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IN THE CLINIC

# The application of leukocyte- and platelet-rich fibrin (L-PRF) in maxillary sinus augmentation

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**Abstract**

**Background:** Since the introduction of sinus augmentation in the 1970s the procedure has been performed with or without biomaterials. Autologous blood products (ABPs) for use in sinus augmentation was first introduced in the 2000s, to aid potentially in bone and soft tissue healing.

**Methods:** Three different applications of leukocyte- and platelet-rich fibrin (L-PRF) in maxillary sinus augmentation are presented in this case series. In case 1, L-PRF is used in bilateral sinus augmentation to support placement of implants to support a maxillary hybrid denture. Case 2 highlights the use of L-PRF in a complication associate with Schneiderian membrane elevation. Case 3 provides histology taken at the time of implant placement 6 months following L-PRF/xenograft sinus augmentation.

**Results:** All cases resulted in the successful placement of dental implants. In case 2, an osseodensification procedure was performed with freeze-dried bone allograft, which provided an approximate 4 mm of additional vertical height for implant placement. Histology from case 3 at 6 months post sinus augmentation demonstrated the presence of new vital bone in contact with the xenograft.

**Conclusion:** To date, there is only a limited amount of evidence reporting on platelet-rich fibrin (PRF) or L-PRF use in maxillary sinus augmentation. Bone gain from either product has ranged from 3.2 to 11.8 mm, with the percentage of newly formed bone reported in case series as 33% ± 5%. Despite the lack of strong evidence, L-PRF appears to have beneficial effects on bone regeneration when used in sinus augmentation.

**KEYWORDS**
maxillary sinus, osteogenesis, platelet-rich fibrin

## INTRODUCTION

A challenge encountered in implant dentistry is placement of implants in an atrophic maxilla. Deficiencies in hard and soft tissues, as well as pneumatization of the maxillary sinus can be encountered. When deficiencies are present in the posterior maxilla, augmentation of the maxillary sinus is considered. There has been a continual evolution in the methods and materials used in augmentation of the maxillary sinus. Though Tatum first discussed sinus augmentation in 1977, the first publication of a sinus lift procedure was by Boyne and James in 1980.[1] Their technique involved access to the sinus via a lateral window. Graft materials used in this procedure include autogenous bone, allografts, xenografts, or combinations of the various materials.[2] Others such as Lundgren et al.[3] reported in 2004 one of the first reports of bone reformation in the maxillary sinus of humans with no grafting materials utilized. The first human histologic evidence of new bone formation in the maxillary sinus with only membrane elevation supported by dental implants was reported by Sohn et al. in 2008. In 10 patients with an average residual bone height of 5 mm (range 1–9 mm) blood only filled the space created by the Schneiderian membrane elevation. At 6 months

  

biopsies obtained from the maxillary sinuses demonstrated new bone formation.[4]

Autologous blood products (ABPs) represent a different approach to consider when grafting a maxillary sinus. Their use in combination with a grafting material or as a standalone material can provide a reservoir of growth factors that can act directly on osteoblasts, endothelial cells, chondrocytes, and fibroblasts.[5] Specifically, platelet-rich fibrin (PRF) contains transforming growth factor $\beta$1 (TGF $\beta$1), platelet-derived growth factor (PDGF), vascular endothelial growth factor (VEGF), and interleukin (IL)-1$\beta$, IL-4, and IL-6.[6] These products along with leukocytes within the fibrin network can be key to tissue regeneration with their angiogenic potential, immune system control, potential to recruit circulating stem cells, and their ability to promote wound closure by epithelial tissues.[5]

In this case series, we present three approaches to grafting of a maxillary sinus using leukocyte-platelet-rich fibrin (L-PRF). The first case will highlight the use of L-PRF over the lateral window in a sinus grafted with an allograft/xenograft combination. The second case will demonstrate the use of L-PRF alone when a Schneiderian membrane tear precluded the use of other materials. The third case will utilize an L-PRF/xenograft combination to graft the maxillary sinus.

## METHODS AND RESULTS

### Case 1

A 69-year-old male presented to the Graduate Periodontics department at UT Health San Antonio (UTHSCSA) for comprehensive treatment. The patients' chief complaint was to restore masticatory function and esthetics of his partially edentulous maxillary arch. His medical history consisted of chronic sinusitis, asthma, and a 10 pack-year smoking history. Fexofenadine was used as needed by the patient for seasonal allergies.

Upon clinical evaluation, the patient had a terminal maxillary dentition secondary to caries and coronal tooth fractures, endodontically involved teeth #6, #10–#12, #15, moderate two-body generalized wear, and bilateral pneumatized maxillary sinuses. A prosthodontic evaluation was completed, and the patient was treatment planned for replacement of the maxillary dentition with six dental implants for a maxillary hybrid prosthesis. A decision was made to not place implants immediately at the time of maxillary extractions due to the size of endodontic lesions associated with #6, #10–12, and #15, the need for bilateral sinus augmentation, and the patients' high functional load evident by his two-body wear and opposing natural dentition. The patient was initially referred to a Board-certified otolaryngologist for evaluation of chronic sinusitis. After evaluation, the otolaryngologist performed a septoplasty with balloon sinuplasty to treat the diagnosed chronic sinusitis. The patient was subsequently returned to Graduate Periodontics.

