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# Simultaneous Vertical and Horizontal Reconstruction of the Atrophic Posterior Maxilla Using the Sinus Bone Lid as an Autologous Cortical Membrane: A Retrospective Case Series with Long-Term Follow-Up

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## Abstract

***Background:*** Rehabilitation of the posterior atrophic maxilla frequently requires simultaneous management of vertical and horizontal bone deficiencies. While lateral sinus floor elevation remains the most predictable approach for severe vertical atrophy, reconstruction of associated horizontal defects often requires additional bone augmentation procedures, increasing surgical complexity and morbidity. The use of the lateral sinus wall ("sinus bone window") as an autologous cortical membrane may provide a biologically driven alternative for simultaneous three-dimensional reconstruction. ***Objective:*** To evaluate the clinical and radiographic outcomes of a sandwich grafting technique using the sinus bone window as an autologous cortical membrane combined with particulate autologous bone and plasma rich in growth factors (PRGF-Endoret®) for the treatment of mixed posterior maxillary atrophy. ***Materials and Methods:*** A retrospective case series was performed including patients with combined vertical and horizontal posterior maxillary atrophy treated by lateral sinus floor elevation and simultaneous horizontal ridge augmentation using the sinus bone window as a cortical membrane. Clinical records and CBCT scans were reviewed. Horizontal bone gain, implant survival, prosthetic survival, peri-implant marginal bone loss, and complications were analyzed. Statistical significance was established at $p < 0.05$. ***Results:*** Sixteen patients (81.3% women; mean age 61.2 ± 11.8 years) with 20 regenerated posterior maxillary sites were included. Initial ridge width increased from 2.11 ± 1.52 mm to 8.46 ± 1.65 mm, representing a mean horizontal gain of 5.35 ± 1.75 mm (172.6% increase; $p < 0.001$). All regenerated sites achieved sufficient width for implant placement without additional augmentation procedures. Twenty narrow-diameter implants were placed, achieving a mean insertion torque of 34.71 ± 18.25 Ncm. After a mean follow-up of 80.5 ± 3.6 months, implant and prosthetic survival rates were 100%. No surgical complications were recorded. Mean marginal bone loss was 0.73 ± 0.18 mm mesially and 0.85 ± 0.34 mm distally. ***Conclusions:*** The use of the sinus bone window as an autologous cortical membrane appears to be a predictable technique for simultaneous horizontal and vertical reconstruction of the posterior maxilla. This approach provides substantial horizontal bone gain, avoids a secondary donor site, facilitates implant placement in severely atrophic ridges, and demonstrates excellent long-term clinical and radiographic stability.

**Keywords:** Maxillary sinus floor elevation (Lateral sinus lift), Sinus bone window (Autologous cortical membrane), Horizontal ridge augmentation, Sandwich grafting technique, Posterior maxillary atrophy.



## INTRODUCTION

Implant-supported rehabilitation of the atrophic posterior maxilla continues to represent one of the greatest challenges in oral reconstructive surgery. Following tooth loss, the maxillary sinus undergoes a progressive process of pneumatization accompanied by alveolar ridge resorption, resulting in combined height and width defects that may significantly compromise the placement of dental implants in a prosthetically guided position [1–4]. The coexistence of vertical and horizontal bone loss constitutes a frequent clinical situation, particularly in long-term edentulous patients, in whom the residual bone availability may be insufficient both to achieve adequate primary stability and to provide a peri-

implant bone volume compatible with long-term tissue maintenance [5–8].

When the residual bone height is less than 4 mm, and particularly in extreme situations with less than 2 mm of remaining bone, sinus floor elevation through a lateral window approach remains a reconstructive technique supported by a substantial body of scientific evidence [9–12]. Several systematic reviews and consensus documents have demonstrated that this procedure provides high implant survival rates even in severely atrophic scenarios, with predictable long-term outcomes regardless of the biomaterial used or the implant placement protocol adopted [12,13]. However, a significant proportion of these patients simultaneously present horizontal defects that require complementary transverse augmentation procedures to achieve adequate three-dimensional reconstruction of the alveolar ridge [14–17].

