Wound Closure and Simultaneous Soft Tissue Augmentation at Fresh Extraction Sockets: A Simplified Technique Adopting a Xenogeneic Collagen Matrix

A simplified surgical technique is presented for closure and soft tissue augmentation of fresh extraction sockets that utilizes a xenogeneic collagen matrix as a substitute for a combined onlay-interpositional connective tissue graft. Ten alveoli receiving a socket preservation procedure (n = 5) or an immediate submerged implant (n = 5) were sealed with a xenogeneic collagen matrix, stabilized under small palatal and buccal full-thickness envelope flaps. Eight weeks after surgery, full wound closure was achieved in 9 out of 10 sites with satisfactory esthetic integration (mean ∆E score: 3.76). Results from this descriptive observational study suggest that this technique may represent a valuable and minimally invasive solution to simplify closure and soft tissue augmentation of fresh extraction sockets. Int J Periodontics Restorative Dent 2021;41:457–465. doi: 10.11607/prd.4288

When replacing an unsalvageable tooth with an implant, the management of soft tissues is of utmost importance to achieve optimal esthetic results. Therefore, both in the case of socket preservation procedures and of immediate implant placement with no possibility to perform immediate provisionalization, soft tissue closure has been advocated over the extraction site to guarantee coagulum stabilization in the wound area and to protect it from trauma and contamination. Furthermore, the soft tissue volume should be increased to compensate for postextractive tissue shrinkage. Several alternatives were described to achieve such goals, including: the coronal advancement of a buccal flap to achieve primary closure of the socket; socket sealing procedures, including punch-free gingival grafts; combined onlay-interpositional grafts, and rotated pediculated connective tissue grafts. Sealing procedures prevent the coronal displacement of the mucogingival junction that comes with the coronal advancement of a flap. However, such techniques may be technically demanding, as they require the harvest of wide connective tissue grafts, the preparation of undermined split-thickness vascular beds with dedicated microsurgical instruments, and a flapless tooth extraction with

Alessandro Rossi, DDS
David Palombo, DDS, MSc, MDS
Vincenzo Capilupi, DDS
Matteo Chiapasco, MD

1Unit of Oral Surgery, Department of Health Sciences, San Paolo Hospital, University of Milan, Milan, Italy.
2Unit of Oral Surgery, Department of Health Sciences, San Paolo Hospital, University of Milan, Milan, Italy; Department of Periodontology, University Complutense of Madrid, Madrid, Spain.

Correspondence to: Dr Alessandro Rossi, Unit of Oral Surgery, Department of Health Sciences, San Paolo Hospital, University of Milan, Via Beldiletto 1 - 20142 Milan, Italy. Fax: +39 02 50319040. Email: alessandroluigirossi@gmail.com

Submitted January 10, 2019; accepted May 8, 2019. ©2021 by Quintessence Publishing Co Inc.
maintenance of fully intact papillae. In a variety of clinical scenarios, such premises may not be accomplished. With the presence of deep root fractures and extended root caries, the elevation of a full-thickness flap may be indispensable to the vast majority of clinicians in order to complete the root extraction. Furthermore, patients may be reluctant to the harvest of autogenous connective tissue. Thus, the aim of this report is to present a simplified technique for closure of the socket and simultaneous soft tissue augmentation, combining the elevation of minimally invasive full-thickness flaps with the use of a new xenogeneic collagen matrix as a substitute for a combined onlay-interpositional connective tissue graft. The matrix was placed under the periosteum of the buccal and palatal flaps and left exposed in its central portion, covering the alveolus.

Materials and Methods

Study Design

This is a case series report describing preliminary longitudinal outcomes of a new surgical technique. Patients were informed that their data would be used for scientific publications, and the study was performed in accordance with the principles stated in the Declaration of Helsinki and the Good Clinical Practice Guidelines.

Subject Population

Ten systemically healthy (4 men and 6 women), nonsmoking adult patients (mean age: 53.2 years; range: 37 to 67 years) presented with a single-rooted tooth scheduled for extraction. Reasons for extraction were unsalvageable endo-perio lesions (n = 3) or unsalvageable root caries/fractures (n = 7). Periodontitis patients were included after successful completion of basic therapy. All patients were enrolled in the study once full-mouth plaque and bleeding scores were ≤ 15%.

Clinical Protocol

All patients were treated by the same surgical and prosthetic teams. All surgical procedures were performed in sterile conditions under local anesthesia. The following steps were adopted:

Preoperative Patient Preparation
All patients received a dental prophylaxis 2 weeks prior to surgery. Local antisepsis with 0.2% chlorhexidine mouthwashes was started 3 days before surgery, and a single administration of oral amoxicillin and clavulanate (2 g) was delivered 1 hour before surgery as antibiotic prophylaxis.

