
Istvan A. Urban, DMD, MD1/Mustafa Tattan, BDS2
Andrea Ravida, DDS, MS3
Muhammad H. A. Saleh, BDS, MS, PhD3
Lorenzo Tavelli, DDS, MS4
Gustavo Avila-Ortiz, DDS, MS, PhD5

Severe alveolar ridge deficiencies in concomitance with periodontal attachment loss can represent a serious clinical challenge in the context of implant therapy. The present case report describes the management of a complex defect in the esthetic zone via ridge augmentation and periodontal regenerative therapy using a biologic material. A systemically healthy 55-year-old man diagnosed with peri-implantitis around an implant in the maxillary left central incisor position and with severe bone loss on the mesial aspect of the maxillary left lateral incisor underwent several surgical interventions to achieve simultaneous vertical ridge augmentation and periodontal regeneration. These interventions included implant removal, bone augmentation using a composite bone graft (autogenous bone + xenograft particles), and a bioactive protein (recombinant human platelet-derived growth factor), soft tissue augmentation using connective tissue grafts, and peri-implant keratinized mucosa width augmentation via a labial gingival graft strip and a xenogeneic collagen matrix. Substantial gains in vertical bone and clinical attachment were achieved, which allowed for delayed implant placement and subsequent completion of tooth replacement therapy with an implant-supported prosthesis. The present case report demonstrates how simultaneous vertical ridge augmentation and periodontal regeneration can be achieved to manage a challenging clinical situation. Key factors to consider in this type of scenario are proximal bone level, tooth mobility, surgical flap design and management, biomaterial selection, and proper treatment sequencing. Int J Periodontics Restorative Dent 2022 June 30 doi: 10.11607/prd.6055. Online ahead of print.

1Department of Periodontics and Oral Medicine, University of Michigan School of Dentistry, Ann Arbor, Michigan, USA; Urban Regeneration Institute, Budapest, Hungary.
2Department of Periodontics, College of Dentistry, University of Iowa, Iowa City, Iowa, USA.
3Department of Periodontics and Oral Medicine, University of Michigan School of Dentistry, Ann Arbor, Michigan, USA.
4Department of Oral Medicine and Immunity, Harvard School of Dental Medicine, Harvard University, Boston, Massachusetts, USA.
5Division of Periodontology, Department of Oral Medicine and Immunity, Harvard School of Dental Medicine, Harvard University, Boston, Massachusetts, USA; Department of Periodontics, College of Dentistry, University of Iowa, Iowa City, Iowa, USA.

Correspondence to: Dr Gustavo Avila-Ortiz, Department of Periodontics, University of Iowa College of Dentistry, 801 Newton Road, Iowa City, IA 52242, USA.
Email: gustavo-avila@uiowa.edu

Submitted October 10, 2021; accepted October 29, 2021.
©2022 by Quintessence Publishing Co Inc.

© 2022 BY QUINTESSENCE PUBLISHING CO, INC. PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY. NO PART MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.
To capitalize on the next tooth’s periodontal bone support and maximize the amount of vertical bone gain. In some cases, however, periodontal regeneration in combination with ridge augmentation may be possible. In such scenarios, proper case selection and refined surgical skills are essential to achieve therapeutic success.

Case Report

Clinical Presentation

This case report was prepared according to the CARE guidelines. A 55-year-old man who was systemically healthy presented to the private practice of one of the authors (I.U.) seeking treatment of a failing single-tooth implant in the maxillary left central incisor position (site 21; FDI tooth-numbering system), which was placed immediately after tooth extraction approximately 10 years prior. Deep probing depths (> 15 mm) and bleeding and suppurating on probing were observed in the clinical examination of the peri-implant tissues (Fig 1a). A periapical radiograph revealed the presence of severe peri-implant bone loss (Fig 1b). Additionally, the implant appeared to be in direct contact with the root surface of the adjacent lateral incisor (site 22), which presented a mesial probing depth of 12 mm. Treatment options were discussed with the patient, and informed consent was obtained.

Case Management

Implant removal and debridement

Due to clinical and radiographic evidence of implant failure, the implant was removed by reverse torque. However, a decision was made to retain the tooth at site 22, even though it presented mesial bone loss extending to the apical region. The area was left to undergo unassisted healing after careful debridement.

Vertical bone augmentation and periodontal regeneration

Four months after implant removal, the patient returned to initiate corrective surgical therapy of the severe, combined ridge defect (Seibert Class III) that resulted after implant removal (Fig 2). Once local anesthesia was achieved, a full-thickness safety flap extending from the mesial aspect of the maxillary right canine to the mesial aspect of the left second premolar was elevated. Additionally, a palatal vertical incision was made distal to the left canine. The merit of this flap design is to overcome the presence of a shallow vestibule when significant grafting is necessary. The flap was extended mesiodistally to accommodate for either of two potential intrasurgical pathways: (1) extraction of tooth 22 and vertical ridge augmentation at two sites, or (2) single-site vertical ridge augmentation with concomitant periodontal regeneration on the mesial aspect of tooth 22. After flap elevation, the pronounced mesial bone loss at tooth 22 could be directly visualized (Fig 3); the mesial and palatal bone levels were substantially reduced around the tooth, and the buccal and distal bone support were favorable in comparison. No supraphysiological mobility was observed. Thus, a decision was made to attempt periodontal regeneration and save the tooth.

