

Surgical treatment of circumferential and semicircumferential defects due to periimplantitis: A prospective case series cohort study

Abstract

Objective

Different surgical treatment strategies for periimplantitis using graft material and membranes have been suggested. However, in these, the microbiological aspects of the periimplant environment were underestimated. The present preliminary study was aimed at analyzing a new clinical approach based on disinfection of the implant connection and of the implant surface, as well as the use of only a self-stabilizing graft material in the treatment of circumferential and semicircumferential bony defects resulting from periimplantitis.

Materials and methods

Ten consecutive patients were selected for the present study. After removal of factors that may potentially have influenced the periimplant pathology, the prosthesis was removed and a full-thickness flap was elevated to allow access to the periimplant defect and the exposed implant surface. Once the defect had been degranulated and the implant surface cleaned, bone powder was used to cover the surface. A resorbable, self-stabilizing material (GUIDOR easy-graft CLASSIC, Sunstar Suisse, Étoy, Switzerland) composed of calcium phosphate particles coated with a thin layer of PLGA was used to fill the defect. No membranes were used and the flaps were closed for a submerged healing. Two months thereafter, a new reopening procedure was performed and the cleaned superstructures and crowns were repositioned. The patients were followed for 12 months thereafter and recalled for customized oral hygiene every three months. Radiographic and periodontal analysis were performed preoperatively and every six months postoperatively. Microbiological analysis was performed preoperatively and at the last follow-up. Three types of sites in each patient were analyzed: (a) the periimplant sulcus of each implant; (b) the gingival sulci of the neighboring teeth; and (c) the connection's inside and the abutment surface of each implant. The presence of ten common periodontal pathogens was measured.

Results

The procedure studied was associated with a pronounced increase in mucosal recession and clinical attachment level with stable periimplant conditions at six and 12 months. Plaque index, bleeding on probing and probing depth values were significantly reduced at six and 12 months.

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Radiographic analysis demonstrated a complete or semicomplete filling of the defect in all of the cases, with a significant bone gain at six and 12 months. Microbiological analysis, in terms of total bacterial count and single pathogens, demonstrated a significant decrease of microbiological contamination in all of the test sites between baseline and the 12 months follow-up: at the sulcus, the neighboring teeth and the connection.

Conclusion

Within the limitations of the present preliminary study, the proposed technique, in combination with a self-stabilizing graft material, offers promising results for the treatment of circumferential and semicircumferential bone defects around implants affected by periimplantitis, without the use of a membrane.

Keywords

Periimplantitis, periimplant disease, surgical treatment, graft material.

Introduction

Different treatment strategies for periimplantitis have been suggested.¹⁻³ Despite the unesthetic outcomes, the resective approach was considered the only longitudinally effective strategy.⁴ However, nonsurgical (which basically consisted of simple subgingival mechanical debridement with or without systemic or local anti-infective agent delivery) and regenerative approaches were considered ineffective.⁵ In fact, despite some positive short-term outcomes that have been reported in many studies,^{3, 6} absence of resolution, as well as progression or recurrence after treatment of disease, leading to the loss of implant, were also highlighted.⁵ According to Graziani et al., current literature on periimplant disease prevention and treatment does not provide applicable clinical information.⁷ In fact, the lack of efficacy of the current methods for treating periimplantitis may be due to insufficient understanding of the entire biological etiology of the disease. Therapy concepts for periodontitis have been directly transferred to periimplant disease treatments, neglecting the differences between teeth and implants that may be highly relevant to periimplantitis treatment concepts. In fact, since implant surface and topology differ dramatically on the micro- and macrolevel from tooth structure and shape, conventional bacterial removal and debridement cannot be effective on implants.⁸ At the same time, since implants always present the opportunity for bacterial contamination at the implant-abutment junction,

