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Treatment of peri-implant mucositis using a glycine powder air-polishing or ultrasonic device: a randomized clinical trial

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Abstract

Aim: To evaluate the clinical treatment effects of a glycine powder air-polishing or ultrasonic device on peri-implant mucositis.

Materials and methods: Thirty-seven patients with one implant diagnosed with peri-implant mucositis (probing depth ≥4 mm (0.2N) and bleeding on probing (BOP) (primary outcome)) were randomly assigned to treatment with either glycine powder air-polishing (GPAP) or ultrasonic (US) debridement. Treatment was performed at baseline and at 3 and 6 months. Professional supra gingival cleaning was performed at 9 and 12 months. Oral hygiene instructions were reinforced at each visit.

Results: At 12 months there was a statistically significant reduction in mean plaque score, bleeding on probing and number of periodontal pockets ≥4 mm within the treatment groups compared to baseline. The percentages of diseased sites were significantly reduced for both groups.

Conclusions: Treatment with a glycine powder air-polishing or an ultrasonic device is effective in non-surgical treatment of peri-implant mucositis.

Key words: air-abrasive device; mechanical therapy; non-surgical treatment; peri-implant mucositis

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Dental implants are often used to replace lost teeth and present a high level of predictability, patient satisfaction and long-term success (Schnitman et al. 1997, Romeo et al. 2004, Pjetursson et al. 2005, 2012, Jung et al. 2012). Biological complications such as peri-implant mucositis and peri-implantitis have, however, become major challenges to the profession (Mombelli et al. 2012).

Conflict of interest and source of funding statement

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The definition of peri-implant mucositis is an inflammation of the soft tissues adjacent to a dental implant diagnosed with bleeding on gentle probing (<0.25N) (Jepsen et al. 2015). If the clinical signs are combined with bone loss the condition is referred to as peri-implantitis (Lindhe & Meyle 2008, Lang et al. 2011).

When exposed in the oral cavity, the implant surface is rapidly colonized by microorganisms (Quirynen et al. 2006, Fürst et al. 2007, Salvi et al. 2007) .

The formation of a complex biofilm on the implant surface, which does not differ from that on tooth surfaces, triggers the host response and initiates an inflammatory reaction that may result in peri-implant tissue destruction. Risk including factors, for example an infected recipient site, inaccessibility to oral hygiene measures, smoking and susceptibility to periodontitis (Renvert & Polyzois 2014), (Quirynen & Vogels 2002) as well as remnants of cement (Linkevicius et al. 2012) have

been associated with the development of peri-implant diseases. The inflammatory lesion around implants also present features of more invasive and progressive nature than that around teeth, therefore peri-implant mucositis should be considered a risk factor in the development of peri-implantitis (Zitzmann et al. 2004, Salvi et al. 2012, Salvi & Zitzmann 2014).

Reports assessing the prevalence of peri-implant diseases revealed that peri-implant mucositis was present in 77% and peri-implantitis in 16% of subjects during a 9–14 year observation (Roos-Jansåker et al. 2006). In a recent meta-analysis, 63% of the individuals represented with peri-implant mucositis (Atieh et al. 2013).

The treatment goal of peri-implant mucositis is to remove or significantly depress the levels of pathogens to allow healing of the soft tissues. Few clinical studies have evaluated the outcome of peri-implant mucositis treatment (Duarte et al. 2009, Máximo et al. 2009, Ramberg et al. 2009, Thöne-Mühling et al. 2010, Heitz-Mayfield et al. 2011, Renvert et al. 2011, Ata-Ali et al. 2015). Clinical improvements can be gained following mechanical-, ultrasonic or laser debridement (Schwarz et al. 2005, Renvert et al. 2008). It is, however, difficult to achieve healthy soft tissues completely free from clinical signs of inflammation following therapy (Heitz-Mayfield & Lang 2004, Heitz-Mayfield et al. 2011, 2012).

