

Increasing the Width of Keratinized Mucosa in Maxillary Implant Areas Using a Split Palatal Bridge Flap: Surgical Technique and 1-Year Follow-Up

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Sufficient soft-tissue coverage of maxillary implant sites may be difficult to achieve, especially after bone augmentation. The use of vestibular flaps moves keratinized mucosa (KM) toward the palate and may be disadvantageous for future peri-implant tissue stability. This study describes a new split palatal bridge flap (SPBF) that achieves tension-free wound closure and increases the KM width in maxillary implant areas. We began SPBF surgery with a horizontal incision in the palatal soft tissue to create a split-thickness flap. The second incision was performed perpendicular to the first, using a bridge design, at a distance of 10 to 15 mm. The superior layer can be moved crestally and sutured to cover the soft-tissue defect. The defect width was measured using a periodontal probe. The inferior layer was left exposed, and secondary wound healing created new KM in this region. This SPBF technique was performed on 37 patients. Of these, 16 patients were included in the assessment of clinical peri-implant outcomes. All of the SPBF procedures successfully resulted in a palatal regeneration of KM through secondary wound healing (mean regeneration width, 4.51 ± 1.17 mm; range, 3–6 mm). The 1-year follow-up of 16 patients revealed a mean pocket probing depth of 3.22 ± 0.6 mm with zero cases of peri-implantitis. The vestibular KM width at the involved implants was 2.82 ± 1.07 mm (range, 1.5–6 mm). Surgery for SPBF may be a promising technique for covering soft-tissue defects and increasing KM width in maxillary implant surgery.

Key Words: dental implant, maxilla, wound closure, keratinized mucosa, split flap, peri-implantitis

INTRODUCTION

Clinicians frequently have to use bone-grafting techniques to reconstruct lost bone before implant rehabilitation treatment. All bone grafts must be covered with soft tissue during the healing period. Postoperative wound dehiscence may lead to infections of the grafted site and therefore may seriously compromise the outcomes. Chaushu et al¹ reported partial or total loss of up to 18% of maxillary bone grafts due to soft-tissue complications. Her et al² found exposure of titanium mesh for maxillary bone augmentation in 5 of 9 cases. Across various membrane types used for bone augmentation, soft-tissue dehiscence has been diagnosed in 16% to 32% of cases.^{3–5}

Soft-tissue dehiscence in peri-implant surgery is often caused by wound tension⁶ and results in the exposure of grafted areas, which may lead to partial loss of bone grafts, among other complications.^{1,7} Maxillary bone augmentations are usually covered with vestibular flaps, particularly crestal

advancements, after the dissection of the periosteum. Crestal advancements also include the KM. Therefore, maxillary implantations together with bone grafting may often lead to later implants without attached and keratinized mucosa (KM).

The absence of KM around teeth and the resulting mobility of marginal tissues promote bacterial invasion of the gingival sulcus.⁸ The presence of KM improves the long-term prognosis of restored teeth.⁹ The impact of a sufficiently wide KM zone on the long-term success rate of dental implants remains unclear and has been a controversial topic in the literature. Earlier studies have shown that peri-implant tissues can be maintained in a healthy state with adequate plaque control. In fact, those studies found no correlation was found between the implant survival and/or success rates and the presence of KM.^{10–12} This finding was confirmed in a recent review.¹³ However, other studies have noted that consistently good oral hygiene around restorations is very difficult to maintain if KM is not present.¹⁴ Several studies have demonstrated increased levels of plaque and inflammation around implants in the absence of KM.^{15–17} More recent studies have shown that even with good oral hygiene and maintenance therapy, implants with less than 2 mm of KM in the peri-implant region were more prone to bleeding and exhibited greater radiologic bone loss and buccal soft-tissue recession.^{18–22} Moreover, elevated immunologic parameters (eg, PGE₂) were observed in these implants.²³ To minimize these risks, various proposals have been made

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DOI: 10.1563/aaid-joi-D-14-00025

regarding a potential surgical extension of the zone of KM around the implants.^{24–27}

This article presents a novel technique (split palatal bridge flap [SPBF] surgery) that uses palatal tissue to cover peri-implant bone-grafting sites and substantially augments the width of the KM. This might contribute to minimize the risk of peri-implant disease in maxillary dental implants. We present preliminary results from a retrospective case evaluation.

