RECONSTRUCTIVE TREATMENT OF PERI-IMPLANTITIS INFRABONY DEFECTS OF VARIOUS CONFIGURATIONS: 5-YEAR RESULTS FROM A PROSPECTIVE STUDY.

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ABSTRACT

Aim: To present the 5-year outcomes of a reconstructive surgical protocol for peri-implantitis defects with different morphologies, by means of deproteinized bovine bone mineral with 10% collagen (DBBMC).

Material and Methods: The original population of this case-series consisted of 75 patients with one crater-like defect and probing depth (PD) ≥ 6 mm. After flap elevation, defects were assigned to one characteristic class and treated by means of DBBMC. Following healing, patients were enrolled in an individualized supportive periodontal/peri-implant (SPT) program.

Results: Fifty-one patients reached the 5-year examination, as 11 patients were lost to follow-up and 13 implants were removed. Overall treatment success was registered in 29 patients (45.3%). Mean PD and BOP significantly decreased at one year and remained stable for the rest of observation period. No correlation was found between implant survival rate and defect configuration (p=0.213). Patients, who did not fully adhere to the SPT, experienced more complications and implant loss than those who regularly attended recall appointments (p=0.009).

Conclusions: The proposed reconstructive treatment resulted in a high 5-year implant survival rate in patients who fully adhered to SPT. The resolution of the peri-implantitis defect does not seem significantly associated with the defect configuration at the time of treatment.

INTRODUCTION

Peri-implantitis is a plaque-associated pathological condition occurring in tissues around dental implants, characterized by inflammation in the peri-implant mucosa and subsequent progressive loss of supporting bone (Berglundh et al., 2018). Its prevalence has been largely evaluated in recent population cross-sectional studies (Romandini et al., 2019; Romandini et al., 2021). Non-surgical approaches appear to be ineffective for the resolution of the disease, particularly in the most severe cases (Renvert et al., 2019; De Ry et al., 2020; Roccuzzo et al.; 2020). On the other hand, several surgical treatment protocols have been suggested, even though information on long-term outcomes is limited (Roccuzzo et al., 2021) to a few studies only (Berglundh et al., 2018; Parma Benfenati et al., 2020). Regardless of the treatment performed, the complete removal of the inflamed tissue and the decontamination of the implant surface are the fundamental initial steps to treatment success (Koo et al., 2019). Recent data suggest a potential association between implant surface characteristics and long-term results of reconstructive procedures (Roccuzzo et al., 2017, 2020), while controversial data are reported in regard to the correlation between defect morphology and the clinical outcomes (Schwarz et al., 2010; Roccuzzo et al., 2016; Aghazadeh et al., 2020).
The aim of this study is to present the 5-year clinical results of a reconstructive surgical procedure of peri-implantitis infrabony defects, and the possible correlation between the outcome of the intervention and the defect configuration at the time of treatment.

MATERIALS AND METHODS

Patient population

The original population consisted of 75 patients with one crater-like defect, around sandblasted large grit and acid-etched surface (SLA) dental implants (Straumann Group AG, Basel CH). Details of the treatment protocol have been described in a previous publication reporting on the 1-year treatment outcomes (Roccuzzo et al., 2016). In brief, 75 patients (39 males and 36 females; mean age: 57.8 ± 8.5 years; 11 smokers), who presented a single peri-implantitis crater-like lesion with a PD of ≥6 mm and no implant mobility, were consecutively treated from those attending the principle investigator's private office (specialist periodontal practice, northwestern Italy) between January 2010–September 2014.
Exclusion criteria were:
(1) PD < 6mm;
(2) Class II defects (characterized by consistent horizontal bone loss);
(3) multiple defects;
(4) implant mobility;
(5) no interest in participating in the study;
(6) implants placed by other clinicians.
Patients had been treated, in the previous years, for periodontitis and subsequently had received therapy by means of non-submerged tissue level dental implants. All implants supported either a single crown or a fixed dental prosthesis.
All patients were informed that their data would be used for statistical analysis and gave their informed consent to the treatment. The present case-series was performed in accordance with the revised principles stated in the Declaration of Helsinki and the Good Clinical Practice Guidelines. The study protocol was approved by the Institutional Ethics Commitee (Nr.00507/2020).

