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Case Report

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Horizontal Ridge Augmentation Using Sticky Bone with Platelet-Rich Fibrin (PRF) in Anterior Maxilla Clinical and Histologic Evidence: A Case Report

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Abstract

Alveolar ridge deficiency is an unavoidable sequela of tooth extraction and poses major clinical challenges when reconstruction is anticipated. Various surgical approaches have been proposed to address horizontal defects, with autogenous bone grafting considered the current benchmark. However, alternative methods, utilizing tissue engineering principles and bone substitutes, offer reduced patient morbidity. This report presents an alternative case of severe horizontal bone defect augmentation in the anterior maxilla using sticky bone in conjunction with platelet-rich fibrin (PRF), and a Ti-reinforced membrane. Histologic evidence of sticky, deproteinized bovine bone material (DBBM) mixed with PRF without the use of autogenous bone is reported.

Keywords: alveolar ridge augmentation, bone substitutes, guided bone regeneration, platelet-rich fibrin, tissue engineering

Introduction

The current emphasis in dental prosthetics is on positioning implants to enhance both functional and aesthetic outcomes.[1] When assessing implant therapy for tooth replacement, the amount of remaining alveolar ridge significantly influences the ability to place the implant at the optimal site. In many cases, the presence of a resorbed residual bony defect poses challenges in achieving implant and volume stability due to insufficient support from the surrounding bone structure. The bony defect manifests as horizontal, vertical loss, or both, in terms of height and volume. According to Benic and Hämmerle[2], such clinical situations are classified as Class 3 or higher, indicating the necessity of a staged approach for bone augmentation prior to implant placement. A decision tree was proposed based on high-level evidence for scenarios requiring more than 6 mm of bone gain. This tree offers options such as autogenous block grafting, titanium mesh or a titanium-reinforced, non-resorbable, high-density, polytetrafluoroethylene (d-PTFE) membrane with bone substitutes, based on guided bone regeneration (GBR) principle.[3,4]

Autogenous bone is considered the gold standard graft, due to its osteogenic, osteoinductive, and osteoconductive properties. However, limitations, such as increased morbidity, limited availability, and variable resorption rates are recognized.[5] Tissue engineering approaches have been introduced, combining biologically inactive scaffolds with bioactive agents to stimulate bone regeneration. Various bioactive agents and growth factors, such as bone morphogenetic proteins (BMPs), enamel matrix derivative (EMD), or platelet-rich fibrin (PRF), have been utilized to enhance or accelerate bone formation.[6]

Case report

A 57-year-old, systemically healthy, Thai female presented with multiple missing anterior teeth, due to childhood trauma. Both the maxillary right and left canines had been extracted, and socket grafting was performed approximately 6-8 months before the examination. The patient expressed a desire to enhance both aesthetics and functionality with a fixed reconstruction in the upper anterior region. The oral examination of the upper maxilla revealed a partially edentulous condition with severe horizontal defect (Figure 1A). Cone beam computed tomography (CBCT) examination showed a severe horizontal ridge defect with sufficient vertical bone height. The bone graft material placed in regions of both the maxillary right and left canines from the ridge preservation appeared to be well-integrated. The crestal area widths at positions of maxillary right and left central incisors demonstrated a limited bone width of only 2-3 mm.

Following meticulous prosthodontic planning, the anatomical evaluation revealed that the bony defect did not allow for dental implants to be placed in positions compatible with prosthodontically-driven positions. The bone defect, classified as Class 3 by Benic and Hämmerle [2], represents one where sufficient volume stability of the area to be augmented is not provided by the adjacent bone walls (Figure 1B). Therefore, a staged bone augmentation was chosen, with implant placement scheduled for six months later. The surgical approach involved using Ti-reinforced d-PTFE with PRF block. Verbal and written informed consent was obtained prior to the surgery.

