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Clinical outcomes and associated factors in the treatment of peri-implant mucositis, combining mechanical debridement and prosthesis modification: A 30-month follow-up prospective case series

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Abstract

Aim: To evaluate the clinical outcome and the associated factors of a treatment protocol for peri-implant mucositis.

Materials and Methods: Patients were evaluated 30 months after a treatment protocol including professional mechanical debridement and modification of the prosthesis contours to improve access for biofilm control. Clinical performance was assessed by means of probing with an electronic pressure-calibrated periodontal probe. The possible impact of implant- and patient-level factors on the changes in peri-implant mucosal inflammation measured with the modified bleeding index (mBI) was evaluated.

Results: Twenty patients and 61 implants were included in the analysis. At the final visit, 50% of the patients presented bleeding on probing, with a mean mBI of 0.22 (SD 0.27). The adjusted linear regression model showed a significant association between patient's compliance with supportive care visits ($p = .006$) and mucosal inflammation. Similarly, at the implant level, modified plaque index ($p < .001$) and an irregular use of interdental brushes ($p = .017$) had a significant impact on final mBI.

Conclusions: Prosthesis modification when needed in association with non-surgical treatment may be an important intervention in the treatment of peri-implant mucositis. Compliance with supportive care visits and the regular use of inter-dental brushes were identified as important factors to achieve mucosal inflammation control.

KEYWORDS
dental implant, dental prosthesis, implant-supported, non-surgical treatment, peri-implant mucositis

Clinical Relevance

Scientific rationale for study: Peri-implant mucositis is a prevalent disease and its treatment seems to be effective; however, there is a high rate of recurrence. There is a need for further investigation of factors associated with this recurrence.

Principal findings: Modification of the prosthesis allow for an improved access to biofilm removal, but compliance of the patient with the use of inter-dental brushes and with the recommended supportive care visits had a significant impact on the outcome.

Practical implications: Prosthesis accessibility to oral hygiene procedures along with patient motivation and compliance with oral hygiene are critical factors to maintain the results of the treatment of peri-implant mucositis.

1 | INTRODUCTION

Dental implants are considered a predictable solution to replace missing teeth (Buser et al., 2017) with implant survival rates exceeding 95%, at 10 years (van Velzen et al., 2015). However, dental implants are not exempt from complications, categorized as biological or mechanical, depending whether they affect the peri-implant tissues or the prosthetic restoration. While mechanical complications are usually treated successfully (Sailer et al., 2012), biological complications may be more difficult to treat and control.

These biological complications, also denominated peri-implant diseases, are plaque-associated pathological conditions occurring in the tissues around dental implants (Berglundh et al., 2018). At the 2017 World Workshop on the Classification of Periodontal and Peri-implant Diseases and Conditions, peri-implant diseases were categorized into peri-implant mucositis, characterized by the presence of reversible inflammatory changes manifested as bleeding on gentle probing, erythema, swelling, and suppuration in the mucosa around an implant; and peri-implantitis, in which the inflammation of the mucosa is associated with progressive loss of the peri-implant crestal bone (Berglundh et al., 2018). Nowadays, peri-implant diseases represent a challenge in daily clinical practice, as their prevalence is consistently high. In a recent systematic review, it was shown that 46.83% (95% confidence interval [CI]: 38.30–55.36) of patients were affected with peri-implant mucositis, whereas a 19.83% (95% CI: 15.38–24.27) presented peri-implantitis (Lee et al., 2017). In Spain, the correspondent figures observed in a cross-sectional study were 27% (95% CI: 22–32) and 24% (95% CI: 19–29), respectively (Rodrigo et al., 2018).