Surgical procedure, peri-implant defect clinical assessment and post-surgical care

All surgeries were performed by one surgeon (MR) with 25 year of experience in periodontal surgery. Following the elevation of a muco-periosteal flap, all granulation tissue was completely removed from the defect area, by means of titanium curettes and a titanium brush (Tigran Peri-brush, Tigran Technologies AB, Malmö; Sweden) under irrigation. Consequently, implant surfaces were covered with EDTA 24% (Prefgel, Straumann AG, Basel, CH) for 2 min and chlorhexidine 1% gel (Corsodyl dental gel, GlaxoSmithKline, Baranzate, Italy) for 2 min. Thereafter, the infrabony defects were filled with a deproteinized bovine bone mineral with 10% collagen

(DBBMC) (Bio-Oss Collagen, Geistlich, Wolhusen, Switzerland). In case of lack of keratinized tissue, a connective tissue graft was excised from the tuberosity area and applied to cover the entire defect to ensure stability of the graft material. Finally, the flap was sutured around the collar of the implant, with a thick cuff seal to ensure an optimal non-submerged healing (Figure 1a-f).
Peri-implant defect class configuration was assessed, after peri-implant granulation tissue removal, by an independent examiner, on the basis of the circumferential and intra-bony components of the lesion according to the classification proposed by Schwarz et al. (2007).
Post-operative care included 1 g of amoxicillin and clavulanic acid twice a day for 6 days and 0.2% chlorhexidine digluconate rinse for 1 min three times a day for 3 weeks. After the healing phase, patients were placed on an individually tailored SPT program.

Supportive peri-implant/periodontal therapy (SPT)
All patients were asked to follow an individualized supportive care program depending on the initial diagnosis, their risk profile, and the results of the therapy. Patients were recalled at various intervals for oral hygiene measures, biofilm removal, monitoring oral health, and reduction in modifiable risks related to peri-implantitis. Every effort was made to motivate the patient and facilitate their ability to maintain optimal plaque control both at implants and teeth, aiming for a low full mouth plaque score (Heitz-Mayfield et al., 2018). Patients, who fully complied with the recall program for the 5-year period, were categorized as "adherent'' to SPT. Patients, who were not able to completely follow the strict and individualized maintenance program, including all the suggested additional treatments, were classified as "not-adherent'' to SPT.

Clinical examinations
At the 1 and 5-year follow-up examination implant survival (i.e. presence of the implant in the oral cavity) and success rates (i.e. no PD>5mm, no BOP, no PUS, no further radiographic bone loss) were calculated and reported in percentages. Moreover, an examiner (SG) with more than 15 years of experience as dental hygienist, blinded to the defect morphology, recorded, for each treated implant, PD measured at four sites (mesial, buccal, distal, and lingual) by means of a periodontal probe (XP23/UNC 15; Hu-Friedy, Chicago, IL, USA). At the same time and sites, the presence of dental plaque (Pl), of bleeding on probing (BOP) and of pus were recorded (Figure 1g-h). Figures were rounded off to the nearest millimeter. Data are reported in accordance with the STROBE checklist.

Radiographic examinations
Digital peri-apical radiographs were taken at baseline, at 1- and at 5-year follow-up, using a long cone technique. Film holders, with no individualized bite blocks, were used. The baseline and follow-up images were displayed on a computer monitor, and inserted in a commercially available software (ImageJ, U.S. National Institutes of Health). Consequently, based on the fact that all implants were Straumann Tissue Level implants, the known distance of 1.0 and 1.25 mm between implant threads was used to calibrate the radiographs. One of the authors (D.P), not involved in patients' treatment, assigned each image to either the group of "no bone loss / bone gain" or "further bone loss", for the evaluation of the variable "treatment success".

