Surgical treatment of peri-implantitis intrabony lesions by means of deproteinized bovine bone mineral with 10% collagen: 7-year-results

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Abstract

Objectives: The aim of this study was to evaluate the long-term results of the surgical treatment of single peri-implantitis intrabony defects, by means of deproteinized bovine bone mineral with 10% collagen (DBBMC).

Material and Methods: The original population consisted of 26 patients with one crater-like defect, around either sandblasted and acid-etched (SLA) or titanium plasma-sprayed (TPS) dental implants, with a probing depth (PD) ≥6 mm and no implant mobility (Roccuzzo et al. J Clin Periodontol. 2011; 38: 738). Implants were mechanically debrided and treated using EDTA gel and chlorhexidine gel. The bone defects were filled with DBBMC, and the flap was sutured around the non-submerged implant. Patients were placed on an individually tailored supportive periodontal therapy (SPT).

Results: Two patients were lost to follow-up. During SPT, additional antibiotic and/or surgical therapy was necessary in eight implants, and four of these were removed for biologic complications. At 7-year, the survival rate was 83.3% for SLA implants and 71.4% for TPS. PD was significantly reduced from 6.6 ± 1.3 to 3.2 ± 0.7 mm in SLA and 7.2 ± 1.5 to 3.4 ± 0.6 mm in TPS.

Bleeding on probing decreased from 75.0 ± 31.2% to 7.5 ± 12.1% (SLA) and from 90.0 ± 12.9% to 30.0 ± 19.7% (TPS). When successful therapy was defined as PD ≤5 mm, absence of bleeding/suppuration on probing, and no further bone loss, treatment success was obtained in 2 of 14 (14.3%) of the TPS and in 7 of 12 (58.3%) of the SLA implants.

Conclusions: Seven years after surgical treatment with DBBMC, patients, in an adequate SPT, maintained sufficient peri-implant conditions in many cases, particularly around SLA implants. Nevertheless, some patients required further treatment and some lost implants. The clinical decision on whether implants should be treated or removed should be based on several factors, including implant surface characteristics.

Key words: biomaterial, bone substitute, defect fill, peri-implantitis, surgical treatment

During the last few years, the interest for the effectiveness of surgical treatment of periimplantitis has grown dramatically as demonstrated by the large number of systematic reviews on the topic (Esposito et al. 2012; AAP 2013, Renvert et al. 2013; Chan et al. 2014; Heitz-Mayfield & Mombelli 2014; Daugela et al. 2016; Khoshkam et al. 2016; Mahato et al. 2016) even though all of them have provided limited evidence for the long-term outcomes. In particular, Esposito et al. (2012) included different surgical and non-surgical interventions, with and without adjunctive treatments, and concluded that there was no reliable evidence suggesting which could be the most effective interventions.
Renvert et al. (2013) found that when regenerative modalities are employed, radiographic evidence of defect fill is reported, and positive treatment results can be maintained over a period of 3–5 years. Moreover, regardless of the treatment performed, adequate plaque control by the patient is fundamental to treatment success.
Chan et al. (2014) reported that the application of grafting materials and barrier membranes resulted in significant pocket reduction and radiographic bone fill, but underlined the lack of high-quality comparative studies.
Heitz-Mayfield & Mombelli (2014) included 43 publications with a follow-up that varied from 3 months to 7.5 years. No meta-analysis, however, was performed due to the heterogeneity of study designs, case definitions, and outcome variables. Successful treatment outcomes, which comprised implant survival with mean probing depth (PD) <5 mm and no further bone loss, were reported between 0% and 100% of patients treated in nine studies and between 75% and 93% of implants treated in two studies.
All 18 included studies by Daugela et al. (2016) underlined an improvement in clinical conditions after the surgical regenerative treatment of peri-implantitis, with no evidence regarding the superiority of the regenerative vs. non-regenerative surgical treatment.
Mahato et al. (2016) incorporated only 20 RCTs with a follow-up of at least 6 months, 10 involving surgical, and 10 involving nonsurgical mechanical procedure. They concluded that non-surgical therapy is not helpful in osseous defect, while surgical therapy removed the residual subgingival deposits additionally reducing the peri-implantitis pocket. Although there was no specific recommendation for the treatment of periimplantitis, surgical therapy in combination with osseous resective or regenerative approach showed the positive outcome. Finally, Khoshkam et al. (2016) limited the search to articles with a follow-up of at least 36 months and found five case series and one controlled trial. The authors concluded that there was limited evidence in the literature reporting long-term results of the regenerative approach for treating peri-implantitis. Regenerative treatment of peri-implantitis resulted in a mean radiographic defect fill of 2.41 mm after a minimum healing time of 36 months, even though these findings must be interpreted with caution, as it is not possible to discern between grafting material and newly formed bone.
Previous papers (Roccuzzo et al. 2011, 2016) have presented a surgical regenerative protocol, after decontamination of the surfaces, using deproteinized bovine bone mineral with 10% collagen (DBBMC) to correct the anatomical defects around the implants in order to facilitate plaque control and to reduce the risk of recurrence, with various degrees of success at 1-year examination.
More years of observation, however, were considered necessary to verify whether the positive preliminary results could be maintained over a long period of time. Hence, the aim of this prospective study was to report the long-term (7-year) results, following surgical treatment of peri-implantitis crater-like defects by means of DBBMC, in patients enrolled in an adequate supportive periodontal therapy (SPT) program.

