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ORIGINAL ARTICLE

Long-term treatment outcomes of single maxillary buccal peri-implant soft tissue dehiscences: A 10-year prospective study

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Abstract

Introduction: To evaluate the 10-year clinical outcomes following surgical treatment of shallow isolated peri-implant soft-tissue dehiscences (PSTD) at single tissue level dental implants.

Methods: The baseline population included 16 patients (16 implants) displaying an isolated peri-implant maxillary buccal soft-tissue dehiscence. The recipient bed was prepared with a minimally-invasive split-thickness flap limited to the buccal aspect to stabilize the tuberosity connective tissue graft (CTG) onto the periosteum. At the end of treatment, patients were enrolled in an individualized supportive peri-implant care (SPC) program. The aesthetic outcome was evaluated on photographs by three clinicians using a visual analog scale (VAS).

Results: SPC during the 10-years proceeded uneventfully in all patients. A total of 12 patients completed the 10-year examination, as 3 patients dropped-out and 1 implant was lost. Complete PSTD coverage was obtained at 7 implant sites (i.e., 58%) while the mean PSTD coverage amounted to 89.6% ± 17.1% without statistically significant differences between 1 and 10 years ($p > 0.05$). Stable peri-implant parameters (i.e., PD and BoP) and full-mouth scores (i.e., FMPS, FMBS) were recorded throughout the observation period ($p > 0.05$). The aesthetic improvements obtained in the short-term were maintained up to 10 years.

Conclusion: Within their limits, the present results indicate that the proposed surgical technique is a simple and reliable treatment option for the treatment of single maxillary buccal PSTDs in selected cases with positive results up to 10 years in patients under regular SPC (NCT04983758—this clinical trial was not registered prior to participant recruitment).

Leonardo Mancini and Crystal Marruganti contributed equally to the manuscript and share second author position.

KEYWORDS
aesthetics, dental implants, peri-implant soft tissue, peri-implant soft-tissue dehiscense, PROMs, soft tissue graft

Summary Box

What is known

Peri-implant soft-tissue dehiscences (PSTD) are a common clinical finding often requiring surgical treatment. Nowadays, only short to medium-term follow-up studies are available reporting positive aesthetic results.

What this study adds

This long-term clinical evaluation shows that the initial obtained positive clinical results, remain stable throughout a 10-year period in patients strictly adherent to a tailored SPC program.

1 | INTRODUCTION

It is nowadays widely accepted that the evaluation of implant-supported fixed dental prostheses should include "classic parameters" (i.e., implant survival and peri-implant marginal bone level changes),[1–4] in combination with aesthetics[5,6] and patient-related outcomes measures (PROMs).[7,8]

Historically, late development of peri-implant soft-tissue dehiscence (PSTD) has been associated with impaired aesthetics[9–11] and increased risk for peri-implant diseases.[5,12–15] Nevertheless, only very recently, a first attempt to estimate the prevalence of such conditions has been performed.[16] Indeed, the analysis of a cohort of 92 patients with 272 implants yielded a prevalence of 16.9% of PSTDs, and buccal implant position and the presence of a thin, soft tissue phenotype were statistically significantly associated with an increased risk for the development of such dehiscences. Due to the multi-factorial etiology of PSTD,[17] a universally accepted classification similar to the one used for gingival recessions[18] has been lacking for many years. To overcome this problem, an attempt to systematically classify PSTDs has been performed by Zucchelli and colleagues (2019) who identified four classes based on the position of the mucosal margin of the implant-supported crown, on the buccolingual position of the implant and on the interproximal papillae height.[19] However, due to the multi-factorial etiology of PSTDs,[20] the standardization of the defects requiring treatment and the applied techniques seem very challenging, leaving the level of scientific evidence behind such therapy in the vast majority of cases to a low-level (i.e., case-series).[21] More specifically, the management of PSTDs has recently gained scientific interest. Following a first attempt by Burkhardt and colleagues[22] to apply the coronally advanced flap (CAF) design combined with a connective tissue graft, a few years later Zucchelli and colleagues proposed a combined surgical-restorative approach to correct such mucosal dehiscences.[23] Thereafter, our group published a pilot study where single maxillary PSTDs were treated with an envelope flap in combination with a CTG, resulting in a mean recession coverage of 89.6%.[24] At the present time, only two of the three techniques above have been documented up to 5-years.[25,26] Consequently, it is of paramount clinical relevance to verify the stability of the obtained results in the long-term providing data for up to 10 years.