In light of the lack of predictable therapies for treating peri-implantitis, current efforts are headed towards preventing the progression from peri-implant mucositis to peri-implantitis, by treating peri-implant mucositis, or instituting early treatment protocols (Roccuzzo et al., 2017; Berglundh et al., 2018; Schwarz et al., 2018). Initial signs of inflammation such as mucosal redness or bleeding on probing should prompt the implementation of effective treatments (Ramanauskaite et al., 2021), since peri-implant mucositis has shown to be reversible, even within 3 weeks (Salvi et al., 2012; Meyer et al., 2017). However, after these simple treatment protocols, high rates of bleeding on probing are frequently reported, which makes relevant the identification of factors that may be associated with the recurrence of peri-implant mucosal inflammation (Salvi & Ramseier, 2015). Among the patient-related factors, their genetic make-up, presence of systemic diseases, a history of previous periodontitis, or smoking have been identified as risk factors associated with peri-implantitis (Ramanauskaite et al., 2014; Renvert & Polyzois, 2015; Stacchi et al., 2016; Turri et al., 2016; Dreyer et al., 2018). However, peri-implant mucositis has been mainly associated with accumulation of biofilm around the implants, either caused by inefficient oral hygiene practices or by an inadequate prosthesis design that prevents from adequate access to biofilm removal (Zitzmann et al., 2001; Salvi et al., 2012). In fact, a randomized clinical trial (RCT) assessing the impact of combining professional biofilm removal and prosthesis modification to improve access for oral hygiene, compared with professional biofilm removal alone and no prosthesis correction, demonstrated a significant improvement in clinical outcomes at 6 months when the contours of the prosthesis were modified (de Tapia et al., 2019). However, despite these improved outcomes, the maintenance of peri-implant health was not consistent in all patients, since a 33.3% of patients still demonstrated bleeding on probing at this timepoint.

It was, therefore, the objective of the present prospective case series to follow-up these patients treated with a combination of debridement and prosthetic modification during 30 months, to study the factors that may influence the recurrence or the resolution of peri-implant mucositis.

2 | MATERIALS AND METHODS

2.1 | Ethical statements

Since this study was an extension of an RCT evaluating a treatment protocol for peri-implant mucositis (de Tapia et al., 2019), we requested and obtained from Research Ethics Committee of the Universitat Internacional de Catalunya (UIC) an amendment (PER-ECL-2017-01 Amendment 1) of the previously approved protocol (PER-ECL-2017-01).

2.2 | Study design

This was a 30-month prospective case series including only the patients from the test treatment arm of the previously reported

6-month RCT (de Tapia et al., 2019). The protocol in this treatment arm consisted of professional mechanical calculus and biofilm debridement, in combination with the modification of the contours of the implant-supported prosthesis, to improve the access for patient's biofilm control.

2.3 | Study population

At baseline, this treatment arm comprised 24 patients and 72 implants, selected among those attending the Department of Periodontology at Universitat Internacional de Catalunya (Sant Cugat del Vallés, Barcelona, Spain). To be included in the study, patients had to exhibit an implant with peri-implant mucositis (identified by the presence of bleeding on gentle probing and no bone loss in comparison with previous radiographs, in case of missing record, <2 mm of bone loss was required), an inappropriate fixed-prosthesis design resulting in difficult access to oral hygiene, presence of >1 mm of keratinized peri-implant mucosa, and a good level of oral hygiene (plaque index < 25%) (O'Leary et al., 1972).

Patients with untreated periodontal conditions, pregnant or lactating women, and patients who received systemic antibiotics or treatment of mucositis in the past 3 months were excluded from the study, as well as those receiving corticoids or medication known to have effect on gingival growth (i.e., calcium channel antagonists, immunosuppressants, or antiepileptic drugs).

Non-surgical mechanical instrumentation was performed combined with the modification of the implant-supported prosthesis, with the goal of improving access of oral hygiene devices to the implant sulcus. The characteristics of the initial sample, procedures, and 6 months outcomes have been described in detail in the previous publication (de Tapia et al., 2019).