Materials and methods

Patient population

The original population consisted of 26 patients with one crater-like defect, around either titanium plasma-sprayed surface (TPS) or sandblasted large grit and acid-etched surface (SLA) dental implants. Details of the treatment protocol have been described in a previous publication reporting on the 12-month treatment outcomes (Roccuzzo et al. J Clin Periodontol. 2011; 38: 738). In brief, 26 patients (10 males and 16 females; mean age: 60 ±7.9 years; four 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), in the period January 2008–June 2009 (Fig. 1). Exclusion criteria included the following: 1. PD <6 mm; 2. Class II defects (characterized by consistent horizontal bone loss); 3. Multiple adjacent defects; 4. Implant mobility; 5. Hollow cylinders and hollow screws; 6. Implants placed by other clinicians; 7. Implants not properly positioned; 8. No interest in participating in the study.
Patients had been treated, in the previous years, for periodontitis and subsequently had received therapy by means of dental implants (Straumann Dental Implant System; Straumann AG, Basel, Switzerland) of identical geometry and two different surfaces, that is, sandblasted and acid-etched (SLA) and TPS. All implants supported cemented fixed dental prostheses only. Patients had been placed on an individually tailored SPT, including continuous evaluation of the occurrence and the risk of disease progression. Patients had been recalled at various intervals, depending on the initial diagnosis and the results of the therapy, for motivation, reinstruction, instrumentation, and treatment, as needed. All patients had complied with the recall program until evaluation of the peri-implantitis.
Only one implant defect per patient was included in the study (Table 1). Each patient was given a detailed description of the procedure. They were also informed that their data would be used for statistical analysis and gave their informed consent to the treatment.
No ethical committee approval was sought to start up this observational study, as it was not required by national law or by ordinance of local inspective authority.
The prospective observational study was performed in accordance with the principles stated in the Declaration of Helsinki and the Good Clinical Practice Guidelines.

Surgical procedures
Each patient underwent scaling and root planing and professional implant cleaning after receiving personalized oral hygiene instructions. No surgery was performed before the reassurance of good motivation and compliance from each single patient, that is, full-mouth plaque score (FMPS) <20% and full-mouth bleeding score (FMBS) <20%.
All surgeries were performed by one surgeon (MR) with 20 year of experience in periodontal surgery. The area selected for surgery was anesthetized with mepivacaine plus epinephrine 1:100,000. Full-thickness, mucoperiosteal flaps were raised by means of intracrevicular incisions. Subsequently, all granulation tissue was completely removed from the defect area, and the implant surfaces were thoroughly debrided. Following cleaning, the exposed implant was covered with EDTA 24% (Prefgel Straumann AG) for 2 min and chlorhexidine 1% gel (Corsodyl dental gel, GlaxoSmithKline, Baranzate, Italy) for 2 min. Before and after this, the implant and the surrounding areas were thoroughly rinsed with sterile physiologic saline (Fig. 2).
Deproteinized bovine bone mineral with 10% collagen (DBBMC) (Bio-Oss Collagen, Geistlich, Wolhusen, Switzerland) was applied to fill the intrabony defect, after was moistening in sterile saline. If the area presented no keratinized tissue, a connective tissue graft was excised from the tuberosity area, trimmed, and adapted over the entire defect to cover 2–3 mm of the surrounding alveolar bone and to ensure stability of the graft material.
Finally, the flap was repositioned coronally and fixed with sutures to ensure a non-submerged healing procedure.

Postsurgical care
Patients were instructed to take 1g of amoxicillin and clavulanic acid twice a day for 6 days, starting at least 1 h prior to surgery, and non-steroidal analgesics, as needed.
Immediately after surgery, patients applied ice packs at the treated area, and it was recommended to them to keep in place for at least 4 h. Patients were advised to discontinue tooth brushing and to avoid trauma at the site of surgery for 3 weeks. They were also instructed to use 0.2% chlorhexidine digluconate rinse for 1 min three times a day for the same period of time. Patients were seen after 7 days and then weekly

for the first month to monitor healing. The sutures were removed after 14 days. After the healing phase, patients were placed on an individually tailored SPT program.

Follow-up

Motivation, reinstruction, supragingival instrumentation, antibiotics, and additional non-regenerative surgical therapy were performed, when needed, during the entire 7-year period (Figs 3–5). The main reason for additional surgery was to facilitate proper plaque control in areas with no keratinized tissue. The cumulative interceptive supportive therapy (CIST) (Mombelli & Lang 1998) was used during SPT. The number of sites treated according to therapy modality C (systemic antibiotic therapy or treatment with local delivery device) and D (antibiotics +surgery), during the 7 years, was registered.

Clinical assessments

Seven years after surgery (Fig. 6), an examiner (SG) with more than 15 years of experience as hygienist, blinded to the classification of the patients, recorded, for each test 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. Figures were rounded off to the nearest millimeter and compared with both the baseline and the 1-year values.

Radiographically, the distance between the base of the implant shoulder and the most coronal visible bone-to-implant contact (BL) measured in millimeters, both at the mesial and the distal aspect of each implant, was collected using standardized periapical intraoral films with a long cone technique (Bornstein et al. 2005). The 7-year BL values were compared with the baseline values according to the technique previously described by Roccuzzo et al. (2011), and the radiographic bone defect (BD) fill was calculated (Figs 7 and 8).

Statistical analysis

Each patient contributed with one periimplantitis lesion and was therefore regarded as the statistical unit. Data were expressed as mean ± SD or percentages. The statistical distribution of the quantitative measures was found to be non-gaussian (Shapiro–Wilk test), and nonparametric tests were used. Comparison between the two groups at the baseline, 1 and 7 years was performed by means of Fisher's exact test for qualitative variables, and the Mann–Whitney rank-sum tests for quantitative variables. Nonparametric analysis of variance for repeated measures with Bonferroni correction was used to evaluate differences between baseline, 1 and 7 years within each group.

All the tests were two-tailed.

The level of significance was set at 5%

Results

Supportive periodontal therapy proceeded with no major complications and minimal discomfort, in most patients. Two female patients dropout were registered during the 7 years of observation, one due to her old age (patient 13) and one for unknown reasons (patient 4). Moreover, during SPT additional antibiotic and/or surgical therapy was necessary in eight implants (2 SLA vs. 6 TPS). The overall implant survival rate was 71.4% for TPS and 83.3% for SLA implants without a significant difference ($P = 0.65$). The clinical parameters in both groups at baseline, at 1- and 7-year evaluation are summarized in Table 2–4, and Fig. 9.