Prior to treatment, the patient was provided with a thorough discussion of the treatment plan, and verbal and written informed consent was obtained for the surgical and restorative treatment plan. Surgical treatment began with extraction of all maxillary teeth with ridge preservation and delivery of an immediate maxillary denture. Ridge preservation was performed at potential implant sites since pooled analysis of different ridge preservation treatment modalities have shown benefits in preventing horizontal resorption, vertical midbuccal and vertical midlingual bone changes.[7] The patient was then allowed to heal four months prior to sinus augmentation surgery. Bilateral sinus augmentations were performed over two separate appointments. L-PRF use was planned for each procedure. The procedure was completed with moderate sedation and local anesthesia. On each side of the maxilla, a midcrestal incision was made on the edentulous ridge, with two vertical releasing incisions, one at the anterior aspect of the flap and the second at the posterior aspect of the flap. Mucoperiosteal flaps were reflected 20 mm from the crest of the ridge until complete visualization of the lateral wall of the maxillary sinus was observed. A lateral window was created on each side using a round diamond bur in a high-speed electric handpiece and Piezo tips with copious irrigation. The bone remaining attached to the Schneiderian membrane was rotated medially and superiorly into the sinus. The Schneiderian membrane was elevated approximately 14 mm based on the planned implant size, length, and amount of ridge reduction required for prosthetic space (Figure 1). No evidence of membrane perforation was observed. L-PRF was prepared with a centrifuge (Intraspin, BioHorizons, Birmingham, AL) according to the manufacturer's instructions for "sticky bone" protocol and L-PRF membranes. The platelet poor plasma was separated from the L-PRF after 3 min at 2700 revolutions per minute (RPM) and mixed with a 50%/50% combination of freeze-dried bone allograft (Freeze-Dried Bone Allograft, Straumann USA, Andover, MA) and anorganic bovine bone xenograft (Bio-Oss, Geistlich Pharma North America, Princeton, NJ), with 3.0 cc total placed into the sinus. A collagen (BioGide, Geistlich Pharma North America, Princeton, NJ) 25 × 25 mm barrier membrane was trimmed and placed over the lateral window osteotomy. The L-PRF membranes (spun for additional 9 min at 2700 RPM) were then placed over the grafted lateral window and collagen membrane (Figure 2) and the flap was repositioned and stabilized with 4-0 dense polytetrafluoroethylene sutures in single interrupted and continuous interlocking fashion. The vertical releasing incisions were closed with 5-0 chromic gut. Medications for postoperative management were 600 mg of Ibuprofen, 500 mg of acetaminophen every 4–6 hours, amoxicillin/clavulanic acid 875/125 starting one full day prior to surgery every 12 hours for seven days, a Medrol Dose Pack starting one day prior to surgery, and 0.12% chlorhexidine mouthrinse. The same medication protocol

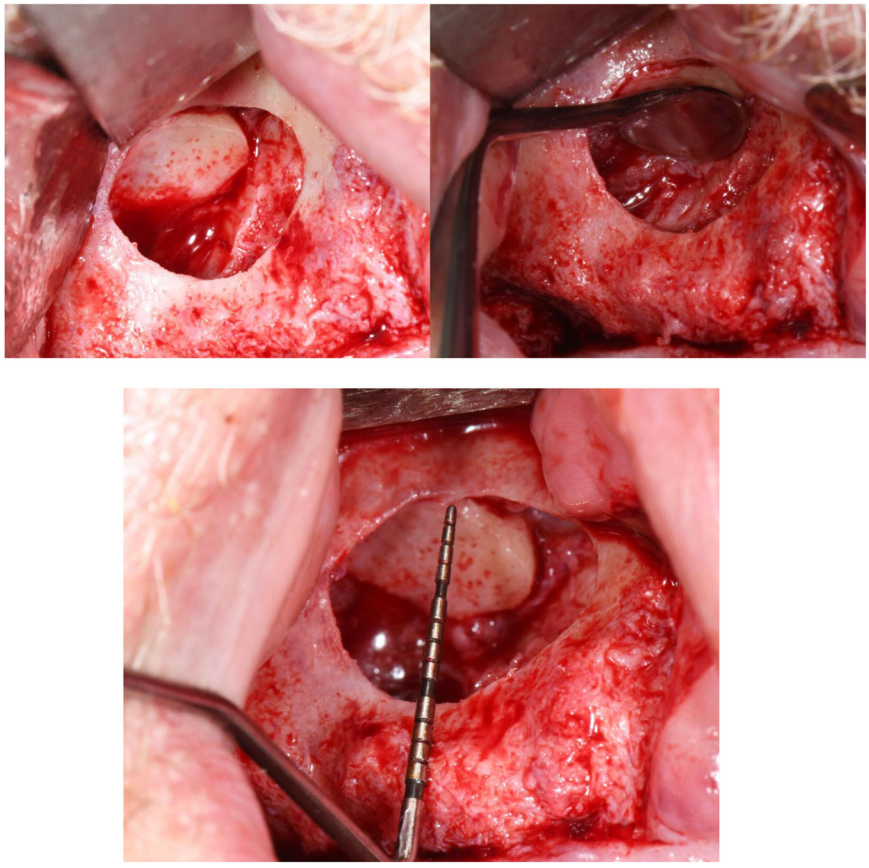

**FIGURE 1** Preparation of the lateral window with Schneiderian membrane elevation. The lower panel shows the approximate vertical elevation obtained.

