40) Age: n.r.	Blinded clinical trial	60 days	GPAP	Singular	Subgingival biofilm removal with EMS Air Flow Master using a subgingival nozzle.	Residual pockets after initial therapy PPD 5 to 8 mm and BOP	Each periodontal pocket was debrided for 25 s.	EMS Electro Medical System, Nyon, Switzerland
Flemmig et al. 2012 [17]	USA	30* (G1: 15 e G2: 15)\ Age: > 21 years old	Blinded clinical trial	10 and 90 days	GPAP	Singular	Subgingival biofilm removal with EMS Air Flow Master using a subgingival nozzle.	Residual pockets after initial therapy PPD 4 to 9 mm and BOP	The nozzle was inserted gently into the periodontal pocket until resistance was felt. After activating the air-polishing device, the nozzle was moved over the entire subgingival root surface using a circular motion. Each tooth surface (mesial, buccal, distal, and lingual) was treated for 5 s	EMS Electro Medical System, Nyon, Switzerland
Hägi et al. 2013 [15]	Switzerland	40* (G1: 20 e G2: 20) Age: n.r.	Blinded Clinical Trial	90 days	Erythritol Powder	Singular	Subgingival biofilm removal with EMS Air Flow Master using a subgingival nozzle.	Residual pockets during SPT PPD ≥ 4 mm and BOP	Test sites were treated for 5 s.	EMS Electro Medical System, Nyon, Switzerland
Simon et al. 2015 [13]	India	10* (G1: 5 e G2: 5) Age: 20–40 years old	Double-blinded clinical trial	21 days	GPAP	Singular	Supra- and subgingival biofilm removal with Dentsply Prophy-Jet. No information	Residual pockets after initial therapy PPD ≥ 5 mm	Test sites were treated for 5 s.	Not mentioned

Table 2 (continued)

Author, year	Country	Sample and age	Study design	Follow-up	Powder type	Use	Biofilm removal, equipment and nozzle	Clinical application	Application mode	Funding
							about the nozzle used.			
Caygur et al. 2017 [19]	Turkey	60* (G1: 30 e G2: 30) Age: 28–68 years old	Blinded clinical trial	30 days	GPAP	Adjunctive to hand and ultrasonic instruments	Subgingival biofilm removal with hand and ultrasonic instruments and EMS Air Flow Master. No information about the nozzle used.	Residual pockets after initial therapy PPD 4 to 6 mm and BOP	Test sites were treated for 5 s.	No funding was provided by the industry
Lu et al. 2018 [20]	China	22* (G1: 22 e G2: 22) Age: n.r.	Blinded clinical trial split-mouth	96 days	GPAP	Singular	Supragingival biofilm removal with EMS Air Flow Master using a supragingival nozzle.	SPT PPD ≤ 5 mm	Test sites were treated for 5 s.	National Science and Technology Pillar Program of the 11th Five-Year Plan of China and the Project of the Key Clinical Disciplines of Ministry of Health of China
Park et al. 2018 [5]	South Korea	21* (G1: 21 e G2: 21) Age: 19-70 years old	Blinded clinical trial split-mouth	30 and 90 days	Erythritol Powder	Adjunctive to hand and ultrasonic instruments	Subgingival biofilm removal with hand and ultrasonic instruments and EMS Air Flow Master using a subgingival nozzle.	Initial therapy with PPD 4 to 6 mm	Test sites were treated with manual scaling and after with air polish for 5 s.	National Research Foundation of Korea

Abbreviations: n.r. not reported, *G1* control group, *G2* test group, *GPAP* glycerin powder air polish, *BOP* bleeding on probing, *PPD* probing pocket depth, *SPT* supportive periodontal therapy

*Gender not specified

Table 3 Risk of bias assessed by the Joanna Briggs Institute Critical Appraisal Tools for use in JBI Systematic Reviews for randomized controlled trials (Tufanaru et al. 2017).

