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Review

An Umbrella Review on Low-Abrasive Air Powder Water Jet Technology in Periodontitis and Peri-Implantitis Patients

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Abstract: This umbrella review was conducted to assess the existing literature and scientific evidence on air powder water jet technology (APWJT) in periodontal and peri-implantitis therapy. A systematic literature search for systematic reviews and meta-analyses of the last decade on the use of APWJT in periodontitis and implant patients was performed in the databases of MEDLINE/Ovid, Embase, Cochrane library and Scopus. An additional hand search on PubMed and Google Scholar was conducted. Ten articles that fit the inclusion criteria were selected after the full-text screening. Two systematic reviews, including one with a meta-analysis, investigated the use of APWJT in active periodontal therapy. The use of APWJT as an adjunct to conventional scaling and root planing (SRP) in active periodontal treatment showed improved results in the test group. Six articles, including two with a meta-analysis, reported on the use of APWJT as a stand-alone therapy or as an adjunct in supportive periodontal therapy. Similarly significant improved results were reported for the use of APWJT. Regarding the active treatment of peri-implant mucositis and peri-implantitis, four systematic reviews could not show an improved clinical outcome when APWJT was used as an adjunct to conventional treatment measures. Furthermore, one article investigated APWJT as a stand-alone therapy or as an adjunct in supportive peri-implant mucositis and peri-implantitis therapy. In systematic reviews that also investigated patient perception, APWJT was generally well-tolerated by the patient. Within the limitations of this umbrella review, it can be concluded that the use of APWJT with low-abrasive powders such as glycine, erythritol or trehalose as an adjunct in active periodontitis therapy shows similar clinical results compared to conventional SRP alone. In surgical peri-implantitis treatment, APWJT can be used adjunctively. It could be considered that the use of APWJT in supportive periodontal treatment results in a comparable clinical outcome and an enhanced patient perception, as well as a shorter clinical time.

Keywords: air powder water jet technology; air polishing; periodontitis; peri-implant disease; peri-implant mucositis; peri-implantitis; periodontal therapy; supportive periodontal therapy; peri-implantitis therapy

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1. Introduction

Air powder water-jet technologies (APWJT) have significantly advanced in recent years to become a clinically valuable method for the non-contact processing of contaminated oral and dental surfaces including teeth and implants. In this context, powders have undergone a major development, and there has been a considerable transition from abrasive and potentially harmful products to low-abrasive and more gentle materials that are water-soluble and biocompatible. These materials have been developed in such a way that they are still able to efficiently remove soft deposits and biofilms from different surfaces [1]. At the same time, application devices have also undergone a significant evolution, and it is now possible to treat hard and soft tissue surfaces with a special emphasis on supra- and subgingival niches in a very targeted manner with individually adaptable output settings, handpieces and nozzles [2,3].

Prophylactic and therapeutic treatment sequences have been advocated and adapted towards specific patient needs, mainly aiming to provide the gentlest possible treatment for patients while minimizing invasive and time-consuming treatment steps and reducing patient discomfort [4]. In this synoptic concept, different methods systematically applying APWJT try to ensure a quality-oriented and systematic process, which enables controlled biofilm elimination or at least reduction by removing biofilm and young calculus [5]. Different treatment modalities, techniques and materials have been introduced in the past years and have been well studied, and—in the meantime—even systematic reviews have been conducted and published in this context. In 2014, at a consensus conference on the supra- and subgingival use of APWJT, a group of dental professionals concluded that low-abrasive powders, such as glycine powder, are more effective in the removal of biofilm on intraoral surfaces up to 9 mm subgingivally than conventional manual or ultrasonic debridement [6]. In reference to recommendations on the clinical application of APWJT for the management of peri-implant mucositis (PIM) and peri-implantitis (PIT), the last expert consensus meeting in 2015 concluded that, at PIM sites, glycine powder air polishing was as effective as control treatments, while the results following the non-surgical treatment of PIT were reported to have a significantly higher bleeding on probing (BOP) reduction compared to mechanical debridement with or without local antiseptic therapy or Er: YAG laser monotherapy [7]. In the meantime, several additional investigations including systematic reviews have been published.

The aim of the present umbrella review is to provide a scientific update in order to obtain an overall impression of the published literature in the last decade which summarizes the evidence of the clinical efficacy of this technology and the materials as compared to the hitherto conservative classical methods, i.e., hand instrumentation using scalers and curettes as well as (ultra)sonic devices. By this, we also aim to delineate the gaps in the existing literature and provide an outlook and future perspective in prophylactic dentistry.

2. Materials and Methods

This umbrella review of current systematic reviews on the topic of air powder water jet technology in dentistry was written in accordance with the PRISMA statement for reporting systematic reviews of studies evaluating healthcare interventions and the methodology for summarizing systematic reviews [8]. This umbrella review was not registered prior to conducting the review process.