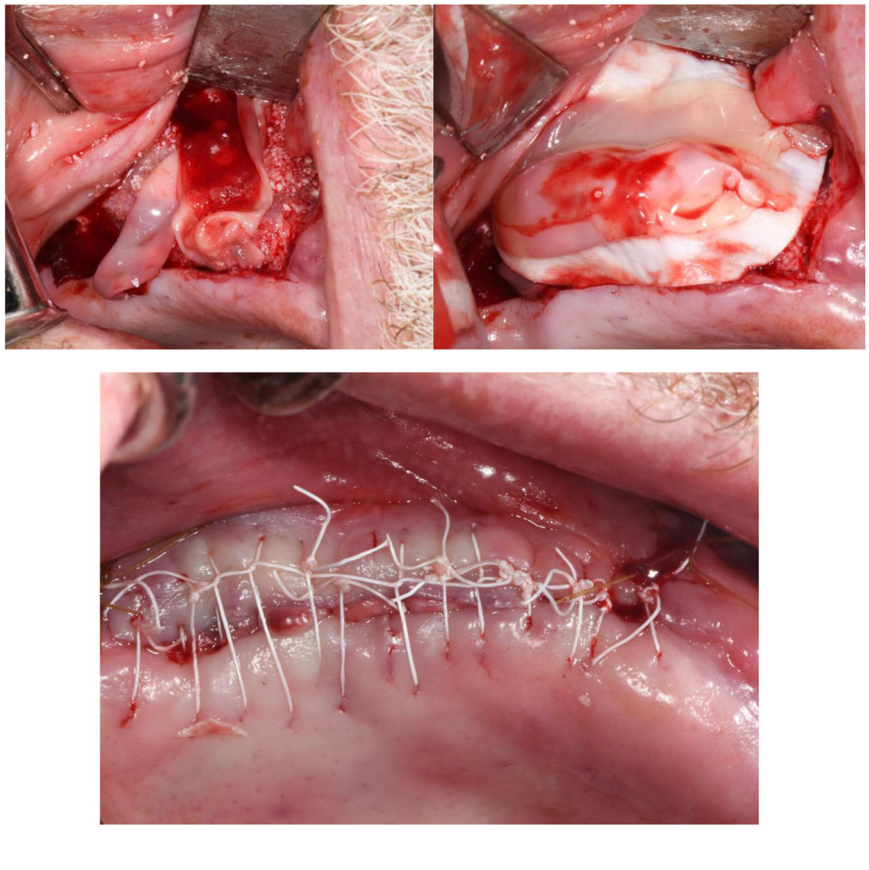

**FIGURE 2** All photos are of the maxillary right surgery. Upper left photo shows L-PRF placed over the grafted lateral window. Upper right photo shows placement of L-PRF over a collagen membrane. Bottom photograph shows immediate postoperative wound closure.