Authors	Q.1	Q.2	Q.3	Q.4	Q.5	Q.6	Q.7	Q.8	Q.9	Q.10	Q.11	Q.12	Q.13	Sample size calculation	Follow-up longer than 180 days	% Yes/risk based on the 15 questions
Follow-up longer than 180 days																
Müller et al. 2014	√	√	√	--	U	√	√	√	--	√	√	√	U	√	√	69.2%/moderate risk of bias
Kargas et al. 2015	√	√	√	--	--	U	√	√	--	√	√	√	U	√	√	66.6%/moderate risk of bias
Tsang et al. 2018	--	U	√	--	--	U	√	√	--	√	√	√	U	U	√	46.6%/high risk of bias
Kruse et al. 2019	√	√	√	--	--	√	√	√	--	√	√	√	√	√	√	80.0%/low risk of bias
Follow-up shorter than 180 days																
Petersilka, et al. 2008	√	--	√	--	--	U	√	√	--	√	√	--	U	U	--	40.0%/high risk of bias
Moëne et al. 2010	√	√	√	--	--	√	√	√	--	√	√	√	U	--	--	60.0%/moderate risk of bias
Wennström et al. 2011	√	√	√	--	--	√	√	√	--	√	√	√	U	√	--	66.6%/moderate risk of bias
Flemmig et al. 2012	√	√	√	--	--	√	√	√	--	√	√	√	√	√	--	73.3%/low risk of bias
Hägi et al. 2013	--	U	√	--	--	√	U	√	--	√	√	√	U	--	--	40.0%/high risk of bias
Simon et al. 2015	√	√	√	--	--	U	√	√	--	√	√	√	√	U	--	60.0%/moderate risk of bias
Caygur et al. 2017	√	√	√	--	--	U	√	√	--	√	√	√	√	U	--	60.0%/moderate risk of bias
Lu et al. 2018	√	√	√	--	--	√	√	√	--	√	√	√	√	U	--	66.6%/moderate risk of bias
Park et al. 2018	√	√	√	--	--	U	√	√	--	√	√	√	√	√	--	66.6%/moderate risk of bias

Q.1) Was true randomization used for assignment of participants to treatment groups? (Q.2) Was allocation to treatment groups concealed? (Q.3) Were treatment groups similar at the baseline? Q.4) Were participants blind to treatment assignment? (Q.5) Were those delivering treatment blind to treatment assignment? (Q.6) Were outcomes assessors blind to treatment assignment? (Q.7) Were treatment groups treated identically other than the intervention of interest? Q.8) Was follow-up complete and if not, were differences between groups in terms of their follow-up adequately described and analyzed? (Q.9) Were participants analyzed in the groups to which they were randomized? (Q.10) Were outcomes measured in the same way for treatment groups? (Q.11) Were outcomes measured in a reliable way? (Q.12) Was appropriate statistical analysis used? (Q.13) Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial? Sample size calculation refers to studies that provided a sample size calculation based on previous studies. Follow-up longer than 180 days refers to studies that have a follow-up of 180 days or longer. √ Yes; – No, *U* unclear

Table 4 Summary of the primary outcome between the use of air polish and the scaling manual-qualitative analysis