Statistical Analysis

Each patient contributed with one peri-implantitis defect and was, therefore, considered as the statistical unit. The clinical parameters (PD, KT, REC, PI, BOP) were expressed as mean values or percentages (%) ± SD. The presence or absence of suppuration (PUS) was reported as a dichotomous variable. Since quantitative variables did not follow normal distribution according to Kolmogorov-Smirnov test, non-parametric tests were applied. Kruskal-Wallis tests were used to investigate between-group differences and Wilcoxon test for intra-group ones, including Bonferroni' s correction in case of multiple pairwise comparisons. McNemar test was used to assess changes of the variable PUS, as a binary outcome. Odds ratio was estimated to assess the likelihood of survival depending on the adherence to SPT using a simple binary logistic regression. All the tests were two-tailed. Significance level of reference was set at $p<0.05$.

RESULTS

Of the initial 75 patients, 51 (68%) reached the 5-year examination and 11 patients (15%) were lost to follow-up. Reasons for drop-out are listed in Table 1. The overall 5-year implant survival rate was 80% (n= 51) as 13 implants had to be removed. Successful therapy, defined as absence of PD>5mm, BOP, PUS, and radiographic bone loss, was found in 37 patients (52.1%) at 1-year, and 29 patients (45.3%) at the 5-year examination (Table 2a).

More in details, considering the 51 implants still in function at 5 year, the mean PD statistically decreased from 6.89 ± 1.58 to 3.82 ± 1.07 mm at 1 year ($p< 0.001$), and to 4.06 ± 1.12 mm at 5 years ($p< 0.001$).

The number of sites with PD>6 mm changed from 2.80 ± 0.96 to 0.45 ± 1.05 ($p< 0.001$) 1-year after treatment and remained stable through time ($p= 0.661$), as well as the mean deepest pocket which decreased from 8.92 ± 1.89 to 4.65 ± 1.40 ($p< 0.001$) and to 5.02 ± 1.44 at the last follow-up visit ($p= 0.177$). Through time, the overall BOP decreased from 70.6 ± 34.9% to 9.3 ± 18. 7% at 1 year ($p< 0.001$), 17.2 ± 22.1% at 5 years ($p= 0.054$). At baseline, plaque was detected around 13.2 ± 24.2% of all implants which reached the 5-year visit and changed to 5.9 ± 13.8% at 1 year, and to 15.7 ± 23.4% at 5 year. Pus was detected around 15 implants (29.4%) before surgical treatment, while it was present only in one (2 %) of them at the 1-year follow-up ($p< 0.001$), and in 3 (5.9%) of them at the final examination ($p= 0.013$). The overall clinical parameters are summarized in Table 3.

When considering the differences in the percentages of implant survival rates among the different peri-implant defect configuration (Table 2b), no statistically significant difference was detected ($p=0.123$). All differences between and intra-groups are listed in details in Tables 4.

A statistically significant correlation was found between patients' adhesion to SPT and the 5-year implant survival rate and (OR 0.17; $p= 0.009$; CI 95% 0.05-0.64) (Table 5).

DISCUSSION

The aim of the present study was to present the 5-year clinical results of a reconstructive surgical procedure to treat peri-implantitis defects and the possible correlation between the outcome of the intervention and the defect configuration at the time of treatment.

This is, to the best of authors' knowledge, the first prospective study that reports on the treatment of a large number of implants of identical macro-design and surface characteristics.

Treatment success (i.e. no PD>5mm, no BOP, no PUS, no further radiographic bone loss) was obtained in 29 of the 64 subjects who reached the 5-year examination. These results are similar to those recently published by different groups which presented similar reconstructive procedures (Mercado et al., 2018, Lo Monaca et al., 2018; Isehed et al., 2018).

In comparison with other studies (Schwarz et al., 2010), several aspects may explain the success of treatment even in cases where the morphology of the defect seemed not favorable. First of all, DBBMC has better handling properties, adhering well to the site, tailoring to the morphology of the defect, and remaining stable for long term, due to the low resorption rate, compared to other material granules (Araújo et al., 2010; Mordenfeld et al., 2010; Sculean et al., 2005).

