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Implant survival after surgical treatment of peri-implantitis lesions by means of deproteinized bovine bone mineral with 10% collagen: 10-year results from a prospective study.

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Author contributions

M.R. conceived the idea, performed the surgeries and critically revised the manuscript
L.F, D.P. collected, analyzed the data and contributed to the writing
P.D. analyzed the data
A.R. collected, analyzed the data and led to the writing

Abstract

Objectives: To evaluate the 10-year outcomes of a regenerative 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 SLA or TPS dental implants, with a probing depth ≥ 6 mm and no implant mobility. After debridement and surface decontamination, the defects were filled with DBBMC. Subsequently, patients were placed in an individualized supportive peri-implant/periodontal therapy (SPT) program.
Results: Fourteen patients (8 SLA & 6 TPS) reached the 10-year examination. The overall implant survival rate was 67%, 80% for the SLA and 55% for the TPS implants. During SPT, five patients were lost to follow-up, eight patients needed additional antibiotic and/or surgical therapy, seven patients had the implant removed. PD was reduced from 6.6 ± 1.3 to 3.2 ± 0.7 mm in SLA and from 7.2 ± 1.5 to 3.4 ± 0.6 mm in TPS. BOP decreased from 75.0 ± 31.2% to

7.5 ± 12.1% (SLA) and from 90.0 ± 12.9% to 30.0 ± 19.7% (TPS). Treatment success was found in 5 of the 12 SLA (42%) and in 4 of the 14 TPS (29%).

Conclusions: The proposed reconstructive treatment, followed by SPT, was able to maintain in function the majority of SLA implants, although the overall treatment success was limited and many of TPS implants were removed. Therefore, the decision to treat implants affected by peri-implantitis should be based on several factors, including surface characteristics.

INTRODUCTION

During the last EFP-AAP World Workshop, peri-implantitis has been defined as an infective pathologic condition affecting a previously installed dental implant, characterized by increased probing depth with concomitant bleeding and/or suppuration besides peri-implant bone loss (Schwarz, Derks, Monje, & Wang, 2018). Its high prevalence has been extensively estimated by several systematic reviews (Derks & Tomasi, 2015; Rakic et al., 2018) and large population cross sectional studies (Dalago, Schuldt Filho, Rodrigues, Renvert, & Bianchini, 2017; Schwarz et al., 2017; Rokn et al., 2017; Renvert, Lindahl, & Persson, 2018; Vignoletti, Di Domenico, Di Martino, Montero, & de Sanctis, 2019). The ideal aim of the treatment of peri-implantitis is the complete elimination of the peri-implant infected tissues combined, if possible, to a reconstructive procedure to re-create an ideal seal around the osseointegrated implants. During the years, since the non-surgical treatment of peri-implantitis has been proved to be ineffective (Faggion, Listl, Frühauf, Chang, & Tu, 2014), several surgical approaches (Chan, Lin, Suárez, MacEachern, & Wang, 2014), some of which by means of regenerative materials (Khoury & Bachmann 2001; Roos-Jånsaker, Renvert, Lindahl, & Renvert, 2007; Schwarz, John, Mainusch, Sahm & Becker et al., 2012), have been proposed with promising preliminary results (Khoskam et al., 2013; Khoskam et al., 2016).

The clinical positive outcomes of the surgical treatment have been advocated to the implant surface characteristics (Roccuzzo, Bonino, Bonino & Dalmasso, 2011; Carcuac et al., 2016), while controversial results have been reported in respect of peri-implant bony defect morphology (Schwarz, Sahm, Schwarz, & Becker, 2010; Roccuzzo, Gaudioso, Lungo, & Dalmasso, 2016). Regardless of the type of surgical approach, patients' adhesion to a supportive peri-implant/ periodontal therapy (SPT) has been demonstrated to be fundamental

for the positive long-term results (Monje et al., 2016; Heitz-Mayfield et al., 2018; Roccuzzo, Layton, Roccuzzo, & Heitz-Mayfield, 2018).

Despite the high-level of evidence of the long-term stability of the results obtained following periodontal regeneration (Cortellini, Buti, Pini Prato, & Tonetti, 2017; Roccuzzo, Marchese, Dalmasso, & Roccuzzo, 2018) with better long-term outcomes and less costs for re-intervention compared to access flap alone, only few studies assessed the long-term results of different peri-implant surgical procedures (Heitz-Mayfield et al 2018; Roccuzzo, Pittoni, Roccuzzo, Charrier, & Dalmasso, 2017; Berglund, Wennström, & Lindhe, 2018; Bianchini et al. 2019; La Monaca, Pranno, Annibali, Cristalli, & Polimeni, 2018).