Author and year	Main outcome	Secondary outcomes				
	Clinical parameters	Microbiological data	Patients' comfort	Adverse effects	Professional time	Others
Follow-up longer than 180 days						
Müller et al. 2014	GPAP showed similar results to conventional SRP about PPD, CAL, and BOP	GPAP was similar to conventional SRP	GPAP has been shown to be more comfortable for patients	Not present	–	–
Kargas et al. 2015	Conventional SRP showed greater improvement of PPD and CAL than GPAP	GPAP was similar to conventional SRP	GPAP has been shown to be more comfortable for patients	Not present	GPAP was more time-efficient than SRP	–
Tsang et al. 2018	Manual scaling and GPAP showed similar results to conventional SRP about PPD, CAL, and BOP	–	–	Not present	–	Manual scaling and GPAP had higher GCF volume reduction than conventional SRP. GCF levels of IL-1b and IL-1ra were similar in both groups
Kruse et al. 2019	Trehalose powder showed similar results to conventional SRP about PPD, CAL, PI, and BOP	–	Trehalose powder has been shown to be more comfortable for patients	Not present		–
Follow-up shorter than 180 days						
Petersilka, et al. 2008	GPAP showed similar results to conventional SRP about PPD, PI, and BOP	–	–	Not present. GPAP also results in less gingival erosion than conventional SRP	–	–
Möene et al. 2010	GPAP showed similar results to conventional SRP about BOP	GPAP was similar to conventional SRP	GPAP has been shown to be more comfortable for patients	Not present	GPAP was more time-efficient than SRP	
Wennström et al. 2011	GPAP showed similar results to conventional SRP about BOP	GPAP was similar to conventional SRP	GPAP has been shown to be more comfortable for patients	Not present	–	–
Flemmig et al. 2012	GPAP showed to be more efficacious than conventional SRP in the removal of subgingival biofilm	GPAP may result in a beneficial shift of the oral microbiota	GPAP has been shown to be as comfortable for patients as conventional SRP	Not present	–	–
Hägi et al. 2013	EPAP showed similar results to conventional SRP about PPD, CAL, PI, and BOP	–	EPAP has been shown to be more comfortable for patients compared to conventional SRP	Not present	No differences between erythritol powder and conventional SRP	–
Simon et al. 2015	GPAP showed similar results to conventional SRP about PI and GI	–	–	Not present. GPAP results in less gingival erosion	–	–

Table 4 (continued)

Author and year	Main outcome	Secondary outcomes				
	Clinical parameters	Microbiological data	Patients' comfort	Adverse effects	Professional time	Others
				than conventional SRP		
Caygur et al. 2017	GPAP showed similar results to conventional SRP about PPD, CAL, PI, BOP, and GI	–	–	–	–	VSC levels (halitosis) were similar in both groups
Lu et al. 2018	GPAP showed similar results to conventional SRP about PPD, PI, and BOP	GPAP was similar to conventional SRP	–	Not present	–	–
Park et al. 2018	Manual scaling and EPAP showed similar results to conventional SRP about PPD, CAL, PI, and BOP	Manual scaling and EPAP were similar to conventional SRP	–	Not present	–	–

Abbreviations: BOP bleeding on probing, *CAL* clinical attachment level, *EPAP* erythritol powder air polish, *GI* gingival index, *GPAP* glycerin powder air polish, *IL* interleukin, *PI* plaque index, *PPD* pocket probing depth, *SRP* scaling and root planing, – not evaluated

completion. Additionally, as few studies provided a sample size calculation, one may speculate whether the lack of difference between therapies was not related to underpowered studies. A similar thought would also apply to studies that presented problems related to randomization or blinding. However, one should bear in mind that the lack of difference between therapies was not a phenomenon limited to "high-risk-of-bias" studies, as those with a higher methodological quality achieved similar results. Regardless of the limitations, our study has some strengths that should be further stressed. Firstly, this systematic review comprises a thorough literature search, which included the grey literature without restriction of time, language, and publication status. Besides, the "Joanna Briggs Institute Critical Appraisal Tools for Use in JBI Systematic Reviews Checklist for Randomized Controlled Trials" was rigorously applied by the authors to assess the risk of bias, in addition to two other questions to assess the quality of the studies. Finally, according to the Oxford Center for Evidence-Based Medicine, our study indicates a good level of evidence to support our findings [22].

