Postextraction Socket Seal Surgery with an Epithelized Connective Tissue Graft Using a Subpapillar Tunneling Procedure

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Ridge preservation in the esthetic area is still a challenging procedure. The aim of the present case series was to introduce a technique for postextraction socket seal surgery using an epithelized connective tissue graft and socket filling with a xenogeneic biomaterial. Using a tunneling approach, the buccal gingiva and interdental papillae are undermined and augmented with the soft tissue graft. This method was applied and evaluated in 16 sites in 13 patients with need for extraction of at least one maxillary anterior tooth. Five months postoperative, the mean reduction of the horizontal width of the alveolar ridge was 0.5 mm, while the height of the mesial and distal papillae were reduced by 0.2 mm and 0.4 mm, respectively. The buccogingival margin of the alveolar ridge showed a vertical gain of 0.5 mm. Therefore, the presented technique seems appropriate for preservation of the alveolar ridge in esthetically relevant areas.

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studies have shown that biomaterials placed in extraction sockets might limit shrinking processes; however, they are not able to completely preserve the buccal bone wall. Systematic reviews have reported that regarding the various materials used for ridge preservation, no significant differences could be determined (except that collagen plug alone leads to negative results).

To improve the concept of ridge preservation, soft tissue grafts have been suggested to seal the alveolar socket and enhance the soft tissue prior to or simultaneously with implant placement. Socket seal surgery, introduced by Landsberg and Bichacho, uses a gingival graft to close the orifice of the extraction socket. Jung et al. combined this method with socket grafting using a bovine-derived bone substitute and reported improved soft tissue healing 6 weeks after extraction. However, due to the limited blood supply there is a risk of incomplete wound healing and necrosis, which was evaluated by Tal. Stimmelmayr et al. used a combined epithelialized connective tissue graft with two connective tissue parts placed in a supraperiosteal tunnel prepared on the buccal and oral sides of the socket. The latter had the advantage of additional thickening supporting the buccal gingiva of the socket, which can help avoid the problem of recessions in cases with thin gingival biotypes. However, none of the previously reported socket seal techniques included the thickening of the interproximal papillae. This would be desirable since interproximal soft tissue loss has been reported as a problem after extraction and, therefore, one of the disadvantages of delayed implant placement.

To optimize ridge contour and enhance the support of the interdental tissue, a modified socket seal technique with a buccally and interproximally placed epithelialized connective tissue graft using a tunneling procedure has been developed. The aim of the present study was to describe this technique in combination with socket grafting using a deproteinized bovine bone mineral and to analyze contour changes of the alveolar ridge 5 months after extraction.

**Method and materials**

Fifteen patients (9 women and 6 men), aged 29 to 59 years, requiring extraction of at least one maxillary anterior tooth, were recruited. Reasons for tooth extraction were endodontic lesions (n = 6), root fractures (n = 4), periodontics (n = 4), caries (n = 2), and prosthetic reasons (n = 2). All patients were systemically healthy and had adequate oral hygiene.

**Surgical procedure**

Before surgery, patients rinsed with 0.2% chlorhexidine solution for 2 minutes. Infiltration anesthesia was administered using articaine (Ultracain D-S, Hoechst). A crevicular incision was made around the tooth to separate the gingival crevice. Extraction was performed with particular care to preserve the buccal bone and the gingival tissue. Then, the socket was debrided and granulation tissue was carefully removed using a sharp spoon. Afterwards, a subperiosteal tunnel was prepared on the buccal side of the socket ranging toward the adjacent teeth and including the mobilization of both adjacent papillae (Figs 1a, 1b, 1c, 2a, 2b, and 2i). For this purpose, the buccal alveolar wall was first carefully exposed using a microblade (Keydent Micro Key-Blades, ADSystems) and a small papilla elevator (Papilla Elevator PHW, Aesculap) up to 2 to 3 mm beyond the margin of the bone crest. Then, preparation of the buccal tunnel was extended up to the mucogingival junction using tunneling instruments (Tunnelling Knives 1 and 2, Hu-Friedy) to achieve mobility of the tunnel. Subsequently, the interproximal tissue of both adjacent papillae was carefully elevated from the underlying bone using the papilla elevator, allowing a coronal elevation of the subpapillarily extended buccal tunnel.