often positioned at the bone level,⁹ guided bone regeneration techniques or regenerative procedures cannot be successful (at least in the long run) owing to the recontamination of the site through the implant-abutment junction. An additional reason for low surgical outcomes might be the misunderstanding of triggering conditions for the implant disintegration process. In fact, according to Sanz and Chapple, the use of unequivocal case definitions would help in increasing the quality of research on this topic.¹⁰ As it is easy to understand, differences in periimplant environment (soft- and hard-tissue conditions, 3-D implant positioning, triggering factor of disease) could completely change the prognosis and give rise to different treatment plans. However, one of the most important factors affecting surgical outcomes, particularly in the case of regenerative procedures, appears to be the selection of patients, especially as regards the shape of the bone defect.⁶ In fact, self-containing or three-wall bone defects demonstrated a higher clinical and radiographic improvement in terms of bone regeneration.⁶

Circumferential and semicircumferential intrabony defects displayed promising outcomes when treated with the application of a particulate bone material stabilized with a collagen membrane.^{3, 6} Besides loose particulate bone materials, alloplastic biomaterials designed to harden *in situ* are commonly used in dental indications.¹¹ These resorbable materials (GUIDOR easy-graft CLASSIC, Sunstar Suisse, Étoy, Switzerland) are composed of calcium phosphate particles coated

with a thin layer of PLGA, enhancing the material handling and forming a stable scaffold for regeneration within the defect site. This *in situ* hardening PLGA-coated biomaterial has been proven to provide excellent soft-tissue healing after socket grafting and equivalent performance in terms of new bone formation has been found,¹² comparable to the results reported for other bovine and synthetic biomaterials.¹³ The aim of the present preliminary prospective study was to test the outcome of a surgical approach to treating periimplant circumferential and semi-circumferential defects using only a self-stabilizing graft material.

Materials and methods

In January 2013, at the Department of Oral Surgery, University of Valencia, Valencia, Spain, a preliminary prospective clinical trial was designed to test the efficacy of a self-stabilizing graft material in the treatment of bony defects resulting from periimplantitis. Only those patients who had received implant therapy at the Department of Stomatology in the past, had a good-quality periapical baseline radiograph obtained after prosthetic rehabilitation, attended control visits, were older than 18 years, and presented with a circumferential or semicircumferential periimplant bony defect were included in the study.⁶ Exclusion criteria were relevant medical conditions (American Society of Anesthesiologists Physical Status Class III or IV), > 10 cigarettes/day or pipe or cigar smokers, plaque index and bleeding on probing scores > 25%, pregnant or lactating patients, and patients with a history of bisphosphonate therapy (**Fig. 1**).

The patients were informed about the study and the intervention and asked to sign an informed consent document in order to be involved. The investigation was conducted according to the principles embodied in the Declaration of Helsinki of 1975, as revised in 2013. All of the procedures and materials in the present prospective study were approved by the local ethics committee of the University of Valencia (H1447757419931).

Preoperative phase

Factors possibly influencing the periimplant pathology were evaluated and problems solved before the surgical phase. This included occlusal adjustment, modification or change of poorly

designed prostheses, and periodontal treatment when necessary. Two weeks prior to the surgical therapy, all of the patients received professional prophylaxis (total oral district disinfection) and 0.12% chlorhexidine digluconate (rinsing b.i.d.; GUM Paroex 0.12%, Sunstar Suisse) was prescribed. Antibiotic treatment consisting of amoxicillin 850 mg and clavulanate 125 mg every 8 h was administered to all of the patients, starting two days before the surgical treatment and ending one week after the intervention.