In the treatment of periodontitis, biofilm control is critical to prevent or to arrest disease progression. After a treatment phase, including non-surgical and surgical approaches, patients usually follow supportive periodontal treatment [23]. A previous systematic review revealed that air polishing and ultrasonic instrumentation showed similar clinical efficacy, while air polishing showed a preferable level of comfort than ultrasonic instrumentation [8], supporting our findings. Furthermore, we also observed similar results when comparing air polishing to hand instrumentation alone (Tables 1, 2, and 4). Results are not surprising since most periodontal treatments performed in practice aim to restore the homeostasis between the biofilm and the host immune system by mechanically reducing the microbial load to levels that are compatible with health. What can be deduced from our findings is that air polishing, manual scaling, and ultrasonic scaling are all clinically efficient in controlling the biofilm to levels compatible with periodontal inflammation reduction measured by plaque accumulation, bleeding, pocket depth, and attachment level.

Our findings also revealed that side or adverse effects related to the use of air polishing devices are rare and usually include non-serious events, such as increased tooth sensitivity or painless gingival erosion. None of the studies observed any adverse effect related to the use of air polishing for subgingival biofilm removal. Thus, it seems to be a safe therapy to be used as part of the routine periodontal care. On a similar note, a previous study demonstrated that air polishing with glycine powder resulted in fewer areas of gingival erosion compared to hand instrumentation or air polishing with

sodium bicarbonate [4]. However, sifting through the evidence regarding the safety of air-polishing devices reveals that other rare complications may occur, such as subcutaneous emphysema and abrasion of the root cementum.

A critical finding of our study relates to the industry's involvement in the studies using air-polishing devices. Out of 13 RCT's on the topic, seven were funded by the industry, and in some, authors were involved in the development of the powder used in the air-polishing device. This fact should raise caution to the reader when interpreting our findings since it is not possible to determine whether studies with negative results have been subjected to publication bias.

Conclusion

Our findings suggest that there is no difference between the efficacy of air polishing and hand or ultrasonic instrumentation to control biofilm and to reduce periodontal inflammation. In addition, air polishing seems to be a safe, comfortable, and less time-consuming tool to be incorporated in the periodontal care combined to hand instruments during initial periodontal therapy, or alone for treatment of residual inflamed pockets and supportive periodontal therapy. However, these findings must be carefully interpreted owing to a potential conflict of interest related to industry funding and a moderate quality of the evidence. In addition, randomized clinical trials with a follow-up period longer than 12 months with a higher methodological quality, including a properly calculated sample size, are required to assess the stability of periodontal parameters treated with air polishing.

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Compliance with ethical standards

Conflicts of interest The authors declare that they have no conflicts of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent For this type of study, formal consent is not required.

Appendix

Table 5 Strategies for database search

Database	Search strategy (Outubro, 2019)
PubMed http://www.ncbi.nlm.nih.gov/pubmed	(("Air-Powder" OR "Air Polishing" OR "Air-Polishing" OR "Air Abrasion" OR "Air Abrasion, Dental" OR "Abrasive Powder" OR "Tooth Polishing" OR "Dental Polishing") AND ("Periodontal" OR "Periodontitis" OR "Periodontal Diseases"))
Scopus http://www.scopus.com/	(("Air-Powder" OR "Air Polishing" OR "Air-Polishing" OR "Air Abrasion" OR "Air Abrasion, Dental" OR "Abrasive Powder" OR "Tooth Polishing" OR "Dental Polishing") AND ("Periodontal" OR "Periodontitis" OR "Periodontal Diseases"))
Cochrane Library https://www.cochranelibrary.com/	(("Air-Powder" OR "Air Polishing" OR "Air-Polishing" OR "Air Abrasion" OR "Air Abrasion, Dental" OR "Abrasive Powder" OR "Tooth Polishing" OR "Dental Polishing") AND ("Periodontal" OR "Periodontitis" OR "Periodontal Diseases"))
Web of Science http://apps.webofknowledge.com/	((("Air-Powder" OR "Air Polishing" OR "Air-Polishing" OR "Air Abrasion" OR "Air Abrasion, Dental" OR "Abrasive Powder" OR "Tooth Polishing" OR "Dental Polishing") AND ("Periodontal" OR "Periodontitis" OR "Periodontal Diseases")))
Embase http://www.embase.com	(("Air-Powder" OR "Air Polishing" OR "Air-Polishing" OR "Air Abrasion" OR "Air Abrasion, Dental" OR "Abrasive Powder" OR "Tooth Polishing" OR "Dental Polishing") AND ("Periodontal" OR "Periodontitis" OR "Periodontal Diseases"))
ProQuest https://www.proquest.com/	(("Air-Powder" OR "Air Polishing" OR "Air-Polishing" OR "Air Abrasion" OR "Air Abrasion, Dental" OR "Abrasive Powder" OR "Tooth Polishing" OR "Dental Polishing") AND ("Periodontal" OR "Periodontitis" OR "Periodontal Diseases"))
OpenGrey http://www.opengrey.eu	(("Air-Powder" OR "Air Polishing" OR "Air-Polishing" OR "Air Abrasion" OR "Air Abrasion, Dental" OR "Abrasive Powder" OR "Tooth Polishing" OR "Dental Polishing"))