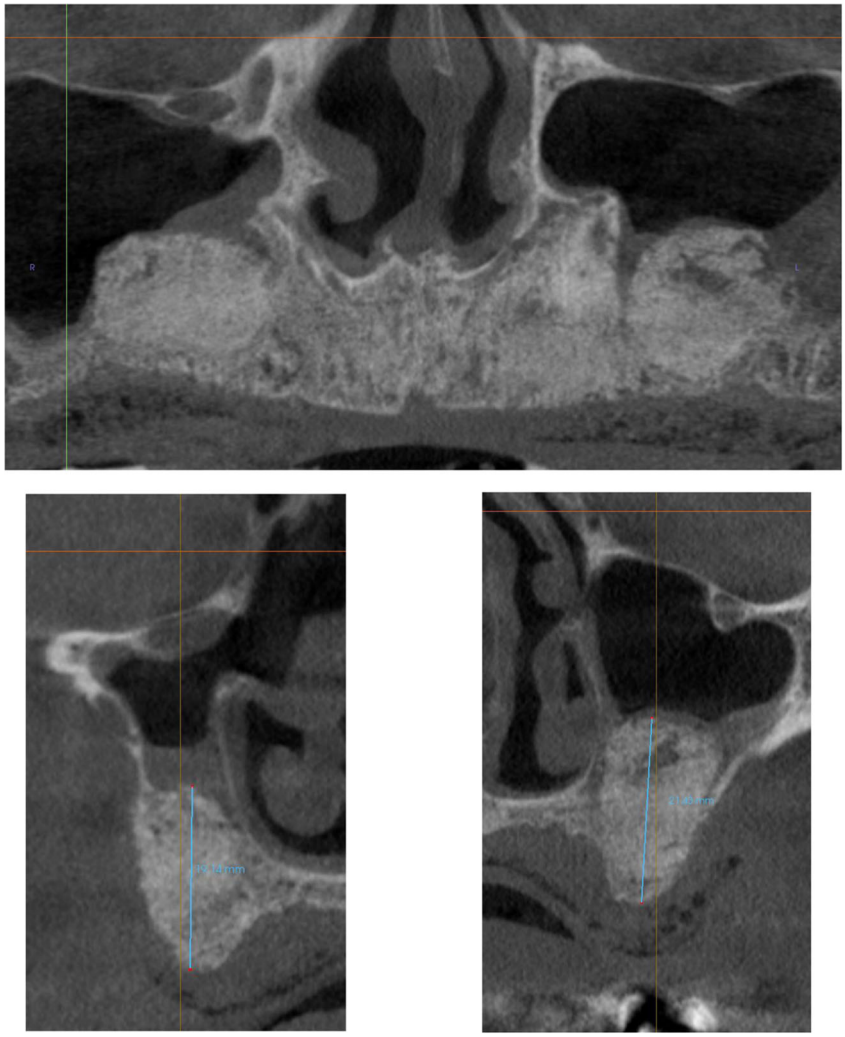

**FIGURE 3** CBCT obtained 6 months post sinus augmentation

was followed for the patient's right side and the patient was allowed to heal undisturbed for six months following sinus augmentation surgery while wearing a complete maxillary denture. Postoperative care was provided after each surgery at two weeks for suture removal. Thereafter the patient was seen at four weeks, three and six months. The patient reported no postoperative complications, and there were no wound dehiscences or signs of infection at any postoperative visit. A new CBCT was obtained at six months (Figure 3) prior to the placement of six dental implants at sites #3, #5, #7, #10, #12, and #14. All implants demonstrated an insertion torque >35 Ncm at placement. The existing maxillary denture was converted by a prosthodontic resident on the day of implant placement to an interim hybrid prosthesis. A final hybrid prosthesis will be constructed following six months of implant healing.

## Case 2

A 65-year-old male presented to the Graduate Periodontics department at UTHSCSA for comprehensive treatment. The patient was seeking care for placement of a dental implant in the left maxillary posterior region. His medical history was positive for hypertension, hypercholesterolemia, and depression. Medications reported were sertraline 100 mg daily, fenofibrate 5 mg daily, and rosuvastatin 10 mg daily. Implants were present at sites #7, #9 and #11. Cone beam computed tomography (CBCT) revealed approximately 3.5 mm of vertical bone height at the #14 edentulous site (Figure 4).

Examination findings were discussed with the patient and verbal and written informed consent were obtained for the surgical procedures and restorative plan. Lateral window sinus augmentation was performed at the maxillary left sinus. The procedure was completed under moderate sedation with local anesthesia. Sulcular incisions were made from the mesial of #13, midcrestal at the edentulous area, and sulcular at #15 with vertical release distal to #15. A mucoperiosteal flap was reflected approximately 15 mm from the crest of the ridge until complete visualization of the lateral wall of the maxillary sinus was observed. A 10 mm × 8 mm window was made using a round diamond bur in a high-speed electric handpiece and Piezo tips with