Hence, the aim of this prospective study was to report the 10-year clinical outcomes of a surgical technique for the correction of single buccal soft tissue dehiscences at maxillary tissue level implants.

2 | MATERIALS AND METHODS

The 10-year study protocol was submitted to and approved by the Institutional Ethics Committee (Nr.168/2021). The investigation was conducted according to the revised principles of the Helsinki Declaration (2018). All participants signed written informed consent prior to the initiation of the study. This clinical trial was not registered prior to participant recruitment. However, this study was retrospectively registered at http://ClinicalTrials.gov (NCT04983758) and data reporting followed the STROBE guidelines.

2.1 | Study population

The original population consisted of 16 patients (3 males and 13 females; mean age: 53.1 ± 11.7 years; 3 smokers) attending the senior investigator's specialist periodontal practice in Torino, Italy.

Details on the treatment protocol, the 1-year outcomes,[24] and the 5-year outcomes[26] have been previously reported.

Briefly, patients were treated for periodontal disease and consequently rehabilitated with non-submerged dental implants (Straumann Tissue Level Implants, Straumann AG) in anterior and posterior maxillary areas with a smooth neck of two different heights (i.e., 2.8 mm or 1.8 mm) according to a standardized protocol[27] with no bone/soft-tissue augmentation procedures prior to or concomitant with implant placement. All implants supported metal-ceramic cemented fixed dental prostheses. At the end of the active treatment, patients were enrolled in a tailored SPC[28] program including oral hygiene re-instruction, motivation, subgingival/mucosal instrumentation, and treatment, as needed.

Between June 2007 and December 2010, patients displaying a buccal and consequent exposure of the collar of the implant were consecutively enrolled according to the following inclusion criteria:

1. Presence of one implant-supported single-unit crown in the maxillary area displaying an apical displacement of the mucosal margin without bidimensional radiographic evidence of interproximal bone loss[29] and/or adjacent recession of the papillae
2. Healthy systemic conditions that could interfere with implant therapy
3. Lack of adhesion to the proposed SPC program

The exclusion criteria were:

1. Presence of multiple adjacent PSTDs
2. Presence of interproximal PSTDs
3. Presence of PSTDs associated with 3-D incorrect implant positioning (i.e., implant placed too buccally or with an incorrect mesio-distal inclination)
4. Peri-implant probing pocket depth ≥5 mm at the interproximal sites of adjacent teeth
5. Heavy smoking (>15 cigarettes/day)

2.2 | Baseline examination and pre-surgical care

Subjects were clinically and radiographically monitored at baseline. Full-mouth plaque score (FMPS)[30] and full-mouth bleeding score (FMBS)[31] were recorded. Peri-implant soft tissue dehiscence (REC) was measured from the implant shoulder to the coronal margin of the mucosa by means of a Castroviejo Caliper Short, (Salvin Dental Specialties, Inc.) and rounded off to the nearest ½ millimeter by a calibrated examiner, who also collected the following parameters using a periodontal probe (XP23/UNC 15, Hu-Friedy): Probing depth (PD), presence of dental plaque (PI) and presence of bleeding on probing (BOP) at four sites per implant (i.e., mesial, distal, buccal, and palatal/lingual). Figures were rounded off to the nearest millimeter. The aesthetic outcome was evaluated on photographs by three clinicians (Andrea Roccuzzo, Leonardo Mancini, Crystal Marruganti) using a visual analog scale (VAS) (0 = poor, 10 = excellent).