MATERIALS AND METHODS

Ethics statement

We present a new surgical technique to enlarge the amount of KM in maxillary implant areas. In addition, an evaluation of the first cases was carried out in a private dental practice specializing in implants (Northern Hessa Implant Center, Hofgeismar, Hessen, Germany). A retrospective, noninterventional study design was used; we analyzed primary patient data that had been extracted from the patients' records. The study was reviewed and authorized by the Ethics Commission of the Albert-Ludwigs University Freiburg, Germany (application No. 46/10-120329). The recommendations for Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) were followed.²⁸

Patients

We identified patients with dental implants who had received SPBF surgery between January 2008 and December 2012 and who had participated in a post-implant maintenance program. These patients were approached during their follow-up appointments and asked to participate in the study after receiving written information about the aims of the study and the study procedure. The patients who provided written informed consent and met the following inclusion criteria were included:

- Age ≥ 18 years
- Receipt of surgical and prosthetic treatment at the study center
- Regular participation in the supportive postimplant therapy (SIT) program (at least once a year)
- Functional restoration period >1 year
- Availability of the patient's complete medical history, including information about the following potential risk factors: medications (immunosuppressants and bisphosphonates), diabetes, cardiovascular disease, rheumatoid arthritis, and smoking habits

We used the following exclusion criteria:

- Use of implant designs other than the Ankylos system within a restoration
- Noncompliance in the postimplant maintenance program
- Untreated periodontal disease

Course of treatment

Anatomic indications for SPBF surgery were maxillary implantations in fully edentulous jaws or in areas >15 mm width in

partially edentulous patients. All of the patients were treated by a single experienced dentist and oral surgeon (E.F.). Using local anesthesia, a paracrestal incision (~ 5 mm toward the palate along the line angle) was made along the edentulous part of the jaw (Figure 1). Then, a full-thickness flap was elevated toward the vestibular aspect so that the palatal tissue size could be evaluated. After the implantation and hard-tissue augmentation (guided bone regeneration using β -TCP [ChronOs, Synthes GmbH, Umkirch, Germany]), together with autogenous bone chips and a resorbable collagen membrane (BioGide, Geistlich Biomaterials Vertriebs GmbH, Baden-Baden, Germany), wound closure was not possible because of the size of the soft tissue (Figure 2).

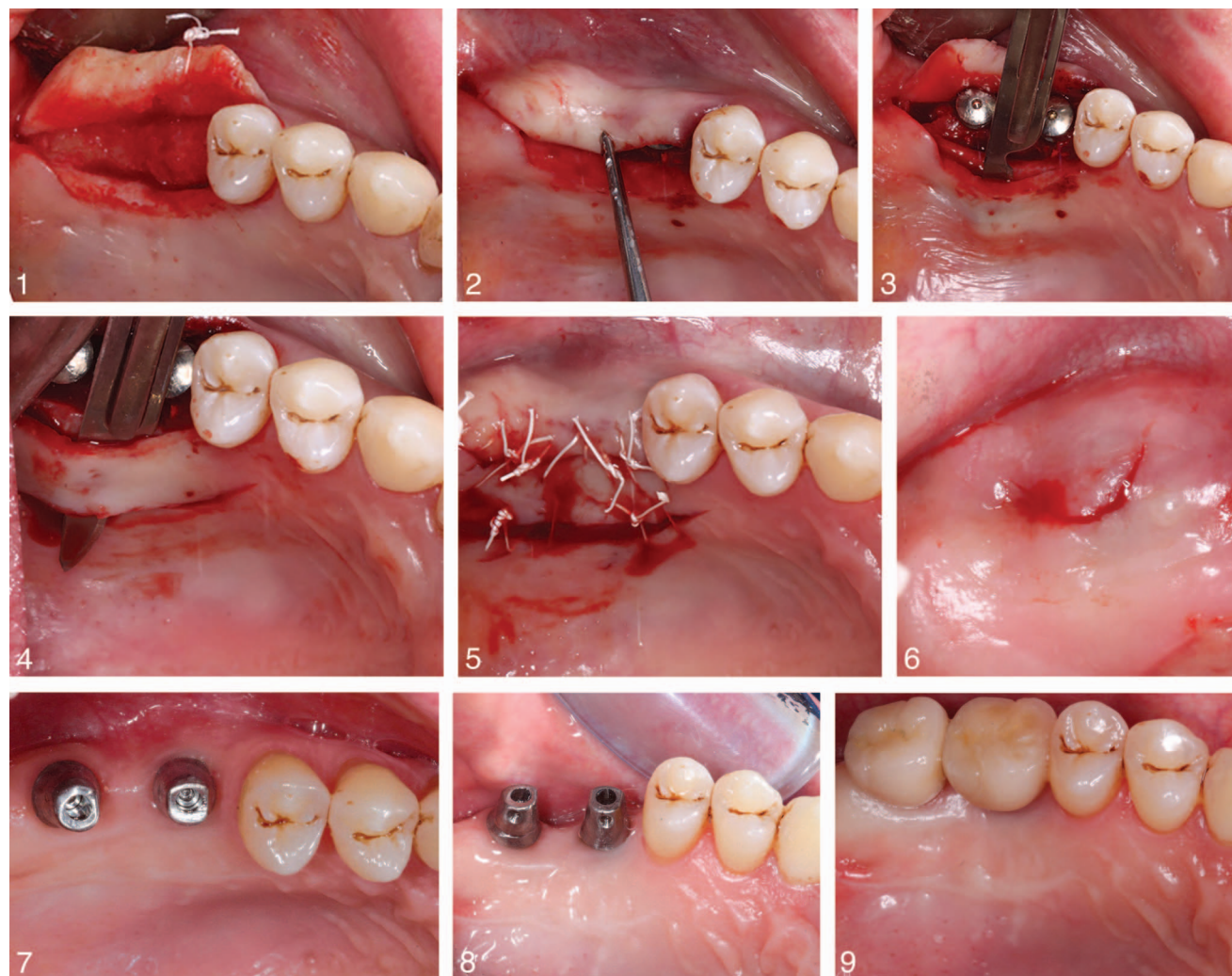
To create an SPBF, a 15-mm-deep split-flap incision was made to separate the superior KM portion of the palate from a portion of the underlying connective tissue (Figure 3).