2.4 | Treatment

After the conclusion of the RCT, 6 months after treatment, all patients and implants were introduced into a supportive periodontal and peri-implant care (SPIC) programme. Individual periodontal risk assessment was performed according to Lang and Tonetti (2003) for each patient, and the ideal recall interval for SPIC was defined. Those patients with high risk profile were scheduled every 3 months, those with a medium risk every 4 months, whereas those with a low risk profile were programmed every 6 months. Furthermore, if peri-implant mucositis was detected, a reinforcement in oral hygiene instruction in that area was performed and a 3–4-month SPIC interval was scheduled regarding the severity of peri-implant mucositis, which was assessed considering modified bleeding index (mBI). So those patients initially scheduled under longer intervals but exhibiting peri-implant mucositis with mBI = 1 were programmed every 4 months, whereas those with mBI = 2 or 3 were scheduled every 3 months. The professionally administered component of the SPIC programme was regularly performed by students in the Postgraduate programme in Periodontology and consisted of mechanical non-surgical debridement of the implant surfaces using a combination of an ultrasonic device (DTE-D5, Woodpecker®) with a plastic tip (Hu-Friedy®), and plastic curettes (Hu-Friedy®). Finally, the prosthetic components were polished with a rubber cup.

2.5 | Clinical and radiographic examinations

Patients were evaluated 30 months after the modification of the implant-supported prosthesis, 24 months after the conclusion of the initial RCT at 6 months of follow-up. The evaluations were performed by the same investigator (M.B.), who was previously calibrated with the examiner responsible for recording data at baseline and at the 6-month follow-up visit (B.d.T.). All clinical variables were recorded using an electronic pressure-calibrated periodontal probe (Pa-On probe®, Orange Dental, Biberach, Germany) with a standardized probing pressure of 20 N/mm^2.

At the full-mouth level, the following parameters were evaluated:

1. Full-mouth plaque index (FMPI), assessed at four sites per tooth (mesial, buccal, distal, and lingual).
2. Full-mouth bleeding index (FMBI), assessed as the presence or absence of bleeding after 30 s of gently probing (Ainamo & Bay, 1975).
3. Full-mouth probing depth, measured at six sites around each tooth, except third molars.

At the implant level, the following clinical variables were recorded at six sites around each implant:

1. Modified plaque index (mPI) (Mombelli et al., 1987).
2. mBI (Mombelli et al., 1987).
3. Implant bleeding on probing (BOPi), assessed dichotomously as the presence or absence of bleeding within 30 s after probing.
4. Implant suppuration on probing (SUPi), assessed dichotomously as the presence or absence of suppuration within 30 s after probing.
5. Peri-implant probing depth (PDi), measured from the mucosal margin to the bottom of the probable peri-implant sulcus.
6. Peri-implant mucosal recession, measured from the implant neck to the mucosal margin.

To improve reproducibility of the measurements, individual acrylic resin occlusal stents, exhibiting six vertical grooves per implant (mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual, and distolingual), were used (Figure 1).

Additionally, the following data were registered at the patient level:

1. Previous history of periodontitis (considered when clinical attachment loss is detectable at ≥2 non-adjacent teeth or when buccal clinical attachment loss ≥3 mm with pocketing is detectable at ≥2 teeth) (Tonetti et al., 2018) and, if so, patients were classified as being a successfully treated periodontal patient (Chapple et al., 2018).