Traditionally, correction of horizontal defects has been performed through guided bone regeneration or autogenous block grafting procedures [18–22]. Although both techniques provide favorable clinical outcomes, the use of autogenous cortical grafts continues to be considered one of the most effective strategies for the reconstruction of severe defects due to their osteogenic, osteoinductive, and osteoconductive properties [18,22]. One of the most widely used techniques for the treatment of horizontal and vertical defects was described by Khoury and co-workers, who proposed a procedure based on harvesting thin autogenous cortical plates used as rigid membranes to contain particulate autogenous grafts. This approach allows a significant increase in reconstructed volume, reduces graft resorption, and optimizes the biological incorporation of regenerated tissue by increasing the vascular and cellular contact surface of the particulate graft [22–25].

The biological philosophy of this technique has promoted the development of different modifications aimed at minimizing the morbidity associated with harvesting intraoral grafts. Among them is a technique proposed by our study group based on the use of the bone window obtained during sinus floor elevation as an autologous cortical membrane. The so-called “sinus bone lid” constitutes a viable cortical fragment obtained within the same surgical field, avoiding the need for a second donor site and allowing the use of a biological resource that is usually discarded or ground for use as particulate graft material. Its use as a bone membrane may simultaneously facilitate horizontal regeneration of the alveolar ridge while performing vertical augmentation of the maxillary sinus, integrating both procedures into a single surgical intervention [26].

Furthermore, the incorporation of autologous platelet concentrates into particulate grafts has generated increasing interest in recent years. Plasma rich in growth factors (PRGF-Endoret®) is a biological technology based on obtaining plasma fractions enriched with autologous proteins and growth factors capable of modulating angiogenesis, cell migration, osteoblastic proliferation, and tissue healing processes [27–32]. Different experimental and clinical studies have demonstrated that its combination with bone grafts may improve biomaterial handling, enhance initial graft stability, and potentiate the biological mechanisms involved in bone regeneration [27,28,33].

The aim of the present case series is to describe a surgical modification for the simultaneous treatment of mixed vertical and horizontal atrophies of the posterior maxilla, based on the use of the bone lid obtained during sinus floor elevation as an autologous cortical membrane to perform a sandwich graft with autologous particulate bone and PRGF-Endoret®, allowing three-dimensional reconstruction of the alveolar ridge through a single surgical intervention.

## MATERIALS AND METHODS

A retrospective review of the clinical database was performed to identify patients treated by simultaneous vertical and horizontal regeneration of the atrophic posterior maxilla using lateral window maxillary sinus floor elevation associated with transverse reconstruction through a bone membrane technique employing the lateral sinus wall. Inclusion criteria were: patients older than 18 years, presence of combined vertical and horizontal atrophy of the posterior maxilla requiring three-dimensional reconstruction prior to or simultaneous with implant placement, availability of CBCT radiographic examinations obtained before reconstructive surgery and during follow-up, and a minimum clinical follow-up of 8 years after implant loading.

The main variables analyzed were the occurrence of surgical complications and the dimensional changes obtained in bone width and height following the regenerative procedure, as well as their maintenance after functional loading of the implants.

All patients received antibiotic prophylaxis consisting of 2 g of amoxicillin one hour before surgery, as well as 1 g of paracetamol preoperatively. Prior to surgery, peripheral blood was collected for the preparation of plasma rich in growth factors (PRGF-Endoret®, BTI Biotechnology Institute, Vitoria, Spain), following the manufacturer’s standardized protocol [34].

