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CASE REPORT

PATIENT-CENTERED VERTICAL RIDGE AUGMENTATION USING THE TENT POLE CONCEPT

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ABSTRACT

Background: Vertical ridge augmentation remains one of the most challenging procedures in implant dentistry because severe alveolar defects frequently require complex regenerative approaches, multiple surgical interventions, and prolonged treatment periods before definitive prosthetic rehabilitation. Maintaining a stable regenerative space during healing is considered a critical factor for successful three-dimensional bone reconstruction.

Case Presentation: This report presents the clinical application of the Tent Pole System, which combines implant-supported tenting abutments (SANTA®) and a wide-head tenting screw (SBB®) to maintain regenerative space during simultaneous implant placement and vertical ridge augmentation. A patient with severe posterior maxillary alveolar ridge deficiency associated with extensive horizontal and vertical bone loss underwent simultaneous implant placement, sinus augmentation, and three-dimensional ridge reconstruction. The regenerative procedure incorporated concentrated growth factor (CGF), StickyBone™, and a collagen membrane. Implant-supported tenting abutments were used in implant sites, while a wide-head tenting screw was applied in an implant-free pontic region to provide continuous space maintenance throughout the defect. Clinical, radiographic, and prosthetic outcomes were evaluated during follow-up.

Results: The Tent Pole System allowed reconstruction of the deficient alveolar ridge with stable maintenance of the augmented volume. Early provisional rehabilitation was achieved, followed by definitive prosthetic restoration with satisfactory functional and esthetic outcomes. At two-year follow-up, stable peri-implant hard and soft tissues were observed without biological or prosthetic complications. Soft tissue enhancement was successfully achieved using a minimally invasive sutureless free gingival graft technique.

Conclusion: The Tent Pole System represents a promising approach for managing severe vertical ridge defects by integrating implant-supported and implant-free space-maintaining devices within a simplified regenerative protocol. Although the presented clinical outcomes are encouraging, further prospective controlled studies with larger patient populations and longer follow-up are required to validate its predictability and long-term effectiveness.

Keywords: Vertical ridge augmentation; Tent Pole Concept; guided bone regeneration; implant dentistry; SANTA®; SBB®; concentrated growth facto

INTRODUCTION

Vertical ridge augmentation remains one of the most challenging procedures in implant dentistry. Conventional techniques, including autogenous block bone grafting, distraction osteogenesis, titanium mesh, and non-resorbable membrane-guided bone regeneration, have demonstrated favorable clinical outcomes. However, these procedures are often associated with significant drawbacks, including donor-site morbidity, unpredictable graft resorption, prolonged treatment periods, multiple surgical interventions, and increased patient morbidity.[1-4] Furthermore, simultaneous implant placement is frequently not feasible in severe vertical defects, resulting in an extended edentulous healing period before functional rehabilitation can be achieved. To overcome these limitations, the author developed the Tent Pole Concept, which utilizes a 2-mm-high tenting abutment (SANTA®, Biotem Implant Co., Seoul, Republic of Korea) connected directly to the platform of an implant placed

simultaneously within the bone defect. In this concept, the implant and the SANTA function together as a biological tent pole by supporting the overlying soft tissue, preventing collapse of the grafted bone, and maintaining a stable regenerative space throughout healing. This approach enables simultaneous implant placement and vertical ridge augmentation while simplifying the surgical procedure, reducing patient morbidity, and shortening the overall treatment period.[5] However, the Tent Pole Concept using the SANTA® alone cannot be applied to implant-free pontic sites or extensive vertical defects where implant placement is not feasible. To address this limitation, the authors subsequently developed the wide-head tent-pole screw (WHTPS; SBB®, Biotem Implant Co., Seoul, Republic of Korea), a wide-head tenting device specifically designed for implant-free sites. Unlike conventional mini-tenting screws, which often require the placement of multiple screws to maintain the regenerative space, the SBB®(Sohn's Bone Builder) provides a substantially larger supporting surface, allowing stable space maintenance with fewer fixation devices while simplifying the surgical procedure.[6]

The present case report represents the clinical application integrating the SANTA and SBB into a unified Tent Pole System. By combining implant-supported and implant-free tenting devices, this approach aims to reconstruct extensive vertical ridge defects while maintaining regenerative space throughout the entire defect.