Adjunctive therapies, such as antiseptic mouth-rinses, local application of chlorhexidine and local or systemically delivered antibiotics have shown limited additional effects to mechanical therapy (Schenk et al. 1997, Porras et al. 2002, Renvert et al. 2006, Hallström et al. 2012).

Recently, air-polishing devices have been shown to be safe and efficient in removing subgingival biofilm around teeth (Petersilka et al. 2008, Moëne et al. 2010, Wennström et al. 2011, Flemmig et al. 2012). A small thin nozzle is placed in the infected pocket and using a glycine-based grain powder and water the surface is irrigated and the biofilm removed.

Results have also indicated subgingival glycine powder air-polishing to be more efficient than mechanical scaling and root planing in removing the subgingival biofilm in moderate-to-deep periodontal pockets and to contribute to a beneficial shift of the oral microbiota in the gingival sulci around teeth (Flemmig et al. 2012) and implants (Schwarz et al. 2009). In a recent clinical trial it was reported that mechanical debridement could effectively control peri-implant mucositis but glycine powder air-polishing had limited additional effect as compared to mechanical debridement alone after 3 months (Ji et al. 2014).

As peri-implant mucositis is a common clinical entity that may develop into peri-implantitis early recognition and proper diagnosis of peri-implant disease is of high importance to all members of the oral team in the treatment and implementation of preventive programs (Tonetti et al. 2015).

The aim of the present study was to evaluate the clinical outcome following treatment of peri-implant mucositis with either a glycine powder air-polishing device or an ultrasonic device with a plastic coated tip over a 12-month period.

Materials and Methods

Study design

This study was a single-blinded, randomized 12-month clinical trial approved by the Ethics Committee of Lund, Sweden. The patients were referred to the department of Periodontology, Institute of Postgrad Dental Education, Jönköping, Sweden between 2010–2012.

Study population

Thirty-seven subjects, 18 females and 19 males were included in the study. The patients had received implant treatment by an experienced periodontist or oral surgeon 1–20 years prior to their referral.

Inclusion criteria

Each patient had to meet the following inclusion criteria:

- Presence of a minimum of one or more peri-implant mucositis sites with probing depth $\geq$4 mm (0.2N) combined with bleeding with or without suppuration.
- Bone loss $\leq$2 mm assessed from the implant shoulder as a consequence of the bone healing remodelling process.

Exclusion criteria

Exclusion was made as follows:

- Patients with uncontrolled diabetes (HbA1c > 55 mmol/mol).
- Patients receiving medication known to have effect on gingival growth eg. calcium channel antagonists, immunosuppressants or antiepileptic drugs.
- Patients requiring antibiotic prophylaxis or whom had received antibiotic treatment in the preceding 3 months.
- Patients receiving systemic corticosteroids.

Randomization

Once the entry criteria had been confirmed the subjects were entered to the study and assigned a patient number. Assignment to the glycine powder air-polishing group (GPAP) and the ultrasonic group (US) was made using a computerized randomization.

Cards with group identification were prepared and placed in numbered envelopes by a member from the staff not involved in the examination or treatment of the patients. The dental hygienist responsible for the treatment broke the seal of the envelope to give the patients treatment according to either group A or B protocol. The code for treatment A and B was revealed to the examiners once the study was completed and the data set locked.

Clinical and radiographic examination

Each participant was given a detailed description of the study and was required to sign a written consent according to the Declaration of Helsinki (version 2008).

The examinations and registrations were performed by two calibrated operators, (CRG,ON) not aware of the treatment group of the patient. The patients were also asked not to discuss their treatment with the examiner. Each visit commenced with an update on adverse effects

and an intra-oral photo of the implant site.

Baseline, 1 month, 3 months, 6 months, 9 months, 12 months

At the baseline examination each participant was interviewed regarding their medical history, including smoking and oral hygiene habits. Implant characteristics and position in the dentition was recorded.

