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Efficacy of the split-thickness labial flap method for soft tissue management in anterior ridge horizontal augmentation procedures: A clinical prospective study in the anterior maxilla

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A B S T R A C T

Objective: To introduce a novel method of split-thickness labial flap in maxillary anterior ridge horizontal augmentation and to evaluate its efficacy and morbidity.

Materials and methods: 230 patients were selected to receive either particulate or onlay grafting. A split-thickness labial flap was applied to cover the grafted area and close the wound. The incidence of post-surgical complications and the level of patient discomfort were evaluated. A visual analog scale was used to quantify the amount of pain and swelling in the patients.

Results: In all 375 surgical sites, passive primary closure was achieved with the split-thickness labial flap method. Membrane exposure after surgery was seen in 6 cases in the onlay group and in 4 in the particulate group. No long-lasting pain (>1 week), paresthesia, or signs of infection occurred during the follow-up period of 6 months. The mean pain and swelling scores in the particulate graft group (2.75 ± 3.01 and 2.02 ± 2.51, respectively) were lower than the scores in the onlay graft group (3.18 ± 2.79 and 3.85 ± 2.25, respectively).

Conclusions: The flap advancement technique presented in this study facilitates clinically passive primary closure. This technique can be used successfully in both particulate and onlay horizontal graft procedures.

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1. Introduction

The reconstruction of alveolar defects after tooth loss is one of the most challenging surgical procedures in implant dentistry. Various grafting methods have been employed for the treatment of bone defects, including guided bone regeneration (GBR) (Yoon et al., 2014) and onlay bone graft (Fretwurst et al., 2015). All of these approaches require passive flap closure to allow bone regeneration. Reflected flaps should be repositioned after surgery for primary wound closure in order to ensure an undisturbed microenvironment during the healing period (Park et al., 2012).

Failure to maintain primary closure results in wound dehiscence, with consequent reduced or even failure of bone regeneration, and thus jeopardizes the implant (Machtei, 2001; Ronda and Stacchi, 2011). According to Storgard Jensen and Terheyden, the use of a bone block as graft material is associated with a higher risk of complications than with particulate graft (29.8% vs. 21.9%, respectively); they attributed this to the increased tension caused by the block graft (Sakkas et al., 2016). Many complications can arise due to the failure to achieve complete flap closure over the implant or barrier membranes, and so flap management can be considered more important than the grafting technique itself (Burkhardt and Lang, 2010).

Different surgical techniques have been proposed to manage the soft tissue and achieve tension-free primary wound closure. A common technique after bone grafting is the use of a buccal advancement flap, with periosteal releasing incisions (Romanos, 2010). This consists of a mid-crestal incision, with one or two vertical incisions and a periosteal releasing incision (PRI) for flap advancement (Romanos, 2010). The disadvantage with the technique is that the buccal advancement flap generates increased tension in the case of large bone augmentation and frequently results in loss of the oral vestibule or the attached gingiva (Kim and Yun, 2012).

Palatal rotational flap (Penarrocha et al., 2005) and palatal subepithelial connective tissue flap (Goldstein et al., 2002) have also been proposed to cover the regeneration site. Both of these flaps are technique-sensitive and require dissections in multiple

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planes to ensure maintenance of satisfactory vascularization (Nemcovsky et al., 2000). Moreover, the rotational flap does not allow for the use of a membrane.

The split-thickness flap has been proven to be effective for wound closure when there are large bony defects (Ogata et al., 2013). The traditional split-thickness flap technique involves only the periosteum and limits coronal positioning. This is also a technique-sensitive procedure, most notably the procedure of splitting of the palatal flap and its release, especially in cases where the palatal gingiva is very thin (Ogata et al., 2013). So far, there have been few studies on its usefulness in different grafting techniques.

The objective of this prospective study was to describe a surgical technique of split labial flap that could be easily performed to allow complete soft tissue closure over membrane placed on particulate or onlay graft. We aimed to evaluate the efficacy of this flap design and identify the postoperative complications.