This report presents two patients with severe vertical ridge deficiencies treated using this integrated Tent Pole System and demonstrates the clinical feasibility of a simplified, biologically based, and patient-centered approach for predictable three-dimensional vertical ridge augmentation.

1. CASE PRESENTATION

A 64-year-old man was referred to our department for the management of a persistent oroantral fistula that had developed following surgical treatment for maxillary sinusitis associated with a bone graft infection in the right posterior maxilla. To close the fistula, **a** vascularized interpositional periosteal connective tissue (VIP-CT) flap was performed, resulting in complete closure of the oroantral communication. Three months later, the patient returned for follow-up. Clinical examination confirmed complete healing of the oroantral fistula without any evidence of recurrent infection. However, severe horizontal and vertical alveolar ridge deficiencies were observed in the right posterior maxilla. Cone-beam computed tomography (CBCT) further demonstrated extensive alveolar bone loss with a persistent communication between the residual alveolar ridge and the maxillary sinus caused by severe bone resorption. (Figure 1).

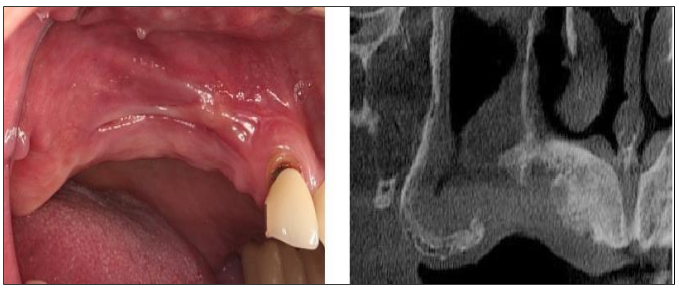


Figure 1. Preoperative clinical and radiographic findings. (A) Preoperative intraoral view demonstrating severe horizontal and vertical alveolar ridge resorption in the right posterior maxilla following healing of the oroantral fistula. **(B)** Preoperative CBCT coronal image showing severe vertical alveolar bone loss with a large osseous communication between the alveolar ridge and the maxillary sinus. Marked thickening of the Schneiderian membrane is also evident, indicating chronic inflammatory changes.

Because the patient desired a fixed implant-supported prosthesis**,** simultaneous maxillary sinus augmentation and three-dimensional alveolar ridge reconstruction were planned. The surgical objectives were to eliminate the residual communication with the maxillary sinus, reconstruct the severely resorbed alveolar ridge, and create sufficient bone volume for implant-supported rehabilitation. After a comprehensive discussion with the patient, it was explained that a conventional staged guided bone regeneration (GBR) approach using an e-PTFE membrane or titanium mesh could require multiple surgical procedures and, depending on the

healing response, an overall treatment period of approximately 18 months or longer before delivery of the definitive implant-supported prosthesis. Such a treatment strategy would inevitably prolong the edentulous healing period, increase patient morbidity, and delay functional rehabilitation. Because the patient's primary goal was to regain oral function with a fixed implant-supported prosthesis as early as possible, a patient-centered treatment strategy was selected instead of the conventional staged protocol. The treatment plan was designed to minimize the number of surgical interventions while simultaneously reconstructing the severely deficient alveolar ridge and facilitating earlier prosthetic rehabilitation.

To accomplish these objectives, simultaneous maxillary sinus augmentation and three-dimensional ridge reconstruction were performed using the Tent Pole Concept**.** Dental implants connected to SANTA® were used as implant-supported tent poles to maintain the regenerative space at the implant sites, while a 6-mm SBB® was placed in the implant-free second premolar (pontic) region to support the grafted bone and maintain space throughout the entire defect.

This integrated approach enabled comprehensive reconstruction of the posterior maxilla while avoiding the prolonged staged treatment associated with conventional GBR.

The surgical procedure was performed under local anesthesia following the intravenous administration of preoperative antibiotics (Flomoxef, Flumarin®, Ildong Pharm, Republic of Korea). Venous blood was drawn from the patient's forearm to produce autologous fibrin glue and concentrated growth factor (CGF) membranes, used to prepare sticky bone, as originally introduced by Sohn et al.[7] A crestal incision with anterior and posterior vertical releasing incisions extending into the vestibular mucosa was made, and a full-thickness buccal mucoperiosteal flap was carefully elevated. After flap reflection, a large bony communication between the posterior alveolar ridge and the maxillary sinus was clearly identified. The Schneiderian membrane was then carefully elevated using sinus elevators. To maximize the blood supply to the newly created subantral space and promote bone regeneration, the palatal bony wall of the maxillary sinus was widely exposed during membrane elevation. In addition, a bony defect was observed around the previously placed implant site in the premolar region. During elevation of the Schneiderian membrane, a small membrane perforation occurred. Rather than filling the sinus cavity with particulate bone graft material, four CGF (concentrated growth factor) blocks were placed into the elevated sinus cavity.