Table 6 Studies excluded in the reading of the full texts and the reasons for exclusion (n = 07)

	Study excluded	Reason for exclusion
1.	*Dosumu et al. 2002* [24]	Not related to the aim.
2.	*Flemmig et al. 2007* [7]	Ex-vivo study.
3.	*Michalowicz et al. 2006* [25]	Pregnant women study.
4.	*Petersilka et al. 2008* [4]	Article not found.
5.	*Marcones et al. 2010* [26]	Pregnant women study.
6.	*Jaramilo et al. 2012* [27]	Pregnant women study.
7.	*López et al. 2014* [28]	Diabetes patients.

Table 7 Probing pocket depth (PPD) analysis of the usage of air polishing

Author, year	Test group	Control group	Probing pocket depth (PPD)																			
			Baseline		7 days		14 days		21 days		30 days		60 days		84 days		90 days		180 days		365 days	
			G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2
Petersilka, et al. 2008	GPAP	m.s.	4.4 ± 1.8	4.3 ± 1.7	n.r.	n.r.	4.3 ± 1.5	4.4 ± 1.8	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Wennström et al. 2011	GPAP	u.s.	5.7 ± 0.62	5.8 ± 0.7	n.r.	n.r.	5.1 ± 0.79	5.0 ± 0.71	n.r.	n.r.	n.r.	n.r.	4.4 ± 0.93	4.5 ± 0.85	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Flemmig et al. 2012	GPAP	m.s.	4.2 ± 0.5	4.3 ± 0.9	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	4.1 ± 0.5	4.1 ± 0.8	n.r.	n.r.	n.r.	n.r.
Hägi et al. 2013	EPAP	m.s.	4.64 ± 0.09	4.46 ± 0.07	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	4.16 ± 0.14	3.72 ± 0.12	n.r.	n.r.	n.r.	n.r.
Müller et al. 2014	GPAP	m.s.	2.8 ± 0.3	2.8 ± 0.3	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	2.7 ± 0.5	2.8 ± 0.5
Kargas et al. 2015	GPAP	m.s.	4.5 ± 0.09	4.78 ± 0.1	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	4.36 ± 0.1	4.44 ± 0.1	n.r.	n.r.	n.r.	n.r.	4.40 ± 0.1	4.40 ± 0.1	4.52 ± 0.1	4.52 ± 0.09	n.r.	n.r.
Caygur et al. 2017	GPAP	m.s	4.89 ± 0.68	4.71 ± 0.57	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	3.41 ± 0.67	3.77 ± 0.93	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Lu et al. 2018	GPAP	m.s.	2.47 ± 0.3	2.48 ± 0.32	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	2.38 ± 0.27	2.34 ± 0.32	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Park et al. 2018	EPAP + m.s.	m.s.	3.12 ± 0.40	3.11 ± 0.43	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	2.64 ± 0.15	2.63 ± 0.44	n.r.	n.r.	n.r.	n.r.	2.64 ± 0.15	2.63 ± 0.44	n.r.	n.r.	n.r.	n.r.
Tsang et al. 2018	GPAP + m.s.	m.s.	5.58 ± 0.63	3.61 ± 1.03	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	3.49 ± 0.91	3.61 ± 1.03	n.r.	n.r.	n.r.	n.r.	3.16 ± 0.79	3.26 ± 0.75	2.98 ± 0.83	3.15 ± 0.88	n.r.	n.r.
Kruse et al. 2019	TPAP	u.s.	5.55 ± 0.9	5.52 ± 0.93	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	4.11 ± 1.08	4.25 ± 1.12	3.68 ± 0.86	3.66 ± 0.81	n.r.	n.r.