A previous publication (Roccuzzo et al., 2017) has reported positive results, after 7 years of SPT, of a surgical regenerative procedure on single crater-like peri-implantitis defects. Successful therapy, defined as PD ≤5mm, absence of bleeding/suppuration on probing, and no further bone loss, was found in 14.3 % of the TPS and in 58.3 % of the SLA implants.

Nevertheless, as indicated by the last EFP Workshop, the evidence on the efficacy of the treatment of peri-implantitis defects by reconstructive procedures seems limited, especially in the long-term (Tomasi, Regidor, Ortiz-Vigón, & Derks, 2019). In this regard, the aim of this study is to present the 10-year clinical and radiographic outcomes in patients treated with a regenerative procedure by means of a DBBMC, and enrolled in an individually tailored 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 previous publications reporting on the 1 and 7-year treatment outcomes (Roccuzzo et al., 2011; Roccuzzo et al., 2017). In brief, 26 patients (10 males and 16 females; mean age: 60 $\pm$ 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) between January 2008–June 2009. 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 were rehabilitated by means of dental implants (Straumann Dental Implant System; Straumann AG, Basel, Switzerland) of identical geometry and two different surfaces, either sandblasted and acid-etched (SLA) or titanium plasma-sprayed (TPS). All implants supported cemented fixed dental prostheses. 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, Figure 3). 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. The prospective observational study 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 Ethical Commitee (Nr.: 00188/2020).

Surgical procedures 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, and the implant surfaces 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 intrabony 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.

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 underwent an individualized supportive care according to their needs and risk profile, including 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 plaque control both at implants and teeth, aiming for a low full mouth plaque score (Heitz-Mayfield et al. 2018). If a patient could not to attend follow-up examinations, he/she was classified as a “drop-out.’’.

At signs of recurrence (increasing PD with concomitant BoP) local antibiotics, and/or additional non-regenerative surgical therapy were performed, whenever needed, in order to treat further possible complications and to facilitate proper oral hygiene procedure. During SPT, the cumulative interceptive supportive therapy (CIST) (Mombelli & Lang 1998) was used. 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 10 years, was registered.

Clinical and radiographic examinations

At the 10-year examination, an examiner (SG) with more than 15 years of experience as hygienist, blinded to the patients’ classification, 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 (PI), 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 and 7-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 periapical intraoral films with a long cone technique (Roccuzzo et al. 2001; Bornstein et al. 2005). Film holders, with no individualized bite blocks, were used. The baseline and follow-up images were displayed on a computer monitor and the changes of crestal bone was calculated by means of a commercially available software (ImageJ, U.S. National Institutes of Health, Bethesda, Maryland, USA), using the known implant's length for calibration. All radiological assessments were performed by one investigator (DP), blinded with respect to the implant surface.

The 10-year BL values were compared with the baseline, 1- and 7-year values according to the technique previously described by Roccuzzo et al. (2011) and Roccuzzo et al. (2017). Implants with both a 2.8 mm and a 1.8 mm smooth collar were analyzed, but the reference landmark was always the most coronal level of the rough surface, which was originally at the level of the bone crest.

Statistical Analysis

Each patient contributed with one peri-implantitis lesion and was, therefore, considered as the statistical unit. The clinical parameters (PD, PI, BOP) were expressed as mean values or percentages at 4 sites ± SD, while the radiographic bone level values (BL) were calculated as mean at 2 sites (mesial and distal) ± SD. Finally, the presence or absence of suppuration was reported as a dichotomous variable. Only descriptive statistical analyses were performed due to the small sample size. To evaluate the implant survival rates of either TPS or SLA implants after reconstructive peri-implant surgery, a Kaplan-Meier analysis (with log-rank pooled per strata) was performed.