At 1-month oral hygiene, in terms of full-mouth plaque index and local implant plaque index, was evaluated and reinforced.

At baseline, 3 months, 6 months, 9 months and 12 months clinical measurements on full-mouth plaque score (FMPS), full-mouth bleeding score (FMBS), implant probing depth, local implant bleeding on probing, local implant plaque score and suppuration were performed at six sites on each qualifying implant (mesio-buccal, buccal, disto-buccal, mesio-palatinal, palatinal, disto-palatinal).

Mucosal overgrowth and recession was measured at two sites (buccal and lingual/palatinal).

Full-mouth plaque score (FMPS) was recorded using a disclosing dye (Top Dent Rondell, Top Dent, Sweden) and recorded as a percentage of examined sites within each patient.

Full-mouth bleeding score (FMBS) was measured 30 s after probing and recorded as a percentage of examined sites within each patient (O'Leary et al. 1972).

All implant probing depth (PD) measurements were made with a probing force of 0.2 N with the same probe design (Hawe Click-Probe, HaweNeos Dental, Switzerland).

Implant bleeding on probing score (BOP), local implant plaque score, suppuration and mucosal overgrowth was recorded as either present or absent. Recession of the mucosal margin relative to the restoration margin (REC) at the implant was recorded in millimetres at two sites (buccal or lingual/palatal). If the mucosal margin was located apical to the restoration this was indicated as a positive value (+) and if the margin was located coronal to the restoration this was registered as a negative value(-).

Radiographic examination

At baseline, 6 months and 12 months a digital periapical standardized radiograph using a bite-block (Coltène®PRESIDENT Putty soft, Coltène/Whaledent AG, Altstätten, Switzerland) was taken to detect loss of supporting bone.

Oral hygiene instructions

Oral hygiene instructions were reinforced after each examination.

Treatment protocol

Each subject received treatment according to his or her randomization in either the glycine powder air-polishing group (GPAP) or the ultrasonic group (US). The treatment was performed at baseline, 3 months and 6 months by an experienced dental hygienist (UA) immediately after the registrations.

Glycine-powder air-polishing

The Perio-Flow® nozzle (AIR-FLOW Master Piezon®; EMS, Nyon, Switzerland) was directed into the peri-implant pocket at an angle of 60–90 degrees to the implant and each surface was debrided for 5 s using glycine powder (AIR-FLOW® Powder PERIO; EMS).

Ultrasonic device

An ultrasonic device (AIR-FLOW Master Piezon®; EMS) with a high-tech plastic material coated tip (PI Instrument; EMS, Nyon, Switzerland) was placed in the peri-implant pocket and each surface was debrided for 5 s.

Maintenance care

Supragingival maintenance care was provided at month 9 and 12. After each debridement and each visit the dentition was polished using a rubbercup (Pro-Cup®; KerrHawe, Bioggio, Switwerland) and prophypaste (Prophy Paste; CCS Healthcare AB, Borlänge, Sweden).

Statistical analysis

A software package (IBM SPSS Statistics 21.0; SPSS, Chicago, IL, USA) was used for the statistical analysis. All analyses were performed at patient level. Mean values and standard deviation (mean; SD) for the clinical parameters were calculated for the two groups. Comparisons over time for the investigated variables were performed using Wilcoxon sign rank test, while comparisons between groups were performed using Wilcoxon rank sum test. Results were considered statistically significant at $p < 0.05$.

Results

Sample description

Thirty-seven subjects, 18 females and 19 males were enrolled in this study. One implant in each subject received treatment according to the randomization. Nineteen individuals were treated with the glycine powder air-polishing device (GPAP) and 18 individuals were treated using the ultrasonic device (US). One patient could not attend the 9-month examination but participated at the 12-month examination. One patient dropped out due to personal reasons following the 9-months follow-up (Fig. 1).

The mean age of the patients was 64.3 years. Five patients were current smokers.

The baseline demographic data are presented in Table 1.