2. Materials and methods

2.1. Study population and experimental design

The study participants were recruited between February 1, 2012 and January 31, 2015, from among those attending the outpatient department of the Peking University School and Hospital of Stomatology and requiring implant rehabilitation of missing maxillary teeth. Patients having a site that required bone grafting to increase alveolar bone ridge thickness, and fulfilling the inclusion and exclusion criteria detailed in Table 1, were consecutively recruited. All patients were scheduled for implant installation combined with either particulate (Fig. 1a) or onlay block graft (Fig. 2a), and releasing incisions were expected to be performed.

Patients were told the cost of grafting material and implant, and provided written informed consent. The study protocol was approved by the institutional ethics committee (PKUSSIRB-2016113115).

2.2. Clinical procedures

2.2.1. Preoperative procedure

All participants were evaluated and treated for prophylaxis until a clinically acceptable oral environment was achieved. Cone beam computed tomography (CBCT) was performed to evaluate the dimensions of the alveolar process, and the requirements for three-dimensional restoration-driven implant placement were identified.

2.2.2. Surgical procedure

All patients received prophylactic antibiotic therapy with 2 g of amoxicillin (or 500 mg of clarithromycin in case of penicillin allergy) 1 h before treatment. Surgery was performed under local anesthesia with 4% articaine according to a standardized protocol.

A crestal incision was placed slightly to the palatal side of the alveolar crest. Two secondary perpendicular incisions positioned one or two teeth mesial and distal to the defect area were created and extended 15 mm apically. A full-thickness labial flap was then elevated (Figs. 3a and 4a).

Patients were treated with either particulated or onlay bone graft. In the particulate grafting group, the implant (Thommen Medical AG, Waldenburg, Switzerland) was first placed according to standard surgical protocols (Fig. 3b). Healing abutment connection was carried out at the same time, and Bio-Oss™ (Geistlich Pharma AG, Wolhusen, Switzerland) was applied to cover the bone defect around the implant (Figs. 1a and 3c). In the onlay grafting group, after the bone block was fixed rigidly to the original alveolar bone with 1–2 miniscrews (Figs. 2a and 4b), a particulate anorganic bovine bone mineral graft (Bio-Oss™) was applied to cover the graft and the spaces around it (Fig. 4c). The fixing screws were removed and the implant was placed 4–6 months after the bone graft surgery. If necessary, additional Bio-Oss™ was applied to cover the bone defect around the implant. Healing abutment connection and soft tissue adjustments were carried out at the same time.

At the grafting surgery, the augmented sites in both groups were further covered by two layers of collagen membrane (Bio-Gide™; Geistlich Pharma AG, Wolhusen, Switzerland) (Figs. 1b and 2b). A horizontal incision was made perpendicular to the surface of the flap, 2–3 mm from the apex of the flap, and extended to a depth of approximately half the flap thickness (Figs. 1c, 3d, 4d). The labial flap was split into two, with the deeper flap comprising the periosteum and the inner part of the subepithelial connective tissue, and the superficial flap comprising the epithelium and the superficial part of the connective tissue (Figs. 1d and 2c). The deeper flap was then elongated and transformed into a pediculated one, so that it was mobile and easily reflected. The neighboring teeth were used as a reference point for the release flap. The margin of the deeper part of the labial flap was then adapted below the palatal flap and above the grafted area (Figs. 1d, 2d, 3e, 4e). Final adaptation of the flap margins was accomplished by horizontal mattress sutures (Figs. 1f, 2e, 3f, 4f).

Table 1
Inclusion and exclusion criteria for participation in the study.