The literature databases MEDLINE/Ovid, Embase, Cochrane library and Scopus were used for a systematic literature search for systematic reviews and meta-analyses published from 2010 to 2022 assessing the use of APWJT devices in periodontitis and peri-implantitis therapy. The literature search was conducted between the 22nd of February and the 15th of March 2022. The following search terms were applied: "air-polishing" OR "air polishing" OR "air-flow" OR "air powder water jet technology" AND "glycine" OR "erythritol" OR "trehalose" AND "gingivitis" OR "periodontitis" or "periodontal disease" OR "peri-implant mucositis" OR "periimplant mucositis" OR "peri-implantitis" OR "periimplantitis" AND "randomized clinical trial" OR "prospective clinical trial" OR "clinical control study". Additionally, a hand search on PubMed and Google Scholar was performed.

According to the discovered literature, the focused questions for the review were formulated as follows:

1. Does low-abrasive (glycine, erythritol or trehalose powder) APWJT have a beneficial effect on clinical parameters (PPD, BOP, gingival recessions, CAL) as compared to standard mechanical debridement in active or supportive periodontal and peri-implantitis therapy?

2. Can low-abrasive APWJT powders be used in the active or supportive treatment phase alone or in combination with other treatment measures?

Screening and Selection

Two independent reviewers (CRH and JMT) initially screened the titles and abstracts of all the search results. All of the selected articles were agreed upon before being finally included or excluded with full text. Any discrepancies were discussed and resolved by consensus, or, if required, a third reviewer (CCL) was consulted.

Systematic reviews and meta-analyses of clinical studies published from 2010 to 2022 with a full text available in English reporting clinical parameters such as pocket depth reduction, bleeding on probing, gingival recession and clinical attachment level gain were included.

For periodontal treatment, peri-implantitis and peri-implant mucositis therapy, the reviews should include a comparison of APWJT use with conventional scaling and root planing with curettes or ultrasonic devices or its use as an adjunctive measure. If used as an adjunctive measure, the only difference should be between the control and test group.

Systematic reviews and meta-analyses of ex vivo, in vitro and animal studies or publications that did not focus on the mentioned clinical parameters were excluded. Systematic reviews that did not conclude on the use of APWJT devices were also excluded.

3. Results

The search and selection processes are described in Figure 1 The systematic literature search and the additionally performed hand search found 38 reviews with the used search terms. Twenty-two articles were excluded after title and abstract screening because they were narrative reviews [2,9–20], did not concern the use of air powder water jet technology in dentistry [21], did not investigate APWJT for tooth/implant cleaning [22–24], did not report clinical in vivo data [19,25–27] or their full text was not available in English [28].

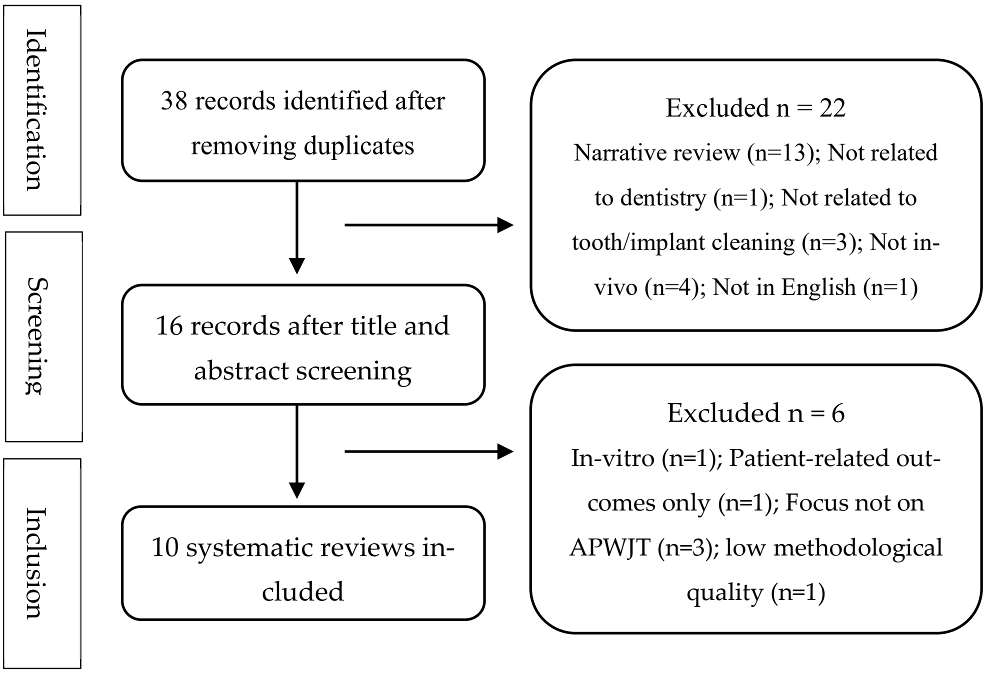

Figure 1. Modified PRISMA 2020 flow diagram of study selection [29].

After full-text screening, five other reviews were excluded because of in vitro data [30] reporting only on patient-related outcomes [31] or because their conclusion was not focused on the use of APWJT measures [32–34]. One study was excluded after the full-text screening because of the low methodological quality [35].

Finally, 10 systematic reviews were included in this umbrella review. The main study characteristics of the included systematic reviews are shown in Table 1. The funding of the included studies is shown in Appendix A Table A1. A quality assessment according to AMSTAR 2 [36] was performed (Figure 2).

Table 1. Characteristics of the included studies (CT: controlled clinical trial; m: month; RCT: randomized controlled trial; w: week).