Next, a slightly curved incision was made at a perpendicular angle to the first incision, 10 to 15 mm from the first incision, resulting in a sliding split-thickness strip of maxillary KM (Figure 4). This strip was moved crestally as an anterior and posterior pediculated bridge flap to cover the defect, and it was sutured in a tension-free manner (Gore 5x0, W.L. Gore & Associates, Flagstaff, Ariz). Finally, the wound margins in the palatal donor area were gently approximated with additional sutures (Figure 5). The donor area was sutured and covered with a previously fabricated stent (Erkodent 1.5 mm, Erkodent GmbH, Pfalzgrafenweiler, Germany) to facilitate wound healing. The entire procedure was performed under 4-fold magnification loupes. Periapical radiographs were taken postoperatively. The patients were given analgesics (ibuprofen; 400 mg) and advised to rinse with 0.2% chlorhexidine (Chlorhexamed, GlaxoSmithKline Consumer Healthcare GmbH & Co KG, Bülh, Germany) twice a day for up to 4 weeks. No chlorhexidine-related tooth staining was observed. The sutures were removed after 7 days, and additional wound control was performed after 28 days. After 3 months, the implant was uncovered using a semicircular incision (Figure 6).

After the implant-supported reconstructions were complete, oral hygiene instructions were given to the patients. Subsequently, they were scheduled for a postoperative implant maintenance program with trimonthly visits. Compliance was assessed during at least 1 follow-up session every year. The follow-up sessions included evaluation of the following peri-implant parameters: the Quigley-Hein plaque index (QHI),²⁹ periodontal probing depths measured at 4 locations per implant (mesiobuccal, distobuccal, mesiolingual, and distolingual), and bleeding on probing (BOP). After these evaluations, the patients were encouraged and instructed to perform plaque control measures (using dental floss and interdental brushes but no rinsing agents). Finally, the implants and the teeth involved were subjected to professional maintenance with polishing paste and a rubber cup (FSI Slimline, De Trey GmbH, Konstanz, Germany).

Radiographic bone loss

Following the usual post-implant radiology schedule of our center and using the long-cone parallel technique, intraoral radiographs were obtained to assess peri-implant bone levels on the mesial and distal aspects of each implant. An experienced dentist (D.Z.), who was not the implant surgeon, evaluated both the postsurgical and follow-up radiographs.