RESULTS

Supportive peri-implant therapy proceeded with no major complications in most patients. From the initial 26 patients included at baseline, 14 (6 TPS & 8 SLA) reached the 10-year examination. Five patients (19%) were lost to follow-up. Reasons for drop-out are listed in Table 2. During the 10-year examination, additional antibiotic and/or surgery was needed in 8 patients (6 TPS & 2 SLA). Patient demographics and implant characteristics are reported in Table 3. Excluding the drop-outs, the overall implant survival rate at 10-year was 55% for the TPS and 80% for the SLA implants, respectively. Figure 1 illustrates the implants' survival rate as a function of time from the surgical treatment of peri-implantitis. The clinical and radiographic parameters in both groups at baseline and at the 10-year follow-up are summarized in Table 4.

More in details, out of the implants still in function at 10 year, the overall PD decreased from 6.9 ± 1.3 to 3.7 ± 1.5 mm at 1 year, to 3.2 ± 0.7 mm at 7 year and to 3.3 ± 0.5 at 10 year. In TPS group PD decreased from 7.0 ± 1.4 to 4.5 ± 1.7 mm at 1 year, to 3.2 ± 0.7 mm at 7 year and to 3.5 ± 0.5 at 10 year, while in SLA group, PD decreased from 6.8 ± 1.4 to 3.2 ± 1.0 mm at 1 year, to 3.1 ± 0.8 mm at 7 year and to 3.2 ± 0.5 at 10 year.

Through time, the overall BOP decreased from 82.1 ± 25.7% to 28.5 ± 31.1% at 1 year, 14.3 ± 18.2% at 7 years and 14.3 ± 18.2% at 10 year. In particular at baseline BOP was 92.0 ± 13% in TPS and 75.0 ± 32.7% in SLA, at 1-year 54.2 ± 36.8% in TPS and 12.5 ± 13.4% in SLA, at 7- year 33.0 ± 20.4% in TPS and 6.3 ± 11.6% in SLA and at 10- year 12.5 ± 21% in TPS and 12.5 ± 19% in SLA.

At baseline, plaque was detected around 59 ± 27% of all implants which reached the 10-year visit and decreased to 21.4 ± 19.2% at 1 year, 5.4 ± 11% at 7 year and to 7.1 ± 12% at 10 year. In detail, plaque was found around 75 ± 22.4% of TPS and 75 ± 32.7% of SLA implants. At 1-year examination, plaque was present around 25 ± 22.4% of TPS and 18.8 ± 17.7% of SLA. At 7-year examination, plaque was present around 8.3 ± 13% and 3.1 ± 8.8%, respectively. At 10-year examination, plaque was present around 4.2 ± 10.2% of TPS and 9.4 ± 13% of SLA.

The overall mean BL decreased from 3.2 ± 1.1 to 0.9 ± 1.0mm. According to the type of implant, mean BL decreased from 3.4 ± 1.5 to 1.4 ± 0.1 mm at 10-year around TPS implants and from 3.1 ± 0.9 to 0.4 ± 0.6 mm at 10-year around SLA implants.

Before treatment, pus was present around ten of TPS and four of SLA implants. When considering only the 14 implants that reached the 10-year analysis, pus was present at

baseline around four of TPS and three of SLA implants. At the 10-year analysis, no implants presented suppuration.

Successful therapy, defined as PD ≤5 mm, absence of bleeding/suppuration on probing, and no further bone loss, was found in 4 of 14 (29%) of the TPS and in 5 of 12 (42%) of the SLA implants (Figure 2). Overall, 9 out of 26 (35%) implants were successfully maintained for the entire observation period, while 7 implants had to be removed. (Table 5, Figure 4).

DISCUSSION

The aim of the present study was to evaluate the long-term (10-year) clinical and radiographic outcomes of a regenerative surgical procedure by means of DBBMC to treat peri-implantitis crater-like defects. This is, to the best of our knowledge, the first 10-year prospective study that presents results on the influence of the surface characteristics on the long-term implant survival rate, after treatment of peri-implantitis in a private clinic.

The present protocol was effective in BOP and PI reduction in both groups in the short (1-year) as well as in the long-term (7, 10-year). Mean peri-implant pocket depths in both groups markedly decreased at the 1-year evaluation and remained stable during the following years of observation. Regarding interproximal bone levels, it has to be underlined that both groups experienced a significant improvement 1-year after treatment, while a slight tendency to relapse around the TPS surfaces was detected at the 7 and 10-year analysis. During the 10-year examination, 5 implants with a TPS surface (35.7%) and 2 implants with an SLA surface (16.6%) had to be removed due to recurrent infections. Treatment success (PD ≤5 mm, absence of bleeding/suppuration on probing, and no further bone loss) was obtained in 4 of 14 (29%) of the TPS and in 5 of 12 (42%) of the SLA implants. These results confirm the short-term findings that surface characteristics may have an impact on the surgical regenerative treatment of peri-implantitis defects.