Author	Year	No. of Included Studies	Meta-Analysis	Type of Included Studies	Follow-Up
Abdulbaqi et al. [37]	2022	8	Yes	RCT, CT	3 m–12 m
Tan et al. [38]	2022	6	Yes	RCT	6 m–12 m
Boeira et al. [39]	2021	7	Yes	RCT, CT	3 m–12 m
Nascimento et al. [40]	2021	13	No	RCT	1 w–12 m
Ramanauskaite et al. [41]	2021	80	Yes	RCT, CT	3 m–12 m
Zhu et al. [42]	2021	17	Yes	RCT	1 w–6 m
Zhang et al. [43]	2019	6	No	RCT	2 w–12 m
Ng et al. [44]	2018	8	Yes	RCT, CT	1 w–12 m
Schwarz F & Renvert et al. [7]	2015	5	Yes	CT	3 m–12 m
Muthukuru et al. [45]	2012	9	No	RCT	6 m–12 m

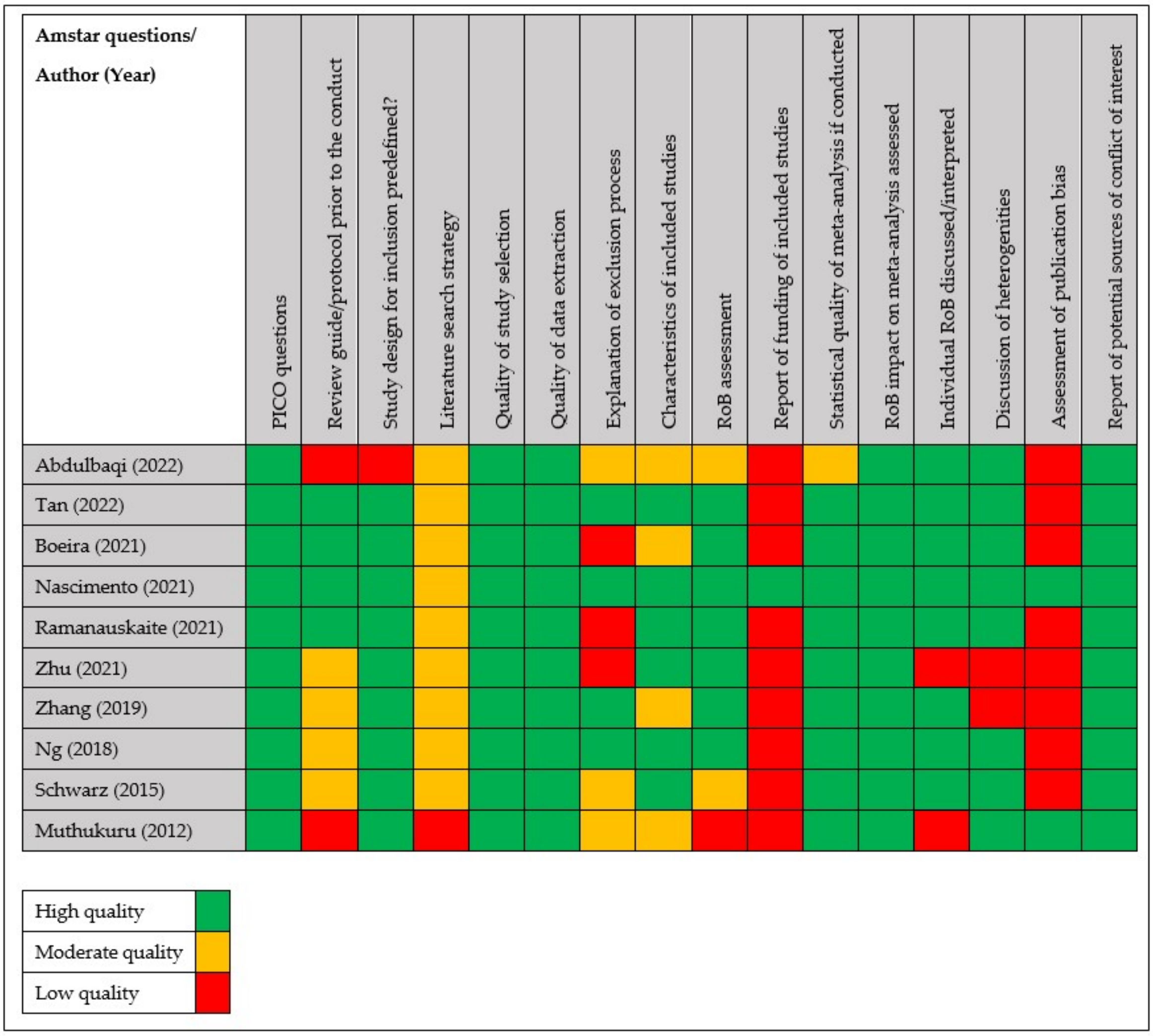

Figure 2. Quality assessment of included systematic reviews according to AMSTAR 2 (RoB: risk of bias) [7,36–44].