Surgical phase

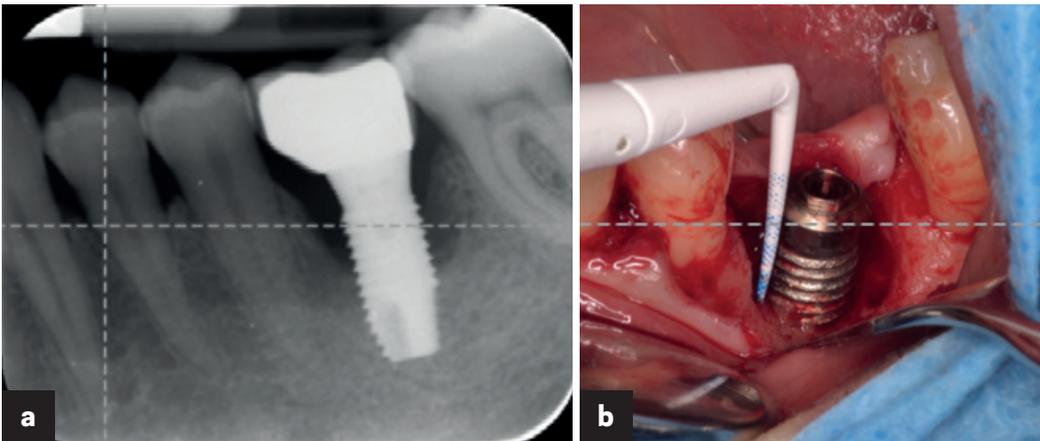
The surgical intervention was performed under local anesthesia with 4% articaine and 1:100,000 epinephrine (Laboratorios Inibsa, Barcelona, Spain). The prosthesis was removed and a full-thickness flap was elevated to allow access to the periimplant defect and the exposed implant surface.

Once the granulation tissue had been removed, the implant surface was mechanically debrided using PTFE curettes and further cleaned with a cotton pellet soaked in 0.2% chlorhexidine digluconate. The inside of the implant connection was cleaned using 0.2% chlorhexidine (GUM Paroex 0.2%, Sunstar Suisse). Perforations were performed to increase blood supply to the remaining bone and the periimplant bone defects were filled using a double-layer graft:¹⁷ autologous bone on the implant surface (collected from a neighboring area using scrapers) and an alloplastic, resorbable bone graft substitute consisting of 100% beta-tricalcium phosphate (GUIDOR easy-graft CLASSIC) to fill the remaining gap and act as a stabilizing shell, that is, a tent-like structure. After defect filling, cover screws were inserted. Tensionless soft-tissue closure of the flap was performed with a 5-0 suture (**Fig. 2**). Sutures were removed two weeks after the intervention. Abutments and prostheses were cleaned according to Canullo et al. using ultrasound and an extraoral argon plasma device (Plasma R, Diener Electronic, Jettingen, Germany).¹⁴ One to two months thereafter, the cleaned prosthetic components were reinserted after microsurgical reopening.

Follow-up and maintenance

Before suture removal, the patients were advised to discontinue toothbrushing and to avoid trauma at the site of surgery. After the healing phase, the patients were placed on an individually tailored

Figs. 1a & b



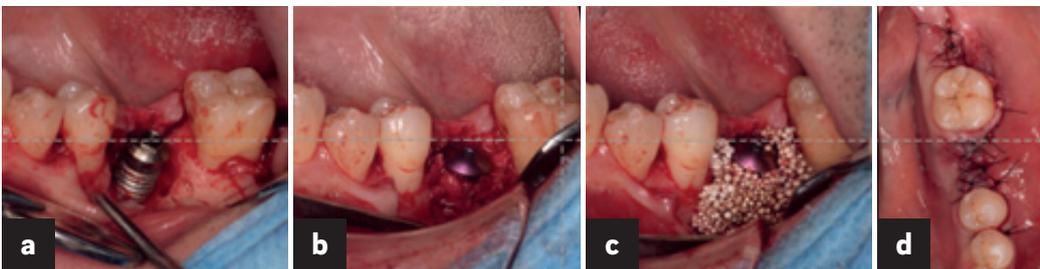
Figs. 1a & b

Preoperative radiograph and (b) intraoperative measurement of the bony defect.

Figs. 2a–d

Surgical phases: (a) degranulation of the defect, (b) autogenous bone graft apposition, (c) easy-graft apposition and (d) primary intention flap suturing.