Inclusion criteria
- Voluntary informed consent
- Age >18 years
- Clinical indication for horizontal bone augmentation as a result of inadequate bone thickness
- Edentulous opposing dentition with a denture (implant-borne or conventional) or natural teeth
- A minimum healing period of 4 months after tooth extraction

Exclusion criteria
- General contraindications for implant surgery
- Severe bleeding disorder
- History of radiotherapy to the head and neck region in the preceding year
- Poor oral hygiene
- Uncontrolled diabetes
- Pregnancy or lactating status
- Psychiatric problems or unrealistic expectations
- HIV infection
- Smoking of >10 cigarettes or cigar equivalents per day or chewing of tobacco corresponding to >10 cigarette equivalents per day
- Acute infection in the area intended for implant placement
- Local inflammation, including untreated periodontitis
- Severe bruxism or clenching habits
- Presence of osseous lesions

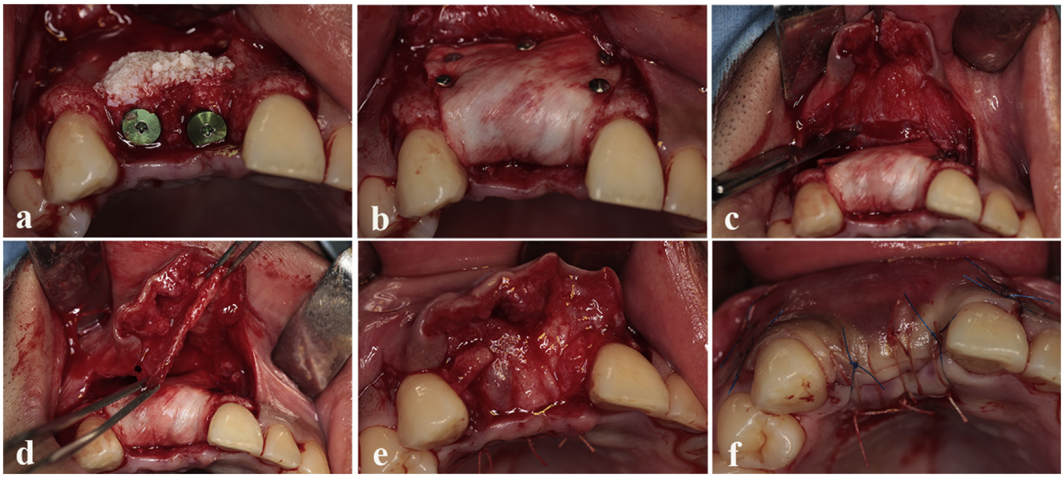

Fig. 1. Split-thickness labial flap technique for particulate grafting. a) Particulate grafting material mixed with autogenous bone was applied to cover the defect area. b) The augmented site was further protected with a two layers of collagen membrane. c) A horizontal incision was performed perpendicular to the surface of the flap and extended to a depth of approximately half the flap thickness. d) The flap was dissected using a split-thickness technique. e) The deeper flap was reflected over the alveolar crest and inserted into a palatal pocket, where it was fixed with sutures. f) The soft tissues were closed with horizontal mattress sutures.

2.2.3. Postsurgical care

After surgery, amoxicillin (750 mg three times a day), ibuprofen (600 mg three times a day), and 0.2% chlorhexidine mouthwash were prescribed for 7, 4, and 10 days, respectively. Patients were instructed to use the chlorhexidine rinse for 20 s three times a day. Their healing conditions were evaluated after 14 days (Fig. 2f).

2.2.4. Prosthetic procedures

After a 4-month healing period, conventional prosthetic procedures were performed to fabricate all-ceramic crowns.

2.2.5. Follow-up procedures and clinical assessments

Healing of the surgical site was clinically assessed on days 1, 7, and 14, and then at 24 weeks. The assessment results were categorized as 1) primary healing, without any tissue necrosis; 2) suppuration or infection; or 3) compromised wound as a result of dehiscence or marginal flap necrosis.

Complications related to the augmentation procedure were recorded as 1) intraoperative flap dehiscence, 2) membrane exposure, 3) infection, and 4) any other discomfort. Premature membrane exposure was defined as loss of primary closure during the 6-month healing period. The presence of infection was evaluated clinically; redness, swelling, pain, heat, and any other symptom requiring an additional course of antibiotics was taken as indication of infection.

Successful integration of the graft was indicated by 1) absence of pain or subjective discomfort, 2) graft stability at the time of implant placement, 3) absence of infection during the healing period, and 4) absence of radiographic signs of bone graft resorption.