3.1. Active Periodontal Treatment

Abdulbaqi and co-workers analyzed in their systematic review the efficacy of erythritol APWJT in active periodontal treatment as an adjunct to conventional SRP or surgical periodontal treatment. Their meta-analysis included four trials, and the authors concluded that slightly improved but statistically non-significant differences regarding PPD reduction and BOP change could be achieved with the adjunct use of erythritol APWJT [37]. CAL gain was shown to be significantly improved in the test group. Regarding the microbiological outcomes, there were no differences between erythritol APWJT and conventional treatment, but remarkable differences in patient-related outcomes (discomfort and/or pain) could be found [37]. Similar outcomes were described in another systematic review, which analyzed clinical trials with the use of glycine, erythritol or trehalose powders in APWJT. No differences in clinical and microbiological outcomes could be found as compared to the control treatments, which consisted of hand instruments and ultrasonic devices. On the other hand, the patient-related outcomes showed improved patient comfort and less professional working time with the use of APWJT [40] (Table 2).

Table 2. Results of the included systematic reviews on active periodontal therapy.(BOP: bleeding on probing reduction; CAL: clinical attachment level gain; EPAP: erythritol powder air polishing; GPAP: glycine powder air polishing; HI: hand instruments; M-a: meta-analysis; N: number of included studies; n.a.: not available; PPD red: periodontal pocket depth reduction; TPAP: trehalose powder air polishing; Rec: gingival recession; SPPT: simplified papilla preservation technique; SRP: scaling & root planing; US: ultrasonic scaler; WMD: weighted mean difference; =: no difference; ↑: (* significant) better results in the test group; ↓: (* significant) worse results in the test group).

Author	Year	Test Measures	Control Measures	Clinical Outcomes	Microbiological Outcomes	Patient-Related Outcomes
Abdulbaqi et al. [37]	2022	1. EPAP + SRP (HI or US or HI/US) 2. SPPT + EPAP + SRP (HI/US)	1. SRP (HI or US or HI/US) 2. SPPT + SRP (HI/US)	M-a APT (N = 4) *PPD red:* ↑ (0.03 mm, WMD; p = 0.71) *BOP:* ↑ (−0.62%,WMD; p = 0.67) *Rec:* n.a. ***CAL:* ↑* (0.16 mm, WMD, p < 0.02)**	(N = 5) =	No m-a available: *Patient comfort* (N = 3): =/↑ *Working time* (N = 0): n.a. *Adverse effects* (N = 0): n.a.
Nascimento et al. [40]	2021	1. GPAP (singular or + HI + US) 2. TPAP	HI or US or HI/US	No m-a available: *PPD:* = *BOP:* = *Rec:* n.a. *CAL:* =	(N = 7) =	No m-a available: *Patient comfort* (N = 7): ↑ *Working time* (N = 3): ↑ *Adverse effects* (N = 12): =

3.2. Supportive Periodontal Treatment

Six systematic reviews were identified, which analyzed the use of APWJT during supportive periodontal therapy [37,38,40,42–44]. The systematic reviews for which no meta-analysis was performed reported similar results in terms of clinical outcomes compared to conventional mechanical debridement with hand instruments or ultrasonic devices [40,43]. The four reviews including meta-analyses show heterogenous, statistically non-significant results when APWJT was used as a stand-alone device or as an adjunct to conventional treatment measures [37,38,42,44]. All of the articles, which also dealt with patient-related outcomes, concluded that APWJT devices correlated with better to significant patient comfort and less treatment pain [37,38,40,42–44] (Table 3).

Table 3. Results of the included systematic reviews on supportive periodontal therapy. (BOP: bleeding on probing reduction; CAL: clinical attachment level gain; CHx: Chlorhexidine; EPAP: erythritol powder air polishing; GI: gingival index; GPAP: glycine powder air polishing; HI: hand instruments; M-a: meta-analysis; N: number of included studies; n.a.: not available; PPD red: periodontal pocket depth reduction; TPAP: trehalose powder air polishing; Rec: gingival recession; SPPT: simplified papilla preservation technique; SRP: scaling & root planing; US: ultrasonic scaler; VAS: visual analogue scale; WMD: weighted mean difference; =: no difference; ↑: (*significant) better results in the test group; ↓: (*significant) worse results in the test group).