After administering local anaesthesia at the surgical site, a full-thickness mucoperiosteal flap was elevated to expose the alveolar crest and extended at least 5 mm beyond the bone defect. The defect was evaluated, confirming a knife-edge ridge with a crest width of 3 mm (Figure 2A). Multiple cortical perforations were created on the recipient sites to expose the medullary space, facilitating the migration of osteogenic cells, and enhancing blood supply[7] (Figure 2B). Prior to surgery, six tubes of blood were collected: five red-topped glass tubes were used to create A-PRF membrane (Figure 2C), and one green-topped plastic tube was used to create S-PRF plasma. The collected blood was centrifuged with the DUO Quattro (Duo Centrifuge, Nice, France), at 1300 rpm, for 14 minutes to obtain membranes and PRF plasma. The membranes were chopped into small pieces and mixed with 0.5 g of deproteinized bovine bone mineral (DBBM) (Bio-Oss®, small particles, Geistlich, Switzerland) at a 50:50 ratio[8] (Figure 2D). PRF plasma was added to enhance the stability of the bone graft, creating a PRF block (Figure 2E).

A Ti-reinforced, non-resorbable, high-density PTFE membrane (Cytoplast™, Biohorizons, USA) was initially secured on the buccal side with titanium tacks. The PRF block was applied, overcorrecting the defect, and obtaining approximately 10 mm of grafting material, specifically at positions of maxillary right and left central incisors (Figure 2F). The membrane was then anchored on the

palatal side and overlaid with a PRF membrane to enhance soft tissue healing and minimize membrane exposure risk.[9] (Figure 2G). After periosteal releasing incisions, a tension-free primary closure was achieved using horizontal mattress and single interrupted sutures (Figure 2H). Patients underwent follow-ups at 1 week, 2 weeks, 3 weeks, 2 months, and 6 months. Complete suture removal was performed at 3 weeks. Special care was taken to avoid the compression of removable dentures on the grafted sites during the initial stage of healing. At the re-entry, after 6 months, implant placements were performed using guided implant surgery.

Results

After 6 months, following the GBR procedure, primary closure was successfully maintained without any instances of wound dehiscence or membrane exposure. A well-rounded augmented ridge was noted, with good soft tissue condition (Figure 3A). Volumetric assessment, comparing pre- and post-augmentation, was performed using Materialise Magics (Materialise, Belgium) which indicated a significant increase in ridge width, approximately ranging from 4 to 6 mm (Figure 3B). A CBCT at 6 months revealed well-integrated bone graft material in the augmented area, resulting in horizontal bone gain of approximately 4 to 6 mm (Figure 3C). The homogeneity of the augmented area, with no irregularities, was noted.

At implant placement surgery, intra-surgical ridge assessment confirmed a horizontal bone gain of approximately 4 to 6 mm. An acceptable contour and curvature with a homogeneous surface and no residual graft particles were noted. (Figure 3D). During the implant osteotomy site preparation at positions of maxillary right and left central incisors, bone samples were collected for assessment using a trephine (Figure 3E). Guided implant placements were successfully performed without additional guided bone regeneration (GBR), at positions of maxillary right and left central incisors. However, simultaneous GBR

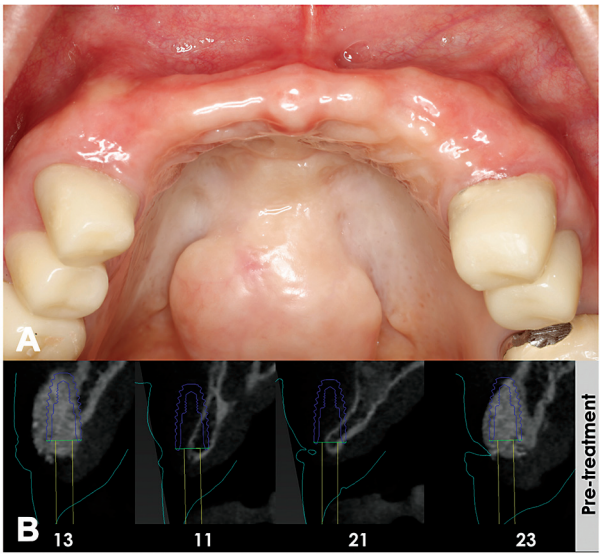

Figure 1: (A) An intra-oral photograph revealed a partially edentulous area from tooth 13 to 23 with a significant horizontal deficiency, but good soft tissue condition was noted (B) Prosthetic implant planning was performed using Co-diagnostix software (version 10.2.0, Dental Wings Inc., Canada). Class IV defects, as classified by Benic and Hämmerle (2014), were particularly notable in the areas of teeth 11 and 21[2]