In TPS group, PD decreased from 7.2 ± 1.5 to 4.8 ± 1.9 mm at 1 year ($P < 0.001$) and to 3.4 ± 0.6 mm at 7 year ($P = 0.04$). In SLA group, PD decreased from 6.6 ± 1.3 to 3.4 1.0 mm at 1 year ($P < 0.001$) and to 3.2 ± 0.7 mm at 7 year ($P = 0.74$).

At baseline BOP was 90.0 ± 12.9% (TPS) and 75.0 ± 31.2% (SLA), at 1-year 55.0 ±38.7% (TPS) and 12.5 ± 13.2% (SLA), at 7-year 30.0 ± 19.7% (TPS) and 7.5 ± 12.1%(SLA). The final difference between the two groups was statistically significant ($P = 0.01$).

At baseline, plaque was found around 67.5 ± 23.7% of TPS and 50.0 ± 23.6% of SLA implants. At 1-year examination, plaque was present around 32.5 ± 26.5% (P = 0.001) and 17.5 ± 16.9% (P = 0.002), respectively.
At 7-year examination, plaque was present around 15.0 ± 17.5% (P < 0.001) and 2.5 ± 7.9% (P < 0.001), respectively. The reduction was statistically significant in both groups, and the difference between SLA and TPS did reach a statistically significant level (P = 0.05).
Around TPS implants, mean BL decreased from 3.7 ± 1.6 to 1.7 ± 0.9 mm, at 7-year (P < 0.001). In SLA implants, BL decreased from 2.9 ± 0.9 to 0.8 ± 1.0 mm, at 7-year (P < 0.001). Both reductions were statistically significant, but the difference between the two groups was statistically significant (P = 0.03).
Before treatment, pus was present around 10 of TPS and four of SLA implants. At 1-year examination, all SLA implants healed, while four of TPS did not. Two of these four TPS implants presented deep pockets with pus and were subsequently removed. When considering only the 20 implants that reached the 7-year analysis, pus was present at baseline around seven of TPS and four of SLA implants. At the 7-year analysis, pus was detected only around one TPS implant.
Successful therapy, defined as PD ≤5 mm, absence of bleeding/suppuration on probing, and no further bone loss, was found in 2 of 14 (14.3%) of the TPS and in 7 of 12 (58.3%) of the SLA implants.

Discussion

This is, to the best of our knowledge, the first study, which provides evidence for the long-term outcomes following peri-implantitis treatment, with a surgical regenerative procedure by means of DBBMC.
The proposed treatment was effective in reducing BOP and Pl even though it produced, at 7-year, better results in the SLA group. The mean pocket depth significantly decreased in both groups with no significant difference between SLA and TPS.
The surgical therapy was also effective in reducing the proximal BDs, especially around SLA. In particular, at 7-year mean bone level (measured mesially and distally at each implant) was 1.7 ± 0.9 in TPS and 0.8 ± 1.0 mm in SLA, with a significant difference between the groups (P = 0.03).
When successful therapy was defined as PD ≤5 mm, absence of bleeding/suppuration on probing, and no further bone loss, treatment success was obtained in 2 of 14 (14.3%) of the TPS and in 7 of 12 (58.3%) of the SLA implants, with a statistical significant difference between the two groups (P = 0.04).
These results confirm that surface characteristics may have an impact on the long-term clinical outcome following surgical regenerative treatment.
One limitation of this study is that radiological analysis was performed with no previous calibration and that double assessments were not performed.
Another limitation of this study is that additional treatments were performed, as needed, during the entire period of SPT, in accordance with the CIST protocol, depending on the health conditions of the peri-implant tissues. This means that several patients, in the presence clinical signs of inflammation, received multiple treatments for the same peri-implantitis defect, during the 7-year period.
Overall, additional treatment was performed in 6 of 14 TPS and 2 of 12 SLA sites.
On a similar topic, Schwarz et al. (2009), reported that one patient, during SPT, was discontinued from the study after receiving further peri-implantitis non-surgical and surgical regenerative treatment.
Similarly, Schwarz et al. (2013) reported that four patients had to be discontinued from the study between 24 and 36 months of healing due to pus formation and progressive radiographic bone loss.
On the other hand, Froum et al. (2015) reported that in a consecutive series of 170 implants in 100 patients with 2- to 10-year follow-up, 18 implants required one additional surgery, and 10 implants required to two additional surgeries to reach the desired outcomes. From the above-mentioned studies, it must be underlined that in a number of cases, SPT may include additional non-surgical and/or surgical treatment. The benefit of this clinically oriented approach, in accordance with the Consensus Report of 6th EWP (Lindhe & Meyle 2008), is that subjects recruited from private or public dental clinics, rather than university clinics, provide information on the ‘effectiveness’ rather than ‘efficacy’ in implant therapy.

The question about the ideal protocol for SPT is still open. Participants were enrolled in a maintenance program with visits every third month by Roos-Jans_aker et al. (2014), while according to Serino et al. (2015), patients, enrolled in a recall system every 6 months, presented stable peri-implant conditions in the majority of subjects and implants during a 5-year period. Froum et al. (2015) reported an overall survival rate of 98.8% with 2–10 years follow-up when patients were kept on a strict schedule of 2- to 3-month professional maintenance and monitoring. On the other hand, patients were recalled at least six monthly for monitoring and SPT in the study by Heitz-Mayfield et al. (2016). In the present study, patients were recalled according to an individually tailored schedule, based on their own risk profile. At the 7-year evaluation, both FMPS (17.0 ± 6.2% vs. 15.9 ± 6.4%) and FMBS (14.5 ± 5.3% vs. 13.3 ± 5.7%) were maintained at acceptable level, with no difference between the two groups, which is a good indication of an effective SPT.