Author	Year	Test Measures	Control Measures	Clinical Outcomes	Microbiological Outcomes	Patient-Related Outcomes
Abdulbaqi et al. [37]	2022	1. EPAP + SRP (HI or US or HI/US) 2. SPPT + EPAP + SRP (HI/US)	1. SRP (HI or US or HI/US) 2. SPPT + SRP (HI/US)	M-a SPT (N = 4) *PPD red:* ↑ (−0.04 mm, WMD, p = 0.78) *BOP:* ↑ (−2.11%, WMD, p = 0.41) *Rec:* n.a. *CAL:* ↑ (0.15 mm, WMD, p = 0.32)	(N = 5) =	No m-a available: *Patient comfort* (N = 3): ↑ *Working time* (N = 0): n.a. *Adverse effects* (N = 0): n.a.
Tan et al. [38]	2022	1. EPAP 2. GPAP 3. TPAP	HI US	M-a: *PPD red* (N = 4)*:* ↑ (0.11, WMD, p = 0.08) *BOP* (N = 3)*:* = *Rec:* n.a. *CAL* (N = 3)*:* ↑ (0.08, WMD, p = 0.39)	(N = 0) n.a.	No m-a available: *Patient comfort* (N = 2): ↑ *Working time* (N = 0): n.a. *Adverse effects* (N = 0): n.a.
Nascimento et al. [40]	2021	1. GPAP (singular or + HI + US) 2. TPAP	HI or US or HI/US	No m-a available: *PPD:* = *BOP:* = *Rec:* n.a. *CAL:* =	(N = 7) =	No m-a available: *Patient comfort* (N = 7): ↑ *Working time* (N = 3): ↑ *Adverse effects* (N = 12): =
Zhu et al. [42]	2021	GPAP	HI or US	M-a *PPD* (N = 10): ↑ (0.25, WMD, p = 0.35) *BOP* (N = 3): ↑ (−8%, WMD, p < 0.00001) *Rec* (N = 5): = (0.04−0.5 mm, WMD, p > 0.05) *CAL* (N = 2): ↑ (+0.3 mm, WMD, p > 0.05)	(N = 0) n.a.	M-a ***Patient comfort* (N = 4): ↑*** **(VAS −1.5, WMD, p < 0.00001)** *Working time* (N = 0): n.a. *Adverse effects* (N = 0): n.a.
Zhang et al. [43]	2019	1. GPAP 2. EPAP 3. TPAP	US	No m-a available: *PPD* (N = 5): = *BOP/BI/GI* (N = 6): = *Rec* (N = 3): = *CAL* (N = 3): =	(N = 0) n.a.	No m-a available: *Patient comfort* (N = 5): ↑ *Working time* (N = 0): n.a. *Adverse effects* (N = 0): n.a.
Ng et al. [44]	2018	1. GPAP 2. EPAP 3. EPAP + CHx	HI/US	M-a (N = 8) *PPD red:* ↑ (0.05, WMD, p = 0.34) *BOP:* = (0.01, WMD, p = 0.26) *Rec:* n.a. *CAL:* ↑ (−0.17, WMD, p = 0.11)	(N = 8) =	No m-a available: *Patient comfort* (N = 6): ↑ *Working time* (N = 0): n.a. *Adverse effects* (N = 0): n.a.

3.3. Active Peri-Implant Mucositis/Peri-Implantitis Therapy

Four systematic reviews analyzed the use of APWJT during active peri-implant therapy [7,39,41,45]. All of the included studies used glycine as an air polishing powder.

3.3.1. Active Peri-Implant Mucositis

When APWJT was used as an alternative to conventional methods in the treatment of peri-implant mucositis, it was concluded that both treatment methods resulted in comparable clinical outcomes [7,39,41]. Just one study performed a meta-analysis that resulted in contradictory results, showing an additional benefit of APWJT regarding PPD reduction in the treatment of peri-implant mucositis [39].

APWJT used as an adjunct in the treatment of peri-implant mucositis was investigated in three reviews [7,39,41]. All of them reported from the same two clinical studies [46,47].

The reviews reported that Ji et al. showed no additional effect if APWJT was used as an adjunct [46]. On the contrary, it was reported that De Siena et al. showed a significant additional effect on BOP and PPD reduction [47]. The results on the reduction of clinical probing depth from the two studies could be included into a meta-analysis that resulted in no significant differences between the test and control groups [41].

3.3.2. Active Peri-Implantitis Therapy

When APWJT was used as an alternative in the non-surgical treatment of peri-implantitis, it was concluded that BOP reductions could be improved, while there were no differences in the other investigated clinical parameters [7,41,45]. Overall, significantly higher reductions in BOP, but no significant differences in PD reductions, were also validated in a meta-analysis [7].

APWJT used as an adjunct in the treatment of peri-implantitis resulted in no beneficial clinical effects [41].

Regarding the adjunctive use of APWJT on implant surfaces during the surgical treatment of peri-implantitis, Ramanauskaite and co-workers reported the data from two clinical studies [41]. Lasserre et al. [48] compared open flap debridement (OFD) with APWJT versus OFD with implantoplasty and showed comparable results, with less recession development for APWJT after 6 months. Toma et al. compared OFD with APWJT to OFD alone during surgery, which resulted in greater PPD reductions [49] (Table 4).

Table 4. Active peri-implantitis (PIT) and peri-implant mucositis (PIM) therapy.