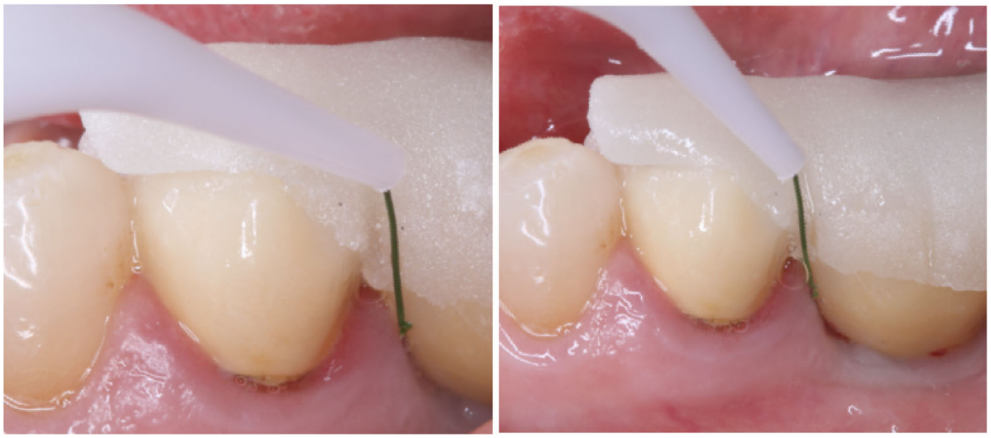

FIGURE 1 Clinical evaluation using an individual acrylic resin occlusal stent and electronic pressure-calibrated periodontal probe [Colour figure can be viewed at wileyonlinelibrary.com]

2. Total number of implants.
3. Attendance at SPIC visits. Patients were classified as compliers, partial compliers (when attendance was delayed by 2 or more months in relation to the suggested recall interval), and non-compliers (when the patient did not return for SPIC visits).
4. Smoking habit: patients were considered as light smokers if their consumption was <10 cigarettes per day and as heavy smokers if their consumption was >10 cigarettes a day.
5. Use of new medications known to have an effect on gingival growth (i.e., calcium channel antagonists, immunosuppressants, or antiepileptic drugs).
6. Presence of new-onset systemic disease.

At the implant level, the following information was recorded:

1. Presence or absence of intermediate abutment.
2. Type of implant connection, categorized as:
   a. internal connection;
   b. external connection;
   c. platform switching: presence of an abutment with a smaller diameter than the implant platform diameter;
   d. tissue level implants with a polished implant neck locating the implant–prosthesis connection at the mucosal level.
3. Implant position: implants were categorized as anterior, in canine or incisor position, or as posterior, in premolar and molar locations.
4. Regular use of inter-dental brushes: defined by, at least, one usage per day, plus ability of the patient to reach the implant neck properly.

In addition, a periapical radiograph of all studied implants involved in the study was taken using a long-cone paralleling technique and a film-holder (7 mA–60 kV/20 ms), in order to detect any loss of supporting bone, compared with the baseline records.

2.6 | Data and statistical analysis

The analysis was carried out at patient and implant levels. Qualitative variables were expressed as absolute frequencies and percentages, while for quantitative variables we used the mean, SD, median, and quartiles. The Kolmogorov–Smirnov test was used to assess the normality of distributions. To evaluate the performance of the treatment protocol, a per protocol analysis assessing the pre-post differences with the Wilcoxon test was used. An adjusted linear regression model was used to identify factors influencing the level of mucosal inflammation at 30 months, assessed by mBI values.

Sociodemographic and clinical variables at the end of follow-up were included as independent factors. Although BOPi was the primary outcome used for sample size calculation in the original RCT, mBI was selected for the analysis of the performance of the proposed treatment protocol, since it better captures the changes in the inflammatory condition in the peri-implant tissues.

To test the intra-examiner and inter-examiner agreement, PDi and mBI at six sites per implant (mesiobuccal, buccal, distobuccal, mesiolingual, lingual, and distolingual) were assessed around five implants not involved in the study by both examiners. This evaluation was repeated after 48 h and the intra-class correlation coefficients (ICC) were generated.

For all the tests, p values <.05 were considered statistically significant. The statistical package R Studio (2.5) was used for the statistical analyses.

3 | RESULTS

1. Intra- and inter-examiner reproducibility.
   ICCs for intra-examiner reproducibility were 0.87 (95% CI: 0.63–0.98, SE = 0.16) for PDi, and 0.84 (95% CI: 0.21–0.98, SE = 0.21) for mBI. ICCs for inter-examiner reproducibility were 0.86 (95% CI: 0.43–0.94, SE = 0.16) for PDi and 0.85 (95% CI: 0.28–0.98, SE = 0.19) for mBI.
2. Description of the patient sample.
   Initially, 24 patients were included in the test group (de Tapia et al., 2019) and completed the 6-month evaluation. These patients were then contacted by phone to return for the 30-month re-evaluation. One of the patients could not be reached, two refused to return adducing COVID-19 related reasons (illness or