Secondly, if the area presented no keratinized mucosa, a connective tissue graft was excised from the tuberosity, and adapted around the collar of the implant and over the entire defect so as to cover 2–3 mm of the surrounding alveolar bone to ensure a greater stability of the graft.

Third, the type of implants, treated in this study, presented low thread pitch and thread depth values, which appear to be the most favorable condition for the optimal removal of the biofilm from the surface with mechanical instrumentation (Sanz-Martín et al., 2020). Implant surface decontamination is considered a fundamental step in the treatment of peri-implantitis defects (Claffey et al., 2008). For this purpose, a titanium brush was employed for mechanical decontamination, after tissue debridement by means of titanium curettes. The efficacy of this tool has been recently confirmed in an RCT by de Tapia and co-workers (2019) who reported statistically significant benefits in terms of PPD reduction compared to controls (i.e. no use of titanium brush). Furthermore, the increasing evidence on the long-term (i.e. ≥ 5-year follow-up) efficacy of peri-implantitis surgical interventions whether by resective (Berglundh et al., 2018, Heitz-Mayfield et al., 2018) or reconstructive (Roccuzzo et al., 2017; Isehed et al., 2018) approaches, stressed the importance of patients' enrollment and adhesion to a tailored SPT program to maintain the positive short-term results (Roccuzzo et al., 2018). The present data support these findings: indeed, patients who did not completely adhere to the SPT (n= 9) experienced more implant loss (39.1%) than those who regularly attended recall appointments (n= 4) (9.8%). In the present study, in order to reduce the number of variables, and to increase the number of patients in each group, only two degrees of adherence were defined. Nevertheless, it has to be pointed out that most of patients were asked to be visited 3 to 4 times per year, based on their risk profile at the time of the visit (Carcuac et al., 2017; Roccuzzo et al., 2018; Heitz-Mayfield et al., 2018).
This study has several limitations: first, the relative high number of drop-outs (i.e. 15%) might have had an impact on the final analysis, even though it was in the same range of other recent publications (Lo Monaca et al., 2018; Carcuac et al., 2020), and other studies have demonstrated that over time, the majority of patients demonstrate only partial compliance (Zeza et al., 2017). Second, the clinical measurements did not follow a calibration session, even though they were collected by an experienced dental hygienist, blinded to the defect morphology, as it is usually carried out in a private clinic. Third, due to the lack of standardized radiographic analysis, the radiographic findings were not reported in numeric measurements. It is worth to mention that the classification of the peri-implant defects was the first ever published more than a decade ago (Schwarz et al., 2007). Consequently, some questions are still open on the exact description of peri-implant pathologic bone defects.

CONCLUSIONS

Within the limitations described, the proposed reconstructive surgical approach was able to re-create and maintain peri-implant healthy conditions around most of the treated implants for the 5-year period, regardless of the initial defect configuration. Nevertheless, patients who did not completely adhere to the SPT experienced a high implant failure rate. Therefore, the decision whether to treat or remove an implant affected by peri-implantitis should be taken after a careful evaluation of several factors, starting from the motivation and the compliance of the patient.