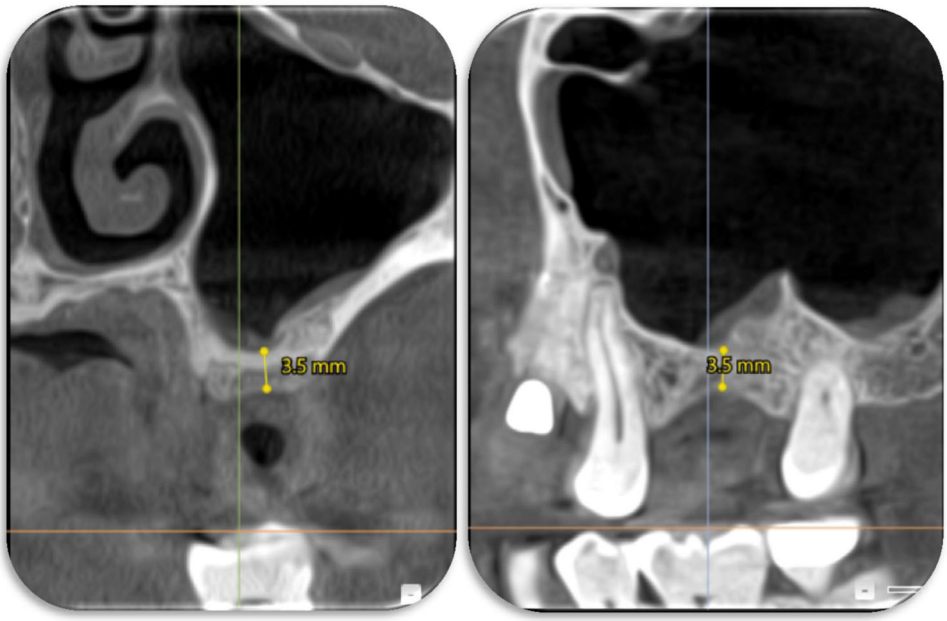


**FIGURE 4** Preoperative CBCT. Approximately 3.5 mm of vertical bone height is present at the #14 edentulous site.

copious irrigation on the lateral wall of the sinus. Intraoperatively Schneiderian membrane adhesions were found on the inferior aspect of the sinus. Medical history was inconclusive as to the reason why adhesions were found. While attempting to free the adhesions, the Schneiderian membrane tore approximately 10 mm. Due to the size of the tear, L-PRF alone was placed in the sinus to aid in blood clot formation and help support the elevated Schneiderian membrane. L-PRF was prepared with a centrifuge (Versah, Jackson, MI) according to the manufacturer's instructions, spun for 12 min at 2700 RPM. A collagen membrane (Zimmer TSV, Zimmer Biomet, Carlsbad, CA) was placed over the window and primary closure was obtained with 4-0 dense polytetrafluoroethylene single interrupted sutures, and the vertical releasing incision was closed with 5-0 chromic gut. Medications for postoperative management were 600 mg of Ibuprofen, 500 mg of acetaminophen every 4–6 hours, amoxicillin/clavulanic acid 875/125 every 12 hours starting one day prior to surgery for 7 days, and 0.12% chlorhexidine mouthrinse. At six months, a new CBCT was taken, which demonstrated a gain of 4.5 mm of vertical bone height (Figure 5), for a total of 8.0 mm of vertical height. At eight months, an osseodensification procedure was performed according to the Densah Sinus Lift Protocol I with freeze-dried bone allograft, which provided an approximate 4 mm of additional vertical height. A 4.7 × 10 mm implant (Salvin Variable Speed Centrifuge, Salvin Dental, Charlotte, NC) was placed, with an insertion torque of 35 Ncm (Figure 6). The patient reported no postoperative complications, and at 3 months postimplant placement, the implant was uncovered and a healing abutment was placed.

## Case 3

A 68-year-old female presented to Graduate Periodontics at the University of Colorado School of Dental Medicine (CUSDM) requesting evaluation for implant placement at site #3 (Figure 7). Her medical history was positive for type 2 diabetes mellitus, hypertension, and ulcerative colitis. Medications reported were verapamil, losartan, mesalamine, fluticasone, and valacyclovir. At the time of surgery, the patient's latest HbA1c was 6.3%, and diabetes was controlled by diet and exercise. CBCT evaluation showed a pneumatized right maxillary sinus with insufficient vertical bone height to support an implant.

Following a thorough discussion of exam findings verbal and written informed consent was obtained for the surgical and restorative treatment plan. Lateral window sinus augmentation was performed under moderate sedation with local anesthesia. Sulcular incisions were made from the distal of #2 to the distal of #5, with midcrestal incision at the edentulous site. Vertical releasing incisions were placed at #2 distal and #4 mesial. A mucoperiosteal flap was reflected approximately 25 mm from the crest of the ridge until complete visualization of the lateral wall of the maxillary sinus was observed. A 10 × 10 mm lateral window was created by removing all bone over the window with a round diamond bur in a high-speed handpiece and Piezo tips. The Schneiderian membrane was elevated approximately 15 mm vertically and was observed to be thin. Blood was drawn and L-PRF was prepared using a centrifuge (Salvin Variable Speed Centrifuge, Salvin Dental, Charlotte, NC) set at 2700 RPM for 12 min. One L-PRF membrane was placed over the Schneiderian membrane, with a second L-PRF cut

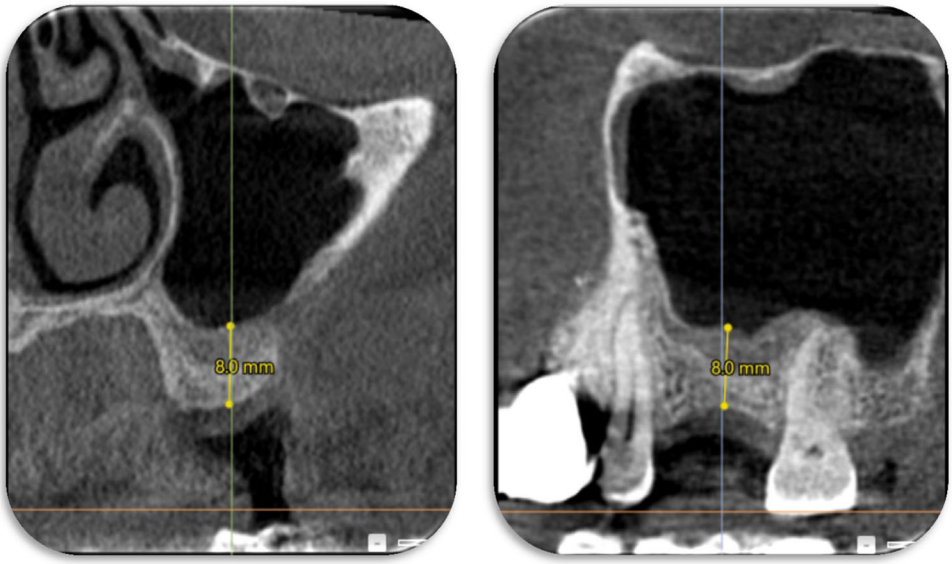


**FIGURE 5** Six months post sinus augmentation CBCT radiographically suggests an approximate gain of 4.5 mm of vertical bone height over preoperative CBCT.