A recent long-term study evaluated the outcomes of supportive maintenance (Serino et al. 2015). Of the 71 treated implants, 43 presented healthy peri-implant condition, while 28 had residual peri-implant pockets either of 4–5 mm or ≥6 mm associated with BOP /suppuration. Of the 28 implants with residual pockets, nine showed clinical attachment loss during the 5-year follow-up. Thus, of 71 treated implants, probing attachment loss occurred in only in nine (13%) of the implants in four patients during the 5-year period.

A recent long-term study evaluated the outcomes of supportive maintenance on 24 patients with 36 dental implants (Heitz-Mayfield et al. 2016). Five years following regular supportive therapy, the peri-implant conditions established following peri-implantitis surgery were maintained in the majority of patients and implants. Some patients had recurrence of peri-implantitis, and some lost implants over the 5-year period.

Regarding the outcomes, it should be underlined that, in the present study, even though probing measurements were carried out without applying a standardized pressure, it must be emphasized that all examinations were performed by dental hygienist with more than 15 years of experience, blinded to the type of implant surface and to the additional treatment performed.

Unlike the studies of Schwarz et al. (2009, 2013), Roos-Jans_aker et al. (2014), Froum et al. (2015) where several implant types and implant surfaces were pooled and treated, this research evaluated the outcome of the same surgical protocol on implants that differ by only one variable of interest, that is, surface characteristics. Indeed, implants from the two groups were, with the adopted technique, similar in all aspects, except for implant surface.

This was particularly interesting from a statistical point of view, as bias and variability were reduced to minimal levels. It would be useful in the future, to assess whether the geometry of the surface and/or the pitch may influence the treatment outcomes, as no previous studies have taken these parameter into careful consideration.

The advantages of the technique presented in the present study are that healing seems to be present without the need of the removal of the prosthetic restoration in order to submerge the implant reducing time and cost of treatment. It must be said, however, that a minimal amount of keratinized tissue was considered necessary for a successful application of the technique. Therefore, in areas with no keratinized mucosa, a connective tissue graft was trimmed and adapted to ensure stability of the graft material.

The potential benefit of the presented technique has been recently confirmed by Rotenberg et al. (2016). They treated 11 patients with peri-implantitis around a single restored dental implant. Following surgical debridement of the peri-implant defect and treatment of the implant surface with a 0.12% chlorhexidine gluconate solution, bony defects were grafted with DBBMC. All patients reached 12 months of follow-up. The authors concluded that the use of a porcine collagen-coated bovine bone graft to treat peri-implantitis represents a potentially predictable therapeutic modality.

We disagree with the authors of a recent systematic reviews (Khoshkam et al. 2016) who concluded ‘that regenerative procedures are among several options – including nonsurgical, chemotherapeutic, resective, or implant removal – that may be considered for dealing with peri-implantitis.’ In our opinion, similarly what happens for the treatment of periodontal lesions, regenerative surgeries must be indicated after a thorough selection of patients and defects. Moreover, we do agree with de Waal et al. (2016) that the outcome of surgical peri-implantitis treatment is influenced by the experience of the surgical team.

A recent systematic review (Monje et al.2016) investigated the impact of maintenance therapy for the prevention of peri-implant diseases. Interestingly, mean peri-implant maintenance therapy interval was demonstrated to influence the incidence of periimplantitis at implant level. The authors concluded that implant therapy must not be limited to the placement and restoration of dental implants, but to the implementation of SPT, tailored to a patient's risk profiling, to potentially prevent biologic complications and hence to heighten the long-term success rate. Therefore their findings suggested reason to claim a minimum recall SPT interval of 5–6 months, even though it was stressed that even in the establishment of SPT, biologic complications might occur, which is in accordance with what presented in the present protocol. Thus, patient-, clinical-, and implant-related factors must be thoroughly explored before, during and after the surgical treatment of peri-impantitis in accordance with Heitz-Mayfield et al. (2014), Figueroet al. (2014), and Renvert & Polyzois (2015).

In conclusion, the antimicrobial and surgical technique described, in conjunction with an appropriate SPT, resulted in a clinical healthier situation around many of the treated implants so that their function could be fully maintained for the 7-year observation period, particularly around SLA implants.

Nevertheless, due to the fact the complete resolution of peri-implantitis, defined as the absence of BOP and deep pockets at all sites, is not easy to achieve, the clinical decision on whether implants should be removed or treated should be based not only on the implant characteristics but also on several patient-related elements.

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Table 1. Data on patients, defect location, implant type, additional treatment, and implant survival

n	Sex	Age	Smoking	Site	Implant type	CIST (C/D)	7-Year survival
1	M	56		25	ø 4.1 9 10 mm TPS	C	Yes
2	F	53		31	ø 3.3 9 12 mm TPS		Yes
3	M	68		21	ø 4.1 9 10 mm SLA		Yes
4	F	66		35	ø 4.1 9 10 mm TPS	*	–
5	M	55		46	ø 4.1 9 08 mm SLA		Yes
6	F	55		14	ø 4.1 9 10 mm TPS		Yes
7	F	60		24	ø 4.1 9 10 mm SLA	C	No
8	M	68		27	ø 4.8 9 08 mm SLA		Yes
9	F	67		26	ø 4.1 9 10 mm TPS	D	No
10	M	58	Yes	13	ø 4.1 9 10 mm SLA		Yes
11	F	70		23	ø 4.1 9 08 mm TPS		Yes
12	F	56		37	ø 4.8 9 08 mm SLA	C	No
13	F	79		35	ø 4.1 9 10 mm TPS	*	–
14	M	60		26	ø 4.1 9 10 mm TPS	C	Yes
15	F	54		26	ø 4.1 9 10 mm TPS	C	Yes
16	F	63		31	ø 4.1 9 10 mm TPS		Yes
17	F	46	Yes	17	ø 4.8 9 10 mm SLA		Yes
18	M	51	Yes	46	ø 4.1 9 12 mm TPS	D	No
19	F	71		17	ø 4.8 9 10 mm SLA		Yes
20	M	64	Yes	35	ø 4.1 9 12 mm TPS		Yes
21	F	57		36	ø 4.1 9 08 mm TPS		Yes
22	F	56		27	ø 4.1 9 08 mm SLA		Yes
23	F	56		14	ø 4.1 9 10 mm SLA		Yes
24	F	63		46	ø 4.1 9 10 mm SLA		Yes
25	M	45		36	ø 4.1 9 12 mm TPS	D	Yes
26	M	62		36	ø 4.8 9 10 mm SLA		Yes