Mean values of full-mouth plaque scores at baseline between the two groups were estimated to be 19.8 ± 4.1% (GPAP) and 18.5 ± 4.4% (US). Plaque scores decreased to 8.1 ± 1.4% and 8.7 ± 1.6% at 1 month. Mean full-mouth bleeding score was low 9.2 ± 2.7% (GPAP) and 9.6 ± 2.8% (US) at baseline for both groups. The difference according to full-mouth plaque score between baseline and 12 months was statistically significant ($p < 0.05$) for the GPAP group and according to bleeding score for the ultrasonic group (Table 2).

Mean local implant plaque index at baseline was 25.5 ± 6.8% in the GPAP group and 24.1 ± 6.6% in the ultrasonic group. Local plaque index varied between the groups during the study period and was significantly reduced between baseline and 12 months in both groups to 5.6 ± 3.8% and 7.4 ± 6.4%, ($p < 0.05$). Mean local implant bleeding on probing was 43.9 ± 7.3% (GPAP) and 53.7 ± 7.9% (US) at baseline and was significantly reduced ($p < 0.001$) in both groups to 12.1 ± 3.8% (GPAP) and 18.6 ± 6.4% (US) at the end of the study (Table 3). No

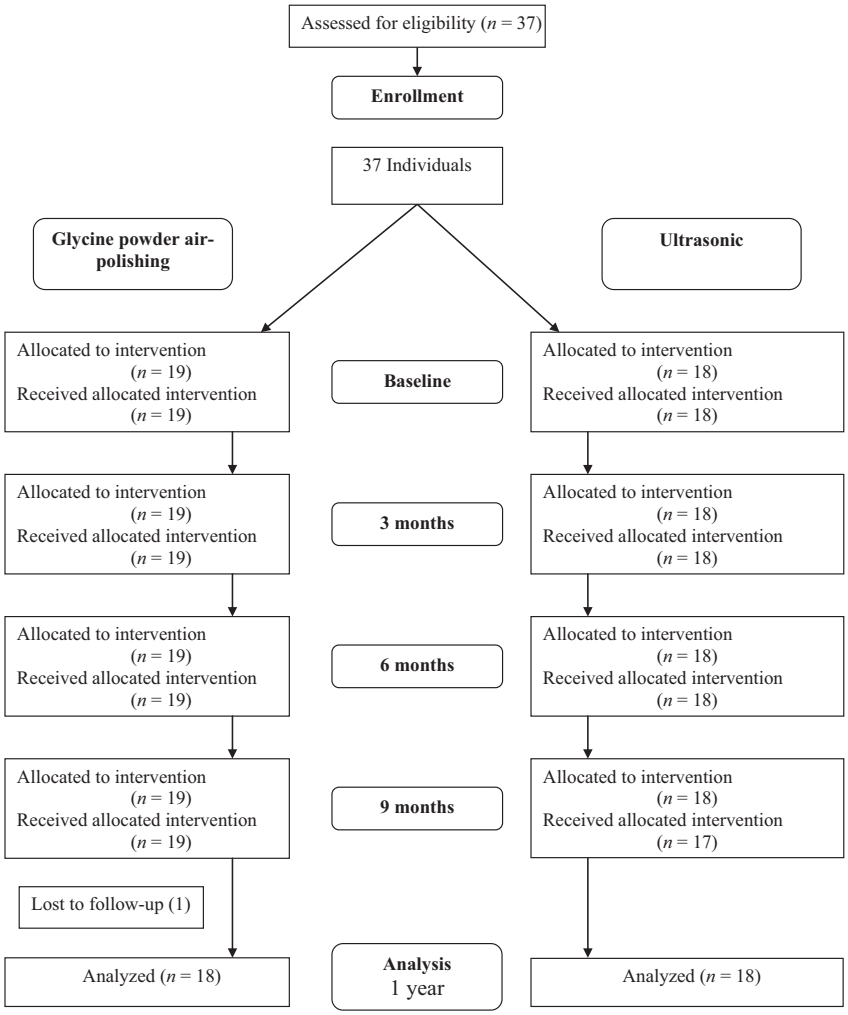

Fig. 1. Demographic data and baseline characteristics for the GPAP and ultrasonic group.

statistically significant difference existed between groups.