Following selection, all patients received appropriate initial therapy, consisting of motivation, proper oral hygiene instruction, scaling, and root planning with the aim of creating optimal conditions. Patients were also instructed to brush using the roll-stroke technique. No surgery was performed before the assurance of excellent motivation and compliance from every single patient (FMPS<15%; FMBS<15%) was obtained.

2.3 | Surgical intervention and post-surgical care

All surgeries were performed by the same surgeon (Mario Roccuzzo) with more than 30 years of experience in periodontal and implant surgery. Details of the technique have been previously reported.[24]

Briefly, an intracrevicular incision was carried out on the buccal aspect of the included implant in order to prepare the recipient bed with a minimally-invasive split-thickness flap. Next, a soft-tissue cuff was excised by a gingivectomy from the tuberosity area, deepithelialized, and trimmed with a mucotome to achieve a U-shape to facilitate an optimal adaptation around the collar of the implant. The prepared connective tissue was stabilized on the periosteum of the recipient bed and the flap was sutured coronally to completely cover the graft (Figure 1A-F). Sutures were removed after 2 weeks. At the completion of the healing phase, patients were enrolled in an individualized SPC program.

2.4 | Follow-up and clinical assessments

At the 5 and 10-year follow-up examination which took place before the planned SPC session, the same examiner (SG) with more than 15 years of experience as hygienist, blinded to the treatment provided recorded for each test implant PD measured at four sites (mesial, buccal, distal, and lingual) and mid-buccal soft tissue recession (i.e., from the implant shoulder to the coronal margin of the mucosa) (REC) using a periodontal probe (XP23/UNC 15; Hu-Friedy). In the same session, the presence of dental plaque (PI) and of bleeding on probing (BOP) were recorded at the same four peri-implant sites together with the assessment of FMPS and FMBS. Figures were rounded-off to the nearest millimeter and compared with baseline, 1, and 5-year scores. Finally, patients' aesthetic satisfaction was recorded by means of a visual analog scale (VAS) with a score between 0 (poor) and 10 (excellent).

2.5 | Data analysis

All analyses were performed using an ad hoc statistical software (STATA BE, version 17.1, StataCorp), setting the significance level at 5%. Continuous variables were presented as Mean ± Standard Deviation (SD), and categorical variables were presented as number of observations. Data distribution was checked using Shapiro–Wilk's test. Given the non-normal data distribution, non-parametric tests for repeated measures (Friedman test) were used to test any difference across timepoints (i.e., Baseline, 1 year, 5 years, and 10 years). Wilcoxon signed-rank test for matched pair with post hoc Bonferroni correction was then used for multiple comparisons. The same evaluations were performed with the McNemar test for categorical variables. All two-sided p-values <0.05 were considered statistically significant.

3 | RESULTS

3.1 | Demographic characteristics

From the 5- to the 10-year follow-up, one patient, unwilling to attend the final examination, dropped out, thus leaving 12 patients that completed the follow-up and consequently were available for statistical