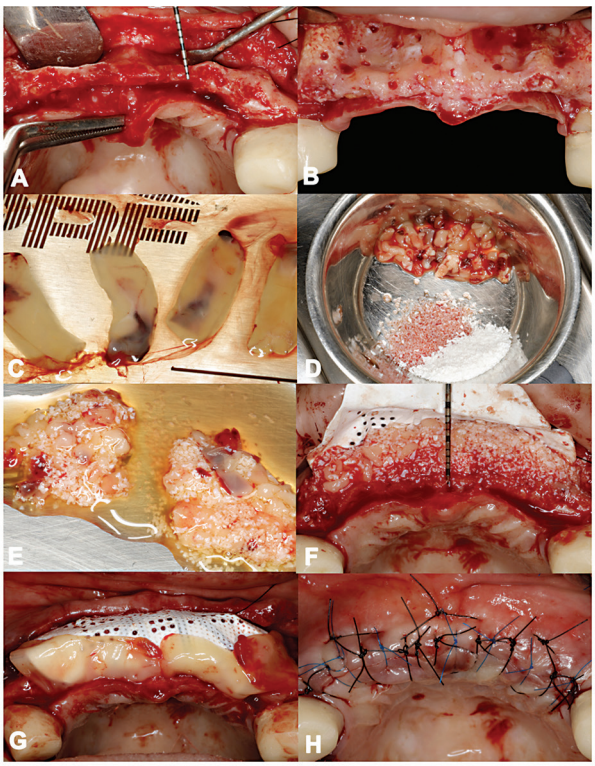

Figure 2: (A) The surgical assessment of the ridge defect. (B) Cortical perforation of the surgical site. (C) Preparation of PRF membranes. (D) Preparation of sticky bone. (E) The addition of liquid fibrinogen. (F) Application of the grafting material and d-PTFE membrane. (G) Application of PRF membranes over the d-PTFE membrane. (H) A primary closure, following periosteal releasing incisions, was performed

procedures were conducted at positions of maxillary right and left canines due to buccal dehiscence. Cover screws were installed, and a submucosal healing period of at least 4 months is planned before proceeding with prosthetic reconstruction (Figure 3F).

Histological analysis

Histological examination through Hematoxylin and Eosin (H&E) staining illustrates the presence of residual bone graft particles enveloped by recently synthesized woven bone with prominent irregular place reversal line (Figure 4A and 4B) Within this region, conspicuous vascularized fibrous connective tissue is observable, accompanied by regions populated by osteoblastic cells and multinucleated osteoclast giant cells (Figure 4C and 4D).

Discussions

The case illustrated that using a tissue engineering approach, with PRF as a bioactive agent, effectively augmented a large horizontal ridge defect in the anterior maxilla. However, success was contingent upon securing other crucial factors, including membrane placement, graft stability, and primary closure during the healing process.[4] To the best of our knowledge, this is the first case report which provided histologic evidence of using PRF mixed with DBBM without the use of autogenous bone.

PRF is produced through centrifugation, without the addition of additives, making it a purely autogenous substance.[10] PRF offers a fibrin-based scaffold enriched with a high concentration of platelets and leukocytes. It facilitates the continuous release of growth factors such as platelet-derived growth factor (PDGF), transforming growth factor beta-1 (TGFβ-1), insulin-like growth factor I (IGF-1), and vascular endothelial growth factor (VEGF) for up to 14 days.[11] Studies have shown that PRF membrane improved revascularization, enhanced soft tissue healing, and reduced the risk of bone or membrane exposure, thus minimizing complications following bone augmentation.[9,12] Despite showing promising clinical outcomes in promoting soft tissue repair and angiogenesis at the injury site, the effect of PRF on bone regeneration during GBR procedures has yet to be fully demonstrated.[13] Its ability to enhance angiogenesis is believed to be a critical factor in promoting bone regeneration during the early stages of healing.[9]