Suppuration was recorded in 1–3 sites in 10 subjects and was reduced to affecting five subjects in the end of the study.

Mucosal overgrowth of 1–3 mm was detected in three subjects and mucosal recession of 1–6 mm in eight subjects. No differences were found in the group or between groups at the end of the study.

Periodontal pockets were grouped into sites with pockets between 0 to 3 mm and pockets ≥ 4 mm (Table 4).

The percentage of periodontal pockets with ≥4 mm in probing depth at baseline was 30% in the GPAP group and 34% in the ultrasonic group. After 3 months the number of sites ≥ 4 mm were reduced to 22% and 29%, respectively. At the 12 month follow-up a reduction to 13% in the GPAP group and 20% in the ultrasonic group was observed, ($p < 0.001$). No

Table 1. Baseline examination

	GPAP	US	Total
No. patients	19	18	37
Male	10	9	19
Female	9	9	18
Age range (years)	25–85	25–86	25–86
Mean age (years)	64.4	64.3	64.3
Smokers	1	4	5
Never smokers	13	8	21
Non-smokers	5	6	11
Packyears (years)	4.1	8	2–45
Implant design			
ASTRA TECH Implant System™	3	2	5
Nobel Biocare® Implant System	12	10	22
Straumann®Dental Implant System	4	6	10
Referred from			
Department of Prosthodontics	6	6	12
Department of Periodontology	4	3	7
General dentist	9	9	18

Table 2. Full-mouth plaque score and bleeding score at different time intervals (mean ± SEM).

	Group	*N*	FMPS (%)		FMBS (%)	
			Mean	SEM	Mean	SEM
Baseline	GPAP	19	19.8	4.1	9.2	2.7
	Ultrasonic	18	18.5	4.4	9.6	2.8
1 month	GPAP	19	8.1	1.4	–	–
	Ultrasonic	18	8.7	1.6	–	–
3 months	GPAP	19	9.5	1.8	3.8	0.9
	Ultrasonic	18	12.4	3.3	5.1	1.9
6 months	GPAP	19	8.2	2.0	4.8	2.4
	Ultrasonic	18	14.4	4.5	5.1	1.8
9 months	GPAP	19	10.7	3.4	3.3	0.9
	Ultrasonic	17	6.3	1.8	2.0	0.6
12 months	GPAP	18	5.7*	1.2	3.4	1.1
	Ultrasonic	18	9.9	5.5	2.2*	0.8

FMPS, full-mouth plaque score; FMBS, Full-mouth bleeding score.
Changes in mean full-mouth plaque and bleeding score at different time intervals.
*Statistically significant difference according to full-mouth plaque score between baseline and 12 months in the GPAP group and according to bleeding score for the Ultrasonic group ($p < 0.05$).

Table 3. Implant plaque score and bleeding on probing at different time intervals (mean ± SEM)

		N	IPS (%)		IBoP (%)	
			Mean	SEM	Mean	SEM
Baseline	GPAP	19	25.5	6.8	43.9	7.3
	Ultrasonic	18	24.1	6.6	53.7	7.9
1 month	GPAP	19	7.9	3.5	–	–
	Ultrasonic	18	16.8	5.5	–	–
3 months	GPAP	19	6.2	2.6	23.0	6.1
	Ultrasonic	18	13.0	4.2	25.1	5.6
6 months	GPAP	19	13.2	7.3	16.7	4.6
	Ultrasonic	18	14.9	6.0	23.2	5.4
9 months	GPAP	19	13.2	5.8	18.5	5.7
	Ultrasonic	17	4.9	3.1	11.9	2.4
12 months	GPAP	18	5.6*	3.8	12.1*	3.8
	Ultrasonic	18	7.4*	6.4	18.6*	6.4

IPS, Implant plaque score; IBS, Implant bleeding on probing.
Changes in mean implant plaque score and bleeding on probing at different time intervals.
*Statistically significant difference according to implant plaque score and implant bleeding on probing between baseline and 12 months for both groups ($p < 0.05$).

significant difference in the number of sites with 0–3 mm and ≥ 4 mm existed between the two groups.