Figs. 2a–d



maintenance care program. Motivation, reinforcement of oral hygiene instruction, supragingival instrumentation and antiseptic therapy were performed as needed. All of the patients were subsequently recalled every three months for data collection and maintenance therapy. Nonsurgical treatment with ultrasound plastic instruments and air polishing and erythritol powder was repeated every three months throughout the entire follow-up period (**Fig. 3**).

Clinical analysis

All of the clinical analysis were performed by a single trained clinician using a predefined standard protocol. The following clinical variables were assessed at six and 12 months with the aid of a periodontal probe with a millimeter scale (Hawe Neos Probe 1395, Hawe, London, U.K.):

- plaque index;
- bleeding on probing, evaluated as present if bleeding was evident within 30 s after probing or absent if no bleeding was observed within 30 s after probing;
- probing depth, measured from the mucosal margin to the bottom of the examined pocket;
- mucosal recession, measured from the implant shoulder or restoration margin to the mucosal margin; and

- clinical attachment level, measured from the implant neck to the deepest point of the periimplant pocket.

Probing depth, mucosal recession and clinical attachment level scores were recorded to the nearest millimeter at six aspects per implant.

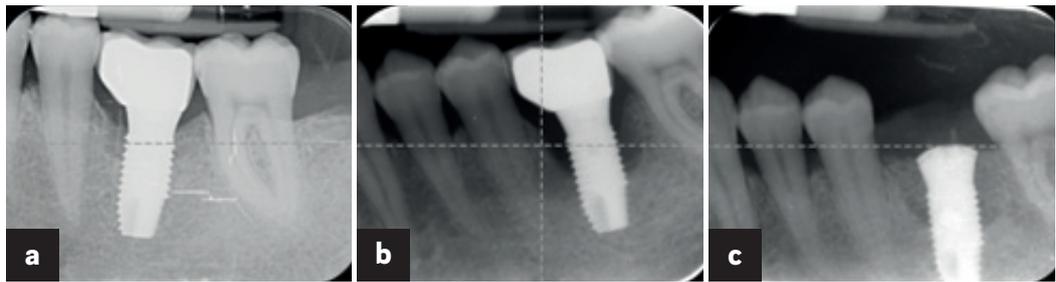
Radiographic analysis

Radiographic changes (bone gain or loss) were evaluated using periapical radiographs obtained at baseline and at six and 12 months using paralleling rings and silicone bites to reproduce the exact film position. Periimplant marginal bone changes were evaluated with a computerized measuring technique applied to digital radiographs.

The distance from the mesial and distal margin of the implant neck to the most coronal point where the bone appeared to be in contact with the implant was measured. Evaluation of the marginal bone level around the implants was performed using image analysis software (Scion Image for Windows, Version 4.02, Scion Corp., Frederick, Md., U.S.) able to compensate for radiographic distortion. The software calculated bone remodeling at the mesial and distal aspects of the implants. The mean of both values was used.

Figs. 3a–c

Radiographic sequence of the site at the time of periimplantitis detection and at the time of surgery.



Figs. 3a–c

Microbiological analysis

Sampling for microbiological analysis was performed by a single researcher. Samples were obtained from three types of sites in each patient: (a) the periimplant sulcus of each implant; (b) the gingival sulcus of the neighboring teeth; and (c) the connection's inside and the abutment surface of each implant.

Samples were obtained before the cleaning procedures and 12 months after treatment. Sampling was performed using the GUIDOR Perio-Implant Diagnostic Kit (Sunstar Iberia, Barcelona, Spain; provided by Institut Clinident, Aix-en-Provence, France), consisting of five sterile absorbent paper tips and an empty sterile 2 mL Eppendorf tube. Prior to subgingival plaque sampling, supragingival plaque was eliminated from the implants and teeth using a curette or cotton roll, without penetrating the gingival or periimplant sulcus. Cotton rolls were used for relative isolation and the sampling sites were dried with a pistol. The paper tips were inserted into the gingival or periimplant sulcus for 30 s.