*Patient lost to follow-up

Table 2. Parameters for TPS (n = 14) and SLA (n = 12) implants

	TPS	SLA	*P*
Implants at baseline	14	12	
Dropout	2	0	0.48
CIST C/D*	6	2	0.22
Implant lost	2	2	0.99
Survival rate at 7-year	10 (71.4%)	10 (83.3%)	0.65
Treatment success†	2 (14.3%)	7 (58.3%)	0.04

*Sites treated according to modalities C and D of CIST (antibiotics and/or surgery).
†No further bone loss, no pus, PD ≤5 mm, and BOP = 0, at 7 years.

Table 3. Full-mouth plaque scores (FMPS) and full-mouth bleeding scores (FMBS) at initial visit (when diagnosis of peri-implantitis was made), at 1 and 7 years following treatment

	Initial visit	1-year	7-year	Initial visit vs. 1-year	1-year vs. 7-year	Initial visit vs. 7-year
FMPS (%)						
TPS (*n* = 14)	30.5 ± 9.1	21.0 ± 6.8	17.0 ± 6.2	<0.001	0.21	<0.001
SLA (*n* = 12)	27.5 ± 7.5	19.5 ± 5.2	15.9 ± 6.4	<0.001	0.09	<0.001
P	0.33	0.66	0.67			
FMBS (%)						
TPS (*n* = 14)	29.4 ± 7.6	20.6 ± 6.0	14.5 ± 5.3	0.003	0.06	<0.001
SLA (*n* = 12)	26.8 ± 10.4	18.6 ± 6.1	13.3 ± 5.7	0.005	0.03	<0.001
P	0.21	0.39	0.65			

Table 4. Clinical parameters around the 10 SLA & 10 TPS implants, which reached the 7-year examination (means ± SD)

				P value		
	Baseline	1-year	7-year	Baseline vs. 1-year	1-year vs. 7-year	Baseline vs. 7-year
PD (mm)						
TPS	7.2 ± 1.5	4.8 ± 1.9	3.4 ± 0.6	<0.001	0.04	<0.001
SLA	6.6 ± 1.3	3.4 ± 1.0	3.2 ± 0.7	<0.001	0.74	<0.001
Deepest PD (mm)						
TPS	8.8 ± 1.5	6.0 ± 2.2	4.2 ± 0.8	<0.001	0.004	<0.001
SLA	8.0 ± 1.2	3.7 ± 1.2	3.8 ± 0.6	<0.001	0.96	<0.001
Bone level (mm)						
TPS	3.7 ± 1.6	2.0 ± 1.2	1.7 ± 0.9	<0.001	0.99	<0.001
SLA	2.9 ± 0.9	1.0 ± 0.8	0.8 ± 1.0	<0.001	0.99	<0.001
BOP at the implant site (%)						
TPS	90.0 ± 12.9	55.0 ± 38.7	30.0 ± 19.7	0.003	0.04	<0.001
SLA	75.0 ± 31.2	12.5 ± 13.2	7.5 ± 12.1	<0.001	0.71	<0.001
PI at the implant site (%)						
TPS	67.5 ± 23.7	32.5 ± 26.5	15.0 ± 17.5	0.001	0.14	<0.001
SLA	50.0 ± 23.6	17.5 ± 16.9	2.5 ± 7.9	0.002	0.26	<0.001
Pus						
TPS	7 (70%)	3 (30%)	1 (10%)	0.05	0.16	<0.01
SLA	4 (40%)	0 (0%)	0 (0%)	0.05	–	0.05

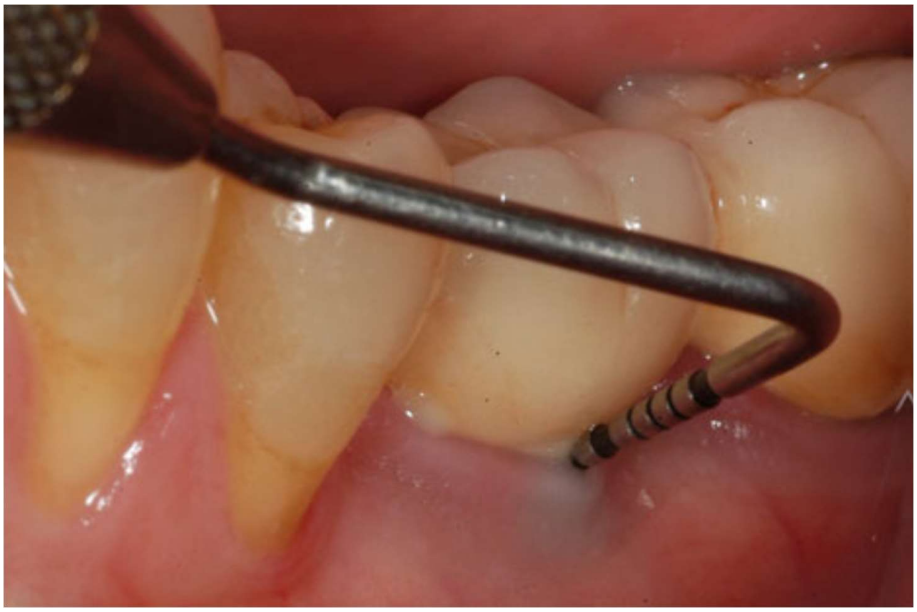

Fig. 1. Lower left molar ceramic crown on a TPS implant, placed 8 years before, showing excessive probing depth and pus (Patient 25).