The key-role of implant surface on re-osseointegration has been investigated in animal studies, with controversial results (Persson, Berglundh, Sennerby, & Lindhe, 2001; Albouy, Abrahamsson, Persson, & Berglundh, 2011; Carcuac, Abrahamsson, Charalampakis, & Berglundh, 2015; Almohandes, Carcuac, Abrahamsson, Lund, & Berglundh, 2019). However, an interesting recent case report suggested this possibility in a clinical human scenario (Fletcher et al. 2017).

In a long-term retrospective study up to 11-year, Berglundh et al. 2018, reported better clinical outcomes in term of PPD and BOP reduction at implants with non-modified surfaces than at those with a modified surface. These results confirmed those previously published by the same group in a 1 and 3-year RCT (Carcuac et al., 2016; Carcuac et al., 2017) pointing out how the implant surface had a role on the treatment outcomes. One of the major differences between the surgical procedures used in these studies and the present proposal protocol is the use of an access flap, aimed to pocket elimination compared to a regenerative approach aimed to reconstruct the intrabony component of the peri-implant defects. Due to this main difference, comparisons among studies seem difficult. Moreover, it should be noted that the study by Carcuac et al. (2017) was not specifically designed to evaluate the impact of implant surface characteristics on treatment outcomes, as underlined by the uneven distribution between modified and non-modified implants. Therefore, the results referred to the category “modified”, which included different surface modifications, should be therefore interpreted with great caution.

Recently, long-term studies with at least 3 years of follow-up evaluating different regenerative protocols to treat peri-implant defects have been published (Roos-Jånsaker, Persson, Lindahl, & Renvert, 2014; Schwarz, John, Schmucker, Sahm, & Becker, 2017; Andersen, Aass, & Wohlfahrt, 2017; Isehed, Svenson, Lundberg, & Holmlund, 2018; Mercado, Hamlet, & Ivanovski, 2018; La Monaca et al., 2018):

Roos-Jånsaker investigated, in a 5-year RCT, the adjunctive use of a resorbable membrane with or without a bone fill to treat peri-implantitis intrabony defects. The obtained data failed to suggest its clinical use since comparable results in terms of radiographic bone fill were detected.

The 7-year results on 15 patients treated with a combined resective and regenerative approach reported by Schwarz et al. 2017 showed clinical stable parameters in term of PD and BOP reduction, even-though no data on the radiographic measurements were provided.

More recently, long-term (7-year) data on alternative regenerative materials (i. e. porous titanium granules) to successfully treat peri-implantitis defect have been published by Andersen et al. 2017: around the 12 patients available for analysis, radiographic defect depth changes were comparable to the 1-year results with no difference when compared OFD group. Similar results have been published by Isehed et al. 2018, who investigated the efficacy of EMD to treat peri-implantitis: at the 5-year follow-up, only 14 patients were considered for analysis which did not revealed any statistically significant difference between test (OFD + EMD) and control (OFD).

A tendency to relapse after more years of observation following regenerative procedures to manage peri-implant defects has been also recently reported by La Monaca et al. 2018: in particular the percentage of implants successfully treated at 1-year 91% dropped down to 59% at the 5-year evaluation, underlining the difficulties in maintaining the promising short-term results.

Following these findings, the question of which regenerative material should be considered ideal is still open. In the present study, DBBMC was preferred to DBBM alone due to the better handling modality and the possibility to be used with no membrane. The positive results seem corroborated by a 3-year prospective study (Mercado et al. 2018) where similar clinical results (i.e. PD and BOP reduction) after a regenerative approach with the same bone substitute, were found. However, it has to be underlined that the wide difference in follow-up periods (10 vs. 3-year), the use of different clinical thresholds to define “treatment success”, as well as the adjunctive use of EMD and a locally delivered antibiotic, make precise comparison difficult.

Irrespective of the surgical approach, the adhesion to an adequate maintenance care program has been shown to be crucial to preserve the obtained results in the long-term. A recent systematic review by Roccuzzo et al. (2018), based on 13 publications with a follow-up of at least 3 years, reported the favorable results in term of implant survival rate after therapy of peri-implantitis followed by regular supportive care. Nonetheless, due to the high heterogeneity between studies in terms of frequency and protocols applied during SPT, no clear clinical recommendations could be indicated. More recently, a tool for preventing peri-implant disease, based on the assessment of various risks, was presented. The tool could also help clinicians to optimize the maintenance care of patients after they received treatment of peri-implantitis defects (Heitz-Mayfield et al., 2020).