One drop of RNA- and DNA-free water (Water Molecular Biology Reagent, code W4502, Sigma-Aldrich, St. Louis, Mo., U.S.) was placed inside the implant connection and the paper tips were inserted for 30 s. Quantitative real-time polymerase chain reaction (PCR) assays were carried out for total bacterial count and for ten pathogens at Institut Clinident: *Aggregatibacter actinomycetemcomitans* (Aa), *Porphyromonas gingivalis* (Pg), *Tannerella forsythia* (Tf), *Treponema denticola* (Td), *Prevotella intermedia* (Pi), *Peptostreptococcus micros* (Pm), *Fusobacterium nucleatum* (Fn), *Campylobacter rectus* (Cr), *Eikenella corrodens* (Ec) and *Candida albicans* (Ca).

Quantitative real-time PCR assays was performed in a volume of 10 μ L composed of 1 \times QuantiFast SYBR Green PCR (Qiagen, Berlin, Germany), 2 μ L of DNA extract and 1 μ M of each primer. The species-specific PCR primers (Metabion, Martinsried, Germany) used in this study were provided by Institut Clinident. The bacte-

rial primers used were derived from previously published ribosomal 16S ribosomal RNA sequences^{15, 16} and were adapted to the real-time PCR conditions. The Ca primers used in this study were derived from 18S/28S ribosomal RNA sequences.

Assays were carried out on the Rotor-Gene Q thermal cycling system (Qiagen) with the following program: 95 °C for 5 min, followed by 40 cycles of 10 s at 95 °C, 10 s at 60 °C, and 35 s at 72 °C. A final melting curve analysis (70–95 °C in 1 °C steps for 5 s increments) was performed. Fluorescence signals were measured every cycle at the end of the extension step and continuously during the melting curve analysis. The resulting data were analyzed using Rotor-Gene Q Series Software (Qiagen).

Serial dilutions of bacterial standard DNA, provided by Institut Clinident, were used in each reaction as external standards for absolute quantification of the targeted bacterial pathogens. Standard bacterial strains used for standard DNA production were obtained from the DSMZ (Braunschweig, Germany), the Collection of Institut Pasteur (Paris, France) and from the BCCM/LMG Bacteria Collection (Ghent, Belgium): Aa (DSM No. 8324), Pg (DSM No. 20709), Tf (CIP No. 105220), Td (DSM No. 14222), Pi (DSM No. 20706), Pm (DSM No. 20468), Fn (DSM No. 20482), Cr (LMG No. 18530) and Ec (DSM No. 8340). A Ca standard DNA (DSM No. 6659) was also used as external standard for identification and semiquantification.

Statistical analysis

The statistical analysis was performed using a commercially available software program (IBM SPSS Statistics for Windows, Version 20.0, IBM Corp., Armonk, N.Y., U.S.). Mean values and standard deviations were calculated for each variable using the implant as the statistical unit. The data rows were examined with the Kolmogorov–Smirnov test and proven to be normally distributed. For the statistical evaluation of the chang-

Table 1

	Baseline	6-month follow-up	12-month follow-up	P-value [†]
Plaque index	0.36 ± 0.61	0.06 ± 0.02	0.00 ± 0.00	0.003
Bleeding on probing (%)	81.10 ± 12.40	21.09 ± 19.20	20.20 ± 16.80	0.000
Probing depth (mm)	7.2 ± 1.8	3.1 ± 1.2	3.3 ± 1.1	0.000
Mucosal recession (mm)	0.65 ± 0.51	-0.40 ± 0.20	-0.30 ± 0.20	0.002
Clinical attachment level (mm)	7.8 ± 1.8	3.5 ± 1.4	3.6 ± 1.7	0.003
Radiographic bone loss (mm)	4.2 ± 0.9	1.8 ± 0.6	1.7 ± 0.7	0.040

[†] Comparison within group (paired *t*-test)

es over time, the paired *t*-test was used. The α error was set at 0.05.