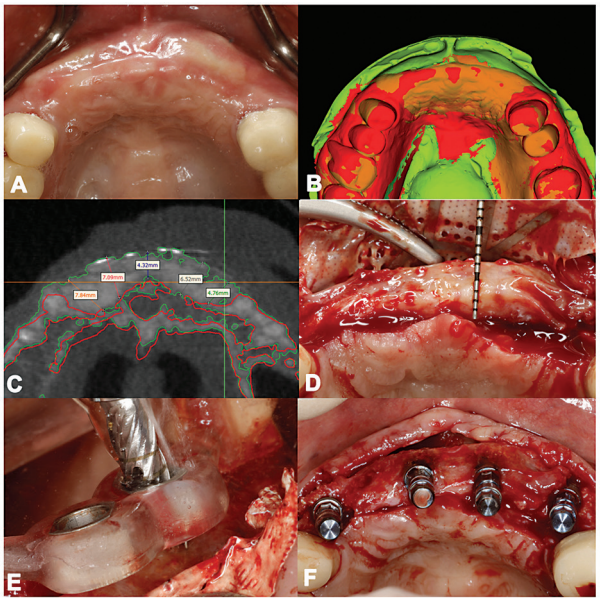

Figure 3: At 6 months following surgery. (A) An intra-oral ridge assessment. (B) The superimposition of intra-oral scans. The red scan represents the condition prior to the surgery, and the green scan represents the condition at 6 months post-surgery. (C) The superimposition of CBCT images. The red outline depicts the pristine condition, and the green outline displays the augmented areas. (D) An intra-surgical ridge assessment. (E) The augmented bone at positions of maxillary right and left central incisors was collected with a trephine for histologic evaluation. (F) Bone-level implants were placed according to prosthodontically planned positions to achieve the correct 3-dimensional position

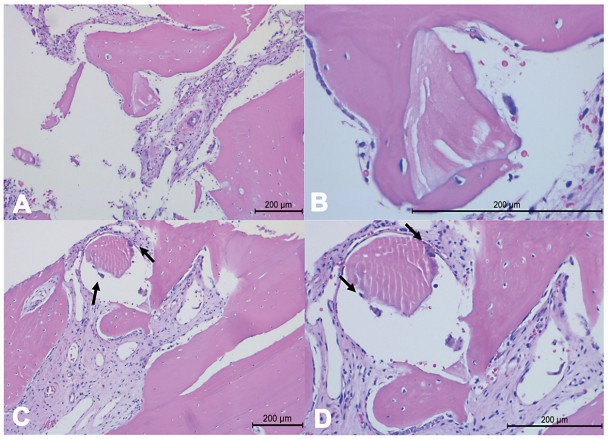

Figure 4: Photomicrographs of histologic samples stained with H&E. Focal areas of bone graft surrounded by new woven bone formation with prominent reverse lines, as seen in (A) at a magnification of x100 and (B) at a magnification of x400. Also, focal areas of bone graft surrounded by seams of osteoblasts and multinucleated osteoclast cells (indicated by black arrows) are depicted in (C) at a magnification of x100 and (D) at a magnification of x400

In this case, a tissue engineering approach that combined a biologically-inactive scaffold, specifically a xenograft material, with a bioactive agent (PRF) is expected to enhance or facilitate new bone formation.[14] A proof-of-concept study by Cortellini *et al.,*[8] showed the effectiveness of a PRF block; consisting of DBBM (xenograft) and PRF in augmenting deficient alveolar ridges. The result was a mean horizontal bone gain of 4.7±2 mm. However, resorbable collagen membranes were used instead of non-resorbable membranes. Similarly, a recent prospective study suggested that utilization of a composite of PRF, in conjunction with particulate xenograft, may effectively promote horizontal bone gain.[14] It is worth noting that only PRF membranes were used, and implants were simultaneously placed. Notably, a recent systematic review indicated a mean horizontal bone gain of 3.45±1.18 mm following staged lateral bone augmentation.[15] Consequently, it can be inferred that PRF block presents a viable alternative approach for horizontal bone augmentation, when compared to other surgical approaches.[16] From a patient perspective, this approach circumvents the need for invasive harvesting surgery and reduces morbidity.