For wound closure and soft tissue augmentation, a partially epithelialized connective tissue graft was harvested from the hard palate. Therefore, the first incision was made using a no. 15 blade (Swann Morton) approximately 4 to 5 mm beyond the margin of the palatal gingiva and traversing the widest horizontal diameter of the socket orifice. This incision marked the epithelialized part of the graft. The following two incisions were horizontal releasing incisions placed mesially and distally parallel to the margin of the palatal gingiva (Figs 1d and 2c). Subsequently, a split flap was
prepared beyond the epithelized part of the graft (the apical margin) and the horizontal releasing incisions. Then the complete graft was elevated using another internal incision directly over the bone involving the epithelized portion and the connective tissue pouch and extended mesially, distally, and apically (Figs 1e and 2d). After the graft was harvested, the donor site of the epithelized portion was covered with

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**Fig 1** Clinical example of the modified socket seal procedure on two lateral incisors. (a) Clinical situation before extraction of two hopeless lateral incisors. (b) Undermining preparation of the buccal gingiva beyond the mucogingival line using tunneling instruments directly after extraction of both teeth. (c) Tunneling preparation and undermining the adjacent interdental papillae. (d) Incision design for harvesting a combined epithelized connective tissue graft. (e) Harvested combined epithelized connective tissue graft. (f) Insertion of the connective tissue portion of the graft beyond the buccal and interproximal soft tissue using a guiding suture. (g) Graft in situ with epithelized portion over the socket orifice. (h) Filling of the socket using the DBBM-C material. (i) Closure of the socket and sutures. (j) Augmented ridge 5 months postoperative. (k) Implants with healing abutments. (l) Healing result directly after insertion of temporary implant crowns.
a collagen fleece (Tissufleece, Baxter) and the complete donor area sutured using transverse mattress sutures (Gore-Tex 5-0, W.L. Gore & Associates).

The graft was then carefully inserted into the prepared tunnel using a guiding suture (Gore-Tex 5-0) so that the connective tissue part of the graft was placed on the buccal side of the socket and under the adjacent papillae, whereas the epithelialized part was placed over the socket orifice and could be regarded as the lid of the socket (Figs 1f, 1g, and 2e). Subsequently, the socket was filled with a deproteinized bovine bone mineral embedded in a 10% collagen matrix (DBBM-C) (Bio-Oss Collagen, Geistlich) (Figs 1h and 2f). In cases with a fenestration or dehiscence within the buccal bone wall, a trimmed piece of a collagen membrane (Bio-Gide, Geistlich) was used to cover the defect at the inner side of the socket before the socket was grafted with the DBBM-C. Then the epithelialized lid of the graft was closed (Figs 2g and 2j) and sutured with single sutures using a monofilic material (Seralene 6-0, Serag-Wiessner) (Figs 1i and 2h). Further, crossed vertical mattress sutures (Gore-Tex 5-0) were used to fix the subpapillary portion of the connective tissue graft.

Patients were instructed to rinse with a 0.2% chlorhexidine solution (Chlorhexamed Forte 0.2%, Glaxo-SmithKline) for 2 weeks and to take antibiotics (amoxicillin, 500 mg, three times a day) for 7 days as well as pain relievers (ibuprofen, 400 mg) if needed. Patients received a temporary removable denture that also covered the palatal donor area, supporting the wound healing. Sutures were removed after seven days. Afterwards, patients followed their individual maintenance programs and were reevaluated 5 months after socket grafting.

Follow-up

Five months after socket seal surgery, patients were reevaluated (Fig 1j) and implants (Camlog Screwline, Camlog, or Osseospeed, Dentsply) were inserted. In five cases, buccal augmentation was done using a deproteinized bovine bone mineral (Bio-Oss, 0.25 to 1.0 mm, Geistlich) in combination with a collagen membrane (Bio-Gide, Geistlich), while in two cases the bone mineral was used alone to fill circumferential incongruences. Another 5 months later, implants were uncovered (Fig 1k) using a simple incision or, where deemed useful to support the soft tissue thickening, a roll flap. Implant sites were then restored with definitive crowns or temporary crowns, as the situation dictated.