G1 control group, *G2* test group, *n.r.* not reported, *GPAP* glycerin powder air polish, *m.s.* manual scaling, *u.s.* ultrasonic debridement, *EPAP* erythritol powder air polish, *TPAP* trehalose powder air polish

Table 8 Clinical attachment level (CAL) analysis of the usage of air polishing

Author, year	Test group	Control group	Clinical attachment level (CAL)																			
			Baseline		7 days		14 days		21 days		30 days		60 days		84 days		90 days		180 days		365 days	
			G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2
Hägi et al. 2013	EPAP	m.s.	5.07 ± 0.21	4.90 ± 0.19	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	4.57 ± 0.25	4.43 ± 0.22	n.r.	n.r.	n.r.	n.r.
Caygur et al. 2017	GPAP	m.s.	2.26 ± 1.09	2.06 ± 1.09	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	1.21 ± 1.41	1.16 ± 1.03	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Park et al. 2018	EPAP + m.s.	m.s.	3.49 ± 0.5	3.59 ± 0.7	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	3.09 ± 0.5	3.13 ± 0.54	n.r.	n.r.	n.r.	n.r.	3.35 ± 0.56	3.24 ± 0.56	n.r.	n.r.	n.r.	n.r.
Tsang et al. 2018	GPAP + m.s.	m.s.	6.16 ± 1.04	6.44 ± 1.48	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	4.64 ± 1.47	4.95 ± 1.48	n.r.	n.r.	n.r.	n.r.	4.28 ± 1.44	4.60 ± 1.37	4.11 ± 1.41	4.54 ± 1.29	n.r.	n.r.
Kruse et al. 2019	TPAP	u.s.	7.27 ± 1.80	6.93 ± 1.5	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	6.00 ± 1.73	5.80 ± 1.65	5.84 ± 1.71	5.30 ± 1.52	n.r.	n.r.

G1 control group, *G2* test group, *n.r.* not reported, *GPAP* glycerin powder air polish, *m.s.* manual scaling, *u.s.* ultrasonic debridement, *EPAP* erythritol powder air polish, *TPAP* trehalose powder air polish