Author	Year	Test Measures	Control Measures	Clinical Outcomes	Microbiological Outcomes	Patient-Related Outcomes
Ramanauskaite et al. [41]	2021			**PIM—Standalone**		
		OHI + GPAP	OHI + US	No m-a available: *PPD:* n.a. *BOP:* = *Rec:* n.a. *CAL:* n.a.	(*N* = 0) n.a.	(*N* = 0) n.a.
				PIM—Adjuncts		
		1. OHI + US + GPAP 2. OHI + HI + polishing + GPAP	1. OHI + US 2. OHI + HI + polishing	M-a (PPD): *PPD:* ↑ (−0.33 mm WMD, $p = 0.34$) *BOP/BI:* 1. = / 2. ↑ *Rec:* n.a. *CAL:* n.a	(*N* = 0) n.a.	(*N* = 0) n.a.
				PIT—Standalone		
		1. OHI + GPAP 2. OHI + GPAP	1. OHI + Er:Yag laser 2. OHI + HI + CHx	No m-a available: *PPD:* = *BOP:* 1. = / 2. ↑ *Rec:* 1. n.a. / 2. = *CAL:* n.a.	(*N* = 0) n.a.	(*N* = 0) n.a.
				PIT—Adjuncts		
		OHI + removal of suprastructure + US + GPAP + CHx for 2 weeks	OHI + removal of suprastructure + US	No m-a available: *PPD:* = *BOP:* = *Rec:* = *CAL:* n.a.	(*N* = 0) n.a.	(*N* = 0) n.a.
				Surgical PIT—Adjuncts		
		OHI + OFD with HI + GPAP + CHx mouth rinse for 10 days	OHI + OFD with HI + implantoplasty + CHx mouth rinse for 10 days	No m-a available: *PPD:* = *BOP:* = *Rec:* ↑ *CAL:* n.a.	(*N* = 0) n.a.	(*N* = 0) n.a.
		OFD with HI + GPAP + CHx mouth rinse for 10 days	OFD with HI + CHx mouth rinse for 10 days	No m-a available: *PPD:* ↑ *BOP:* = *Rec:* n.a. *CAL:* n.a.	(*N* = 0) n.a.	(*N* = 0) n.a.

Table 4. *Cont.*

Author	Year	Test Measures	Control Measures	Clinical Outcomes	Microbiological Outcomes	Patient-Related Outcomes
Boeira et al. [39]	2021			**PIM—Standalone**		
		1. GPAP 2. GPAP 3. GPAP	1. HI 2. HI + CHx 3. HI	M-a (*N* = 2) *PPD* (6 m): 1. =/ 2. + 3. ↑ (-0.83, WMD, $p < 0.00001$) *BOP* (6 m): 1. =/ 2. + 3. = (−14.97, WMD, $p < 0.67$) *Rec:* n.a. *CAL:* n.a.	(*N* = 0) n.a.	No m-a available: *Patient comfort* (*N* = 0): n.a. *Working time* (*N* = 0): n.a. *Adverse effects* (*N* = 7): =
				PIM—Adjuncts		
		1. OHI + US + GPAP 2. OHI + HI + polishing + GPAP	1. OHI + US 2. OHI + HI + polishing	No m-a available: *PPD:* 1. =/ 2. ↑ *BOP:* 1. =/ 2. ↑ *Rec:* n.a. *CAL:* n.a.	(*N* = 0) n.a.	No m-a available: *Patient comfort* (*N* = 0): n.a. *Working time* (*N* = 0): n.a. *Adverse effects* (*N* = 7): =
				PIT—Standalone		
		OHI + GPAP	OHI + HI + CHx	No m-a available: *PPD:* = *BOP:* ↑ *Rec:* n.a. *CAL:* =	(*N* = 0) n.a.	No m-a available: *Patient comfort* (*N* = 0): n.a. *Working time* (*N* = 0): n.a. *Adverse effects* (*N* = 7): =
Schwarz et al. [7]	2015			**PIM—Standalone**		
		OHI + GPAP	OHI + US	No m-a available: *PPD:* n.a. *BOP:* = *Rec:* n.a. *CAL:* n.a.	(*N* = 0) n.a	(*N* = 0) n.a
				PIM—Adjuncts		
		1. OHI + US + GPAP 2. OHI + HI + polishing + GPAP	1. OHI + US 2. OHI + HI + polishing	No m-a available: *PPD:* 1. =/ 2. ↑ *BOP/BI:* 1. = / 2. ↑ *Rec:* n.a. *CAL:* n.a.	(*N* = 0) n.a	No m-a available: *Patient comfort* (*N* = 1): = *Working time* (*N* = 0): n.a. *Adverse effects* (*N* = 2): =
				PIT—Standalone		
		1. OHI + GPAP 2. OHI + GPAP	1. OHI + Er:Yag laser 2. OHI + HI + CHx	M-a *PPD red:* = (0.4 mm, WMD, $p = 0.119$) *BOP:* ↑ (−24%, WMD, $p = 0.048$) *Rec:* n.a. *CAL:* n.a.	(*N* = 0) n.a	No m-a available: *Patient comfort* (*N* = 0): n.a. *Working time* (*N* = 0): n.a. *Adverse effects* (*N* = 1): =
Muthukuru et al. [45]	2012			**PIT—Standalone**		
		1. OHI + GPAP 2. OHI + GPAP	1. OHI + Er:Yag laser irradiation 2. OHI + HI + CHx	No m-a available: *PPD:* 1. =/ 2. n.a. *BOP:* = *Rec:* 1. n.a./ 2. = *CAL:* 1. n.a./ 2. =	(*N* = 0) n.a.	(*N* = 0) n.a.

Furthermore, no adverse events (emphysema or allergic reactions) were reported in the reviews investigating the use of APWJT in non-surgical treatments [7,39].

3.3.3. Supportive Peri-Implant Therapy and Maintenance

In a recent systematic review, Tan et al. analyzed the efficacy of APWJT compared to conventional hand and ultrasonic debridement in implant maintenance and supportive periodontal treatment. Two of the included original articles reported glycine powder air-polishing alone or as an adjunct to curettes compared to curettes and/or ultrasonic treatment on implants. In general, no inter-group differences regarding PPD reduction, CAL gain or BOP could be found in the meta-analysis [38] (Table 5).