In a clinical scenario, requiring more than 6 mm of horizontal bone gain, several surgical approaches have been proposed, including: block grafting; titanium mesh, combined with bone grafting; or a titanium-reinforced membrane, with bone grafts, based on the guided bone regeneration (GBR) concept.[3] Compared to other surgical approaches, GBR appears to offer greater predictability, reproducibility, and results in fewer surgical complications.[2] In addition, a split-mouth prospective study comparing bone regeneration between the use of d-PTFE and titanium mesh found that both devices could yield similar outcomes. However, higher incidences of membrane exposure with compromised results were noted, possibly due to the stiffness and sharp edges of the titanium mesh.[17] In this case, Ti-reinforced d-PTFE was chosen for to its ability to provide mechanical stability for the particulated graft, create a secluded space, and prevent soft tissue ingrowth.[18] The pores in d-PTFE, measuring less than 0.3 mm,[19] prevented the migration and colonization of bacteria while allowing the diffusion of essential molecules.

DBBM stands as one of the most widely studied bone grafting materials, renowned for its safety, osteoconductive properties, and biocompatibility. While lacking the ability to induce new bone formation, DBBM can maintain volume over time due to its non-resorbable properties. This attribute holds clinical relevance for specific indications, such as in the anterior maxilla.[20] It was observed that the graft resorption rate was approximately 15.6% for the DBBM and PRF approach. In contrast, the cases using allograft and collagen membranes observed results of approximately 50%.[21]

The histological depiction of residual bone graft particles amidst the woven bone matrix signifies the integration and potential incorporation of the bovine graft material into the host tissue. This integration process is facilitated by the surrounding vascularized fibrous connective tissue, which aids in the recruitment of osteogenic cells and supports the bone formation around the graft material. Moreover, the presence of osteoblastic cells and multinucleated osteoclast giant cells indicates active bone remodelling and suggests ongoing tissue regeneration at the graft site. Such observations underscore the dynamic interplay between host tissue and bovine graft material, ultimately contributing to the success of bone grafting procedures in promoting bone regeneration and repair. In some areas, bone grafts were embedded in dense connective tissue (provisional matrix), rich in mesenchymal cells, fibers, and vascular structures. It may be speculated that a longer healing time may be required to facilitate increased new bone formation.[22-23]

This case demonstrates that, prior to augmentation, implant placement was not feasible while considering prosthodontically-driven positions. However, following the augmentation procedure, the planned position lies entirely within the augmented area or the graft site, eliminating any anticipated simultaneously GBR. A systematic review revealed that implant survival rates, when placed in regenerated bone, ranged between 79% and 100%.[24] Moreover, an experimental study indicated that peri-implant tissue, after GBR using DBBM, exhibited a similar degree of bone resorption in an experimental, ligature-induced, peri-implantitis model, compared to that of native bone.[25] Despite the advantages of DBBM mentioned above, it has demonstrated a limited ability to induce bone formation.[26] By being in direct contact with the implant surface, it could adversely affect osseointegration and bone-to-implant contact (BIC). Additionally, a long-term follow-up is imperative to assess the effect

of loading on this augmented area and the survival of dental implants.

Conclusions

The use of sticky bone with PRF and d-PTFE membrane are a promising alternative surgical strategy for the augmentation of a large horizontal defect of the anterior maxilla. The advantages from the patient's perspective are clear, reducing patient morbidity by avoiding a second invasive harvesting surgery to collect autogenous bone. Nevertheless, autogenous bone is still considered the gold standard graft material, and long-term data on the stability of this augmented bone remains to be demonstrated.

Acknowledgments

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Conflicts of Interest

The authors do not have any financial interests, either directly or indirectly, in the products listed in the study.

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