Implant survival was indicated by 1) absence of clinically detectable implant mobility, 2) absence of pain or any subjective sensation, 3) absence of recurrent peri-implant infection, and 4) absence of continuous radiolucency around the implant.

A questionnaire to assess discomfort was administered on postoperative day 7. A visual analog scale (VAS) was used to quantify pain and swelling (Kim et al., 2015). For pain, the score on the scale indicated different intensities of pain, from 0 (no pain) to 10 (unbearable pain), and for swelling it indicated different grades

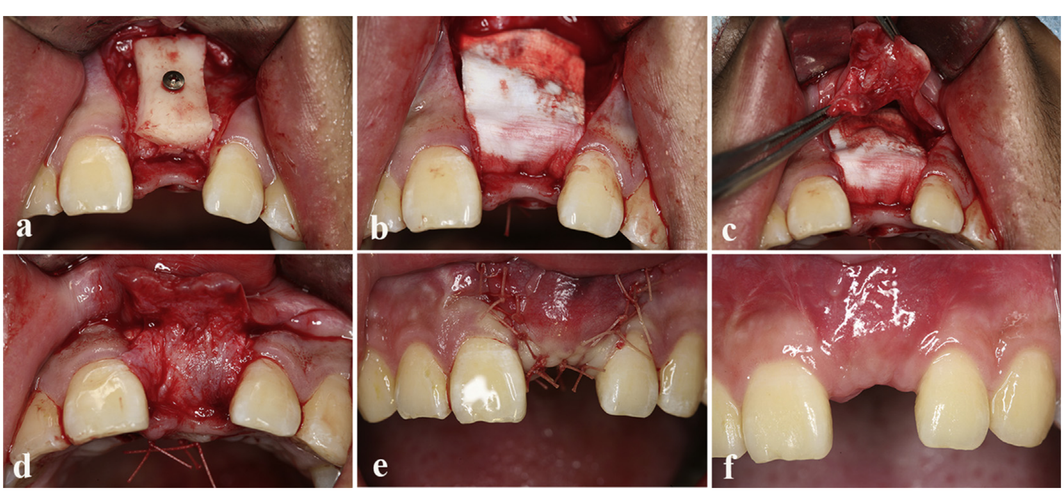

Fig. 2. Split-thickness labial flap technique for onlay grafting. a) The bone was fixed rigidly with a screw to reconstruct the buccal defects. b) The augmented site was covered with two layers of collagen membrane. c) The flap was dissected using a split-thickness technique. d) The deeper part of the flap was then reflected over the alveolar crest and inserted into a palatal pocket, where it was fixed with sutures. e) The soft tissues are closed with horizontal mattress sutures. f) At second-stage surgery, the soft tissues appear very favorable, with a nice margin around the neighboring teeth.