Table 5. Results of the included systematic reviews on supportive peri-implantitis therapy (PIT) and peri-implant mucositis therapy (PIM). (BOP: bleeding on probing reduction; CAL: clinical attachment level gain; CHx: Chlorhexidine; GPAP: glycine powder air polishing; HI: hand instruments; M-a: meta-analysis; N: number of included studies; n.a.: not available; PPD red: periodontal pocket depth reduction; Rec: gingival recession; SS: sonic scaler; =: no difference; ↑: (*significant) better results in the test group; ↓: (*significant) worse results in the test group).

Author	Year	Test Measures	Control Measures	Clinical Outcomes	Microbiological Outcomes	Patient-Related Outcomes
Tan et al. [38]	2022	1. GPAP 2. HI + GPAP + prophylaxis brush 3. HI + GPAP + prophylaxis brush + CHx varnish	1. HI + CHx 2. HI + SS + prophylaxis brush 3. HI + SS + prophylaxis brush + CHx	No m-a available: *PPD:* ↑/= *BOP:* ↑/= *Rec:* n.a. *CAL:* =	(*N* = 0) n.a.	(*N* = 0) n.a.

4. Discussion

The systematic literature search showed that several systematic reviews and meta-analyses that addressed air powder water jet technology were performed in the past decade. Whereas the proof for equality in the supportive periodontal treatment is well demonstrated by several studies, systematic reviews on the effect of APWJT as a single measure in active periodontal treatment are scarce. Most of the clinical trials included in the systematic reviews for active periodontal treatment used low-abrasive air powder water jet technology as an adjunct to conventional subgingival debridement with curettes or (ultra)sonic devices. Regarding peri-implantitis/mucositis, systematic reviews exist for both active and maintenance therapy, but the underlying clinical studies, although evenly distributed, are few.

The focus questions, as formulated above, can be, based on the results of this umbrella review, discussed as follows.

Does low-abrasive (glycine, erythritol or trehalose powder) APWJT have a beneficial effect on clinical parameters compared to standard mechanical debridement in active or supportive periodontal and peri-implantitis therapy?

The included reviews for periodontal treatment on teeth, as active or supportive therapy, showed that APWJT is a validated adjunct in active periodontal therapy and can be used alone in supportive therapy. The use of APWJT devices either alone or as an adjunctive measure showed similar results to conventional subgingival debridement with hand instruments or ultrasonic devices.

For the treatment of peri-implant mucositis, APWJT devices may be used as an alternative. Schwarz et al. [7] and Ramanauskaite et al. [41] reported that APWJT as a standalone therapy leads to comparable clinical results. Boeira et al. [39] even reported higher PPD reduction by APWJT after 6 months, as a meta-analysis of two included studies showed. While Boeira et al. [39] included three studies reporting on APWJT as a standalone, Schwarz et al. [7] and Ramanauskaite et al. [41] included only one, which was not used by Boeira et al. [39] (Table 4). This might be the reason for the slightly different conclusions and discloses the low level of evidence.

The use of APWJT as an adjunct in the treatment of peri-implant mucositis does not lead to further improvements [7,39,41]. All of the reviews included the same two studies. While one study [47] showed improved results concerning BOP and PPD reduction, the other included study [46] showed no improvements. The meta-analysis by Ramanauskaite et al. that compared PPD reduction showed no significant differences [41].

In the treatment of peri-implantitis, the alternative use of air powder water jet technology may yield better results, while its use as an adjunct does not lead to further improvements [7,41,45]. A meta-analysis that compared PD and BOP reduction using APWJT as an alternative technique to conventional measures showed results that favored APWJT regarding BOP reduction [7]. Additionally, Boeira et al., Muthukuru et al. and Ramanauskaite et al. concluded that the alternative use of APWJT may lead to an enhanced BOP reduction compared to conventional measures [39,41,45]. Anyway, one must note that the conclusions are based on a maximum of three included studies (Table 4). Further, two of these studies used carbon curettes and 0.1% CHx rinsing as a comparison but reported on the same patient cohort [50,51]. The other study used Er:Yag laser irradiation as a comparison [52]. The adjunctive use of APWJT was only investigated by Ramanauskaite et al. (2021), who could only find one study that showed no additional effect [41].

Overall, most systematic reviews were based on very few clinical studies, and all stated the need for more studies in the future. Furthermore, only one systematic review that specifically gathered data on APWJT for peri-implantitis therapy could be found.

Should low-abrasive APWJT powder be used in the active or supportive treatment phase, and should it be used alone or in combination with other treatment measures?

The analyzed systematic reviews for the use of APWJT in active periodontal treatment from Abdulbaqi et al. [37] and Nascimento et al. [40] showed the results of four clinical trials that used the GPAP or EPAP as an adjunct to hand instruments and ultrasonic device [53–56]. In general, the clinical outcome parameters improved similarly to the control groups despite the clinical attachment gain that was in favor of the APWJT test groups. In the meta-analysis by Abdulbaqi et al. [37], APWJT was not tested as a standalone in active periodontal treatment.