TABLE 1 Sociodemographic data and general characteristics of the patients and implants at the 30-month visit

	Patient level[a]	Implant level[a]
No. of patients	20	
No. of implants	3.18 (1.66)	61
Age (years)	58.84 (10.45)	
Gender		
Male	13 (65%)	
Female	7 (35%)	
New-onset disease	1 (5%) Prostate cancer	
Smoking habit		
Light smokers (%)	0%	
Type of restoration		
Single crown		7 (11.48%)
Fixed partial denture		48 (78.69%)
Full fixed ceramic denture		6 (9.84%)
Hybrid prosthesis		0 (0%)
History of periodontitis		
Yes	17 (85%)	56 (91.8%)
No	3 (15%)	5 (8.2%)
Compliance with maintenance		
Compliers	11 (55%)	39 (63.93%)
Partial compliers	9 (45%)	22 (36.07%)
Non-compliers	0 (0%)	0 (0%)
Intermediate abutment		
Yes		20 (32.79%)
No		41 (67.21%)
Type of implant connection		
Internal		39 (63.93%)
External		7 (11.48%)
Platform switching		9 (14.75%)
Transmucosal implants		6 (9.84%)
Implant position		
Anterior		6 (9.84%)
Posterior		55 (90.16%)
Regular use of inter-dental brush		
Yes	14 (70%)	40 (65.57%)
No	6 (30%)	21 (34.43%)

[a]All parameters are expressed as total number (%), except for number of implants and age, which are expressed as mean (SD).

TABLE 2 Clinical parameters at the patient and implant levels at the 30-month visit

Clinical parameters	Patient level[a]	Implant level[a]
FMPI	0.15 (0.09)	
FMBI	0.15 (0.08)	
FMPD (mm)	2.41 (0.27)	
mPI	0.43 (0.51)	0.49 (0.69)
mBI	0.22 (0.27)	0.23 (0.34)
BOPi (%)	10 (50%)	29 (26.85%)
SOPi (%)	0 (0%)	0 (0%)
PDi (mm)	3.09 (0.41)	3.08 (0.54)
MRi (mm)	0.19 (0.32)	0.20 (0.41)

Abbreviations: BOPi, implant bleeding on probing, yes or no; FMBI, full-mouth bleeding index (Ainamo & Bay, 1975); FMPD, full-mouth probing depth; mPI, modified plaque index (Mombelli et al., 1987); FMPI, full-mouth plaque index (O'Leary et al., 1972); mBI, modified bleeding index (Mombelli et al., 1987); MRi, mucosal recession of the implant; PDi, implant probing depth; SOPi, implant suppuration on probing.
[a]Values are expressed as mean (SD) except in the case of BOPi and SOP, which are total number (%).

awareness), and one did not want to continue the treatment. The remaining 20 patients were available for re-examination (Figure S1).

These 20 patients were evaluated with 61 implants included in the analysis. Mean number of implants per patient was 5.35 (SD = 2.98), whereas the mean number of implants included in the study, per patient, was 3.05 (SD = 1.88). Sixty-five percent of this sample were male with a mean age of 58.84 (SD = 10.45), ranging between 37 and 75 years. None of the patients were smokers. No patient reported the use of any new medication related to gingival health, and only one patient reported a significant change in their general health (prostate cancer under control). Most patients (85%) had a previous history of periodontitis and were under control, being considered as presenting health on a reduced periodontium. Seventeen of 20 patients (85%) were scheduled for SPIC initially every 4 months, of these, the interval was reduced to 3 months in three patients only in one occasion due to the severity of peri-implant mucositis (mBI) at that timepoint. The remaining three patients were initially scheduled every 6 months. One of them, after the first SPIC, was scheduled every 4 months throughout the whole study period. Fifty-five percent of the patients included in the study were considered compliers with their assigned SPIC, 45% as partial compliers, and 0% as non-compliers.