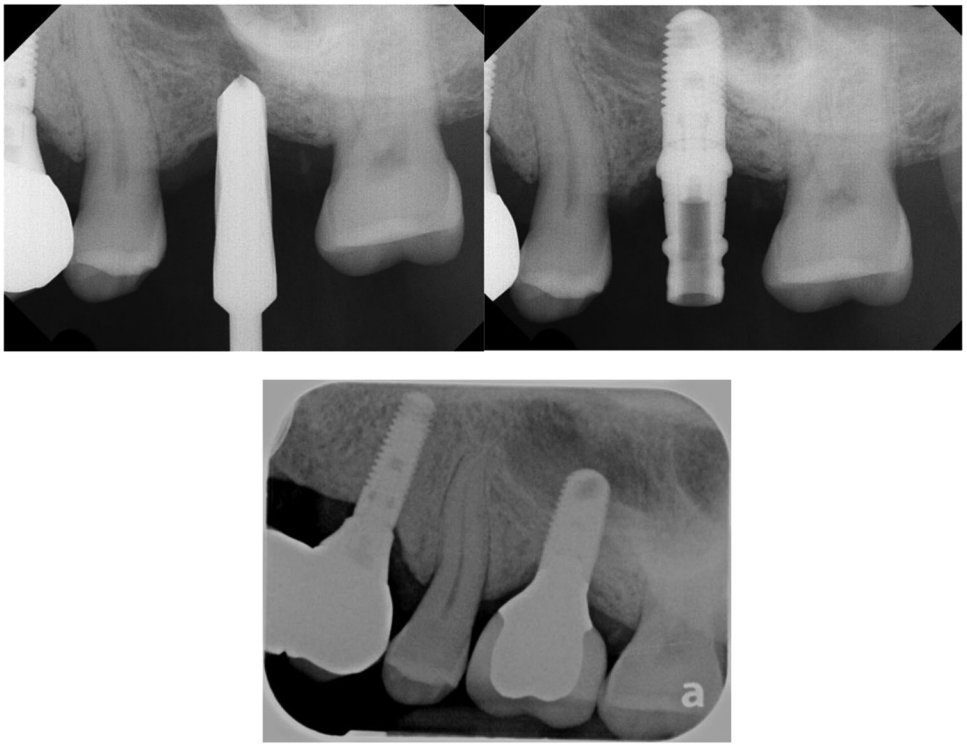


**FIGURE 6** Implant placement procedure. Osseodensification preparation is shown on the upper left panel. Implant placement is shown on the upper right panel. Implant with final restoration is shown at lower radiograph.

up and mixed with a porcine xenograft (Z-Core, Osteogenics, Lubbock, TX). The combination L-PRF/xenograft was placed within the sinus, and the window was covered with a porcine collagen membrane (MemLok Pliable, BioHorizons, Birmingham, AL) (Figure 8). A third L-PRF membrane was then placed over the collagen membrane, the flap was repositioned, and sutured with a horizontal mattress and interrupted 4-0 dense polytetrafluoroethylene sutures. Medications for postoperative management were 600 mg of Ibuprofen, 500 mg of acetaminophen every 4–6 hours, azithromycin 500 mg starting one day prior to surgery followed by azithromycin 250 mg the next four days,