In a recently published systematic review by Patil and co-workers, they analyzed antiseptic methods used for implant surface decontamination [57]. It was concluded that chlorhexidine (0.2%, 0.12%), citric acid (40%) and sodium hypochlorite (1%) are used the most as an adjunct in peri-implantitis therapy and are effective in killing bacterial cells. These findings are in line with the analyzed treatment strategies in the included systematic reviews of this umbrella review, even though the included reviews also focused on abrasive devices for implant surface decontamination.

Another indication for the use of APWJT devices is described in a case report of retrograde peri-implantitis by Soldatos et al. The group treated a patient with retrograde peri-implantitis surgically and with an APWJT device with glycine powder and an Er, Cr: YSGG laser to decontaminate the implant surface [58]. After six and thirteen months, the infected peri-apical site of the implant showed re-ossification, which underlines the effectiveness of this treatment strategy. Further investigation of this specific treatment indication is needed to evaluate the use of APWJT in this field.

The main advantages of the low-abrasive air powder and waterjet technology might be the enhanced patient comfort and reduced treatment time during supportive periodontal therapy. The higher patient acceptance and comfort were shown in all the included systematic reviews that evaluated this technology in the supportive therapy on teeth [37,38,40,42–44]. These findings correlated with a systematic review on patient perception when using APWJT devices that was conducted by Bühler and co-workers in 2016 [31]. Similar findings were reported in a recent survey-based clinical study with 100 recall patients by Furrer et al. [4]. The mean visual analog scale after APWJT-based tooth cleaning was very low, with only 0.66, and the patient acceptance of air powder waterjet technology was higher compared to that of hand instruments and ultrasonic devices.

A significantly reduced treatment time was shown in a randomized clinical trial by Moëne et al., where 0.5 min per side was used when using APWJT devices subgingivally versus 1.4 min/site when using curettes ($p < 0.001$) [2]. In another recently published randomized clinical trial by Fu et al., a shorter treatment time could also be shown. Biofilm removal (with or without prior plaque disclosure) by air powder waterjet technology needed significantly less treatment time compared to rubber cup polishing (marginal mean treatment duration: 325 s vs. 407 s) [59].

The following limitations must be considered for this umbrella review. Only systematic reviews that were written in English and found in the mentioned databases above were included. A search for grey literature and articles that were published in other languages was not performed. Furthermore, the included systematic reviews, especially the reviews on the use of APWJT in peri-implantitis treatment, are based on limited clinical trials in which the devices were used in different treatment protocols.

5. Conclusions

For the use of low-abrasive air powder water jet technology (APWJT) as a standalone, the clinical outcome parameter regarding PPD reduction, CAL gain and BOP is equal to conventional measures in supportive periodontal treatment. As an adjunct to conventional SRP in active periodontal therapy with hand instruments and/or ultrasonic devices, it shows similar clinical results compared to conventional SRP alone. The main clinical benefit of APWJT use in periodontal therapy is the improved patient comfort during supportive therapy. Furthermore, the clinical chairside time can be reduced when using APWJT in supportive periodontal therapy.

For the treatment of peri-implant mucositis, APWJT devices may be used as a valid alternative. In the surgical treatment of peri-implantitis, APWJT can be considered as an adjunct to conventional treatment measures.

Indications for future research:

1. Further clinical trials with a long-term follow up testing APWJT as a standalone therapy for supportive periodontal therapy and for the treatment of peri-implant mucositis are needed.
2. More studies exclusively evaluating the adjunctive effect of APWJT during the surgical treatment of peri-implantitis are needed.
3. Further clinical trials are necessary to investigate cost-effectiveness for dental practitioners and patients.
4. An updated meta-analysis focusing only on APWJT compared with conventional measures would be needed.

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Appendix A

Table A1. Funding information of the included systematic reviews.

Author	Funding
Abdulbaqi et al. [37]	Self-funded by the authors' own departments.
Tan et al. [38]	Research University Grant (RU Faculty), Universiti Malaya, Grant No.: GPF007E-2019
Boeira et al. [39]	Coordenação de Aperfeiçaomento de Pessoal de Nivel Superior—Brasil (CAPES) [Finance Code 001]; The Brazilian National Research Council (CNPq); National Council for Scientific and Technological Development (CAPES).

Table A1. *Cont.*

Author	Funding
Nascimento et al. [40]	CAPES (Coordination for the Improvement of Higher Education Personnel—Brazilian Ministry of Education) [Finance Code 001]; CNPq (Council for Scientific and Technological Development—Brazilian Ministry of Science, Technology and Innovation) [Finance Code 307808/2018-1].
Ramanauskaite et al. [41]	Self-funded by the authors' own departments.
Zhu et al. [42]	Program for Innovation Team Building at Institutions of Higher Education in Chongqing in 2016 (grant no. CXTDG201602006) and the Natural Science Foundation of Chongqing (2015msxm055).
Zhang et al. [43]	Nanjing Medical Science and Technique Development Foundation (QRX17176).
Ng et al. [44]	Self-funded by the authors and their institutions.
Schwarz et al. [7]	The authors declare that they received an unrestricted grant from EMS, Nyon, Switzerland. The systematic review was self-funded by the authors and their institution.
Muthukuru et al. [45]	Not available. Declaration of no conflict of interest.

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