Efficacy of air polishing for the non-surgical treatment of peri-implant diseases: a systematic review


Abstract

Focused Question: In patients suffering from peri-implant diseases, what is the efficacy of air polishing on changing signs of inflammation compared with control treatments (i.e. alternative measures for plaque removal with or without adjunctive antiseptic and/or antibiotic therapy)?

Material & Methods: After electronic database and hand search, 10 full-text articles were independently screened by two reviewers. Finally, a total of five studies (six publications) fulfilled the inclusion criteria. The weighted mean difference (WMD) [p; 95% CI] in bleeding on probing- (BOP) (primary outcome) and probing pocket depth- (PD) reductions was estimated using a random effect model.

Results: All studies reported on residual BOP scores after therapy. A narrative data synthesis did not reveal any major improvement of bleeding index/ BOP or disease resolution following air polishing over mechanical debridement at mucositis sites. At peri-implantitis sites, WMD in BOP reduction between test and control (mechanical debridement with or without local antiseptic therapy, Er:YAG laser) groups was −23.83% [p = 0.048; 95% CI (−47.47, −0.20)] favouring air polishing over control measures.

Conclusions: While glycine powder air polishing is as effective as the control treatments at mucositis sites, it may improve the efficacy of non-surgical treatment of peri-implantitis over the control measures investigated. A complete disease resolution was commonly not obtained.
treatments? inflammation compared with control polishing on changing signs of diseases, what is the efficacy of air patients suffering from peri-implant following focused question: In systematic review was to address the peri-implantitis. peri-implant mucositis and peri-polishing for the management of air assessing the therapeutic effects of air abrasives, dental” (MeSH) OR “dental air abrasion” (MeSH) OR “air abrasive device”. AND peri-implant disease” OR “peri-implant disease” OR “peri-implant infection” OR “periimplant infection” OR “mucositis” (MeSH) OR “peri-implant mucositis” OR “periimplant mucositis” OR “periimplantitis” (MeSH) OR “peri-implantitis” (MeSH)

Electronic search was complemented by a hand search of the following journals: "Clinical Implant Dentistry and Related Research; Clinical Oral Implants Research; International Journal of Oral and Maxillofacial Implants; Journal of Clinical Periodontology; Journal of Periodontology. Finally, the references of all selected full-text articles and related reviews were scanned. If required, the corresponding authors were contacted and requested to provide missing data or information.

Study inclusion and exclusion criteria
During the first stage of study selection, the titles and abstracts were screened and evaluated according to the following inclusion criteria:

1 Prospective randomized controlled (RCT), or non-randomized controlled (CCT) trials (split-mouth or parallel group designs) in humans comparing air polishing with control measures for the non-surgical treatment of peri-implant mucositis and peri-implantitis.

2 Data on the clinical changes in mucosal inflammation (i.e. bleeding scores) after treatment.

At the second stage of selection, all full-text articles identified during the first stage were acquired. During this procedure, the pre-selected publications were evaluated according to the following exclusion criteria:

- Inclusion of less than five patients
- Lack of case definitions
- Surgical treatment protocols
- Lack of clinical data on the changes in peri-implant mucosal inflammation

Materials and Methods
This systematic review was structured and conducted according to the preferred reporting items of the PRISMA statement (Moher et al. 2009).

Focused question
The focused question serving for literature search was structured according to the PICO format (Miller & Forrest 2001): “In patients suffering from peri-implant diseases, what is the efficacy of air polishing on changing signs of inflammation compared with control treatments?”.

- Population: patients with peri-implant mucositis or peri-implantitis, based on case definitions used in respective publications
- Intervention: non-surgical treatment using air polishing
- Comparison: non-surgical treatment using control measures (i.e. alternative measures for plaque removal with or without adjunctive antiseptic and/or antibiotic therapy)
- Outcome: changes in peri-implant mucosal inflammation (i.e. indices to measure mucosal bleeding)

Search strategy
The PubMed database of the U.S. National Library of Medicine and the Web of Knowledge of Thomson Reuters were used as electronic databases to perform a systematic search for relevant articles published in the dental literature between 1992 up to February, 2015. A commercially available software program (Endnote X7, Thomson, London, UK) was used for electronic title management. Screening was performed independently by two authors (F.S. and K.B.). Disagreement regarding inclusion during the first and second stage of study selection was resolved by discussion.