Tooth Extraction
In all cases, tooth extraction was performed through the following steps: (1) intracrevicular incision at the affected tooth; (2) elevation of small buccal and palatal full-thickness flaps, extended to the mid-facial/palatal aspect of the adjacent mesial and distal tooth; (3) minimally invasive extraction of the affected tooth through periotomes, piezoelectric inserts (EX1 insert on Piezosurgery Touch Professional, Mectron), and small forceps; and (4) debridement of the residual alveolus.

Implant Placement and/or Socket Grafting
Immediate implants (OsseoSpeed, Astra Tech Implant System, Dentsply Sirona) were placed in all sockets presenting an intact buccal bone plate with a residual thickness > 1 mm, according to criteria reported by Hämmérle et al 2004. Implants beds were always prepared in a palatal position within the socket, and the gap between implant surface and buccal bone was filled with collagenated demineralized bovine bone mineral (C-DBBM) in the form of a particulated graft (Bio-Oss Collagen, Geistlich Pharma). A submerged healing cap was placed over the implant head. In the absence of adequate buccal bone thickness (≤ 1 mm), no implant was placed at the time of tooth extraction, and the socket was filled with C-DBBM to preserve bone volume for a delayed implant placement.

Wound Closure and Soft Tissue Augmentation
A natural, three-dimensional, porcine collagen matrix (Mucoderm, Botiss Dental) was used as a substitute for autogenous connective tissue for a combined onlay-interpositional graft.

After preliminary hydration in sterile saline for 10 to 15 minutes, the matrix was shaped according to local anatomy. One third of the matrix was placed under the buccal flap and one third under the palatal flap.
The central third of the matrix sealed the crestal aspect of the alveolus and remained exposed to the oral cavity. Closure was achieved with simple interrupted sutures interproximally and with one internal horizontal mattress suture connecting the midfacial and midpalatal aspects of the flaps to keep the matrix in place with a mild compression. No periosteal incisions were performed.

Figures 1 to 4 depict a descriptive case (patient 6) in which the delayed approach was adopted due to the absence of a thick buccal bone crest at the extraction site (Fig 2c).

Follow-up

Patients were recalled at 2, 4, 6, and 8 weeks after surgery, in order to evaluate the timing and quality of wound closure and the esthetic integration of the grafted area with the surrounding soft tissues.

Clinical Measurements

Area of Collagen Matrix Left Exposed at the End of Surgery

At the end of the surgery, the area of matrix left exposed was measured through digital planimetry on occlusal pictures using a dedicated software (Adobe Photoshop CC 2014). Calibration was performed with the use of a periodontal probe (Fig 5).
Wound Closure

Closure of the alveolus with newly formed gingival tissue was assessed at 2, 4, 6, and 8 weeks after surgery by a trained clinical investigator (V.C.).

Specifically, wound closure was classified as: (1) Fibrinoid: visible presence of a fibrin layer over the exposed matrix, typical of early stages of healing; (2) Immature: visible presence of granulation tissue; (3) Integrated: complete wound closure by clinically healthy tissue; or (4) Incomplete: incomplete wound closure with areas of epithelial invagination, which allow access to the underlying alveolus with a periodontal probe (Table 1).

Esthetic Integration

Colorimetric integration of the newly formed tissue with the
surrounding natural gingiva was assessed 8 weeks after surgery through the ∆E score. ∆E is a metric that estimates how the human eye perceives color differences. It is calculated as the Euclidean distance between two points in a CIE color space. Score assessment was performed through clinical photographs taken with a digital SLR (single-lens reflex) camera (Nikon D300 with Nikon AF-S VR Micro-Nikkor 105 mm f/2.8G). All pictures were captured with the same camera settings (manual: F 32, 1/125s, ISO 200, 1/4 manual flash power) and no continuous light sources. Specifically, the following steps were adopted:

The color of the images was assessed with dedicated software (Adobe Photoshop CC, version 15.2). The analysis was performed within the color space CIE 1976 (L*, a*, b*), which is an absolute colorimetric space, independent from the analog/digital reproducing support.

Three areas of 101 × 101 pixels, one from the grafted site and one each from the adjacent mesial and distal natural gingiva, were chosen for comparison. The area from the grafted site was compared with the mean value obtained from the two areas of natural gingiva (Fig 6).

An ∆E score lower than 3.7 was considered an ideal esthetic outcome. Such threshold was described by Johnston and Kao as the smallest colorimetric discrepancy.
that the human eye can appreciate in the oral cavity.21

Data Analysis

Descriptive data were summarized in tables and expressed as means with standard deviation (SD).