Most of the implants (n = 55) were located posteriorly (90.16%), being mostly part of a fixed partial denture (n = 48, 78.7%), while seven were single tooth replacements (11.5%) and six were part of a full fixed ceramic denture (9.84%). The type of implant connection was classified as internal in 63.93% of cases, external in 11.48%, platform switching in 14.75%, and transmucosal in 9.84%; in addition, 32.79% of the implants presented an intermediate abutment.

Inter-dental brushes were used regularly around 65.57% of the implants. Sociodemographic and general characteristics of the patients and implants are detailed in Table 1.

Initially (baseline visit of the RCT), the mean FMPI and FMBI were 0.22 (SD = 0.06) and 0.2 (SD = 0.08), respectively. However, 100% of patients presented BOPi, with a mean mBI of 1.45 (SD = 0.78), mean mPI of 1.13 (SD = 0.99), and mean PDi of 3.08 (SD = 0.90) mm. Five patients exhibited SUPi (25%).

TABLE 3 Mean changes in clinical parameters between the 6- and 30-month visits

Changes 6–30 months		*p* Value
FMPI	−0.07 (0.08)	**<.0001**
FMBI	−0.08 (0.02)	**.022**
FMPD	0.12 (0.28)	.101
mPI	0.24 (0.56)	.096
mBI	0.02 (0.44)	.419
BOPi	16.7%	1
SOPi	−4.0%	.746
PDi	0.07 (0.82)	.106

Note: Values are mean (SD) except in the case of BOPi and SOP, which are total number (%). Statistically significant differences ($p < .05$) within the same group between 6 and 30 months (total sample, control group, and treatment group) are shown in bold.
Abbreviations: BOPi, implant bleeding on probing, yes or no; FMBI, full-mouth bleeding index (Ainamo & Bay, 1975); FMPD, full-mouth probing depth; FMPI, full-mouth plaque index (O'Leary et al., 1972); mBI, modified bleeding index (Mombelli et al., 1987); mPI, modified plaque index (Mombelli et al., 1987); PDi, implant probing depth; SOP, implant suppuration on probing.

3. Clinical findings at the 30-month visit.
   Clinical outcomes at the patient and implant levels are presented in Table 2. At the full-mouth level, a mean FMPI of 0.15 (SD = 0.09) and a mean FMBI of 0.15 (SD = 0.08) were registered. In 50% of the patients and 42.62% of implants, BOPi was present. Of these patients exhibiting BOPi, four already presented inflammation in the 6-month follow-up visit, whereas six of them were considered healthy with no BOP at that timepoint. Three patients improved their status, going from being inflamed (positive BOPi) to being healthy, and seven patients maintained peri-implant tissue health during the whole study time. At the implant level, 12 implants presented BOPi at both the 6-month and at 30-month follow-up; 14 implants presented healthy peri-implant tissues after 6 months, but exhibited BOPi at the 30-month follow-up visit; seven implants improved their status and did not show BOPi at the last evaluation and 28 implants maintained peri-implant tissue health showing no BOPi, neither at 6-month nor at the 30-month evaluation. Mean mBI was 0.22 (SD = 0.27) and 0.23 (SD = 0.34) at the patient and implant levels, respectively. Mean mPI was 0.43 (SD = 0.51) and 0.49 (SD = 0.69) at the patient and implant levels, respectively. Similarly, mean PDi was 3.09 (SD = 0.41) and 3.08 (SD = 0.54), respectively. No SUPi was observed at this evaluation. No bone loss was detected for any of the implants evaluated.
4. Performance of the treatment protocol at the 30 months visit.
   Clinical changes between 6 and 30 months are provided in Table 3, whereas the mean values are shown in Table S1. The comparison of the obtained clinical outcomes between 6 and 30 months demonstrated at the full-mouth level a high degree of stability, with slight reductions in FMPI (from 0.21 [SD = 0.04] to 0.15 [SD = 0.08], $p = .022$) and FMBI (from 0.18 [SD = 0.05] to 0.15 [SD = 0.09], $p < .001$). Mucosal inflammation (mBI) also remained stable (mean difference of 0.02 [SD = 0.44], $p = .419$), although the number of patients with BOPi slightly increased from 8 to 10 patients, representing 50% of the sample. Furthermore, mPi increased by 0.24 (SD = 0.56, $p = .096$).
5. Factors influencing the clinical findings at the 30-month visit.
   Adjusted linear regression model at patient level demonstrated a statistically significant association between mBI and compliance with SPIC ($p = .006$), whereas no association was found with FMPI ($p = .206$), FMBI ($p = .472$), nor previous history of periodontitis ($p = .242$). At the implant level, significant associations were observed between mBI and both mPI and the regular use of the inter-proximal brushes ($p < .001$ and $p = .017$, respectively); meanwhile, no relationship could be found regarding PDi ($p = .456$), type of implants connection ($p = .623$), nor implant position in the arch ($p = .740$) (Table 4).