The combination of key words (i.e. Medical Subject Headings MeSH) and free text terms included: “treatment” OR “nonsurgical treatment” OR “non-surgical treatment” OR “therapy” OR “nonsurgical therapy” OR “non-surgical therapy” OR “air abrasion, dental”
Quality assessment of selected studies

A quality assessment of all selected full-text articles was performed according to the Cochrane collaboration’s tool for assessing risk of bias (low, high, unclear) including the following domains: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, and incomplete outcome data (Higgins & Green 2011). Quality assessment was performed in two different phases. In particular, during phase I quality assessment was based on the published full-text article performed independently by both authors (F.S. and K.B.). In phase II, disagreements were resolved by discussion.

Data extraction

A previously generated data extraction template was used (F.S. and K.B.) and data based on the study design, population, case definition, observation period, interventions, comparisons, primary and secondary outcomes as well as the study quality were used (Schwarz et al. 2015). For data analysis, the changes in bleeding on probing (BOP) scores after respective healing periods were defined as primary outcome. Secondary outcomes included changes in PD as well as the resolution of peri-implant mucosal inflammation.

Method of analysis

Heterogeneity ($I^2$ statistics) between included RCT’s, meta-analysis (weighted mean difference and 95% confidence interval, subject based analysis) and forest plots were assessed using a commercially available software program (Comprehensive Meta-Analysis V2, Biostat, Englewood, NJ, USA). Meta-analysis was based on a random effect model to account for potential methodological differences between studies. Thresholds for the interpretation of $I^2$ values were used as follows: 0–30% (low heterogeneity), 30–60% (moderate heterogeneity), >60% (substantial heterogeneity) (Cochrane Handbook for Systematic Reviews of Interventions, Version 5.1.0., http://handbook.cochrane.org).

Results

Study selection

A total of 288 potentially relevant titles and abstracts were found during the electronic and manual search. During the first stage of study selection, 276 publications were excluded based on title and abstract. For the second phase, the complete full-text articles of the remaining 12 publications were thoroughly evaluated. A total of six papers had to be excluded at this stage because they did not fulfill the inclusion criteria of the present review (Table 1).

Finally, a total of five studies (corresponding to six publications) fulfilled the inclusion criteria required for this systematic review (Fig. 1).

Quality and risk of bias assessment of selected studies

The review author’s judgement about each risk of bias item for each included RCT is presented in Table 2. In particular, the percentages across all included RCT’s for high, low and unclear risk of bias items were 72.0%, 20.0% and 8.0% respectively (Table 2).

Subdivision of selected studies

All selected publications were subdivided according to the primary diagnosis:

- Non-surgical treatment of peri-implant mucositis (two RCT’s and one CCT) (Table 3)
- Non-surgical treatment of peri-implantitis (two RCT’s) (Table 4)

Methodological description of the included studies

Non-surgical treatment of peri-implant mucositis

Two RCT’s reported on the clinical efficacy of glycine powder air polishing (Air Flow Master®, Perio-Flow® nozzle, EMS, Nyon, Switzerland) used either as an adjunct to mechanical debridement (i.e. ultrasonic scalers) (Ji et al. 2014) or as repeated monotherapy (Riben-Grundström et al. 2015) when compared with mechanical debridement (i.e. ultrasonic scalers) alone. In both studies, the air-abrasive device was applied for 5 s per surface aspect. Test and control treatments were commonly supported by oral hygiene instructions and followed over a period of up to 12 months (Riben-Grundström et al. 2015) (Table 3). Basically, both studies considered PD ≥ 4 mm and BOP to assess mucosal inflammation, however, also employed different radiographic threshold levels for case definition. In the study by Riben-Grundström et al. (2015), implants with a bone loss > 2 mm were not included whereas Ji et al. (2014) did not include individuals with detectable loss of supporting bone as compared with periapical radiographs immediately after restoration. In one CCT, glycine powder air polishing (Air Flow Master®, Perio-Flow® nozzle) was used as an adjunct (i.e. 5 s per surface aspect) to mechanical debridement. The case definition included BOP, PD ≤ 3.5 mm and a radiographic bone loss ≤ 3.0 mm (De Siena et al. 2014).