This approach was intended not only to facilitate repair of the Schneiderian membrane perforation but also to reduce the risk of postoperative sinusitis while promoting early new bone formation within the newly created subantral space. Following sinus augmentation, implants (Biotem Implant Co., Seoul, Republic of Korea) were placed in the canine, first premolar, and second molar regions. The implant platforms in the canine and first premolar sites were positioned approximately 2 mm apical to the proximal bone level of the adjacent healthy lateral incisor. SANTA-2 (2-mm height) abutments were connected to these implants to function as implant-supported tent poles. A SANTA-1 abutment was connected to the implant placed in the second molar region to support horizontal ridge augmentation. To maintain the regenerative space in the implant-free second premolar (pontic) region, a 6-mm-diameter SBB® was inserted on the palatal aspect of the defect at 50 rpm using a handpiece connected to an implant motor. The height of the SBB® head was adjusted to correspond precisely with the height of the SANTA® abutments, thereby creating a continuous tenting framework capable of maintaining stable three-dimensional regenerative space throughout the defect. (Figure 2)

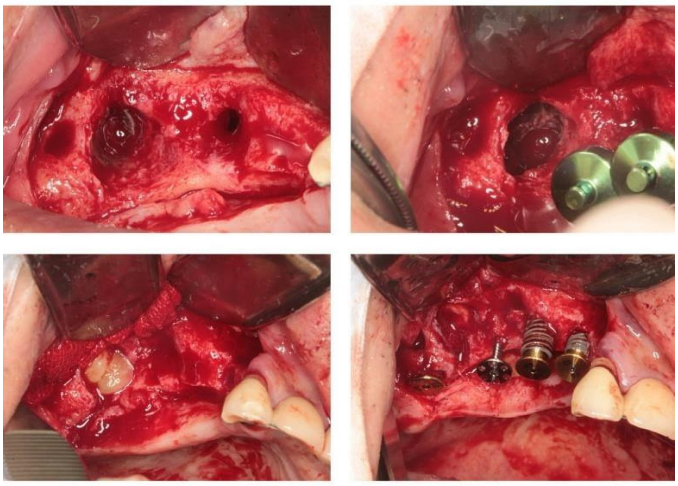


Figure 2 Surgical procedures for reconstruction using the Tent Pole System.

(A) Full-thickness buccal flap elevation revealing a large osseous communication with the maxillary sinus and severe alveolar ridge defect. **(B)** Schneiderian membrane elevation and implant site preparation using a Bone Pen guide**. (C)** Bone graft-free sinus augmentation using four CGF membranes following Schneiderian membrane perforation. **(D)** Placement of a 6-mm SBB® in the implant-free second premolar region and connection of SANTA® abutments to the implant platforms. The combination of the SANTA® and SBB® established the Tent Pole System.

Following implant placement, StickyBone™, prepared by mixing deproteinized bovine bone mineral with autologous fibrin, was applied generously over the reconstructed ridge to completely fill the augmented area and slightly cover the heads of both the SANTA® abutments and the SBB®. The grafted site was then covered with **a** 3 × 4 cm resorbable collagen membrane**.**

Because the Sticky Bone provided excellent graft stability, no additional membrane fixation with tacks was required. After adequate periosteal releasing incisions were performed to achieve tension-free flap advancement, the buccal flap was repositioned and primary wound closure was achieved with slight flap eversion.