FIGURES 1–9. **FIGURE 1.** Paracrestal incision before implant insertion (region: 016, 017). **FIGURE 2.** Insufficient soft tissue for wound closure after implant insertion. **FIGURE 3.** First incision (partial thickness) in preparation for split palatal bridge flap (SPBF). **FIGURE 4.** Final preparation of SPBF. **FIGURE 5.** Wound closure after crestal flap shift (2 palatal adaptation sutures). **FIGURE 6.** Maxillary implant uncovering (17) using a semicircular incision to preserve KM width. **FIGURE 7.** Top view of implant abutments (3 months postoperatively). **FIGURE 8.** Wound healing of palatal donor area (3 months postoperatively). **FIGURE 9.** Implant-supported crowns and palatal donor area (12 months after intraoral delivery).

Bone levels were defined as the distance from the implant shoulder to the point at which the implant first met the bone. The difference in this measurement on the baseline radiographs after the intraoral deliverance of the prostheses compared with the follow-up radiographs was defined as individual bone loss. All of the measurements were taken from a radiograph viewer at $\times 4$ magnification using a graduated periodontal probe, and the results were rounded to the nearest 0.5 mm. To account for the inaccuracies arising from lack of precision in the radiographic examination, the implant lengths were measured at the longest portion. For this reason, an individual index factor (ratio of implant length to visualized length) was calculated to adjust for distortion and magnification effects. The mesial and distal measurements were averaged to arrive at 1 value for each implant.

Diagnostic criteria and statistical analysis

The success of SPBF surgery was defined as follows:

- Complete and tension-free coverage of the tissue defect
- Complete survival of the shifted flap without signs of tissue necrosis
- Uneventful healing of the palatal area of secondary wound healing with a subsequent regeneration of palatal KM

On the other hand, implant survival was defined as the presence of the implant in the mouth, disregarding any biological complications.^{30,31} The current recommendations in the consensus report of the 7th European Workshop on Periodontology were used to diagnose peri-implant soft-tissue diseases³² and to evaluate implant-related complications. Every recorded incident of BOP was defined as peri-implant

Mean ± SD age, y	71.9 ± 10.2	
Gender, n (%)	Female	12 (75)
	Male	4 (25)
Smoking status, n (%)	Nonsmokers	12 (75)
	Smokers	4 (25)
Systemic conditions, n (%)	Diabetes mellitus	1 (6.25)
	Coronary heart disease	9 (56.25)
No. of implants	27	
Mean ± SD (range) implant length, mm	10.56 ± 1 (9.5–11)	

Vestibular Keratinized Mucosa Width, mm		2.82 ± 1.07	Range: 1.5–6
Modified Quigley-Hein plaque index	Mean	0.44 ± 0.68	
	Grade 0	17	(62.96%)
	Grade 1	9	(33.33%)
	Grade 2	0	—
	Grade ≥3	1	(3.7%)
Implants lost	0		—
Peri-implant mucositis (bleeding on probing+)	11		(40.74%)

mucositis.²⁹ No true endpoints have been identified to diagnose peri-implantitis.^{33–37} Therefore, the following surrogate endpoints were used: positive BOP, pocket probing depth (PPD) ≥5 mm, and maximum bone loss ≥3.5 mm.^{30,31} If both criteria of BOP+ and PPD ≥5 mm were fulfilled, radiographic analysis was performed to confirm or confute the diagnosis of peri-implantitis. Because of the small sample size, a meaningful statistical analysis of the potential factors that influence the outcome of the treatment was not possible. Therefore, only descriptive statistics were calculated.

RESULTS

Patient characteristics

Between January 1, 2008, and December 31, 2012, 37 patients (29 women, 8 men) with 63 implants and a mean age of 60.41 ± 10.41 years (range, 35.96–77.55 years) were seen in private practice and underwent SPBF surgery. Of these, 8 patients (21.62%) were smokers, 5 patients (13.51%) suffered from diabetes, and 16 patients (43.24%) suffered from coronary heart disease.

Sixteen individuals (12 women, 43 men) with 27 implants receiving SIT passed a 1-year examination and were included in the follow-up evaluation. Of these, 4 patients (25%) were smokers (each >10 cigarettes/d), 1 patient (6.25%) suffered from (controlled) diabetes, and 9 patients (56.25%) suffered from coronary heart disease. Table 1 summarizes the pertinent patient data. The other patients have not yet reached the 1-year observation period.