Non-surgical treatment of peri-implantitis

In two RCT’s (three publications), the efficacy of glycine powder air polishing (Air Flow Master®, Perio-Flow®

Table 1. Excluded clinical studies at the second stage of selection and the reason for exclusion

<table>
<thead>
<tr>
<th>Publication</th>
<th>Reason for exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duarte et al. (2009)</td>
<td>Observational study</td>
</tr>
<tr>
<td>Maximo et al. (2009)</td>
<td>Observational study</td>
</tr>
<tr>
<td>Bassetti et al. (2013)</td>
<td>Test and control groups received air polishing treatment</td>
</tr>
<tr>
<td>McKenna et al. (2013)</td>
<td>No application of air polishing</td>
</tr>
<tr>
<td>Persson et al. (2011)</td>
<td>Microbiological analysis of the study population reported by Renvert et al. (2010)</td>
</tr>
<tr>
<td>Schär et al. (2013)</td>
<td>Test and control groups received air polishing treatment</td>
</tr>
</tbody>
</table>
nozzle) was compared with that of either mechanical debridement (Sahm et al. 2011, John et al. 2015) or Er: YAG laser (energy density of 12.7 J/cm$^2$) monotherapy (Renvert et al. 2010). The air-abrasive device was either applied 5 s per surface aspect (Sahm et al. 2011) or approximately 15 s at four sites per implant (Renvert et al. 2010). Test and control treatments were supported by oral hygiene instructions and followed over a period of up to 12 months (John et al. 2015) (Table 4). For the case definition, both studies considered different amounts of interproximal bone loss (i.e. $\leq 33\%$ versus $> 3\$ mm) in addition to peri-implant mucosal inflammation.

**Treatment outcomes**

**Non-surgical treatment of peri-implantitis**

At 3 months after therapy, both test and control groups resulted in significant improvements in bleeding index and PD values. The adjunctive single application of glycine powder air polishing was associated with a lower frequency of sites without bleeding when compared with the control group (29.3% versus 42.1%). There were “no complaints or discomfort” reported by any of the patients investigated (Ji et al. 2014). At 6 months, the adjunctive single use of glycine powder air polishing resulted in a significantly higher bleeding index (BI) and PD reduction when compared with mechanical debridement alone. There was “no complication or soft tissue recession” noted after therapy (De Siena et al. 2014).

A repeated application also resulted in significant BOP reductions after 12 months of healing. In both groups, the number of diseased sites (pocket depth $\geq 4\$ mm with bleeding/suppuration) was significantly reduced between baseline and 12 months. However, no significant differences were noted between groups at 12 months or in the reduction in number of diseased sites from baseline to 12 months (Riben-Grundström et al. 2015) (Table 3).

Due to a large heterogeneity in the clinical parameters defined for the assessment of mucosal inflammation (i.e. different modifications of BI, BOP), a meta-analysis was not feasible.

**Non-surgical treatment of peri-implantitis**

At 3, 6 and 12 months after therapy, glycine powder air polishing resulted in a statistically significant higher BOP reduction than mechanical debridement + local antiseptic therapy (i.e. chlorhexidine digluconate) [3 months: 51.6 (SD = 28.6)% versus 24.8 (SD = 29.8)%; 6 months: 43.5 (SD = 27.7)% versus 11.0 (SD = 15.7)%; 12 months: 41.2 (SD = 29.5)% versus 16.6 (SD = 33.4)%]. Between-group comparisons failed to reveal any significant differences in mean PD reductions at 3, 6, and 12 months. No signs of inflammation, complications or allergic reactions in the form of swellings or redness of the surrounding soft tissues could be observed. After treatment with air polishing, no emphysema could be detected (Sahm et al. 2011, John et al. 2015).