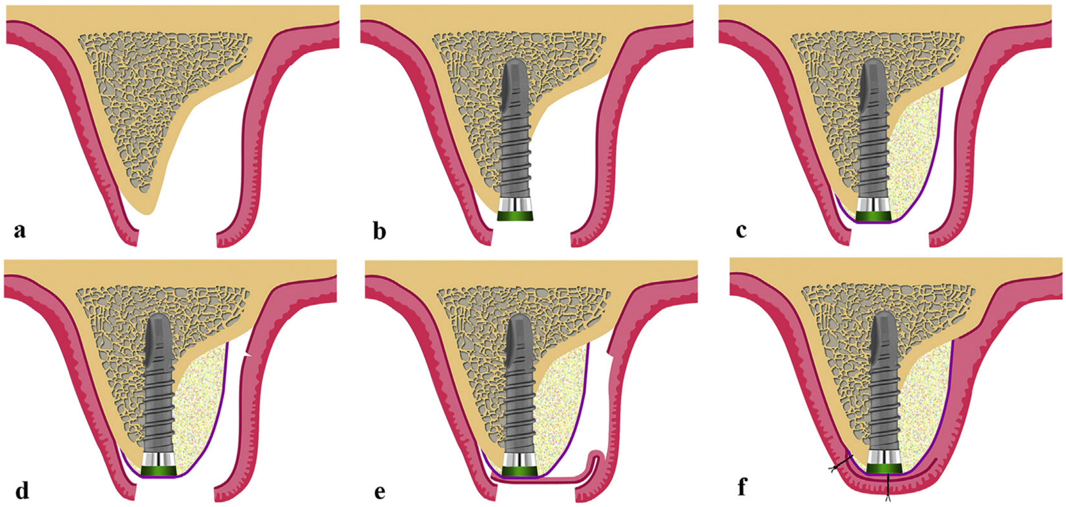

Fig. 3. Schematic drawing of the split-thickness labial flap technique for particulate grafting. a) After an incision is made over the alveolar crest, a mucoperiosteal flap is elevated on the labial side. b) Implant is first placed. c) Particulate grafting material was applied to cover the bone defect around the implant and then augmented sites is covered by collagen membrane. d) A horizontal incision was made perpendicular to the surface of the flap and extended to a depth of approximately half the flap thickness. e) The labial flap was split into two and the deeper part was adapted below the palatal flap. f) Final adaptation of the flap margins was accomplished.

of swelling, from 0 (no visible and palpable difference) to 10 (very noticeable change in size and shape) (Table 3).

2.3. Statistical analysis

Statistical analysis was performed using SPSS 16.0 (SPSS Inc., Chicago, IL, USA). The chi-square test was performed to compare distribution of complications between the two groups, and the independent samples *t* test was used to compare the differences in patient discomfort. Statistical significance was set at $P \leq 0.05$.

3. Results

A total of 230 consecutive horizontal bone graft procedures were performed in this study, with the contextual insertion of 375 implants. The distribution of the surgical sites and grafting techniques are summarized in Table 2. No patients were lost to follow-up. Coronal displacement of the flaps provided complete passive coverage in all the augmented sites.

3.1. Incidence of intraoperative and postoperative complications

During the flap preparation and suture, flap dehiscence occurred in 13 cases (6 in the onlay and 7 in the particulated group). Bleeding related to flap preparation stopped in all after the donor site was sutured. No bleeding occurred during the postoperative period. Although primary closure was achieved in all cases, signs of infection were seen in the augmented zone in 2.3% and 3.1% sites, respectively, in the particulate grafting and onlay grafting groups during the 2 weeks following surgery. Membrane exposure was observed in 10 patients during the healing period (4 in particulate grafting group and 6 in onlay grafting group) (Table 4). In all 10 patients, after irrigation with saline solution, the grafting sites spontaneously re-epithelialized, with no need for resuturing and