4 | DISCUSSION

The present study has investigated the performance of a treatment protocol for peri-implant mucositis based on a combination of mechanical debridement and the modification of the prosthesis to improve access to biofilm removal. Overall, this treatment was successful after 30 months since statistically significant improvements in the inflammatory parameters were observed. mBI changed from 1.45 (SD = 0.78) to 0.22 (SD = 0.27), $p < .001$ and mPI from 1.13 (SD = 0.99) to 0.43 (SD = 0.51), $p < .0001$. However, in 50% of the patients and 42.6% of the implants, there was still presence of BOPi after 30 months. These results are congruent with previous studies on the efficacy of peri-implant mucositis treatment, demonstrating significant improvements in the recorded clinical outcomes (Salvi et al., 2012; Zitzmann et al., 2001), but with limited achievement of disease resolution (Salvi & Ramseier, 2015), defined as absence of any site with BOPi in an implant previously diagnosed with peri-implant mucositis (Sanz et al., 2012).

Few studies have reported long-term results of peri-implant mucositis treatment. Pulcini et al. (2019) reported disease resolution in 50% of their patient sample at 12 months follow-up, while Fernandes-Costa et al. (2019) reported 41.98% of implants and 27.61% of patients showing BOPi after 54 months. These results are similar to those reported in the present study at 30 months (42.62% and 50% of BOPi at implant and patient levels, respectively). However, since BOPi is a dichotomized variable, being positive even with the presence of minimal bleeding in one site, the effect of tissue trauma or probing force cannot be fully discarded (Gerber et al., 2009). The presence of mucosal inflammation was also evaluated in the present study with the mBI, demonstrating that despite 50% of patients had BOPi, their mean mBI was only 0.22 (SD = 0.27), thus revealing that the degree of visual mucosal inflammation was low. There is a clear need of further investigations elucidating what degree of bleeding on gentle probing is clinically relevant and can be associated to peri-implant disease progression.

TABLE 4 Adjusted linear regression analysis of modified bleeding index at the patient and implant levels at the 30-month visit

	Beta	SE (beta)	95% CI, lower limit	95% CI, upper limit	*p* Value
Patient level					
(Intercept)	0.16	0.18	−0.22	0.55	.38
FMPI	1.58	1.19	−0.97	4.12	.206
FMBI	−1.04	1.42	−4.06	1.98	.472
SPIC compliance	−0.32	0.1	−0.54	−0.11	**.006**
History of periodontitis	0.17	0.14	−0.13	0.47	.242
Implant level					
(Intercept)	0.51	0.27	−0.04	1.05	.067
Regular use of inter-proximal brush	−0.22	0.09	−0.4	−0.04	.017
mPI	0.22	0.06	0.1	0.35	**<.005**
PDi	−0.05	0.07	−0.19	0.08	.456
Type of implant connection	−0.06	0.11	−0.28	0.17	.623
Implant position (posterior)	−0.04	0.12	−0.27	0.19	.740

Note: Statistically significance ($p < .05$) is shown in bold.
Abbreviations: CI, confidence interval; mPI, modified plaque index (Mombelli et al., 1987); PDi, implant probing depth; SPIC, supportive periodontal and peri-implant care (SPIC) visits.