Table 9 Plaque index (PI) analysis of the usage of air polishing

Author, year	Test group	Control group	Plaque index (PI)																			
			Baseline		7 days		14 days		21 days		30 days		60 days		84 days		90 days		180 days		365 days	
			G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2
Petersilka, et al. 2008	GPAP	m.s.	23 ± 13	25 ± 30	n.r.	n.r.	28 ± 31	23 ± 34	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Flemmig et al. 2012	GPAP	m.s.	49.3 ± 38.2	47.4 ± 42.2	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	36.1 ± 40.5	33.4 ± 28.5	n.r.	n.r.	n.r.	n.r.
Hägi et al. 2013	EPAP	m.s.	34.45 ± 4.81	31.9 ± 3.79	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	23.89 ± 3.03	29.20 ± 3.96	n.r.	n.r.	n.r.	n.r.
Muller et al. 2014	GPAP	m.s.	13.33 ± 6.66*	13.33 ± 6.66*	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	10 ± 3.33*	10 ± 3.33*
Kargas et al. 2015	GPAP	m.s.	29.33**	37.33**	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	10.67**	16**	n.r.	n.r.	n.r.	n.r.	10.67**	17.33**	14.67**	21.33**	n.r.	n.r.
Simon et al. 2015	GPAP	u.s.	39 ± 2.67*	40 ± 2.67*	n.r.	n.r.	n.r.	n.r.	41 ±3.43*	39.03 ±20.33*	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Caygur et al. 2017	GPAP	m.s.	54.33 ± 24.6*	42.67 ± 22.6*	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	28.33 ± 18*	21.33 ± 15.67*	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Lu et al. 2018	GPAP	m.s.	59 ± 33	54 ± 25	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	44 ± 24	46 ± 34	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.

G1 control group, *G2* test group,

*Converted from 1–3 scale to percentage

**Without standard deviation; *n.r.* not reported, *GPAP* glycerin powder air polish, *m.s.* manual scaling, *u.s.* ultrasonic debridement, *EPAP* erythritol powder air polish, *TPAP* trehalose powder air polish

Table10 Bleeding on probing (BOP) analysis of the usage of air polishing

Author, year	Test group	Control group	Bleeding on probing (BOP)																			
			Baseline		7 days		14 days		21 days		30 days		60 days		84 days		90 days		180 days		365 days	
			G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2	G1	G2
Petersilka, et al. 2008	GPAP	m.s.	18 ± 30	22 ± 40	n.r.	n.r.	21 ± 35	18 ± 30	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Möene et al. 2010	GPAP	m.s.	45 ± 18	41 ± 13	34 ± 15	36 ± 46	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Wennström et al. 2011	GPAP	u.s.	100*	100*	n.r.	n.r.	42*	40*	n.r.	n.r.	n.r.	n.r.	30*	25*	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Flemmig et al. 2012	GPAP	m.s.	33.6 ± 17.9	26.8 ± 27.9	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	16.8 ± 16.3	14.0 ± 20.6	n.r.	n.r.	n.r.	n.r.
Hägi et al. 2013	EPAP	m.s.	36.45 ± 2.84	31.7 ± 2.31	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	23.89 ± 3.03	26.10 ± 2.45	n.r.	n.r.	n.r.	n.r.
Muller et al. 2014	GPAP	m.s.	21 ± 10	22 ± 10	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	14 ± 6	15 ± 6
Caygur et al. 2017	GPAP	m.s.	88 ± 26	78 ± 40	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	13 ± 67	12 ± 32	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Lu et al. 2018	GPAP	m.s.	24.14 ± 13.32	21.82 ± 11.76	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	17.50 ± 10.35	18.01 ± 11.38	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.
Park et al. 2018	EPAP + m.s.	m.s.	25 ± 9.21	27.81 ± 10.28	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	7.45 ± 5.06	8.95 ± 6	n.r.	n.r.	n.r.	n.r.	9.25 ± 4.25	11.98 ± 4.68	n.r.	n.r.	n.r.	n.r.
Tsang et al. 2018	GPAP + m.s.	m.s.	94.3 ± 12.9	97.1 ± 6.1	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	64.2 ± 32.9	65.1 ± 28.5	n.r.	n.r.	n.r.	n.r.	41.4 ± 33.9	55.7 ± 28.4	45.6 ± 30.7	41.2 ± 30	n.r.	n.r.
Kruse et al. 2019	TPAP	u.s.	88.64*	88.36*	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	n.r.	63.64*	59.09*	34.09*	40.91*	n.r.	n.r.

G1 control group, *G2* test group, *n.r.* not reported

**Without standard deviation, GPAP glycerin powder air polish, m.s. manual scaling, u.s. ultrasonic debridement, EPAP erythritol powder air polish, TPAP trehalose powder air polish*

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