The number of diseased sites (pocket depth ≥4 mm with bleeding/suppuration) before and after treatment are presented in Table 5. At baseline 38% of the sites in the GPAP group were diseased compared to 52% in the ultrasonic group. A reduction of diseased sites to 8% in the GPAP group and 17% in the ultrasonic group was achieved. No significant differences were recorded between the two groups at baseline, after 12 months or according to reduction of number of diseased sites from baseline to 12 months. However, for both groups the number of diseased sites were significantly reduced between baseline and 12 months, ($p < 0.01$).

Discussion

The non-surgical treatment in this study resulted in a significant reduction in all clinical measured variables. Gingival bleeding and bleeding on probing, the most important findings in detecting peri-implant disease were continuously reduced throughout the study. One possible reason for the positive outcome, besides the effect of therapy, could be related to the patient's compliance in maintaining low plaque indices during the whole study period.

At the 1-month examination the mean full mouth plaque score had decreased to values below 10%. Oral hygiene conditions have been suggested to be an important variable associated with peri-implant health (Zitzmann et al. 2001, Salvi & Lang 2004, Kracher & Smith 2010, Mombelli & Décaillet 2011). The importance of plaque levels on successful long-term supportive maintenance of dental implants diagnosed with peri-implant mucositis have been evaluated in a few studies. Costa et al. (2012) followed 80 patients diagnosed with peri-implant mucositis for a period of 5 years with and without preventive maintenance. In patients not receiving maintenance treatment 44% developed peri-implantitis compared to 18% of patients receiving maintenance treatment. Higher plaque levels were detected in the group not receiving maintenance therapy.

Despite the low levels of plaque, both groups responded well to treatment. However, 8% of the sites in the GPAP group and 17% of the sites in the ultrasonic were still diseased after 12 months and highlights the difficulties in achieving complete resolution of inflammation at implants. This is in agreement with results from a short-term randomized clinical trial by (Heitz-Mayfield et al. 2011) where the authors reported a complete resolution in 38% of implants and no added benefit using adjunctive chlorhexidine gel. In a recent meta-analysis, air-abrasives had no adjunctive effect to professionally administered plaque removal (Schwarz et al. 2014). Nevertheless, it indicates that mechanical debridement in conjunction with oral hygiene is effective in reducing peri-implant soft tissue inflammation.

In a recent in vitro model, 18 implants were dip-coated and placed in resin blocks with different defect morphologies. Different

Table 4. Number of sites with probing depth 0–3 mm and ≥4 mm at the different time points for implants treated with either a glycine powder air-polishing or an ultrasonic device.

	Baseline		3 months		*p*-value[1]	6 months		9 months		12 months		*p*-value[2]
	Sites 0–3 mm *n*%	Sites ≥ 4 mm *n*%	Sites 0–3 mm *n*%	Sites ≥ 4 mm *n*%		Sites 0–3 mm *n*%	Sites ≥4 mm *n*%	Sites 0–3 mm *n*%	Sites ≥ 4 mm *n*%	Sites 0–3 mm *n*%	Sites ≥4 mm *n*%	
GPAP	48 (22)	66 (30)	66 (30)	48 (22)	**0.01**	71 (32)	43 (19)	77 (36)	37 (17)	79 (37)	29 (13)	**< 0.001**
US	32 (14)	76 (34)	43 (19)	65 (29)	NS	55 (25)	53 (24)	55 (25)	47 (22)	65 (30)	43 (20)	**< 0.001**
Total	80 (36)	142 (64)	109 (49)	113 (51)		126 (57)	96 (43)	132 (61)	84 (39)	144 (67)	72 (33)	
p-value[3]				NS							NS	