Results

Ten sockets were sealed in 10 patients. Five sites received an immediate implant while the other 5 were treated with socket preservation and delayed implant placement. All patients maintained adequate plaque control during the follow-up period. In all cases, the final implant-supported prosthetic restorations were completed successfully.

Area of Collagen Matrix Left Exposed at the End of Surgery

At the end of the surgery, the mean area of matrix left exposed was 26.29 mm² (14.2 to 38.84 mm²; SD: 7.68 mm²; Table 1).

Wound Closure

Eight weeks after surgery, full wound closure was achieved in 9 out of 10 sites with healthy keratinized tissue. A single patient (no. 3) did not achieve full wound closure at this time, starting from the highest postoperative matrix exposure rate of the cohort (38.84 mm²).

Esthetic Integration

The mean colorimetric ∆E score between the regenerated site and the surrounding gingiva at 8 weeks was

Table 1 Clinical Results

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Site</th>
<th>Socket treatment</th>
<th>Area of exposure (mm²)</th>
<th>Healing score</th>
<th>∆E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 wk</td>
<td>4 wk</td>
</tr>
<tr>
<td>1</td>
<td>2.2</td>
<td>IMM</td>
<td>17.72</td>
<td>1.00</td>
<td>2.00</td>
</tr>
<tr>
<td>2</td>
<td>2.2</td>
<td>IMM</td>
<td>25.02</td>
<td>1.00</td>
<td>2.00</td>
</tr>
<tr>
<td>3</td>
<td>2.4</td>
<td>IMM</td>
<td>38.84</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>4</td>
<td>3.3</td>
<td>IMM</td>
<td>14.20</td>
<td>1.00</td>
<td>2.00</td>
</tr>
<tr>
<td>5</td>
<td>1.4</td>
<td>IMM</td>
<td>21.57</td>
<td>1.00</td>
<td>2.00</td>
</tr>
<tr>
<td>6</td>
<td>2.1</td>
<td>SP</td>
<td>33.30</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>7</td>
<td>3.5</td>
<td>SP</td>
<td>29.28</td>
<td>1.00</td>
<td>2.00</td>
</tr>
<tr>
<td>8</td>
<td>1.4</td>
<td>SP</td>
<td>21.54</td>
<td>1.00</td>
<td>2.00</td>
</tr>
<tr>
<td>9</td>
<td>1.2</td>
<td>SP</td>
<td>28.56</td>
<td>1.00</td>
<td>2.00</td>
</tr>
<tr>
<td>10</td>
<td>2.1</td>
<td>SP</td>
<td>32.9</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td></td>
<td>26.29</td>
<td>1.00</td>
<td>1.50</td>
</tr>
<tr>
<td>SD</td>
<td></td>
<td></td>
<td>7.68</td>
<td>0.00</td>
<td>0.71</td>
</tr>
<tr>
<td>Minimum</td>
<td></td>
<td></td>
<td>14.20</td>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Median</td>
<td></td>
<td></td>
<td>26.79</td>
<td>1.00</td>
<td>2.00</td>
</tr>
<tr>
<td>Maximum</td>
<td></td>
<td></td>
<td>38.84</td>
<td>1.00</td>
<td>2.00</td>
</tr>
</tbody>
</table>

∆E = color change of tissues; IMM = socket seal with immediate implant; SP = socket preservation; SD = standard deviation. For healing scores: 0 = incomplete; 1 = fibrinoid; 2 = immature; 3 = mature.
3.76 (3 to 6.55; SD: 1.07). Seven out of 10 patients reported an excellent esthetic integration of the matrix (ΔE score < 3.7). Two patients reported an acceptable integration of the matrix (ΔE = 4.28 for patient 6 [socket sealing without immediate implant]; ΔE = 3.95 for patient 10 [socket sealing without immediate implant]), and only a single patient reported a limited esthetic result (ΔE = 6.55 for patient 3 [socket sealing with immediate implant]).

Discussion

The aim of this case series report is to present a simplified and minimally invasive surgical approach for simultaneous closure and augmentation of soft tissues in single postextraction sites that adopts a xenogeneic porcine collagen matrix as a substitute for an onlay-interpositional connective tissue graft. In 9 out of 10 patients, satisfactory outcomes were achieved, both with respect to wound closure and the esthetic integration of the newly formed tissue (see Appendix Fig 1 in the online version of this article, available at quintpub.com/journals). In a single patient, incomplete wound closure with minor exposure of an implant healing cap occurred, which was still compatible with uneventful case finalization. In all cases, the final implant-supported prosthetic restorations were completed successfully with no need for adjunct augmentation procedures.