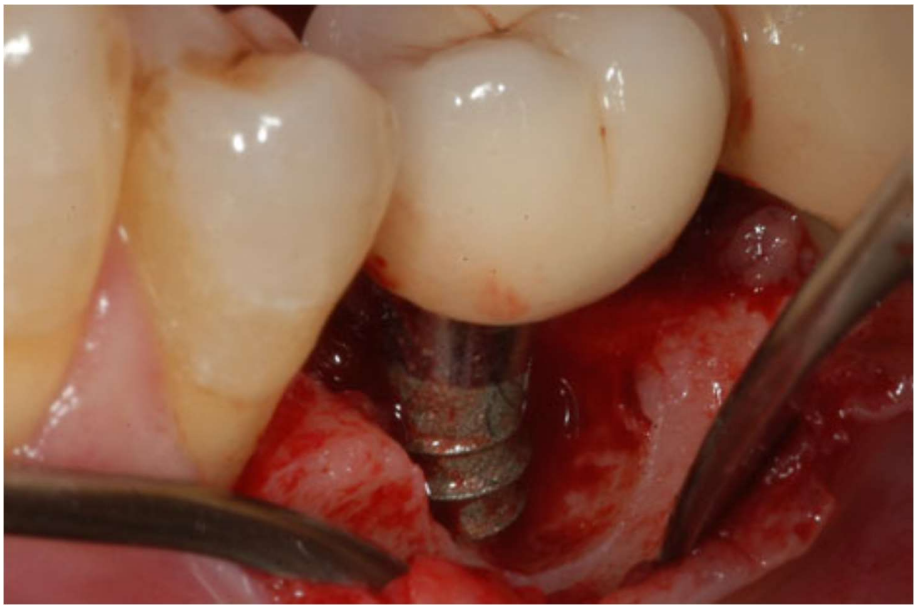

Fig. 2. After raising a full-thickness flap, the granulation tissue is removed, and the implant surface is decontaminated by means of 24% EDTA and 1% chlorhexidine gel, before filling the defect with DBBMC.

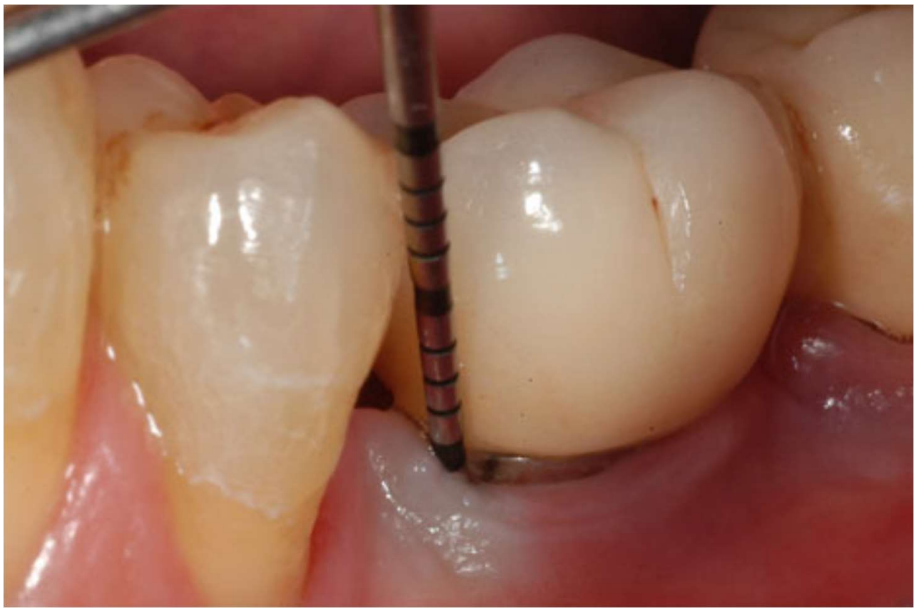

Fig. 3. Clinical situation around the implant, at 1-year follow-up: no signs of inflammation, minimal soft tissue recession, and reduced pocket depth.

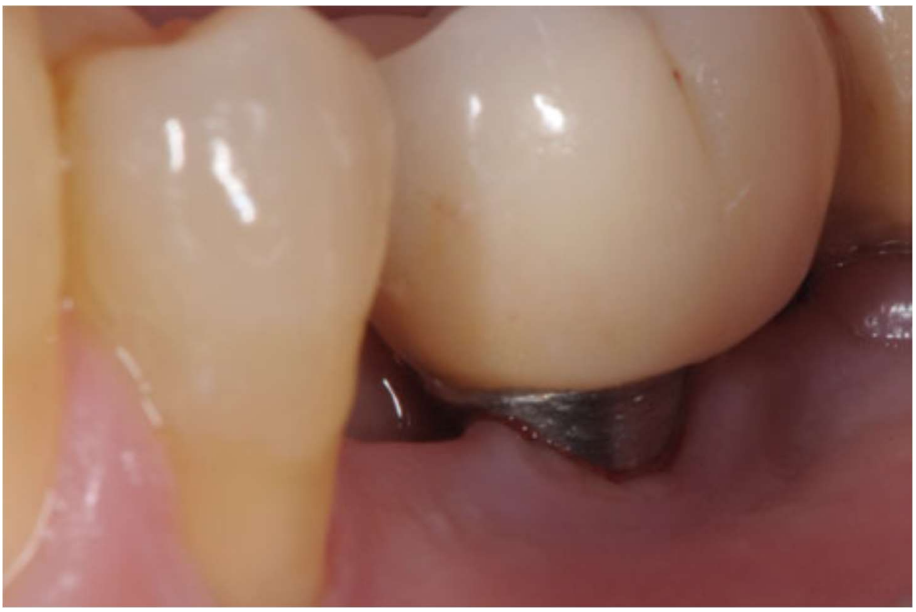

Fig. 4. Six years after surgery for peri-implantitis treatment, during SPT, patient reports discomfort in the area. Even though plaque control is sufficient, BOP is depicted.