Implants and dentures (all individuals)

All of the patients were given implants with a rough surface and a Morse taper design (Ankylos, DentsplyFriadent, Mannheim, Germany). All of the patients were treated surgically and restoratively by a single experienced clinician (E.F.). No implants

were lost, and all prostheses remained functional and in place (implant and prostheses survival rates: 100%). Table 2 summarizes the distribution of implants using the Fédération Dentaire Internationale numbering system.

Surgical outcomes (all individuals)

Wound healing was uneventful, and none of the patients reported extraordinary pain, bleeding, or swelling. All of the donor sites displayed normal wound healing. At the time of suture removal, all of the flaps were in place and seemed to be well perfused. No cases of necrosis could be detected. After 4 weeks, no signs of inflammation were observed. According to the defined criteria, all of the SPBF surgeries were successful.

The primary palatal tissue gap during surgery resulting from soft-tissue movement was left for KM regeneration via secondary wound healing and yielded 4.51 ± 1.17 mm (range, 3–6 mm). Examples of this soft-tissue manipulation technique and the wound healing of the palatal donor area are shown in Figures 7 to 9.

Retrospective case analysis

One year after the placement of the prostheses, 16 individuals with 27 implants were assessed for peri-implant outcomes (Table 3). The mean implant length was 10.56 ± 1 mm (range, 9.5–11 mm).

The overall plaque score (QHI) was 0.44 ± 0.69 (median, 0), while the mean PD was 3.18 ± 0.69 mm (range, 2.17–5 mm).

Bleeding on probing occurred for 11 implants (40.74%) in 7 individuals (43.75%). According to the diagnostic criteria of this study, these cases were classified as peri-implant mucositis. One of these cases had a mean PPD of 5 mm, and therefore, the 1-year radiographs were assessed for peri-implantitis. This diagnosis could not be confirmed using bone loss values, and therefore, no cases of peri-implantitis were observed in this study.

Number of Implants, (n = 27)	0	0	3	4	1	1	0	1	1	2	2	3	4	3	2	0
Tooth position (FDI)	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28

*FDI indicates Fédération Dentaire Internationale.

The KM width at the vestibular aspect of the implants was 2.82 ± 1.07 mm (range, 1.5–6 mm) 1 year after restoration.

DISCUSSION

The goal of this study was to present a new surgical approach for covering soft-tissue deficiencies in maxillary peri-implant sites that simultaneously enlarge the KM width. Using the SPBF technique, bone augmentation areas can be covered with palatal KM, thereby avoiding the elevation and crestal mobilization of buccal flaps. Since 2008, 63 SPBF surgeries have been successfully performed, resulting in a considerable gain in KM before/after SPBF.

This practice-based investigation presents encouraging clinical outcomes of SPBF surgery after 1 year. The limitations of the associated study were the relatively small number of treated patients and implants, the short observational period, and the retrospective study design. Furthermore, no control group was used. Therefore, these data provide only an indication of the potential of this technique, and no strong conclusions can be drawn. Although our study was conducted using one implant system, we are confident that comparable results can be achieved with any other implant system.

Approximately 40 years ago, teeth were postulated to require at least 2 mm of keratinized gingiva to ensure that the marginal soft tissue remained free of inflammation.⁸ Based on several other studies,^{38–42} this dogma regarding the need for an adequate width of attached gingiva to prevent attachment loss has not been scientifically supported.

Today, we know that there is a similar, albeit not identical, form of tissue around implants. Particularly with regard to long-term preservation, it remains unknown whether the KM is necessary or beneficial for the implants. Studies have shown that a lack of KM does not adversely affect implant survival rates if plaque control is adequate.^{36,37} However, it is important to note that in clinical reality, a substantial proportion of patients are not able to ensure optimal plaque control.

More recent studies suggest that KM >2 mm has positive effects on the long-term stability of peri-implant soft tissue.^{18–22} Despite these findings, a recent review revealed only limited evidence supporting the need for KM around implants to maintain health and tissue stability.⁴³ These findings should be taken into account during soft-tissue planning.