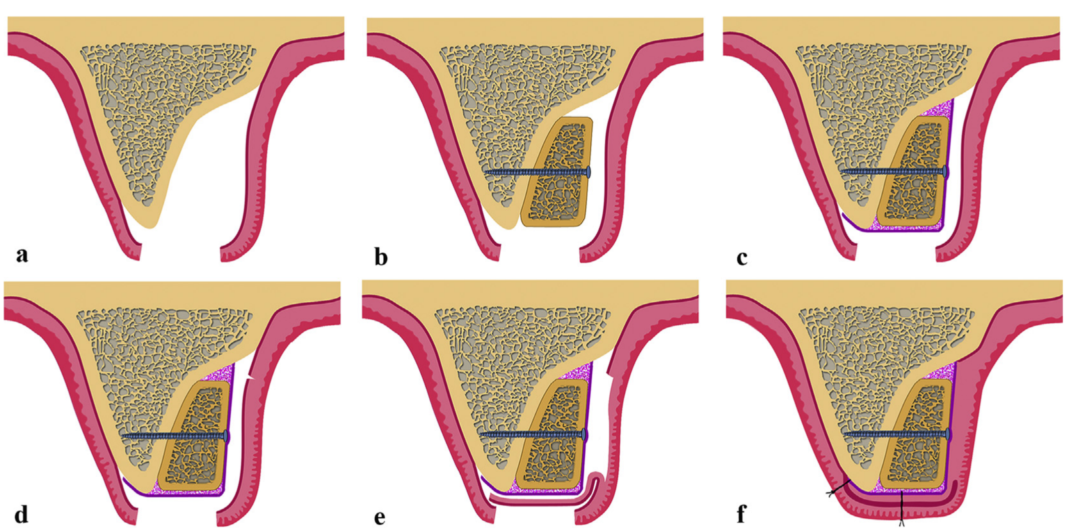

Fig. 4. Schematic drawing of the split-thickness labial flap technique for onlay grafting. a) After an incision is made over the alveolar crest, a mucoperiosteal flap is elevated on the labial side. b) Bone block is fixed rigidly with a miniscrew. c) Additional particulate graft and collagen membrane are applied to cover the graft. d) A horizontal incision is made perpendicular to the surface of the flap and extended to a depth of approximately half the flap thickness. e) The labial flap was split into two and the deeper part was adapted below the palatal flap. f) Final adaptation of the flap margins was accomplished.

Table 2
Characteristics of the patients.

	Onlay graft group	Particulate graft group
Female patients	44 (44.9%)	69 (52.3%)
Mean age at implant insertion (years)	39.5	39.8
Total number of inserted implants	146	229
Patients receiving one implant	63	55
Patients receiving two implants	22	57
Patients receiving three implants	13	20
Implants loss	3	3

Table 3
Patient discomfort questionnaire.

Pain severity (0–10)	
Slight (0–3)	No or little discomfort
Moderate (4–6)	Pain that bothered you or mildly affected your daily functioning
Severe (7–10)	Pain that could not be tolerated or that disrupted your daily functioning
Swelling severity (0–10)	
Slight (0–3)	No change or slightly visible change in appearance to a felling of "fat" that you could not recognize at a glance
Moderate (4–6)	Moderate visible change in size and shape that you could recognize apparently or easily, in addition to a "fat" feeling
Severe (7–10)	Very noticeable change in size and shape

no further problems. These complications did not result in grafting mobility and failure. In the other patients, the wounds healed without complications.

3.2. Patient discomfort survey results

The average pain score was 1.55 ± 1.21 in the particulate grafting group vs. 3.75 ± 2.63 in the onlay grafting group ($P = 0.019$). The average swelling scores for the particulate grafting group and the onlay grafting group were 1.91 ± 0.94 and 3.25 ± 1.29, respectively ($P > 0.05$) (Table 5).

4. Discussion

In this study, we examined the efficacy of split-thickness labial flap in maxillary anterior ridge horizontal augmentation and found that it was effective in achieving and maintaining soft tissue closure over the grafted area, with only 4.3% of membrane exposure.

To enable implant placement in severely atrophic alveolar bone, augmentation procedures such as particulate and onlay grafting are required (Penarrocha-Oltra et al., 2014; Jardini et al., 2016). Often, with larger horizontal and vertical bone augmentations, insufficient mucosa is available (Triaca et al., 2001). This results in either failure to achieve closure of the soft tissues, or closure with tension, with consequent soft tissue dehiscence and bone exposure (Greenstein et al., 2009). To minimize the risk of dehiscence, it is necessary to achieve tension-free wound closure, especially in cases of severe ridge defects. Several surgical techniques have been developed to achieve primary closure of bone augmentation sites, including coronally advanced buccal flap (Mellonig and Triplett, 1993), connective tissue grafts (Rosenquist, 1997), and extension of palatal tissues (Nemcovsky and Artzi, 1999). The traditional split-thickness flap technique involves splitting of the palatal flap into two, with the deeper flap containing the periosteum (Tinti and Parma-Benfenati, 1995). We used the labial flap in the present study because it is easier to perform and because it does not add to the palatal soft tissue trauma. The horizontal releasing incision extends to a depth of approximately half the flap thickness. The deeper flap contains periosteum and also the inner part of the subepithelial connective tissue. The periosteum is a thin but resistant tissue that is mainly composed of densely collagen fibers, and it is therefore capable of absorbing the flap tension (De Stavola and Tunkel, 2014). A deep incision into the submucosa could potentially facilitate tension-free flap advancement; however it would also interfere with the blood supply from the vestibule. Therefore, a 1-mm-deep incision was applied to attain tension-free primary closure without compromise of the blood supply to the pedicle flap (Penarrocha et al., 2007).This method provides substantial advantages in any surgery that requires coronal positioning of the flap. The technique is similar to the one proposed by Park (Park et al., 2012). It is noted that flap dehiscence occurred in 13 patients during surgery. Horizontal incision extension not beyond half the flap thickness is crucial to reduce the incidence of dehiscence, especially for thin gingival biotype.