GPAP, glycine powder air-polishing; US, ultrasonic; *n*, number of sites; *p*-value[1] are the results according to change in number of sites with probing depths ≥4 mm analysed at patient level between baseline and 3 months within both groups; *p*-value[2] are the results analysed between baseline and 12 months within both groups; *p*-value[3] are the results analysed between baseline and 3 months and between baseline and 12 months between the two groups. *p*-value < 0.05 was bold.

Table 5. Percentages (SD) of number of diseased sites at patient level before and after treatment in the GPAP and Ultrasonic group

	GPAP [%(SD)]	Ultrasonic [%(SD)]
Baseline	38 (24)	52 (33)
After 12 months	8 (13)	17 (27)
Baseline-12 months	30 (27)	35 (36)

Statistically significant difference between baseline and 12 months ($p < 0.01$) for both groups.
No significant differences between groups.

vertical bone angulations were chosen and the implants were treated for 10 s using air-flow device employing glycine powder. A complete cleaning of the implant surfaces was not possible in any of the defect models, however, it was possible to clean the majority of the surface to more than 95% in easily accessible defects (Sahrmann et al. 2013). No macro morphological surface alterations were found on the titanium surfaces. This is in accordance with a previous paper by (Petersilka 2011).

A recent review on air-polishing of implant surfaces reported the method to be a promising option for implant surface cleaning in peri-implantitis treatment (Tastepe et al. 2012).

In the present study, the time devoted to both therapies were standardized to 5 s per surface in accordance to the recommendations for the air abrasive device. Subgingival air-polishing has previously been demonstrated to be more time-efficient and more tolerable than scaling and root planing (Moëne et al. 2010, Wennström et al. 2011). Unfortunately, the patient perception of the two different therapies used in the present trial was not evaluated. The results from the present trial clearly demonstrate that treatment of peri-implant mucositis is possible using an air-polishing device and is in agreement with previous reports on treatment of peri-implant mucositis and peri-implantitis using an air-abrasive device (Máximo et al. 2009, Renvert et al. 2011).

This trial further suggests that treatment with a glycine powder air-polishing or ultrasonic device are both effective in non-surgical treatment of peri-implant mucositis. The continued improvements of the clinical parameters after the last treatment was finished at 6 months reflects that both devices are reliable instruments in the regular maintenance therapy of dental implants. This finding is also a reminder that peri-implant tissues could present a clinically, slower healing capacity compared to teeth.

Irrespective of the treatment choice effective plaque control and continuous reinforcement of oral hygiene measures could contribute to mask any differences between treatment modalities.

Randomized clinical trials with large sample sizes are rendered important to further evaluate the long-term effects and peri-implant stability after non-surgical treatment on peri-implant mucositis.

Conclusion

Non-surgical treatment with a glycine powder air-polishing or ultrasonic device is effective in reducing inflammation and number of peri-implant pockets subject to patient compliance.

Although, the majority of the diseased sites at baseline turned healthy during a 12 month period the findings in this study reflects the difficulties in achieving complete resolution of inflammation in the peri-implant tissues once affected.

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Clinical Relevance

Scientific rationale for the study: Peri-implant mucositis is considered a reversible inflammation of the peri-implant tissues and could be a possible risk factor for the development of peri-implantitis and future loss of an implant. To date, no long-term randomized clinical trial has evaluated the effects of glycine powder air-polishing compared to ultrasonic debridement on peri-implant mucositis.

Principal findings: We compared a glycine powder air-polishing device and a conventional ultrasonic device in the treatment of peri-implant mucositis during 12 months. This resulted in a reduction of inflammation and number of peri-implant pockets.

Practical implications: Non-surgical treatment and maintenance of peri-implant mucositis.