Modification of the implant-supported prosthesis was a significant factor in the short-term efficacy of peri-implant mucositis treatment, when combined with mechanical debridement, as reported in the previous publication (de Tapia et al., 2019). In the present study, with 30 months of follow-up, peri-implant mucosal inflammation assessed by mBI remained low throughout the study (0.19 [SD = 0.32] and 0.22 [SD = 0.0.27] at 6 and 30 months, respectively), thus demonstrating stable results in the evaluated treatment protocol of peri-implant mucositis. However, it has to be mentioned that, when interpreting the BOPi results, a certain degree of fluctuation was observed, since 45% patients and 54% of the implants changed their status from the 6-month evaluation to the 30-month follow-up visit. Using mBI at 30 months as the dependent variable, the multivariable logistic regression model showed that compliance with the stipulated SPIC visits was significantly associated with lower mucosal inflammation. The importance of compliance with SPIC visits in the prevention of peri-implant diseases has also been observed in previous investigations. Roos-Jansaker et al. (2006) reported that patients not enrolled in regular SPIC exhibited higher levels of peri-implant mucositis, with a prevalence of 48% over an observation period of 9–14 years. Similarly, Costa et al. (2012) reported that peri-implant mucositis subjects not attending a preventive maintenance programme showed a higher incidence of peri-implantitis, 5 years later, and that risk increased in presence of BOPi, deeper probing depths, and in patients with concomitant periodontitis. A systematic review has concluded that the SPIC visit interval significantly influenced the incidence of peri-implant mucositis (Monje et al., 2016).

Although a history of periodontitis has previously been associated with a higher risk of developing peri-implant diseases (Berglundh et al., 2018; Derks & Tomasi, 2015; Lu et al., 2020), in this investigation history of periodontitis was not significantly associated with increased mBI. These results could be related to a high distribution of patients with a history of periodontitis in the present cohort. As well, it should be pointed out that these patients were enrolled in a stricter SPIC, albeit with a high degree of compliance and oral hygiene. In fact, the proper and frequent use of inter-dental brushes was significantly associated with lower values of both mBI and mPI. These results are also congruent with those recently reported in a cross-sectional study, where inter-dental brushing/flossing was observed to have a protective effect against the development of peri-implant diseases, with an odds ratio of 0.27 (95% CI: 0.11–0.68) (Romandini et al., 2021). These results, therefore, corroborate the ideal scenario for providing stable long-term results after the treatment of peri-implant mucositis based on high motivated patients demonstrating low peri-implant plaque levels and a high compliance in the customized SPIC programme (Slot et al., 2020).

The results from this prospective case series, however, must be interpreted with caution, due to the lack of a control group in the long-term follow-up and the relatively small sample size evaluated. In addition, it should be considered that clinical measurements were registered with the prosthesis in place, which could potentially have led to underestimation or inaccurate data.

5 | CONCLUSIONS

In light of the present results, and considering the study limitations, it can be concluded that the prosthesis modification to ensure proper access for oral hygiene when needed, in conjunction with a non-surgical approach, appears to be an adequate treatment to promote stable results at 30 months, in terms of mBI, in the treatment of peri-implant mucositis, even though some degree of fluctuation of BOPi in some patients/implants was observed. Additional factors for treatment success include compliance with the stipulated SPIC protocol and regular use of inter-dental brushes.

AUTHOR CONTRIBUTIONS

Beatriz de Tapia, Cristina Valles and José Nart conceived the idea. Beatriz de Tapia designed the methodology which was critically reviewed by David Herrera and Mariano Sanz. Carla Mozas performed the initial treatment and Maria Bonnin collected the follow-up data. Beatriz de Tapia supervised the data collection, interpreted the data, and led the manuscript drafting supported by David Herrera and Mariano Sanz.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest related to the content of this manuscript.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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