The internal split-thickness layer of the flap could also add stability to the grafted area and was suited to vertical bone augmentation. In a previous study, in which split facial flap after bilaminal cortical tenting grafting was used for vertical reconstruction of severely atrophic alveolar ridges, only one patient exhibited dehiscence, and all recipient sites re-epithelialized without problems after irrigation; no erythema, suppuration, or infection were observed (Yu et al., 2016).

Complications at the recipient site are often caused by soft tissue problems such as wound dehiscence, flap necrosis, and membrane exposure. According to a review by Jensen, the reported rate of soft tissue complications for split-thickness flap designs used for extraction socket preservation varies between 16% and 22% (Jensen and Terheyden, 2009). In the present study, the rates were lower (5.1% in the onlay graft group and 3.0% in the particulate graft group). The use of a block bone rather than particulate graft

Table 4
Incidence of intraoperative and postoperative complications.

Group	Intraoperative flap dehiscence	Membrane exposure	Paresthesia	Infection	Continuous discomfort
Onlay (n = 98)	6	6	0	3	2
Particulated (n = 132)	7	4	2	3	0

Table 5
Results of patient discomfort survey.

Group	Pain score	Swelling score
Onlay graft group (n = 98)	3.18 ± 2.79	3.85 ± 2.25
Particulated graft group (n = 132)	2.75 ± 3.01	2.02 ± 2.51

Scored on VAS with a range of 0–10.

material seems to be associated with a higher risk of healing complications, likely because block bone grafting increases tension (Jensen and Terheyden, 2009). Our findings are consistent with this theory. However, in the present study there was no difference between the two groups with regard to the success of passive flap adaptation. The particulate grafting group also experienced less discomfort than the onlay grafting group, with statistically significant differences in pain and swelling scores.

The thick layer of soft tissue containing part of the connective tissue can extend coronally and has the additional advantage for implant function, especially in the esthetic zone. Firm and stable peri-implant soft tissues act as a protective barrier against microorganism invasion. Vervaeke et al. in a retrospective clinical study have confirmed that initial tissue thickness has a role in crestal bone remodeling (Vervaeke et al., 2014). They assumed that implants with a thin initial gingival thickness, lose more peri-implant bone, possible by a re-establishment of the biological width (Vervaeke et al., 2014). Although the overall biologic width was stable, the proportions of each component of the biological width were not maintained over time. The dimension of the junctional epithelium increased over time, whereas the connective tissue contact decreased (Hermann et al., 2001). More prolonged connective tissue contact during the early healing phase might favor the maintenance of an adequate amount of connective tissue contact following implant function (Chu et al., 2015). Thus, full coverage with the use of connective tissue from the split-thickness flap may be useful for creating an effective soft tissue barrier.

This study had several major limitations. First, this was a single-center study and, second, there was no randomization of patients to the different treatment arms. Our findings therefore need to be confirmed by a large-scale, multicenter, randomized clinical trial.

5. Conclusion

The present study introduces the technique of a split-thickness labial flap for use in advanced implant surgery such as particulate and onlay grafting. This technique facilitated greater flap advancement and therefore caused fewer complications and less morbidity. The technique could be a practical alternative to the conventional periosteal releasing incision.

Conflict of interest

The authors declare no conflicts of interest.

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