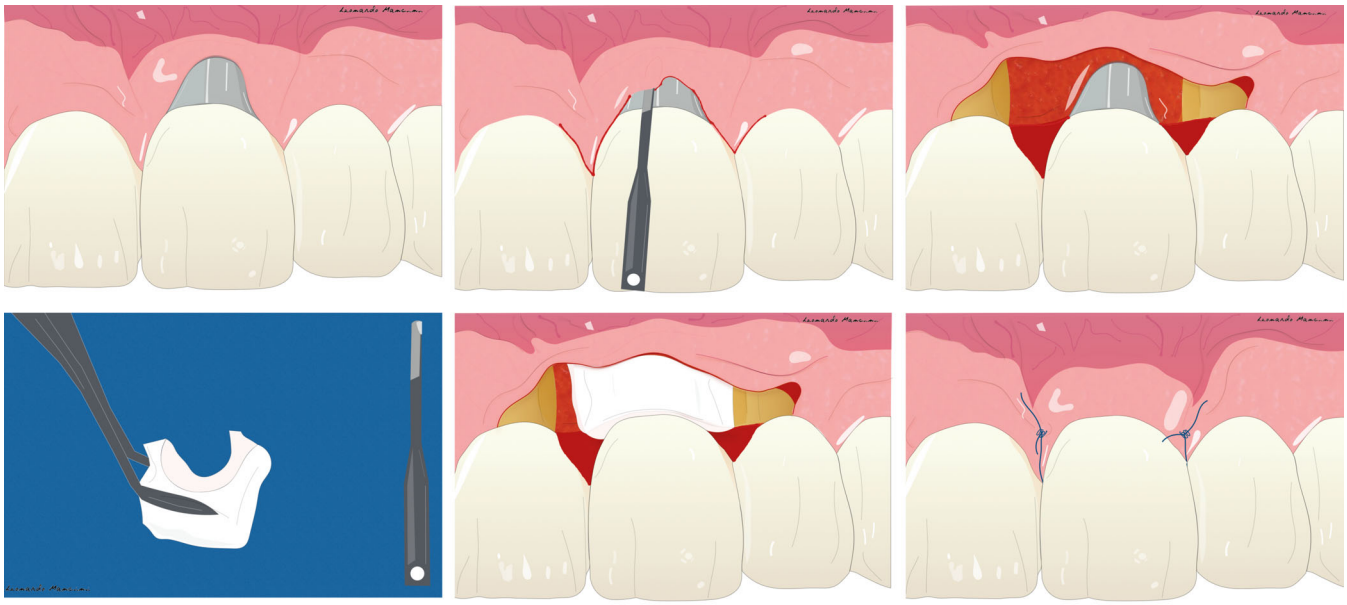

FIGURE 1 Schematic drawing of the proposed surgical technique: (A) Central left incisor ceramic crown on an implant placed 10 years before showing buccal soft tissue dehiscence. (B) Flap preparation by means of an envelope technique (C) Split thickness flap with no releasing vertical incisions. (D) Connective tissue grafts taken from the maxillary tuberosity and U-shaped (E) Graft adaptation to the split-thickness recipient site and around the collar of the implant. (F) Flap covering and suturing with interrupted sutures.

TABLE 1 Patients', implants and peri-implant soft tissue dehiscence (PSTD) defect location, months in function at the time of surgery, and dehiscence extension.

n	Sex	Age	Smoking	Site	Implant type	Months in function	REC Pre-op mm	REC 1 year post-op mm	REC 5 years post-op mm	REC 10 years post-op mm
1	F	55		1.4	S, ø 4.1 × 10 mm	38	3	0.5	-	-
2	F	51		2.3	TE, ø 4.1 × 10 mm	30	1.5	0	-	-
3	F	41		2.4	S, ø 4.1 × 12 mm	70	1.5	0	0	0
4	F	54		1.5	S, ø 4.1 × 12 mm	120	2	0	0	0
5	F	39		1.6	SP, ø 3.3 × 10 mm	26	1	0	0	0
6	F	40		1.3	TE, ø 3.3 × 12 mm	96	2	0	0	0
7	M	70		1.1	TE, ø 4.1 × 12 mm	35	3	1	0.5	0.5
8	F	65		1.4	TE, ø 4.1 × 12 mm	46	2.5	0.5	0	-
9	M	67	Yes	1.5	S, ø 4.1 × 6 mm	20	2.5	0.5	-	-
10	F	50	Yes	2.4	SP, ø 3.3 × 10 mm	14	1	0	0.5	0.5
11	F	28		1.5	S, ø 4.1 × 10 mm	64	1	0	0.5	0
12	F	61		2.5	S, ø 4.1 × 12 mm	31	2	0	0	0
13	M	57		2.1	TE, ø 3.3 × 12 mm	60	2	0.5	0.5	0.5
14	F	50		2.4	SP, ø 3.3 × 10 mm	20	3	0.5	0	0
15	F	55	Yes	2.2	SP, ø 4.1 × 12 mm	38	2	0	0	0
16	F	67		1.3	SP, ø 3.3 × 10 mm	18	1.5	0.5	0.5	0.5

analysis. Information regarding the included participants at each follow-up examination are shown in Table 1.