Results

Ten patients were included in the study. A total of 13 implants were treated. During the entire observation period of 12 months, two patients failed to attend the scheduled recall sessions and, therefore, were excluded from the study. No patient reported any sign of swelling or pain two weeks after the surgery. The clinical and radiographic data are summarized in **Table 1**. Essentially, mean probing depth values were significantly reduced by 4.1 mm and 3.9 mm at six and 12 months, respectively. The surgical procedure was associated with a pronounced increase in mucosal recession and clinical attachment level; however, stable periimplant conditions at six and 12 months were reported. Mean bleeding on probing values were significantly reduced at six and 12 months. Before treatment, pus was present around four implants. At the end of the observation period, the tissue around the implants was in a healthy condition.

All of the patients presented with low plaque index values throughout the entire observation period. Radiographic analysis demonstrated a complete or semicomplete filling of the defect in all of the cases, with a significant bone gain at six and 12 months (**Fig. 4**). Microbiological analysis, in terms of total bacterial count and single pathogens, demonstrated a significant decrease of microbiological contamination in all of the test sites between baseline and the 12 months follow-up: at the sulcus, the neighboring teeth and the connection. The data are summarized in **Table 2**.

Discussion

The data reported in the present study showed a good short-term resolution of periimplantitis defects using the proposed surgical approach and concomitant dental hygienic treatment. The graft material proposed is self-stabilizing in the defect, which might suggest that the use of a membrane with the bone graft substitute can be omitted. This feature helped to stabilize the bone graft substitute *in situ* in a tentlike structure over the autologous bone in a double-layer graft technique, thereby providing and protecting space for bone regeneration around the dental implant. Application of autogenous bone to the implant surface below the biomaterial might increase the osteopromotive capability of the technique as reported before.¹⁷

In the present study, no barrier membrane was used in addition to the bone graft substitute. This was due to the previously mentioned qualities of the tested graft material. The presence of a collagen membrane might additionally prevent the invasion of connective tissue into the grafted site, but it does not provide any additional stabilization of the bone graft substitute. It must be noted, however, that the coverage with the intact periosteum might protect the graft material, allowing bone promotive cell diffusion into the grafted site.¹⁸ For this reason, in this preliminary study, preoperative marginal soft-tissue healing through professional oral hygiene (scaling) was achieved, applied by dental hygienists to resolve periimplant mucositis before treatment. Additionally, accurate soft-tissue management during the surgical phase was provided to minimize periosteum deficiencies.

Table 1

Clinical parameters (mean ± standard deviation) at baseline and at six months and 12 months (13 implants).



Figs. 4a-c

Sites preop	Total count	Aa	Pg	Tf	Td	Pi	Pm	Fn	Cr	Ec	Ca
Periimplant sulcus	137.000	0 ± 0	36.3000 ± 31.6000	0.3230 ± 0.1670	0.0524 ± 0.0232	4.1200 ± 1.9200	0.041500 ± 0.009800	3.4100000 ± 1.0800000	0.4404 ± 0.209	0.2630 ± 0.0870	0.00 ± 0.38
Neighboring teeth	885.000	0 ± 0	0.0212 ± 0.0121	0.0340 ± 0.0167	0.0000 ± 0.6200	2.1500 ± 0.9500	0.704000 ± 0.056900	0.4610000 ± 0.2160000	2.000 ± 0.780	2.4200 ± 1.0100	0.00 ± 0.04
Connection	9600.000	0 ± 0	0.0139 ± 0.0098	175.0000 ± 67.0000	18.3000 ± 7.0900	1.4200 ± 3.2000	9.900000 ± 4.320000	114.0000000 ± 56.2000000	40.300 ± 11.900	188.0000 ± 67.7000	0.00 ± 0.79
Sites postop											
Periimplant sulcus	2.565	0 ± 0	0.0000 ± 0.2600	0.2730 ± 0.0840	0.0000 ± 0.9000	0.0096 ± 0.000	0.001778 ± 0.000000	0.0034430 ± 0.0000000	0.000 ± 0.003	0.0000 ± 0.0023	0.00 ± 0.00
Neighboring teeth	20.200	0 ± 0	0.0000 ± 0.0900	0.0000 ± 0.2300	0.0000 ± 0.2100	0.0250 ± 0.0300	0.079500 ± 0.020000	0.0043900 ± 0.0000000	0.000 ± 0.021	0.2160 ± 0.0540	0.00 ± 0.00
Connection	2.872	0 ± 0	0.0000 ± 0.1100	0.0000 ± 0.1200	0.0000 ± 0.9800	0.0000 ± 0.2800	0.001095 ± 0.000000	0.0018225 ± 0.0000000	0.000 ± 0.000	0.000 ± 0.0030	0.00 ± 0.00
P-value											
Periimplant sulcus	0.0000	1	0.0000	0.0021	0.0011	0.000	0.0001	0.0000	0.0001	0.0024	0.897
Neighboring teeth	0.0000	1	0.0000	0.0000	0.8970	0.000	0.0000	0.0002	0.0000	0.0000	0.912
Connection	0.0001	1	0.0001	0.0000	0.0000	0.000	0.0000	0.0000	0.0000	0.0000	0.563