Evaluation

Both the horizontal and vertical dimensions of the alveolar ridge were evaluated directly after extraction (baseline), directly after socket grafting, and 5 months later, before implant placement. For the measurement of the horizontal width of the alveolar crest, a caliper (Castroviejo-Epker, Medicon) was used. The tips of the caliper were placed 1 mm apical from the extrapolated margin of the gingiva of the adjacent mesial and distal teeth on the buccal and palatal sides. The midbuccal gingival margin of both adjacent teeth was assessed with a periodontal probe. The reference point for the caliper was 1 mm apical from the probe at the midbuccal/midpalatal aspect of the gingiva of the alveolar socket. Since reproducibility of this reference point depends on stable vertical position of the gingiva at both adjacent teeth, cases in which the vertical position of the gingiva at the neighboring teeth was changed after socket seal surgery have been excluded.

For evaluation of the vertical dimensions of the ridge, the positions of both the interdental papillae and the midbuccal gingival margin in relation to the incisal edge of the adjacent teeth were recorded. The distance from the incisal edge of the adjacent teeth to the tips of each of the two adjacent papillae were measured using a periodontal probe (Goldman-Fox/Williams probe, Hu-Friedy). The vertical position of the midbuccal gingival margin was evaluated by dropping a perpendicular from the line connecting the incisal edges of both adjacent teeth using two periodontal probes, one positioned horizontally between both incisal edges and the second perpendicular from the first to the midbuccal gingival margin. All horizontal and vertical values were measured to the nearest half millimeter.
Fig 2  Schematic illustration of the modified socket seal procedure. (a) Tunnel preparation of the buccal gingiva. (b) Undermining preparation and coronal mobilization of the interdental papillae. (c) Incision design for harvesting the graft. (d) Form of the combined epithelialized connective tissue graft. (e) Insertion of the graft into the tunnel. (f) Graft in situ and filling of the alveolar socket with the DBBM-C material. (g) Closure of the epithelialized lid of the graft after filling of the socket. (h) Sutures. (i) Cross section of the preparation of the buccal tunnel. (j) Cross section of the augmented socket (DBBM-C material and soft tissue graft in situ).
Results

The 15 patients had been treated at 18 sites according to the described surgical protocol and had completed the follow-up period up to the final implant-supported crown restoration.

In five cases, a membrane was used to cover a buccal fenestration (n = 4) or dehiscence (n = 1) prior to socket grafting. No intraoperative or postoperative complications occurred. In three grafted sites, an incomplete integration with fibrinoid healing of the graft was recorded after 1 week. However, after 6 weeks complete integration of all grafts had been detected. Implant insertion was combined with additional augmentation using demineralized bovine bone mineral in five sites. Uncovering the implants was done with a simple incision in ten cases and using a roll flap technique in eight cases. Eleven implant sites were restored with definitive crowns, while in seven cases temporary crowns were inserted for a period of 5 to 6 months (Fig 1) until the definitive crowns were established.

In two sites, the margin of the buccal gingiva at one of the adjacent teeth was changed due to recession coverage. Those cases were excluded from evaluation because changes in the position of the gingiva at the adjacent teeth could bias the reference points for the measurement of the width of the alveolar socket. Therefore, 13 cases with 16 extraction sites (eight maxillary central incisors, seven maxillary lateral incisors, and one maxillary canine) were evaluated for dimension changes. Measurement of the horizontal width of the alveolar socket resulted in a mean of 8.7 ± 0.5 mm directly after extraction (baseline), 9.5 ± 0.7 mm directly after socket seal surgery, and 8.2 ± 0.6 mm after 5 months. The reduction of the horizontal width from baseline up to 5 months postoperative was −0.5 ± 0.3 mm. Measurements of the mean distance between the incisal edge to the tip of the mesial papilla were 6.5 ± 0.8 mm at baseline, 6.1 ± 0.8 mm after socket augmentation, and 6.7 ± 0.9 mm 5 months postoperative. The corresponding results for the mean distance between the incisal edge and the tip of the distal papilla were 5.9 ± 0.8 mm, 5.5 ± 0.8 mm, and 6.3 ± 0.8 mm, respectively. The mean reduction of the height of the mesial and distal papilla 5 months postoperative compared to baseline was −0.2 ± 0.4 mm and −0.4 ± 0.2 mm, respectively. The mean distance between the interincisal line of the adjacent teeth and the midbuccal gingival margin was 10.8 ± 0.8 mm at baseline, 10.0 ± 0.9 mm after socket seal surgery, and 10.3 ± 0.8 mm 5 months postoperative. This corresponds to a mean increase in the vertical position of the midbuccal gingiva of 0.5 ± 0.3 mm.