Five months later, a palatal crestal incision was made to expose and remove the SANTA® and the SBB®. Scan bodies were connected to the implants for a digital impression. (Figure 3 - 5)

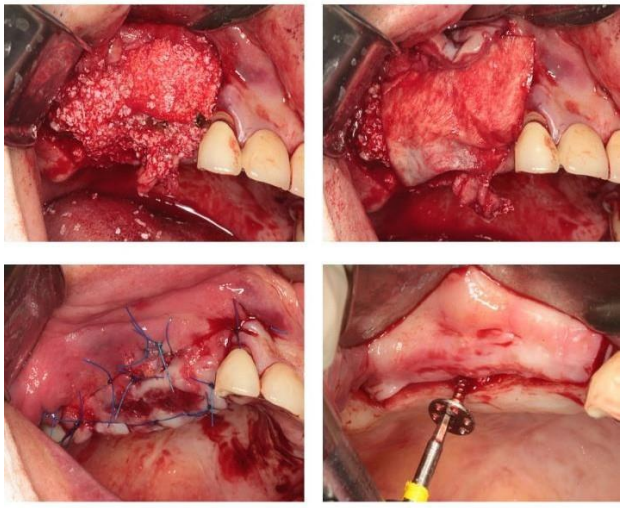


Figure 3. Figure 3. Guided bone regeneration and second-stage surgery.

(A) Sticky Bone was generously applied to reconstruct the vertical ridge defect, completely filling theaugmented area and slightly covering the heads of the SANTA abutments and the SBB. **(B)** The grafted site was covered with a resorbable collagen membrane without additional fixation. **(C)** Tension-free primary wound closure was achieved following adequate periosteal releasing incisions. **(D)** After five months of healing , the SANTA® and the SBB® were exposed through a palatal crestal incision and removed prior to digital impression procedures.

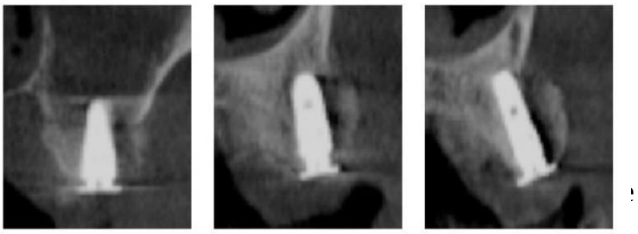
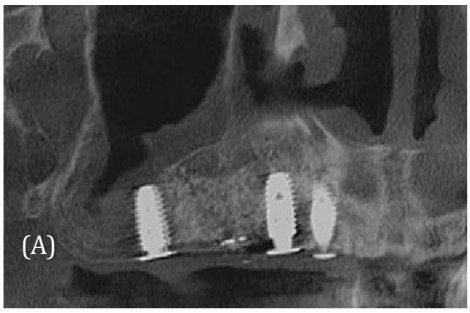


Figure 4. Immediate postoperative CBCT evaluation. **(A)** Coronal CBCT image demonstrating the reconstructed maxillary ridge following simultaneous implant placement and bone graft-free sinus augmentation**.** (B–D) Cross-sectional CBCT images showing the three-dimensional configuration of the reconstructed ridge and maintenance of the augmented space around the implants sites.



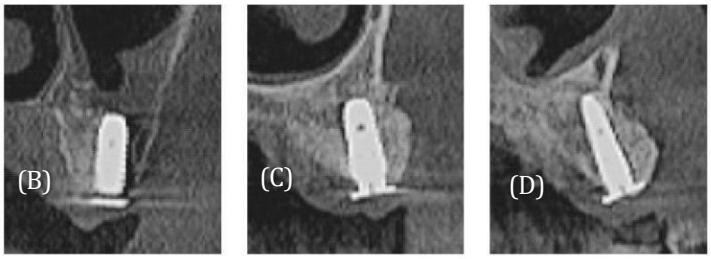


Figure 5. Five-month postoperative CBCT evaluation. (A) Panoramic CBCT image demonstrating stable vertical ridge reconstruction following application of the Tent Pole System and new bone formation with bone graft-free sinus augmentation. **(B–D)** Cross-sectional CBCT images confirming maintenance of the regenerated three-dimensional ridge contour around the implants and in the implant-free pontic sites.

Two weeks later, a screw-retained functional provisional restoration was delivered. Immediate functional loading was initiated while simultaneously promoting prosthetically guided soft tissue healing and peri-implant soft tissue maturation. After confirming stable osseointegration and favorable soft tissue architecture, the definitive prosthesis was delivered. At 18 months after functional loading, the peri-implant keratinized tissue around the definitive prosthesis remained insufficient.