This study presents several limitations: first, and most important, the sample size is very small. Secondly, the number of drop-outs is high, even though it is in the same percentage range of other similar long-term publications (Heitz-Mayfield et al., 2018; Schwarz et al., 2017). Third, the clinical and the radiographic measurements did not follow a calibration session, even though they were all collected by experienced dental professionals, blinded to the type of implants. For these reasons, data analysis did not allow generalizability to a population-based setting through a statistical analysis. Finally, a precise assessment of the quality of supportive therapy, during the entire long observation period, was not possible, even though most patients were seen on average 3 to 4 times a year, in accordance with similar recent studies (Carcuac et al. 2017; Heitz-Mayfield et al. 2018; Isehed et al. 2018).

Within the limitations above described, the proposed regenerative surgical approach, followed by an adequate SPT protocol, resulted in stable clinical parameters during the 10-year period examination, around most of the SLA implants. Indeed, it has to be underlined that most TPS implants were lost, while a significant number of both implants required adjunctive treatment.

In conclusion, it can be suggested that the decision on whether to treat or remove an implant should be based on several factors, thoroughly discussed with the patient, including implant surface characteristics.

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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)**	10-year Survival
1	M	56		25	ø 4.1 x 10 mm TPS	**C**	Yes
2	F	53		31	ø 3.3 x 12 mm TPS	**C**	No
3	M	68		21	ø 4.1 x 10 mm SLA		Yes
4	F	66		35	ø 4.1 x 10 mm TPS	**§**	-
5	M	55		46	ø 4.1 x 08 mm SLA		Yes
6	F	55		14	ø 4.1 x 10 mm TPS		Yes
7	F	60		24	ø 4.1 x 10 mm SLA	**C**	No
8	M	68		27	ø 4.8 x 08 mm SLA	**§**	-
9	F	67		26	ø 4.1 x 10 mm TPS	**D**	No
10	M	58	Yes	13	ø 4.1 x 10 mm SLA	**§**	-
11	F	70		23	ø 4.1 x 08 mm TPS		No
12	F	56		37	ø 4.8 x 08 mm SLA	**C**	No
13	F	79		35	ø 4.1 x 10 mm TPS	**§**	-
14	M	60		26	ø 4.1 x 10 mm TPS	**§**	-
15	F	54		26	ø 4.1 x 10 mm TPS	**C**	Yes
16	F	63		31	ø 4.1 x 10 mm TPS		Yes
17	F	46	Yes	17	ø 4.8 x 10 mm SLA		Yes
18	M	51	Yes	46	ø 4.1 x 12 mm TPS	**D**	No
19	F	71		17	ø 4.8 x 10 mm SLA		Yes
20	M	64	Yes	35	ø 4.1 x 12 mm TPS		Yes
21	F	57		36	ø 4.1 x 08 mm TPS		Yes
22	F	56		27	ø 4.1 x 08 mm SLA		Yes
23	F	56		14	ø 4.1 x 10 mm SLA		Yes
24	F	63		46	ø 4.1 x 10 mm SLA		Yes
25	M	45		36	ø 4.1 x 12 mm TPS	**D**	No
26	M	62		36	ø 4.8 x 10 mm SLA		Yes

§ Patient lost to follow-up

Table 2. List of reasons for drop-out

	n

Death	3
Severe health problems	1
Moved	0
Refused to accept a visit	1
Total	5

Table 3. Parameters for TPS (n= 14) and in SLA (n=12) implants

	TPS	**SLA**
Implants at baseline	14	12
Drop out	3	2
CIST C/D *	6	2
Implant lost	5	2
Treatment success **	4 (29%)	5 (42%)

*Sites treated according to modalities C and D of CIST (antibiotics and/or surgery).