Over 10 years, the SPC program proceeded uneventfully and with minimal patient discomfort.

3.2 | Clinical outcomes

The clinical data at Baseline, 1-year, 5-years, and 10-years follow-up visits are reported in Table 2. From baseline to 10 years, mean

TABLE 2 Baseline, 1-year, 5-year, and 10-year clinical parameters around the implants which reached the 10-year follow up (means ± SD).

					p values					
	Baseline	**1-year**	**5-year**	**10-year**	**Baseline vs. 1-year**	**Baseline vs. 5-year**	**Baseline vs. 10-year**	**1 year vs. 5-year**	**1 year vs. 10-year**	**5-year vs. 10-year**
Recession (mm)	1.9 ± 0.7	0.2 ± 0.3	0.2 ± 0.3	0.2 ± 0.2	<0.0001	<0.0001	0.002	0.99	0.56	0.32
Complete PSTD[a] coverage	-	9/13	8/13	7/12	-	-	-	0.29	0.44	0.56
Mean PSTD coverage	-	89.7 ± 12.9	86.0 ± 19.0	89.6 ± 17.1	-	-	-	0.25	0.64	0.32
VAS	3.6 ± 0.6	8.8 ± 0.6	8.1 ± 0.9	8.5 ± 0.9	<0.0001	<0.0001	0.0005	0.05	0.33	0.23
Local BOP[b]	2/13	1/13	1/13	2/12	0.32	0.57	0.32	0.99	0.56	1.00
PD (mm)	2.7 ± 0.4	3.1 ± 0.5	2.9 ± 0.6	2.9 ± 0.5	0.12	0.88	0.27	0.87	0.61	0.33
FMPS (%)[c]	17.8 ± 9.2	17.9 ± 7.6	16.2 ± 4.7	17.4 ± 4.9	0.99	0.99	0.56	0.99	0.25	0.34
FMBS (%)[d]	17.2 ± 7.9	16.6 ± 8.3	14.8 ± 2.9	15.2 ± 4.1	0.99	0.99	0.18	0.59	0.29	0.75

[a]Peri-implant soft tissue dehiscence.
[b]Number of sites with BOP positive.
[c]Full mouth plaque score.
[d]Full mouth bleeding score.