A single subgingival instrumentation using glycine powder air polishing or an Er:YAG laser (energy density of 12.7 J/cm$^2$) (control) resulted in significant BOP reductions at 6 months. The difference between both groups failed to reach statistical significance. A positive treatment outcome (i.e. defined as PD reduction $\geq 0.5\$ mm and gain or no radiographic bone loss) at the implant level was noted in 47% of the test sites and 44% of the control sites (Renvert et al. 2010).

**Table 2.** Risk of bias (+ low/ – high/ ? unclear) summary for finally selected randomized studies

<table>
<thead>
<tr>
<th>Random sequence generation</th>
<th>Allocation Concealment</th>
<th>Blinding of participants and personnel</th>
<th>Blinding of outcome assessment</th>
<th>Incomplete outcome data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renvert et al. (2010)</td>
<td>+</td>
<td>?</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Sahm et al. (2011); John et al. (2015)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Ji et al. (2014)</td>
<td>+</td>
<td>?</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Riben-Grundström et al. (2015)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

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<table>
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<tr>
<th>Publication</th>
<th>Design</th>
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<th>Case Definition</th>
<th>Period</th>
<th>Test</th>
<th>Control</th>
<th>Mean (SD) Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ji et al. (2014)</td>
<td>RCT, parallel</td>
<td>24 Patients 33 implants molar/premolar sites 1 Implant System</td>
<td>PD ≥ 4 mm, BOP + No radiographic bone loss compared with baseline (i.e. immediately after prosthesis installation)</td>
<td>3 months</td>
<td>OHI+ Mechanical debridement (ultrasonic scaler with carbon fibre tips) + air-abrasive device, glycine powder (sites with PD ≥ 4 mm)</td>
<td>OHI+ Mechanical debridement (ultrasonic scaler with carbon fibre tips)</td>
<td>Test BR: 1.4 (SD:0.57) (BL) to 1.1 (SD:0.58) (3 months, Subject Level) BR: 1.0 (SD:0.65) (BL) to 1.0 (SD:0.85) (3 months, Subject Level) BR: 1.7 (SD:0.93) (BL) to 1.1 (SD:0.98) (3 months, Implant Level) (sign.) Sites without bleeding: 29.3% PD: 3.6 (SD:0.47) (BL) to 3.2 (SD:0.48) mm (3 months, Subject Level) (sign.) Control BR: 1.5 (SD:0.65) (BL) to 1.0 (SD:0.85) (3 months, Subject Level) BR: 1.7 (SD:1.0) (BL) to 0.9 (SD:1.1) (3 months, Implant Level) (sign.) Sites without bleeding: 42.1% PD: 3.5 (SD:0.5) (BL) to 3.1 (SD:0.38) mm (3 months, Subject Level) (sign.) 13 patients did not present bleeding at 6 months Test PD: 3.0 (SD:0.4) (BL) to 2.4 (SD:0.5) mm (6 months, Subject Level) (sign.) 9 patients did not present bleeding at 6 months BI and PD scores sign. lower in the test group at 6 months</td>
</tr>
<tr>
<td>De Siena et al. (2014)</td>
<td>CCT, parallel</td>
<td>30 patients No information on number and types of implants</td>
<td>BOP or spontaneous bleeding with local swelling PD ≤ 3.5 mm Bone loss ≤ 3.0 mm</td>
<td>6 months</td>
<td>OHI+ Mechanical debridement Teflon curets, polishing) + air-abrasive device, glycine powder</td>
<td>OHI+ Mechanical debridement Teflon curets, polishing)</td>
<td>Test PD: 2.9 (SD:0.4) (BL) to 3.0 (SD:0.6) mm (6 months, Subject Level) (n. sign.) 9 patients did not present bleeding at 6 months</td>
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</table>
Meta-analysis (random effect model) considered the primary and secondary outcomes reported after 6 months of healing (Renvert et al. 2010, Sahm et al. 2011).