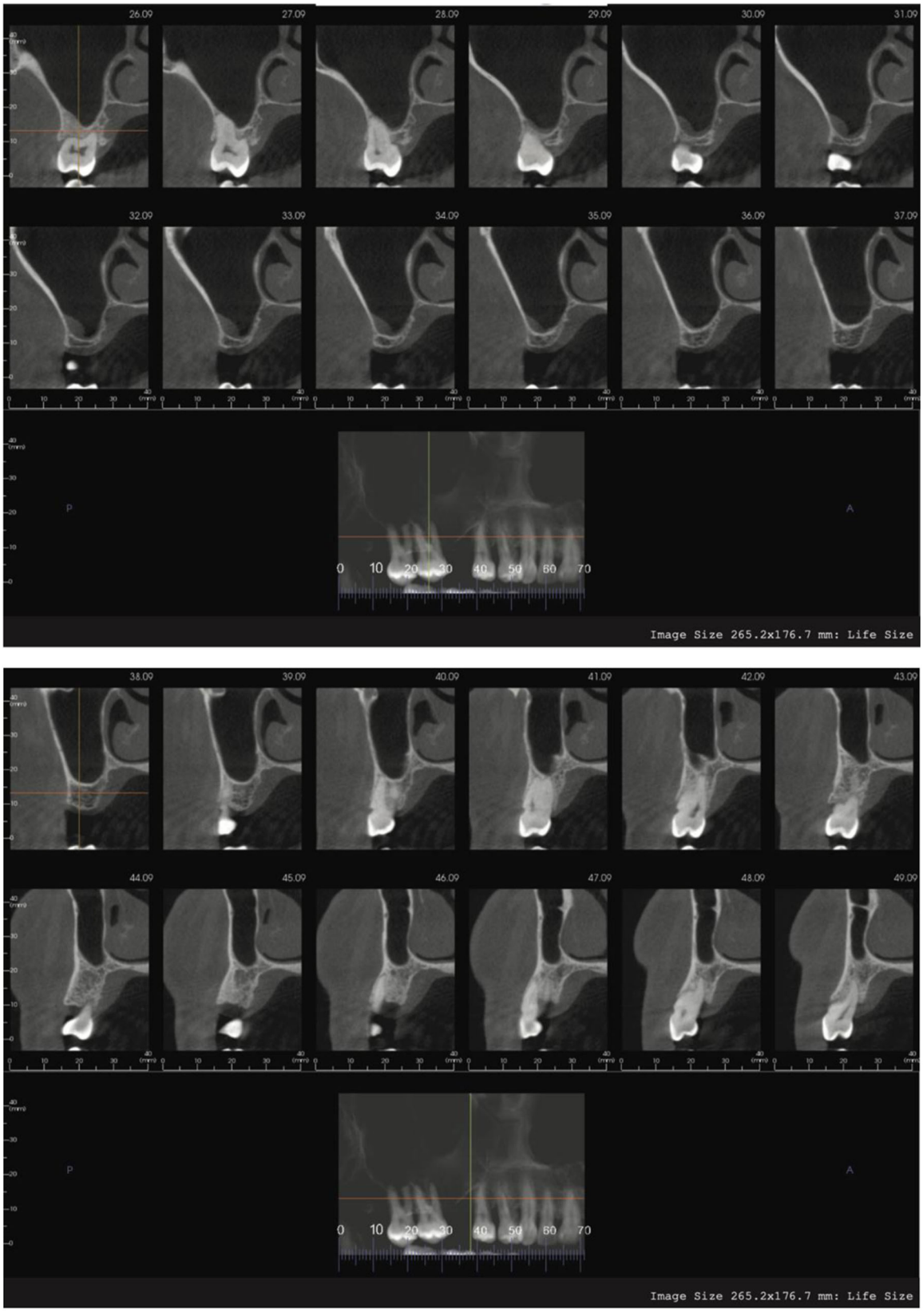


**FIGURE 7** Preoperative CBCT of #3 site

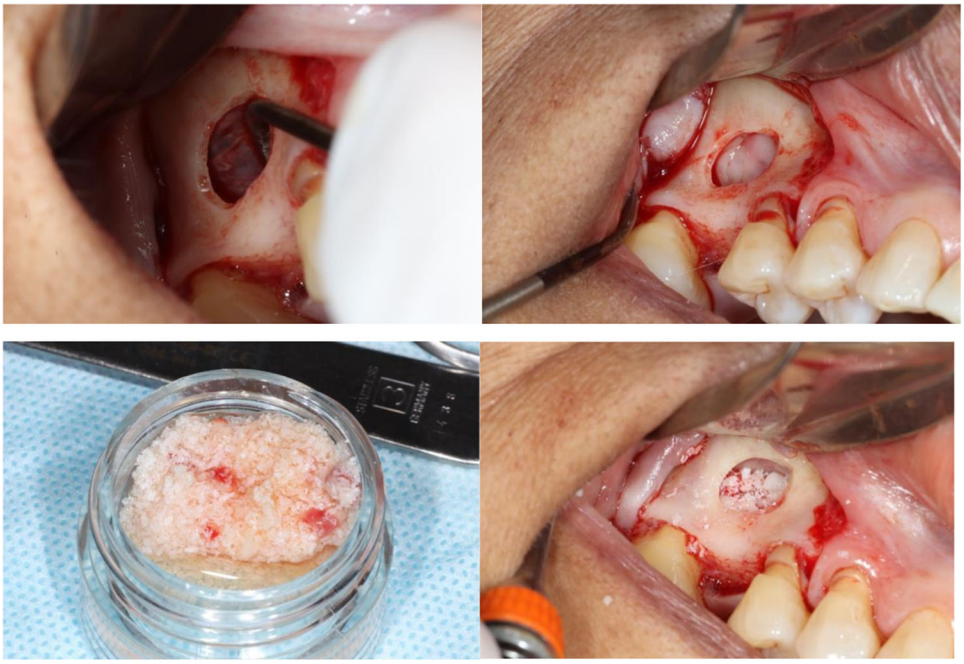

**FIGURE 8** Top left panel demonstrating lateral window preparation. Top right panel shows L-PRF placed over the elevated Schneiderian membrane. Bottom left panel shows "cut-up" L-PRF mixed into xenograft. Bottom right panel shows L-PRF/xenograft combination being placed into the lateral window.

and 0.12% chlorhexidine mouthrinse. Six months following surgery a 4.3 × 11.5 mm implant (NobelReplace, Nobel Biocare, Yorba Linda, CA) was placed at the #3 site at an insertion torque of 35 Ncm (Figure 9). A trephine core was collected at the site from the crest of the ridge for histology (Figure 10). The histologic core demonstrates the presence of new vital bone in contact with the xenograft.

## DISCUSSION

L-PRF use in sinus augmentation has been documented in recent years in combination with various biomaterials or as a sole material. The cases presented highlight the versatility of L-PRF to promote bone healing in a variety of different applications.

Following injury there are four overlapping phases of wound healing: initial hemostasis, an inflammatory phase, a proliferative phase, and a remodeling phase. Platelets regulate hemostasis through vascular obliteration and facilitating fibrin clot formation. In the inflammatory phase, white blood cells and platelets release cellular products that initiate the healing process. If platelet-rich fibrin (PRF) is applied to a wound site, the concentrated growth factors present within PRF augment the healing process by mediating cell migration, proliferation, and differentiation.[8]

Our second case utilizing L-PRF alone produced an approximate 4.5 mm in vertical bone gain as demonstrated on CBCT. This compares favorably to one other study[9] where a lateral window approach was used with L-PRF, and mean bone gain was found to be 5.4 ± 1.5 mm. This study also utilized immediate implant placement to support the Schneiderian membrane. Two studies[10,11] reported bone gain of 10 mm (range 7–13 mm) with L-PRF. To date, only one study[10] has reported on the amount of newly formed bone from the sole use of L-PRF. That study found histologically 33% ± 5% new bone after six months of healing.