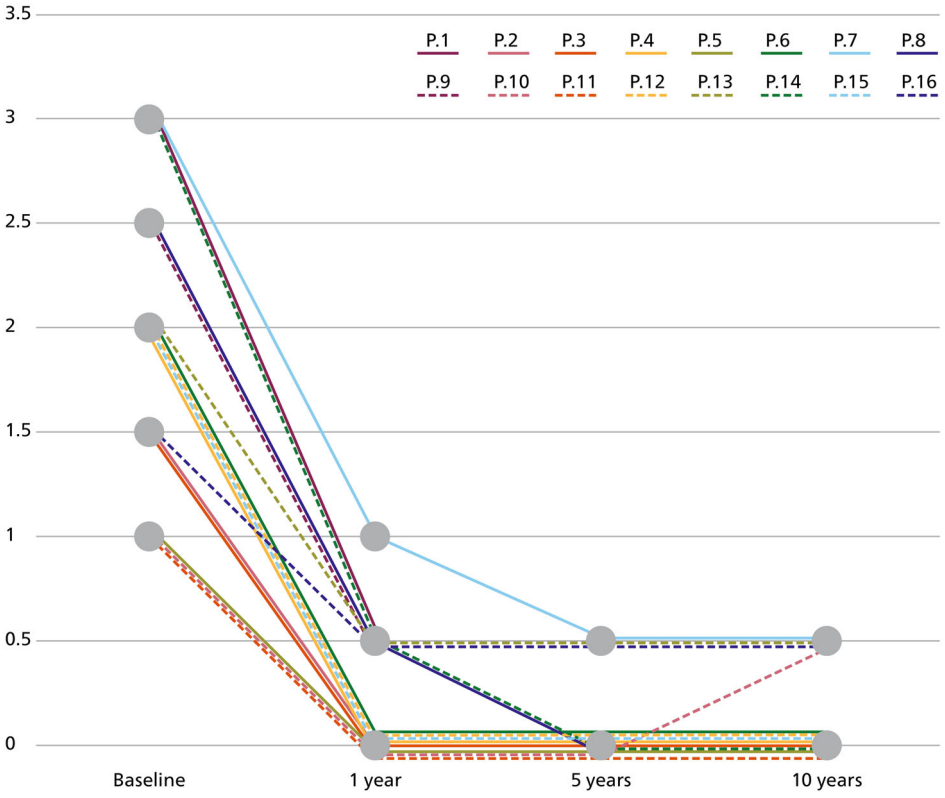

FIGURE 2 PSTD changes in mm through time in the 16 originally included patients.

mucosal recession decreased from 1.9 mm ± 0.7 to 0.2 mm ± 0.3 at 1-year follow-up and remained stable for the rest of the observation period, reaching 0.2 mm ± 0.2 at the 10-year examination. At the 10-year evaluation, mean dehiscence coverage was 89.6% ± 17.1%, and complete dehiscence coverage was recorded in 58.3% (i.e., 7 out of 12 cases). Figure 2 describes the PSTD changes in mm through time in the 16 patients. When focusing on the aesthetic outcome, the mean scores of the three measurements ranged between 3.6 ± 0.6 at Baseline and 8.5 ± 0.9 at 10 years, with a statistically significant difference between Baseline and 10 years ($p = 0.0005$). The improvements recorded at the 1-year follow-up remained stable throughout the observation period ($p > 0.05$).

Concerning the clinical peri-implant parameters (i.e., PD and BOP) no statistically significant differences were detected between the

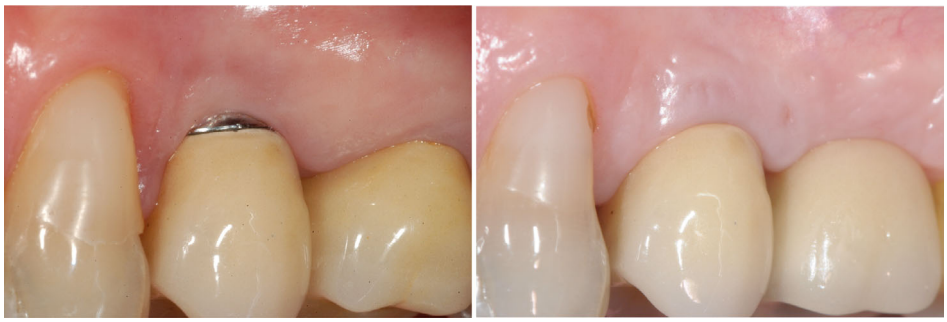

FIGURE 3 Clinical view at baseline and 10-year follow-up examination revealing stable outcomes.

Baseline and any of the 3 follow-up examinations ($p > 0.05$). At the 10-year examination, the mean patients' reported satisfaction score was 9.5 ± 0.8 (min 8, max 10).

Finally, when focusing on FMPS and FMBS scores, they remained stable throughout the whole follow-up period ranging between 17.8% ± 9.2% at baseline and 17.4% ± 4.9% at 10 years ($p = 0.56$) and between 17.2% ± 7.9% at baseline and 15.2% ± 4.1% at 10 years ($p = 0.18$), respectively.

4 | DISCUSSION

The present study aimed to assess the stability of the clinical results obtained with a proposed surgical technique to treat single maxillary buccal PSDTs up to 10-years.

The 10-year results indicate that the clinical improvements obtained both in the short (i.e., 1-year) and mid-term (i.e., 5-year) could be maintained in the long term. Indeed, out of the 12 patients who attended the 10-year follow-up visit, complete soft tissue dehiscence coverage was achieved in 7 cases (i.e., 58%) while the overall mean dehiscence coverage amounted to 89.6% ± 17.1%. These results are virtually impossible to compare with similar studies since, at the present time no data are available with such a long-term follow-up.