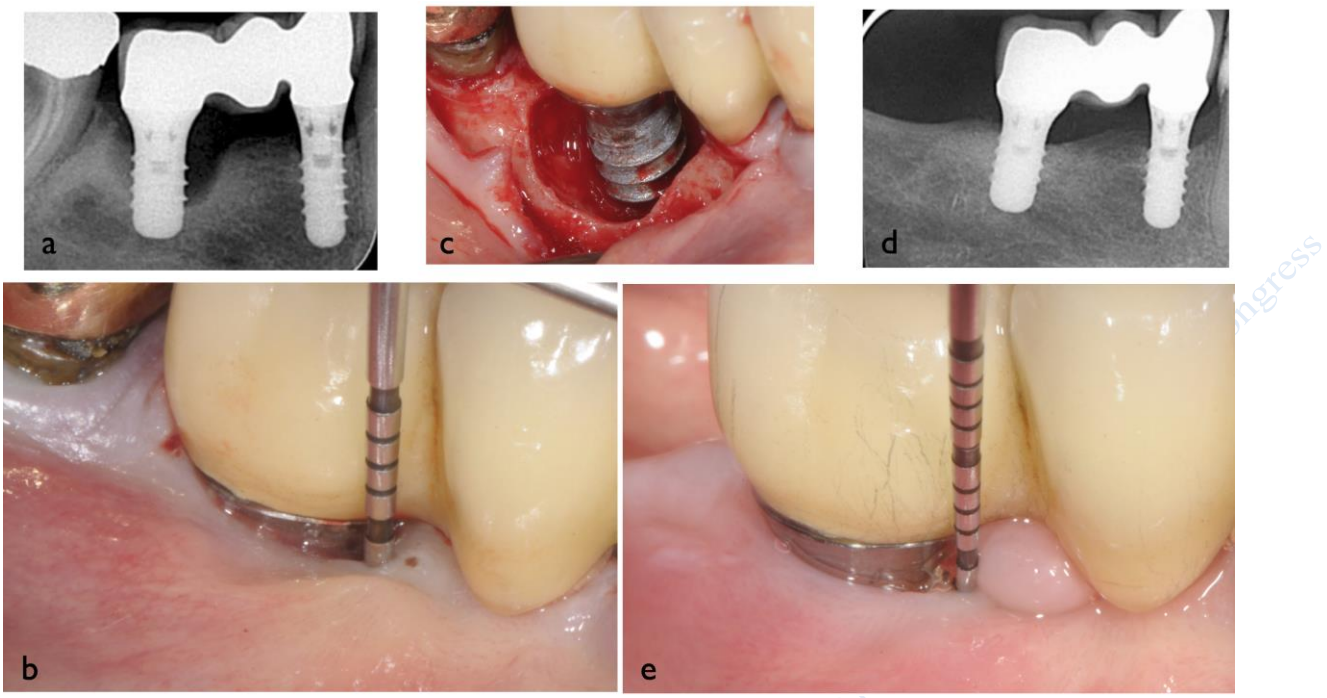

Figure 1 Baseline clinical and radiographic images (a,b), surgical treatment of the infrabony crater-like defect (c), substantial radiographic bone fill (d) and minimal probing pocket depth (e) at 5-year follow-up .

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Table 1. Patient (implant) sample during the study period

	Patients	Implant loss	Lost to follow-up
Baseline	75	-	-
1-year	71	4	0
5-year	51	13	11
List of reasons for drop-out			
Death	1		
Severe health problems	3		
Moved	1		
Refused to accept a visit	6		

Table 2a. Overall results of treatment at 5-years.

	n	%
Success	29	39
Partial resolution	22	29
Lost to follow-up	11	15
Implant loss	13	17

Table 2b. Overall results of treatment at 5-years in relation to the defect configuration.

Defect configuration	**n**	**%**	**Survival rate**		**Implant loss**	
			n	**%**	**n**	**%**
Ia	9	14.0	9	14.0	0	0
Ib	21	33.0	17	81.0	4	19.0
Ic	13	20.0	11	85.0	2	15.0
Id	12	19.0	9	75.0	3	25.0
Ie	9	14.0	5	56.0	4	44.0
Total	**64**	100	**51**	80.0	**13**	20.0

Table 3. Clinical parameters in the 51 patients who reached the 5-year examination (means ± SD)