Discussion

This case series showed that with the presented method of socket seal surgery successful results can be achieved with minimal shrinkage of soft and hard tissues in both horizontal and vertical dimensions. Only maxillary anterior teeth were considered in this study, because the ridge preservations are needed less frequently in the lower incisors. However, it is expected that the results of this study can also be applied to the mandibular anterior teeth.

Although three sites showed delayed integration with fibrinoid healing, the majority of the grafts showed early healing and all grafts were completely integrated during the follow-up period.

The mean horizontal resorption rate of the alveolar socket was −0.5 mm, which corresponds to a mean shrinkage of 5.7%. This confirms the reduction in horizontal shrinkage of the alveolar socket published in previous studies that applied a combination of socket seal surgery with soft tissue grafts and socket filling with bone substitutes. Unfortunately, measurement methods varied in previous studies and changes in dimensions after socket grafting are hardly comparable. Thalmair et al analyzed horizontal shrinkage of alveolar ridge 4 months after tooth extraction and ridge preservation using a combination of a soft tissue punch and socket filling with a xenogeneic bone graft. Although the reference points for horizontal measurements were not the same, −0.8 mm horizontal shrinkage (mean distance) has been reported, which was more than in the present study. It might be supposed, as Stimmelmayr et al conceived, that the additional augmentation in the buccal area using the tunneling procedure could improve maintenance of the volume. However, in the present study an undermining preparation and augmentation of the interden-
tal papillae was performed, leading to an increase in papilla height of 0.4 mm mesial and 0.3 mm distal immediately postoperative and a very limited reduction of the papillae of –0.2 mm mesial and –0.4 mm distal after 5 months. Thus, shrinkage of the interdental papillae, which would have been more pronounced without socket seal surgery, could be largely compensated. The observation that the distal papilla had a minimally higher reduction than the mesial is confirmed by Cosyn et al, who noticed the same after tooth extraction and subsequent implant restoration. Nevertheless, in the present study this difference seems negligible. Moreover, although the follow-up period in the present study was limited to 5 months, it can be expected that after crown restoration the dimensions of the papillae remain stable. This is supported by Si et al, who demonstrated that thickening of the mucosa increases the stability of interdental papillae on implant-supported crowns. Besides, in the present study it was observed that not only was the position of the buccal gingiva maintained in all patients, but several cases even showed a vertical gain leading to a mean increase of 0.5 mm.

The reported maintenance of the alveolar ridge tissues might be caused by an improved blood supply due to the buccal and interdental extension of the graft over the alveolar socket and the coronal mobilization and augmentation of extended tunnel. While Stimmelmayr et al tunneled and increased both buccal and oral parts of the gingiva with the graft, in the present study augmentation of the palatal tissue was bypassed in favor of the interdental extent of the graft because the palatal grafting was regarded as relatively unnecessary for achieving the desired esthetic results. There are, however, two disadvantages to the present approach. First, although certain cases with thin gingival biotype would benefit from this technique, the preparation of the buccal and interdental tunnel is technically demanding and the risk of ruptures in thin interdental papillae must be considered. This is why microsurgical approach and the use of tunneling instruments are recommended. Second, harvesting the graft requires another surgical site with secondary healing leading to increased morbidity. Nevertheless, no complications have been noted in the postsurgical period, which might be due to the fact that sutures were always combined with palatal coverage of the donor region with a temporary prosthesis and postsurgical infection control (local antimicrobial rinsing and antibiotics). Finally, the extent to which the DBBM-C material contributed to the ridge preservation and how other bone replacement grafts would react is not clear. However, deproteinized bovine bone grafts have been shown to have a high stability and low resorption rate, and therefore seem appropriate for ridge preservation.

In summary, the presented technique showed promising results in terms of ridge preservation after tooth extraction in horizontal and vertical dimensions using an epithealized connective tissue graft with a tunneling approach. This procedure can be recommended in esthetically critical regions in patients with high esthetic demands, in particular when there is a thin gingival biotype. Although cases with changes to the gingival margin at the adjacent teeth were not included in the evaluation, the technique seems appropriate to be applied in combination with recession coverage of adjacent teeth (Fig 3). However, there are
limitations that should be considered. Since direct measurements using a caliper and a periodontal probe may show greater deviations than other methods, such as cone beam supported evaluations, the results are preliminary and should not be generalized. Also, the amount of ridge preservation might depend on the tooth type and location, factors that have not been evaluated for this technique. Further studies using a case control design with cone beam supported evaluations should verify the benefits of this technique compared to other socket seal techniques.

References