Table 2

Figs. 4a-c
Clinical (occlusal and lateral) and radiographic view at the 12-month follow-up.

Table 2
Bacteria counts at different sites (values expressed in millions of colony-forming units).

Regarding the microbiological environment at the periimplant sulcus and neighboring teeth, a significant decrease of the bacterial load in terms of total count and single pathogens was observed. At the same time, these data corroborated a significant decrease of the clinical parameters indicative of a reduction of the periimplantitis. The data suggest that a preoperative full-mouth prophylaxis, a tailored program of maintenance, recall and reinforcement of home care, represents a prerequisite for successful soft- and hard-tissue healing. In fact, while preoperative oral district disinfection might be involved in the most considerable improvement of microbiological contamination (essential for a good surgical plan), a tailored program of oral hygiene might represent an essential criterion for the longitudinal maintenance of the periimplant soft- and

hard-tissue during healing. As documented by Renvert and Polyzois and Serino et al., decreasing of home maintenance might compromise the clinically achieved outcomes in the mid-term.^{19,4}

In the analysis of the bacterial contamination at the implant connection level, a statistically significant decrease of the total account was detected during the study. However, all of the connections still demonstrated a bacteriologically polluted environment until the end of the follow-up period. It could be speculated that more effective bacterial control at the implant connection level and in the periimplant sulcus would allow for longer protection of the defect site from the disruptive effects of bacterial presence. For this reason, a different technique providing decontamination and, therefore, maintenance of the condition might be suggested. In fact, as

documented by Paolantonio et al., chlorhexidine was demonstrated to maintain the implant connection decontamination for a period shorter than six months.²⁰

Limitations of the present study clearly relate to the study design itself: The short follow-up period and small sample size suggested to carefully handle the even promising reported outcomes. A further limitation is that only less challenging bone defects were included in this preliminary study; hence, the regenerative outcomes should be considered in light of this.

For this study, only contained circumferential or semicircumferential defects were included that represented the most predictive defect shape, as documented by Schwarz et al., compared with two- or one-wall bone defects.⁶ According to the literature, despite profuse efforts, massive soft-tissue shrinkage has been reported.⁶ For this reason, new surgical techniques should be applied to counteract this phenomenon. For this purpose, as suggested by Schwarz

et al., the use of a connective tissue graft might be effective in controlling soft-tissue architecture if adapted over the regenerated site.²¹ In addition, a new flap design, as reported by Zucchelli and Mounssif, might represent an alternative strategy.²² Furthermore, a study with a longer follow-up, larger sample size and different defect types should be designed to corroborate the findings of the present study. However, it can be concluded that, within the limitations of the present preliminary study, the proposed technique, in combination with a self-stabilizing graft material, offers promising results in the treatment of circumferential and semicircumferential bone defects around implants affected by periimplantitis, without the use of a barrier membrane.

Competing interests

The authors declare that they have no competing interests.

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