The importance of patient's adhesion to a tailored SPC program to maintain the results after both periodontal[32,33] and implant therapy has been widely assessed and documented.[1,34] The results of the present investigation confirm this trend also concerning the surgical treatment of PSTDs as shown by the documented low levels of full-mouth plaque and bleeding scores.

One aspect of the proposed surgical intervention is that no crown removal and/or abutment modifications were required and performed. This was possible because all implant and reconstruction characteristics had been properly controlled from the beginning by the same experienced clinician following a strict ideal surgical and prosthetic protocol. From a clinical perspective, it must be emphasized how a proper case selection has to be performed before going into surgery. An accurate assessment of the adjacent teeth' periodontal attachment is paramount since a compromised periodontium might not allow an ideal healing precluding from optimal results.[35] This topic has been very recently investigated by Tavelli and colleagues,[36] who reported positive results in 10 patients displaying peri-implant soft tissue dehiscences with adjacent teeth affected by interproximal attachment loss following vertical soft tissue reconstructive procedure combined with submerged healing.

The material of choice for such surgical grafting procedures remains controversial. If around teeth the use of a palatal connective tissue graft (CTG) has been documented to be the best treatment option irrespective of the harvesting procedure,[37] around dental implants a soft tissue graft harvested from the maxillary tuberosity might be preferable due to its histological properties (i.e., high in connective tissue fibers and with minimal presence of adipose and glandular components)[38] and reduced patient's morbidity.[39] This hypothesis has been recently confirmed in two RCTs reporting comparable positive results regarding soft tissue thickness at implant sites.[40,41] Nevertheless, it must be pointed out that the main focus of the present investigation was the coverage of the peri-implant soft tissue dehiscence. At the same time, the studies mentioned above mainly dealt with peri-implant soft tissue thickening procedures. However, irrespective of the donor site, there is emerging evidence on the importance of soft tissue phenotype modification obtained after the application of a connective tissue graft in order to enhance the long-term stability of the soft tissue margin.[42]

From the patient's perspective, it can be underlined that adopting the proposed surgical technique, only one intervention with a limited amount of time and morbidity achieved good clinical and aesthetic results, which were maintained for up to 10-years (Figure 3A,B).

The present study presents some limitations. First, and most importantly, is the absence of a control group, as each implant defect was treated to provide the patient with the best possible outcome. In this respect, it must be underlined that due to the difficulties in standardizing the morphology of the soft tissue defects requiring additional treatment, the level of evidence is low in most cases. Moreover, since the proposed technique was tested on one implant system only, the obtained results do not allow any generalizability to a population-based setting and have limited external validity. Finally, an assessment of the keratinized mucosa width and thickness in conjunction with a score to evaluate the implant dehiscence coverage (IDES)[43] would have provided additional information.

5 | CONCLUSION

Within their limits, the present results indicate that the proposed surgical technique is a simple and reliable treatment option for the

treatment of single maxillary buccal PSTDs in selected cases with positive results up to 10 years in patients under regular SPC.

AUTHOR CONTRIBUTIONS

Andrea Roccuzzo collected, analyzed the data and led to the writing. Crystal Marruganti analyzed the data, performed the statistical analysis and contributed to the writing. Leonardo Mancini, Giovanni E. Salvi analyzed the data and contributed to the writing. Anton Sculean, Guglielmo Ramieri critically revised the manuscript. Mario Roccuzzo conceived the idea, performed the surgeries and critically revised the manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare no potential conflict of interest with respect to this study. Andrea Roccuzzo was the recipient of a 3-year scholarship from the Clinical Research Foundation (CFR) for the Promotion of Oral Health, Brienz, Switzerland, and of a 1-year scholarship from the International Team of Implantology (ITI). Leonardo Mancini was the recipient of a 1-year scholarship from the Osteology Foundation.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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