Thorough root planing of the mesial root surface was performed using a periodontal curette (SUB 00, Hu-Friedy). No root conditioning was performed. A perforated nonabsorbable, titanium-reinforced, ..
high-density polytetrafluoroethylene (d-PTFE) barrier membrane (RPM – Reinforced PTFE Mesh, Osteogenics Biomedical) was trimmed, adapted, and fixated to the palatal bone using a titanium pin (Master-Pin-Control Kit, Meisinger USA). Subsequently, 0.25 mL of recombinant human platelet-derived growth factor-BB (rhPDGF-BB; 0.3 mg/mL GEM 21S, Lynch Biologics) was applied to the root surface, and another 0.25 mL was used to soak (for approximately 20 minutes) autogenous bone chips that had been harvested from the ramus of the mandible. After applying the autogenous bone with rhPDGF-BB to the root surface, a 1:1 mixture of autogenous bone chips and bovine bone xenograft particles (Bio-Oss, Geistlich) was employed to augment the ridge (Fig 4). At this stage, complete interproximal bone gain was not attempted. Instead, a more realistic oblique regenerative line corresponding with the facial bone level was used as the reference of expected vertical augmentation, aiming to regenerate approximately 60% of the lost proximal bone height. The nonabsorbable d-PTFE barrier was then folded buccally atop the composite bone graft and secured to the facial wall of the ridge using additional titanium pins. The border of the d-PTFE barrier adjacent to tooth 22 was trimmed, leaving an optimal 2-mm distance between the barrier and the root surface. The partially exposed bone graft was covered with an absorbable porcine collagen membrane (Bio-Gide, Geistlich Pharma), which was secured using one titanium pin and a single sling suture (7-0 Resorbable PGA Suture, Osteogenics Biomedical; Fig 5). Prior to flap closure, additional rhPDGF-BB was applied.
topically over the root surface of tooth 22. The facial and palatal flaps were secured using multiple simple interrupted and horizontal mattress sutures (3-0 PTFE and 6-0 Resorba Resolon, Osteogenics Biomedical; Fig 6). A tooth-supported resin-bonded provisional restoration (Maryland bridge) was fabricated to temporarily replace tooth 21.

Implant placement, vertical bone and soft tissue augmentation, and periodontal regeneration

After a 7-month healing period, a full-thickness flap was elevated. Barrier removal revealed successful vertical ridge augmentation as well as bone growth on the root surface (Fig 7). Approximately one third of the root surface remained exposed. Static computer-aided implant placement with partial guidance was performed according to the manufacturer’s recommendations (N1 implant, NobelGuide, Nobel Biocare) in an adequate prosthetic position (Fig 8). However, a bone dehiscence involving the palatal, distal, and buccal aspects of the implant was noticed. Autogenous bone chips were scraped from an apical region within the surgical field and combined with 0.5 mL of rhPDGF-BB. This construct was applied to correct the peri-implant bone defect (Fig 9). Following this, a 1:1 ratio of bovine bone xenograft particles (Bio-Oss) and autogenous bone was placed on the crestal aspect of the ridge and covered with a non-absorbable d-PTFE barrier (RPM – Reinforced PTFE Mesh) and an absorbable porcine collagen membrane (Bio-Gide), similar to the approach in the previous surgery. With the purpose of augmenting the peri-implant supracrestal tissue height (STH), a connective tissue graft (CTG) was obtained by deepithelializing a free graft harvested from the premolar region of the palate. The CTG was then placed over the collagen membrane and sutured in place using simple interrupted and single sling 7-0 PGA sutures. Then, the flaps were reapproximated and sutured, achieving primary closure (Fig 10).

STH augmentation

Approximately 6 months postoperative, clinical and radiographic evaluation via CBCT scan demonstrated excellent circumferential peri-implant bone augmentation. However, minimal STH augmentation was achieved. Therefore, a thick CTG was harvested from the palatal mucosa via the single incision technique. The soft tissue graft was trimmed to fit the interdental space between the maxillary right central
incisor and the left lateral incisor. A double layer of soft tissue graft was used at the interproximal area to further augment the papilla. The soft tissue graft was positioned over the ridge crest and subsequently sutured via simple interrupted and sling 7-0 PGA sutures. Flaps were approximated, and primary wound closure was achieved (Fig 11).