Therefore, a sutureless free gingival graft (FGG) was performed to increase the width of keratinized tissue. In the sutureless FGG technique, the graft is stabilized with tissue cyanoacrylate adhesive instead of conventional sutures. This approach significantly simplifies the procedure, allowing completion in less than 10 minutes. Compared with the conventional sutured FGG technique, it offers several advantages, including shorter surgical time, reduced patient discomfort, minimal surgical trauma, higher patient satisfaction, and less postoperative graft shrinkage. The technique is simple, predictable, and highly efficient, making it a patient-centered approach to soft tissue augmentation.

At the 2-year follow-up, both the definitive restoration and peri-implant tissues remained stable, with satisfactory esthetic and functional outcomes and no evidence of biological or prosthetic complications. (Figure 6 and 7)

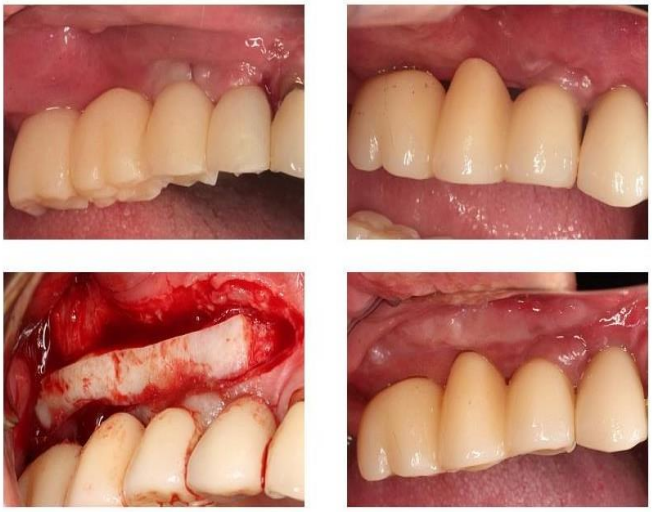


Figure 6. Clinical outcomes following prosthetic rehabilitation.
(A) Clinical view of the screw-retained functional provisional restoration delivered 2 weeks after suture removal, allowing immediate functional loading while promoting prosthetically guided soft tissue healing. **(B)** Definitive implant-supported restoration delivered after 1 month of functional loading with the provisional restoration. **(C)**

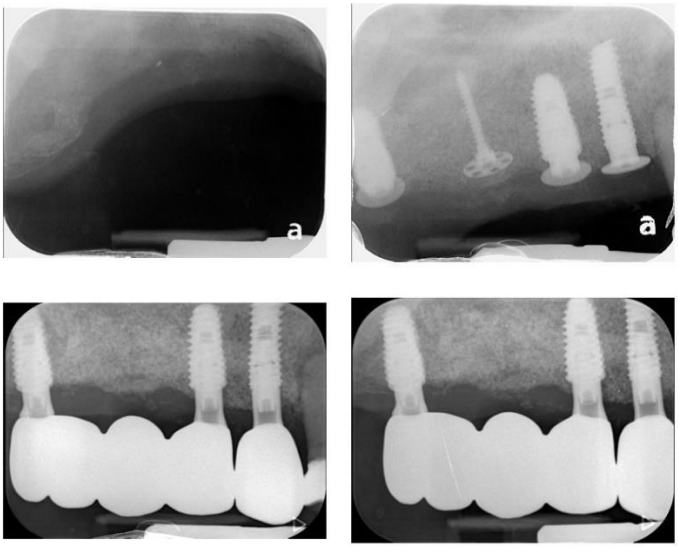


Figure 7. Radiographic evaluation throughout treatment and follow-up.
(A) Preoperative radiograph demonstrating severe vertical alveolar ridge deficiency in the right posterior maxilla. **(B)** Immediate postoperative radiograph following simultaneous implant placement, Tent Pole System application, and vertical ridge reconstruction. **(C)** Radiograph obtained at delivery of the definitive implant-supported restoration, showing successful reconstruction of the alveolar ridge and prosthetic rehabilitation.
(D) Two-year follow-up radiograph demonstrating stable peri-implant marginal bone levels and functional maintenance of the definitive restoration.