The weighted mean difference (WMD) [SD; p; 95% CI] in BOP reduction between test and control groups was $-23.83\%$ [SD = 12.06; \( p = 0.048; 95\% \text{ CI} (-47.47, -0.20)\)] favouring air polishing over control measures (\( p \) value for heterogeneity: 0.128, \( I^2 = 56.88\% = \text{moderate heterogeneity} \) (Fig. 2a). The weighted mean difference (WMD) [SD; p; 95% CI] in PD reduction between test and control groups was $0.37 \text{ mm}$ [SD = $0.23; p = 0.119$; 95% CI ($-0.84, 0.096$)] not favouring air polishing over control measures (\( p \) value for heterogeneity: 0.940, \( I^2 = 0.00\% = \text{low heterogeneity} \) (Fig. 2b).

Due to the low number of available RCT's ($n = 2$), a publication bias assessment was not possible.

### Discussion

The present systematic review was conducted to address the following focused question: In patients suffering from peri-implant diseases, what is the efficacy of air polishing on changing signs of inflammation compared with control treatments?

Due to noted heterogeneous case definitions used in the currently available literature, it was decided to include studies reporting on the treatment of both peri-implant mucositis and peri-implantitis. This issue mainly refers to the definition of peri-implantitis cases, which should consider "changes in the level of crestal bone, presence of BOP and/or suppuration; with or without concomitant deepening of peri-implant pockets" (Lang et al. 2011). Therefore, when interpreting the present analysis, it must be kept in mind that in two studies, a radiographic bone loss of up to 3 mm has been accepted for defining peri-implant mucositis cases (De Siena et al. 2014, Riben-Grundström et al. 2015).

Basically, all studies investigated employed the same type and configuration of an air-abrasive device. Moreover, supra- and submucosal debridement was commonly accomplished using glycine powder, which

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Basically, all studies investigated employed the same type and configuration of an air-abrasive device. Moreover, supra- and submucosal debridement was commonly accomplished using glycine powder, which
has been demonstrated to be less abrasive to titanium surfaces than sodium bicarbonate (Schwarz et al. 2009).

Both available RCT’s failed to identify any superior effect of air polishing (i.e. adjunctive use and monotherapy) over mechanical debridement in either reducing clinical signs of inflammation (i.e. BI and BOP) or obtaining disease resolution at mucositis sites (Ji et al. 2014, Riben-Grundström et al. 2015). A significantly higher BI reduction in adjunctive air polishing was merely observed in one CCT (De Siena et al. 2014).

However, the present data analysis has pointed to an improved efficacy of glycine powder air polishing in reducing BOP scores after non-surgical treatment of peri-implantitis. WMD in BOP reduction between test and control groups was −23.83%. In this context, it must be emphasized that the rational for conducting a meta-analysis was to facilitate understanding rather than to strengthen the level of the available evidence (Jepsen et al. 2015). Moreover, due to methodological differences noted between both RCT’s (Renvert et al. 2010, Sahm et al. 2011), the calculated WMD must be interpreted with caution. However, when considering the follow-up observation of the latter study population, it was noted that these improvements were maintained over a period of up to 12 months. The reported differences in mean BOP scores were 41.2 (SD:29.5)% in the test group and 16.6 (SD:33.4)% in the control group respectively (John et al. 2015). However, despite these clinically important improvements, a complete disease resolution could not be obtained by any of the treatment and maintenance protocols investigated (Renvert et al. 2010, Sahm et al. 2011, John et al. 2015). When further evaluating the outcomes of non-surgical treatment of peri-implantitis, it was also noted that WMD in PD reduction between test and control groups failed to reach statistical significance. In this context, it must be emphasized that BOP is the key parameter for the diagnosis of peri-implant mucositis (Lang & Berglundh 2011). Therefore, the “resolution of peri-implant