** No further bone loss, no pus, PD ≤5mm, and BOP=0, at 10 years

Table 4. Clinical parameters around the 8 SLA & 6 TPS implants, which reached the 10-year examination (means ± SD)

	Baseline	1-yr	7-yr	10-yr
PD (mm) Overall	6.9 ± 1.3	3.7 ± 1.5	3.2 ± 0.7	3.3 ± 0.5
SLA	6.8 ± 1.4	3.2 ± 1.0	3.1 ± 0.8	3.2 ± 0.5
TPS	7.0 ± 1.4	4.5 ± 1.7	3.2 ± 0.7	3.5 ± 0.5
Deepest PD (mm) Overall	8.2 ± 1.3	4.6. ± 1.9	3.9 ± 0.8	4.1 ± 0.8
SLA	8.0 ± 1.3	3.5 ± 1.2	3.8 ± 0.7	4.1 ± 0.8
TPS	8.5 ± 1.4	5.7 ± 2.1	4.0 ± 0.9	4.2 ± 0.8
Bone level (mm) Overall	3.2 ± 1.1	1.3 ± 0.9	0.9 ± 0.8	0.9 ± 1
SLA	3.1 ± 0.9	1.6 ± 0.8	0.5 ± 0.6	0.4 ± 0.6
TPS	3.4 ± 1.5	1.8 ± 0.1	1.4 ± 0.2	1.4 ± 0.1
BOP at the implant site (%)				
Overall	82.1 ± 25.7	28.5 ± 31.1	14.3 ±18.2	14.3 ± 18.2
SLA	75 ± 32.7	12.5 ± 13.4	6.3 ± 11.6	12.5 ± 19
TPS	92 ± 13	54.2 ± 36.8	33.3 ± 20.4	12.5 ± 21
PI at the implant site (%)Overall	59 ± 27	21.4 ± 19.2	5.4 ± 11	7.1 ± 12

SLA	75 ± 32.7	18.8 ± 17.7	3.1 ± 8.8	9.4 ± 13
TPS	75 ± 22.4	25 ± 22.4	8.3 ± 13	4.2 ± 10.2
Pus Overall	7 (50%)	1 (21%)	0 (0%)	0 (0%)
SLA	3 (20%)	0 (0%)	0 (0%)	0 (0%)
TPS	4 (30%)	1(21%)	0 (0%)	0 (0%)

Table 5. Success rates expressed in number and percentages at 1, 7 and 10-year follow-up after treatment and SPT

N=26	1 year		7 years		10 years	
	n	%	n	%	n	%
Success	8	31	9	35	9	35
Partial resolution	18	69	11	42	5	19
Lost to follow-up	0	0	2	8	5	19
Implant loss	0	0	4	15	7	27

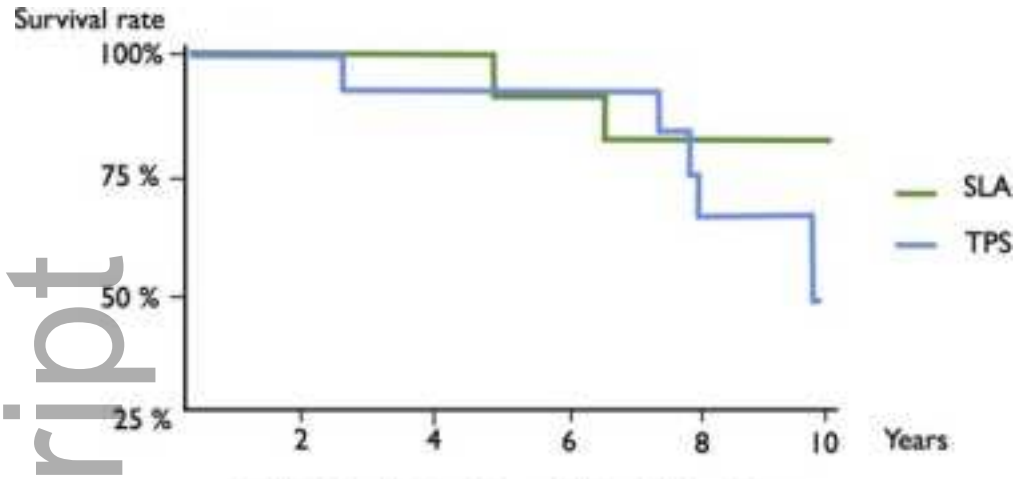

Figure 1

Kaplan-Meier estimate of the survival rate of the implants as a function of the time since peri-implantitis surgical treatment