DISCUSSION

Vertical ridge augmentation continues to represent one of the greatest challenges in implant reconstruction because successful treatment requires not only sufficient bone formation but also stable maintenance of the regenerated space throughout healing. Numerous surgical techniques have been proposed to manage severe vertical ridge deficiencies; however, each has inherent limitations that may compromise treatment efficiency or increase patient morbidity. Autogenous block bone grafting has traditionally been regarded as the gold standard for vertical ridge reconstruction because of its osteogenic potential. Nevertheless, donor-site morbidity, limited graft availability, unpredictable graft resorption, and the need for a second surgical site remain significant disadvantages. In addition, implant placement is frequently delayed until graft maturation, resulting in prolonged edentulous healing periods and delayed functional rehabilitation.[8)] Distraction osteogenesis provides simultaneous expansion of both hard and soft tissues and can achieve substantial vertical bone gain. However, previous systematic reviews have reported complication rates approaching 50%, including vector deviation, infection, hardware-related complications, and patient discomfort. Similarly, sandwich osteotomy is

technically demanding and carries risks of transport segment fracture, wound dehiscence, and compromised vascularity.[9] Vertical guided bone regeneration using titanium mesh or non-resorbable membranes has also demonstrated favorable regenerative outcomes. However, membrane or mesh exposure remains one of the most common complications and may adversely affect bone regeneration. Furthermore, these techniques generally require a second surgical procedure for removal of the fixation devices, thereby increasing surgical invasiveness, patient morbidity, and treatment duration. Likewise, conventional mini-tenting screw techniques often require placement of multiple screws to support large grafted areas, increasing operative time and surgical complexity.[10-12]

The concept underlying the present technique differs fundamentally from conventional vertical augmentation procedures. Rather than focusing solely on maximizing bone volume, the Tent Pole System was developed according to a patient-centered philosophy, with the primary objectives of reducing surgical invasiveness, minimizing the edentulous healing period through simultaneous implant placement whenever feasible, simplifying the surgical procedure, and restoring oral function as early as possible. Our previous clinical study demonstrated that the SANTA® (Sohn's Augmentation New Tenting Abutment) enables simultaneous implant placement while maintaining stable regenerative space above the implant platform, allowing predictable three-dimensional bone reconstruction with a simplified surgical approach. Unlike conventional tenting devices, the SANTA functions as both a healing abutment and a biological tent pole, eliminating the need for additional fixation devices around the implant.[13]

However, the original SANTA concept was limited to implant-supported regions and could not be applied to implant-free pontic sites or extensive defects where simultaneous implant placement was impossible. To overcome this limitation, we subsequently introduced the Sohn's Bone Builder (SBB®), a novel wide-head tenting screw specifically designed for implant-free regions. In our previous retrospective study, the SBB® achieved a mean vertical bone gain of 8.86 mm with only 17.8% radiographic resorption during healing.[6] Histomorphometric analysis further demonstrated newly formed bone ranging from 21.2% to 57.5% beneath the screw head without inflammatory reactions, confirming that stable maintenance of regenerative space promotes predictable vertical bone regeneration.[14] The present report expands these previous concepts by integrating the SANTA® and SBB into a unified Tent Pole System. Rather than functioning as independent devices, the two components complement each other according to the anatomical requirements of the defect.

The SANTA® provides space maintenance in implant-supported regions, whereas the SSBB® maintains regenerative space in implant-free pontic areas. This integrated approach enables reconstruction of extensive vertical defects with fewer fixation devices, shorter operative time, simplified surgical procedures, and simultaneous implant placement whenever clinically feasible. From a clinical perspective, the greatest advantage of the Tent Pole System is not merely the amount of regenerated bone but its ability to simplify treatment while improving the patient's overall experience. By reducing the number of surgical procedures, shortening the edentulous healing period, and facilitating earlier prosthetic rehabilitation, this strategy reflects the fundamental principles of patient-centered implant dentistry.

The limitations of this report include the small number of cases and the absence of long-term comparative data. Prospective controlled clinical studies with larger patient populations are therefore necessary to validate the long-term effectiveness, stability, and reproducibility of the Tent Pole System.

CONCLUSION

The SANTA®represents a patient-centered approach to vertical ridge augmentation by combining simultaneous implant placement with predictable space maintenance using an implant platform-connected tenting abutment.

In the case presented, favorable vertical bone regeneration and stable implant outcomes were achieved while reducing surgical complexity and overall treatment time. For implant-free sites, the SBB® extends the same biological principle by providing stable regenerative space maintenance without the need for multiple conventional mini-tenting screws. Its wide-head design simplifies the surgical procedure and may reduce operative time while maintaining graft stability.

DECLARATIONS

Ethical Approval

Not applicable.

Competing Interests

The author is the developer of the SANTA® and SBB® systems.

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None.

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