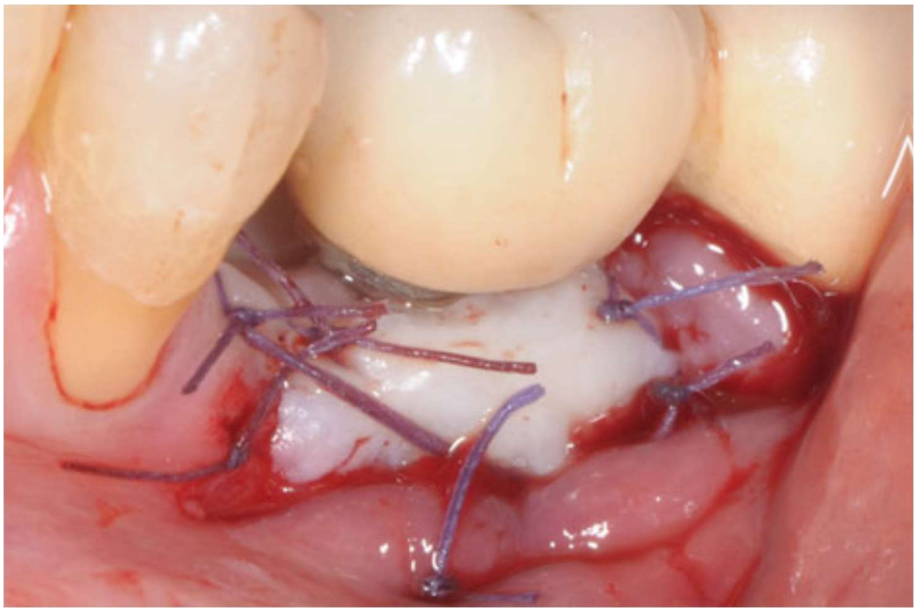

Fig. 5. Free gingival graft is sutured, over a partial thickness flap, to increase tissue thickness.

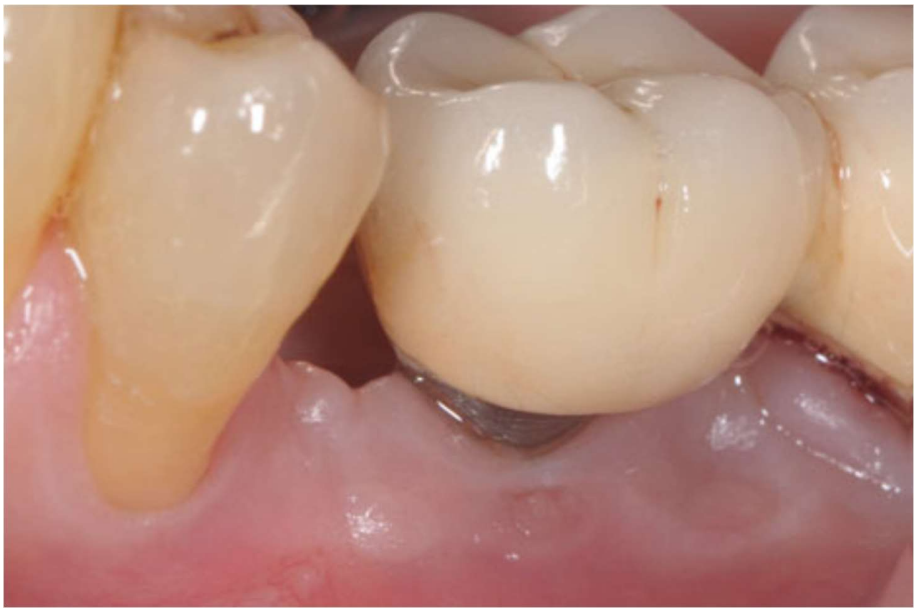

Fig. 6. Seven-year follow-up: patient reports no discomfort when performing plaque control around the implant. No signs of inflammation and reduced soft tissue recession.

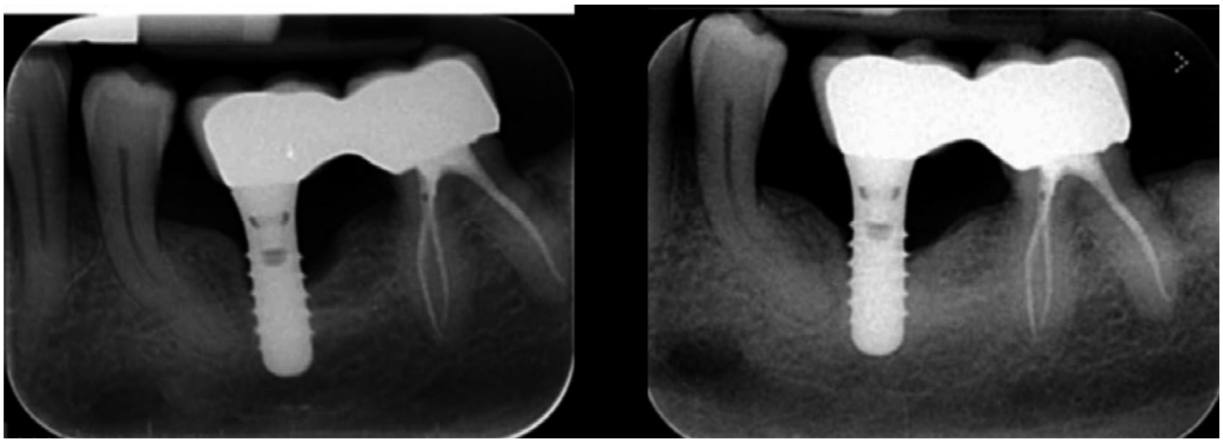

Fig. 7. Periapical radiographs at TPS implant at baseline and 7 years after treatment