	Baseline	**1-yr**	**5-yr**	*p* value		
				Baseline vs 1-yr	*1-yr vs 5-yr*	*Baseline vs 5-yr*
PD (mm) ɜ	6.89 ± 1.58	3.82 ± 1.07	4.06 ± 1.12	**<0.001**	0.332	**<0.001**
PD≥ 6 (mm) ɜ	2.80 ± 0.96	0.45 ± 1.05	0.63 ± 1.13	**<0.001**	0.661	**<0.001**
Deepest PD (mm) ɜ	8.92 ± 1.89	4.65 ± 1.40	5.02 ± 1.44	**<0.001**	0.177	**<0.001**
KT (mm) ɜ	3.37 ± 1.41	2.76 ± 1.31	2.78 ± 1.19	**0.008**	1.000	**0.007**
REC (mm) ɜ	-	0.69 ± 0.79	0.69 ± 0.79	-	1.000	-
*BOP at the implant site (%)*ɜ	70.6 ± 34.9	9.3 ± 18.7	17.2 ± 22.1	**<0.001**	0.054	**<0.001**
*Pl at the implant site (%)*ɜ	13.2 ± 24.2	5.9 ± 13.8	15.7 ± 23.4	0.090	**0.020**	1.000
Pus (%)#	15 (29.4)	1 (2.0)	3 (5.9)	**<0.001**	1.000	**0.013**

BOP= Bleeding on probing at the implant site
Pl= Plaque at the implant site

ɜ Wilcoxon test with Bonferroni´s correction

McNemar test with Bonferroni´s correction

Table 4. Differences pre - 5-year treatment between-groups and intra-groups (means±SD)

Defect Configuration	Ia (n=9)	Ib (n=17)	Ic (n=11)	Id (n=9)	Ie (n=5)	*p* (between)
PUS elimination (%)	3/3 (100)	2/2 (100) Ø	4/4 (100)	4/4 (100)	1/2 (50)	0.219
p (intra)	p=0.083	p=1.000	**p=0.046**	**p=0.046**	p=0.317	
PD (mm)	1.67 ± 0.94	2.41 ± 1.30	3.32 ± 1.82	3.22 ± 1.61	4.60 ± 2.75	**0.042**
p (intra)	**p=0.012**	**p<0.001**	**p=0.003**	**p=0.008**	**p=0.042**	
PD≥6mm§	1.67 ± 1.00	1.82 ± 1.33	2.45 ± 1.69	2.56 ± 1.42	3.00 ± 1.22	0.182
p (intra)	**p=0.011**	**p=0.001**	**p=0.006**	**p=0.011**	**p=0.041**	
Deepest PD (mm)	2.89 ± 1.90	3.41 ± 2.00	4.36 ± 2.16	4.67 ± 2.35	5.00 ± 2.35	0.411
p (intra)	**p=0.012**	**p<0.001**	**p=0.003**	**p=0.007**	**p=0.042**	
KT (mm)	1.11 ± 0.93	0.35 ± 1.37	0.64 ± 1.29	0.22 ± 1.48	1.00 ± 0.71	0.471
p (intra)	**p=0.014**	p=0.227	p=0.143	p=0.726	p=0.059	
BOP (%)	38.9 ± 43.5	57.4 ± 26.2	56.8 ± 46.2	52.8 ± 49.1	60.0 ± 41.8	0.836
p (intra)	**p=0.044**	**p<0.001**	**p=0.010**	**p=0.020**	p=0.063	
PI (%)	-5.6 ± 32.5	-1.5 ± 33.6	-4.6 ± 38.4	-5.6 ± 39.1	10.0 ± 22.4	0.219
p (intra)	p=0.581	p=0.952	p=0.914	p=0.595	p=0.317	

§ Number of sites per patient with PD ≥ 6mm.
Bop= Bleeding on probing at the implant site.
Pl= Plaque at the implant site.
Kruskal-Wallis test (between-groups comparisons)
Wilcoxon test (intra-group comparisons)

Table 5. Five-year implant survival rate in relation to the adhesion to SPT

Adhesion to SPT	NO (n=23)	YES (n=41)	OR (95% CI)	*p*
Survival rate	14 (60.9 %)	37 (90.2%)	0.17 (0.05-0.64)	0.009
Implants removed	9 /23	4 /41		