Results from this study suggest that this approach may represent a predictable alternative to achieve the sealing of fresh extraction sockets. Its main advantages are represented by (1) the elevation of minimally invasive full-thickness flaps, which in some cases may be indispensable to complete the root extraction; (2) no coronal displacement of the mucogingival junction; (3) no need for periosteal releasing incisions or undermined split-thickness dissections; and (4) no need to harvest autogenous connective tissue grafts.

Wound Closure

Data by Stimmelmayr et al on the use of autogenous onlay-interpositional connective tissue grafts for socket sealing reported a single case of wound dehiscence over 58 treated sockets and two cases of wound dehiscence over 43 treated sockets. Similarly, Stein and Hammächer reported complete graft integration in all sites (18 maxillary anterior teeth) treated with an autogenous onlay-interpositional connective tissue graft through a tunneling approach. However, in such papers, no specific data were reported regarding the area of gingival graft left exposed over the socket nor the anatomical location of the treated sites.

Due to the exploratory nature of the present publication, different sites and socket dimensions were tested with the use of the Mucoderm collagen matrix, both with and without immediate implant placement. Even though a very limited number of patients were treated, a trend in the timing and quality of early wound closure (2 to 4 weeks) can be hypothesized in relation to the area of matrix left exposed at the end of surgery (from 14.2 to 38.84 mm² of exposed matrix surface; Table 1). Thus, it could be speculated that the risk of wound dehiscence and incomplete or delayed socket closure increases with the dimensions of the socket and consequently with the area of collagen matrix that is left exposed to the oral cavity, presumably being subjected to a faster degradation. Furthermore, the presence of an immediate implant in the socket could be an additional factor hampering the achievement of uneventful socket closure, as it is an avascular socket closure, as it is an avascular structure not contributive to plasmatic circulation. Plasmatic circulation from the socket blood clot was demonstrated to significantly support the survival of gingival grafts adopted for socket sealing, up to overcoming the role of peripheral supply. Interestingly, the only patient in the present study who developed a significant delay in wound closure presented the highest postoperative matrix exposure area of the cohort (38.84 mm²) and received an immediate implant (patient 3).

Esthetic Integration

Adoption of the ΔE score for colorimetric evaluation in socket sealing procedures was introduced by Jung et al. In that paper, 20 circular free gingival autografts placed in sockets grafted with C-DBBM achieved an optimal colorimetric integration with the adjacent tissues (mean ΔE...
score: 2.91). However, this analysis was conducted on single pixels dots from printed photographs acquired through a digital scanner. In order to contain the risk of both selection and detection bias, the colorimetric evaluation in the present study was performed on native digital pictures using the broadest area allowed by the imaging software (101 × 101 pixels; Adobe Photoshop CC, version 15.2). One area was randomly selected by a blinded investigator (V.C.) within the grafted surface of the alveolus and compared with the mean value obtained from the two areas (mesial and distal) of adjacent natural gingiva. Optimal integration (∆E < 3.7) was achieved in 7 out of 10 patients, acceptable integration in 2 patients (∆E = 3.95 and 4.28), and limited results were only observed in patient 3, which developed a delayed wound closure (∆E = 6.55).

**Conclusions**

Within the limitations of the present case series report exploring the possible applications of a new surgical approach, the results suggest that this simplified technique may represent a valuable and minimally invasive approach for socket sealing and simultaneous soft tissue grafting. Further clinical trials are required to clearly establish the area of collagen matrix that can be safely left exposed to the oral cavity, how the presence of an immediate implant in the alveolus affects soft tissue healing over the socket through its avascular surface, and which degree of buccal soft tissue augmentation and socket closure can be achieved with the present technique compared to grafting with autogenous connective tissue.

**References**


Erratum for Chu et al, 2021

In the article by Chu et al (Use of a Novel Implant with an Inverted Body-Shift and Prosthetic Angle Correction Design for Immediate Tooth Replacement in the Esthetic Zone: A Clinical Case Series) in Volume 41, Number 2 (March/April), 2021, a periapical radiograph was incorrectly published for Figure 12b. The correct image is a CBCT cross-section. This has been corrected in the online version of the article. doi: 10.11607/prd.5401

Erratum for Ragghianti-Zangrando et al, 2021

In the article by Ragghianti-Zangrando et al (Clinical Outcomes and Gingival Blood Flowmetry of Two Types of Subepithelial Connective Tissue Graft for Root Coverage in Multiple Gingival Recession: A Preliminary Study) in Volume 41, Number 2 (March/April), 2021, the article doi was incorrectly listed as 10.11607/prd.4653. The correct doi is 10.11607/prd.4353. This has been updated in the online version of the article.
Appendix

Appendix Fig 1  Baseline (top two rows of images) and 8-week healing (bottom two rows of images) of the 10 treated cases.