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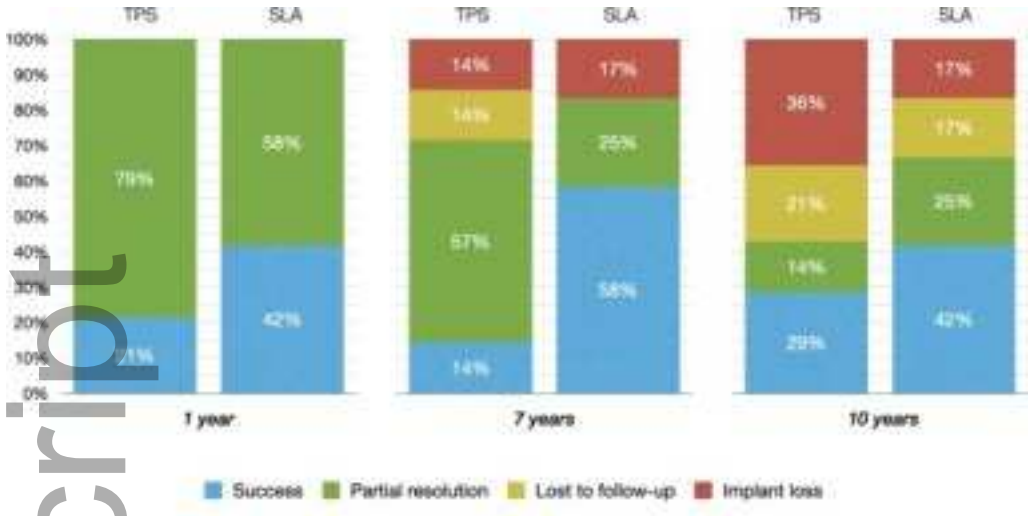

Figure 2 Success rate within the TPS and SLA implant surfaces through time

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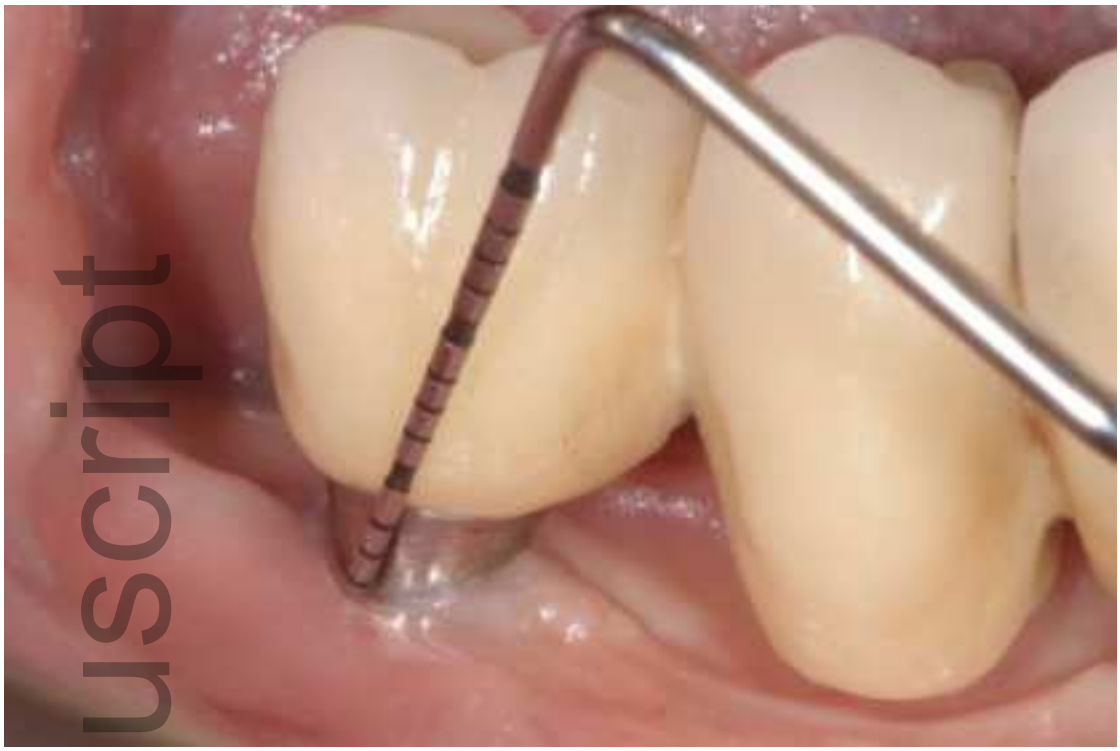

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