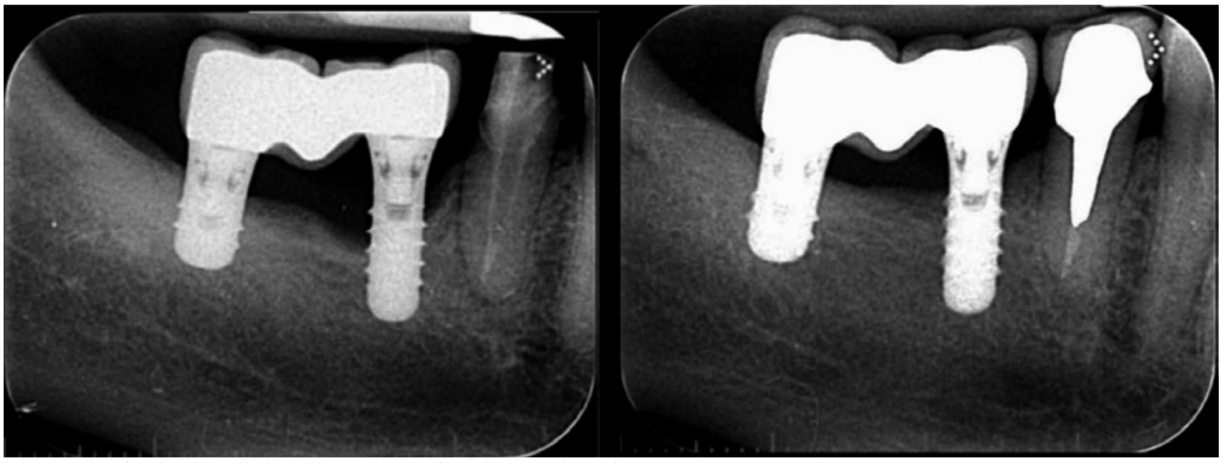

Fig. 8. Periapical radiographs at SLA implant at baseline and 7 years after treatment.

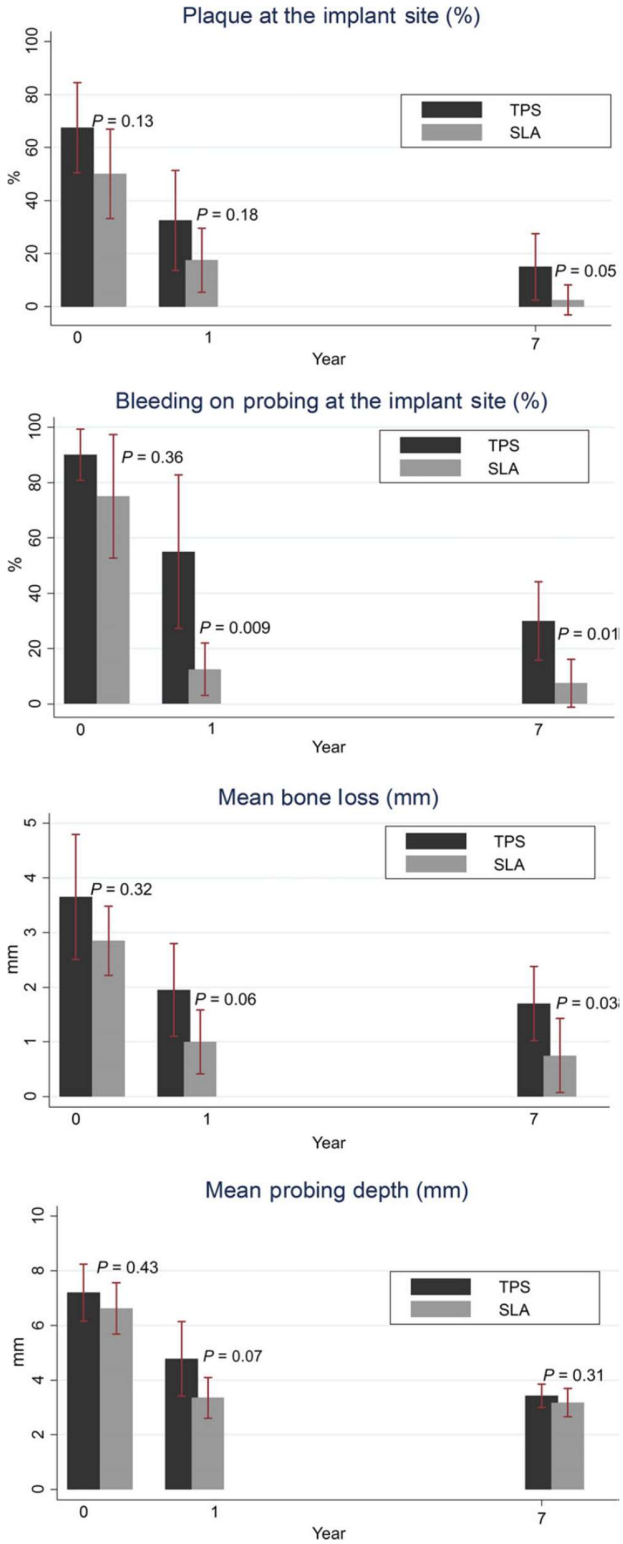

Fig. 9. Clinical parameters around the implants at baseline, at 1 year after treatment, and at the 7-year follow-up, in both groups.