**KMW augmentation**

After a 3-month healing period, although adequate STH augmentation was achieved, keratinized mucosa width (KMW) and vestibular depth were diminished due to displacement of the mucogingival junction (Fig 12). To correct this mucogingival deformity, a partial-thickness flap was elevated on the facial aspect of the ridge to create a recipient bed and increase the vestibular depth, with care not to take away from the soft tissue height gained in the previous soft tissue augmentation procedure. Then, two labial strip gingival grafts were harvested from the contralateral region of the buccal maxillary mucosa and the mandibular anterior sextant. One strip was sutured apical to the region where keratinized mucosa was expected to form. Additionally, a gingival strip was also sutured to the palatal border to prevent palatal soft tissue migration and to enable the formation of a labial corridor with optimal esthetics. The intermediate region was covered with a xenogeneic porcine collagen matrix (Mucograft, Geistlich), as described elsewhere (Fig 13).

**Implant uncovering and loading**

After 3 months of healing, the abundant amount of augmented KMW demonstrated excellent tissue integration (Fig 14). Notably, the probing depth on the mesial aspect of tooth 22 was 3 mm, indicating a substantial amount of clinical attachment gain. Implant uncovering was performed using a reverse “w” flap to maximize soft tissue preservation. The final implant-supported prosthesis was inserted at 8 weeks after implant uncovering (Fig 15).

**Discussion**

Vertical ridge augmentation via guided bone regeneration is highly technique-sensitive and requires a
Fig 11  (a) After 6 months of healing, the site was reentered. (b and c) A double-layer CTG was used to augment both the supracrestal tissue height and the papilla, and (d) primary closure was achieved.

Fig 12  Following a 3-month healing period, a lack of buccal KMW and reduced vestibular depth were evident.

Fig 13  The surgical area after KMW augmentation via the labial strip gingival graft procedure.

Fig 14  Postoperative view of the site after 3 months of healing.

Fig 15  (a) Clinical and (b) radiographic views of the site after placing the final implant-supported prosthesis.
long and controlled learning curve. Beyond proper patient management and adequate manual skills, understanding the biologic principles of tissue regeneration is essential to success. In the present case, tooth 22 played a defining role in achieving a favorable clinical outcome despite its compromised periodontal status. The final decision concerning the fate of tooth 22 was made intraoperatively, when the flap was elevated and different structural aspects could be precisely evaluated. A crucial factor that must always be considered when contemplating periodontal regenerative therapy, but is often overlooked, is tooth mobility. In the present case, because tooth 22 did not exhibit supraphysiologic mobility and had acceptable facial/palatal bone levels, a decision was made to retain the tooth and attempt periodontal regeneration. While true periodontal regeneration cannot be claimed due to a lack of histologic evidence, the clinical and radiographic findings are consistent with stable and healthy regenerated tissues, and periodontal regeneration can be plausibly inferred.

Although periodontal regeneration may be achieved without the use of biologic materials, rhPDGF-BB has been documented as a therapeutic resource that can harness cellular mechanisms, such as proliferation and chemotaxis, to increase the potential for successful periodontal regeneration. Aside from the treatment of periodontal defects, rhPDGF-BB may also be applied in other scenarios to obtain tissue regeneration. A recent systematic review that assessed the efficacy, safety, and clinical benefit of rhPDGF-BB in hard and soft tissue regeneration concluded that the combined use of bone graft substitutes (ie, xenografts and allografts) and rhPDGF-BB demonstrated clinical benefits for the purpose of periodontal regeneration, root coverage, alveolar ridge augmentation, and alveolar ridge preservation.

Regarding the clinical approach to achieve STH augmentation, the first CTG could have been avoided. A CTG overlaying a bone graft material always adds an additional risk for early wound dehiscence and is usually advised for clinicians with greater experience. However, when possible, this combination enables additional soft tissue augmentation at the time of implant placement if substantial volume is required, potentially avoiding the need for an additional surgical intervention. It is worth noting that, in the present case, the second double-layered CTG added an aesthetic benefit by increasing the papillary height on the mesial aspect of the lateral incisor.

Recognizing the components of the peri-implant phenotypes and their clinical significance is crucial to successful dental implant therapy. Although the absence or lack of KMW may not be a risk factor for peri-implantitis, several investigations have reported increased plaque accumulation and brushing discomfort in association with deficient KMW. Therefore, it is often recommended that a minimum KMW of 2 mm be present, particularly in erratic periodontal compliers. In the present case, a lack of KMW was evident after the second STH augmentation surgery. This is not uncommon following ridge augmentation procedures. The gold standard to achieve peri-implant KMW augmentation is the autogenous free gingival graft. To avoid the unfavorable esthetic outcomes that typically result after using a conventional free gingival graft obtained from the palatal mucosa, the labial strip gingival graft is a viable therapeutic alternative that has been associated with superior patient-reported outcome measures related to esthetics and overall satisfaction.

Multiple surgical interventions and extended healing periods are usually required to manage complex clinical situations, such as the one presented in this case report. Thus, careful case selection is strongly recommended, along with patient preparation for surgery, including a thorough discussion about the expected outcomes. It must be acknowledged that the surgical interventions presented herein, however encouraging, should be investigated in rigorous randomized controlled trials prior to recommending them for routine clinical practice.

Conclusions

The present case report demonstrates the successful application of staged surgical therapy with the purpose of achieving combined vertical ridge augmentation and periodontal regeneration to manage a complex clinical situation. Key factors to consider in this type of
References