The influence of PRF on soft tissue healing in humans is emerging. In a recent systematic review,[12] nine of 13 studies using appropriate controls reported results favoring the use of PRF in soft tissue regeneration and wound healing. Data on the use of PRF with biomaterials when assessed by pooled analysis has shown that radiographically there are no statistically significant differences in mean augmented bone height.[11] Histomorphometric assessment has reported new bone formation with PRF and biomaterials to range from 17% to 45%, compared to new bone formation of 13%–33% with biomaterials alone.[13] Meta-analysis showed 1.98% more new bone formation when PRF was added to biomaterials, although findings were not statistically significant and there was moderate heterogeneity[11] between the studies. As for residual biomaterial, pooled analysis showed statistically significant less residual biomaterial (4.60%) with PRF use.[13]

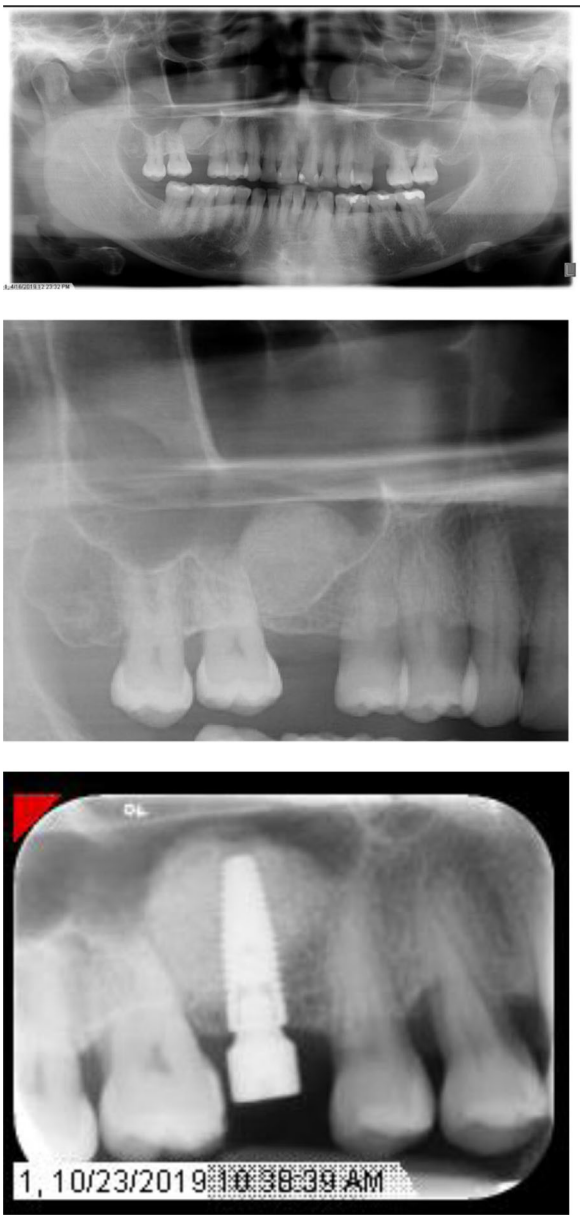


**FIGURE 9** Top and middle panels show six months post sinus augmentation. Bottom panel periapical radiograph shows implant placement into grafted site.

## CONCLUSION

While to date there is not robust evidence on the use of ABPs in sinus augmentation procedures, there is a trend suggesting that L-PRF may offer an advantage to the clinician through enhanced bone formation and soft tissue healing. Due to the presence of growth factors, osteoinduction as well as enhanced revascularization may occur.

### ACKNOWLEDGMENTS

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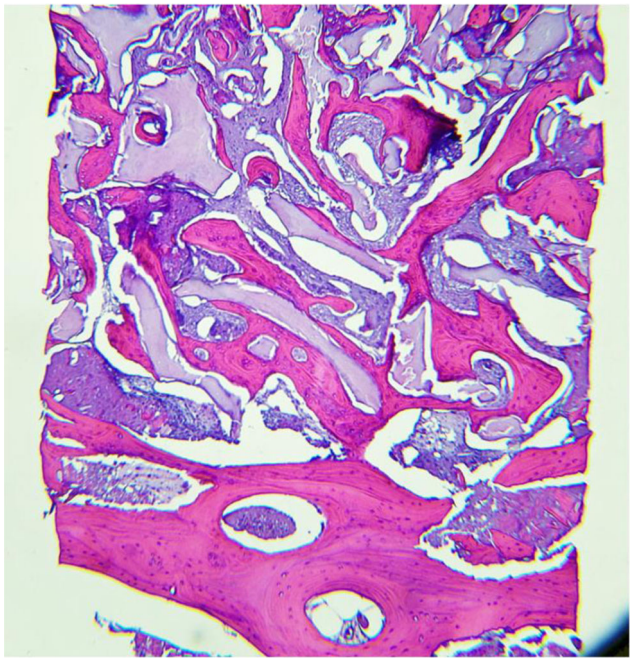

**FIGURE 10** A trephine core taken at the time of implant placement, six months post sinus augmentation (H&E staining). The bottom third of the slide demonstrates the existing native bone. The middle and top third demonstrates xenograft particles and the formation of new vital bone in contact with some of the xenograft.

### CONFLICT OF INTEREST

All authors declare no conflict of interest.

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