### Table 4. Included studies – non-surgical treatment of peri-implantitis

<table>
<thead>
<tr>
<th>Publication</th>
<th>Design</th>
<th>Population</th>
<th>Case Definition</th>
<th>Period</th>
<th>Test</th>
<th>Control</th>
<th>Mean (SD) Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Renvert et al. (2010)</td>
<td>RCT, parallel</td>
<td>42 patients</td>
<td>PD ≥ 3 mm, BOP ≥ 5 mm, and/or pus</td>
<td>6 months</td>
<td>Test</td>
<td>Control</td>
<td>absence of BOP: 30.9% (6 months, Subject Level) mean PD reduction: 0.9 (SD:0.6) (6 months, Subject Level)</td>
</tr>
<tr>
<td>Sahm et al. (2011)</td>
<td>RCT, parallel</td>
<td>25 patients</td>
<td>PD ≥ 4 mm, BOP ≥ 5 mm, and/or pus</td>
<td>12 months</td>
<td>Test</td>
<td>Control</td>
<td>absence of BOP: 57.8% (12 months, Subject Level) mean PD reduction: 3.7 (SD:3.2) (12 months, Subject Level)</td>
</tr>
<tr>
<td>John et al. (2015)</td>
<td>RCT, parallel</td>
<td>30 patients</td>
<td>PD ≥ 4 mm, BOP ≥ 5 mm, and/or pus</td>
<td>12 months</td>
<td>Test</td>
<td>Control</td>
<td>absence of BOP: 57.8% (12 months, Subject Level) mean PD reduction: 3.7 (SD:3.2) (12 months, Subject Level)</td>
</tr>
</tbody>
</table>

BL, baseline; BOP, bleeding on probing; CHX, chlorhexidine digluconate; OHI, oral hygiene instructions; PD, probing pocket depth; RCT, randomized controlled clinical trial; SD, standard deviation.

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mucosal inflammation as evidenced by the absence of BOP” was the suggested endpoint following non-surgical treatment of mucositis lesions. At peri-implantitis sites, a “composite outcome of disease resolution including the absence of deep PD with bleeding and suppuration” should be considered (Sanz et al. 2012). However, PD at implant sites may be influenced by several local factors, including the soft tissue thickness or vertical implant positioning, and therefore the classification of a “deep” pocket needs to be accomplished on an individual basis. Moreover, the definition of severity and extent of the disease must also include “proportions of affected implants per patient in the presence of multiple implants” (Jepsen et al. 2015). When considering the threshold levels for “deep” PD’s, as employed in both studies investigated, the respective analyses also failed to identify any superiority of air polishing in reducing these critical pockets over control measures (Renvert et al. 2010, Sahm et al. 2011, John et al. 2015). Currently, there is only one study reporting on the microbiological outcomes following non-surgical treatment of peri-implantitis using an air-abrasive device. At 6 months after therapy, both test and control (i.e. Er:YAG laser) procedures failed to reduce the bacterial load (Persson et al. 2011), thus explaining at least in part, the frequency of residual BOP scores at specific sites (Renvert et al. 2010, Sahm et al. 2011). This might be due to a limitation of both devices to effectively remove hard deposits such as calculus from exposed implant surfaces (Speelman et al. 1992, Schwarz et al. 2003).

Finally, it must be emphasized that air polishing was not associated with any adverse events (e.g. emphysema formation), thus demonstrating clinical safety of this specific device for the supra- and submucosal debridement at mucositis and peri-implantitis sites (Renvert et al. 2010, Sahm et al. 2011, De Siena et al. 2014, Ji et al. 2014, John et al. 2015, Riben-Grundström et al. 2015).

In conclusion, the present systematic review and meta-analysis has indicated that glycine powder air polishing is as effective as the control treatments at mucositis sites. However, it may improve the efficacy of non-surgical treatment of peri-implantitis over the control measures investigated.

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Principal findings: While air polishing using glycine powder did not reveal any major improvement of bleeding index/BOP or disease reso-
lution at mucositis sites, it resulted in a significantly higher BOP reduc-
tion at peri-implantitis sites when compared with control measures (i.e. mechanical debridement with or without local antiseptic therapy, Er:YAG laser).

Practical implications: Air polishing may improve the efficacy of non-surgical treatment of peri-implantitis.

**Clinical Relevance**

**Scientific rationale for the study:** This systematic review focused on the efficacy of air polishing on changing signs of inflammation following non-surgical treatment of peri-implant diseases.