The preservation or creation of adequate soft-tissue is one of the goals of implant therapy, and aims to achieve the long-term success of the implant and the patient's esthetic desires. Therefore, the prevention of peri-implant mucosal recession has received increasing attention. Marginal tissue recession around natural teeth has been recognized as a phenomenon that occurs even in populations with high oral hygiene standards.^{44,45} Analogously, recession can also be expected at implant sites despite the presence or absence of peri-implant inflammatory diseases (ie, mucositis or peri-implantitis). Data on this topic, especially over the long term, have been scarce. Bianchi and Sanfilippo⁴⁶ investigated 22 implants in 22 individuals that received submerged implants using connective tissue grafts. Furthermore, 20 implants were placed immediately in 20 patients without using a connective tissue graft. These patients served as the control group. After 6 to 9

years, mucosal recession >1 mm occurred in 5% of the connective tissue graft group and 20% of the control group. Evans and Chen⁴⁷ found that midfacial recession was a common phenomenon and could be expected in 40.5% of the sites with values ≥ 1 mm. Individuals with thin biotypes and implant shoulders in the buccal position were more prone to recession.

To create a sufficiently wide KM zone, perisurgical procedures appear to be advantageous. These procedures minimize the amount of time and surgery for the patient. In modern peri-implant surgery, the need to cover existing soft-tissue defects (including immediate implant placements and uncovered implants after hard-tissue grafting) frequently arises. If the aim is to build or preserve a sufficiently wide KM zone for implants, classic coverage and crestal mobilization of the vestibular flap can be disadvantageous because of the crestal movement of the KM. Grafting techniques, such as free gingival or connective tissue grafts, are more complex from a surgical point of view and require an additional donor site. Therefore, we developed a technique that covers these defects and uses existing palatal tissue, which is readily available. After the preparation of a palatal split flap, a 10- to 15-mm strip can be mobilized regularly. This strip is moved crestally as an anterior and posterior pediculated bridge flap to cover the defect, and it is sutured in a tension-free manner. Thus, the primary soft-tissue defect is shifted geometrically toward the palate and can heal via secondary intention. This process leads to a marked widening of the KM zone in the implant area. The mucogingival junction does not have to be mobilized crestally. In 25 implants (92.59%), ≥ 2 mm of vestibular KM width could be achieved by uncovering the implants without increased surgical effort (Figure 8). Unlike other proposed techniques, such as expander techniques,^{48,49} this perisurgical procedure does not appear to be very technique sensitive and does not place a significant additional strain on patients.

The Consensus of the 7th European Workshop on Periodontology describes peri-implant mucositis as a host response to the presence of bacterial biofilm and a preliminary phase of peri-implantitis.³² With a mucositis prevalence rate of 41% and no cases of peri-implantitis, the data in the present study reveal lower rates of peri-implant disease than those reported by Lindhe and Meyle,⁵⁰ who reported mucositis and peri-implantitis rates of 50% and 22% to 43%, respectively. Two additional current reviews found peri-implantitis in $\sim 10\%$ of included implants and in $\sim 20\%$ of individuals.^{35,51} Recent studies yielded peri-implantitis rates of 18%, 11.2%, and 9.1% among individuals that were periodically returning for postimplant hygiene programs.^{30,31,52} Considering the short observation period, the results of our study seem to support these findings.

We have shown that SPBF is a feasible and relatively simple technique that increases the amount of KM in maxillary implant areas. In cases of maxillary soft-tissue dehiscence, SPBF may prevent the crestal mobilization of the mucogingival junction. Therefore, it seems suitable to facilitate the aim of creating a sufficient KM zone at the vestibular aspect of maxillary implants. In further evaluations, SPBF should be compared with conventional flap closure.

CONCLUSION

Despite the limitations of this study, SPBF appears to be well suited to cover soft-tissue defects in maxillary peri-implant surgery for a distance of up to 6 mm using the palatal KM. SPBF might facilitate a sufficient KM zone for maxillary implants. However, because of the lack of a control group, no strong conclusions can be drawn. Future independent and prospective evaluations with larger sample sizes and control groups should be conducted.

Furthermore, future studies should assess the potential of the described surgical method for expanding KM width in immediate implant surgery as well as in implant uncovering surgery.

ABBREVIATIONS

BOP: bleeding on probing
 KM: keratinized mucosa
 PPD: pocket probing depth
 QHI: Quigley-Hein plaque index
 SIT: supportive postimplant therapy
 SPBF: split palatal bridge flap

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