Under local anesthesia, a full-thickness mucoperiosteal flap was elevated to expose the lateral wall of the maxillary sinus. Access to the sinus was performed using piezoelectric surgery (BTI Ultrasonic®, BTI Biotechnology Institute), obtaining a lateral bone window that was preserved intact throughout the procedure. Once the Schneiderian membrane had been elevated and vertical sinus augmentation completed, the harvested access window was preserved in non-activated

PRGF-Endoret® for its subsequent use as an autologous bone membrane [26].

Horizontal reconstruction was performed using a modification of the bone membrane technique originally described by Khoury. The graft consisted of particulate autologous bone harvested during the surgical preparation or obtained using bone scrapers from adjacent donor areas. This material was mixed with the F2 fraction of PRGF-Endoret® and placed on the buccal aspect of the horizontal defect. Subsequently, the previously harvested lateral sinus wall was adapted over the graft, acting as a rigid autologous cortical membrane and stabilized with osteosynthesis microscrews when required. Finally, the lateral sinus access window was covered with an autologous fibrin membrane obtained from the F1 fraction of PRGF-Endoret®, and wound closure was achieved using 5/0 monofilament sutures.

Clinical evaluations were performed at 7 and 14 days after surgery, as well as during the subsequent follow-up visits until implant placement and after prosthetic loading. At each visit prior to implant placement, the occurrence of biological or surgical complications related to the regenerative procedure was recorded. During the implant and prosthetic follow-up period, implant- and prosthesis-related complications were registered.

Radiographic measurements of horizontal bone gain and its maintenance were performed on CBCT scans obtained after graft integration and at the final follow-up examination using dedicated implant planning software (BTI Scan® III, BTI Biotechnology Institute, Vitoria, Spain). Marginal bone loss was determined on calibrated radiographs using a known reference length (the actual implant length) and analyzed with Digora for Windows software (SOREDEX Digital Imaging Systems), allowing correction of the inherent magnification of the radiographic technique. Bone loss was measured from the implant shoulder to the first clearly visible bone-to-implant contact. The radiograph obtained at the time of prosthesis placement was used as the baseline reference for calculating bone changes, allowing accurate estimation of the remodeling occurring throughout the follow-up period.

### *Statistical Analysis*

Data collection was performed by two independent investigators. For descriptive analysis, the implant was considered the statistical unit for morphometric and radiographic variables, whereas the patient was used as the unit for general and medical characteristics.

Quantitative variables were expressed as mean and standard deviation, whereas qualitative variables were described using absolute and relative frequencies. Comparisons between preoperative and postoperative bone dimensions were performed using paired-sample statistical tests. Statistical significance was established at $p < 0.05$.

Prosthetic survival at the end of follow-up was also estimated according to the criteria established by Misch *et al.,* and Albrektsson *et al.,*[35]. A prosthesis was considered “surviving” when it:

- Remained in function throughout the entire follow-up period without requiring removal due to failure.
- Presented no detectable mobility.
- Did not require complete replacement due to mechanical or biological complications.
- Provided adequate masticatory, esthetic, and phonetic function according to clinical evaluation.
- Showed no clinical signs of active infection or progressive bone loss compromising prosthetic function.

Minor complications such as screw loosening, ceramic fractures, or occlusal wear were recorded but were not considered causes of prosthetic failure if they could be resolved without replacing the prosthesis.

Statistical analysis was performed using SPSS software (IBM Corp., Chicago, IL, USA).

## RESULTS

A total of 16 patients were included, with a mean age of 61.2 ± 11.8 years (range: 54–74 years), of whom 13 (81.3%) were women and 3 (18.7%) were men. In total, 20 posterior maxillary sites presenting combined vertical and horizontal atrophy were regenerated using maxillary sinus floor elevation and the bone membrane technique employing the sinus bone lid.

The initial bone width was 2.11 ± 1.52 mm, reaching a mean width of 8.46 ± 1.65 mm after regeneration. The mean horizontal gain achieved was 5.35 ± 1.75 mm, representing a mean increase of 172.6% compared with baseline values. Comparison between preoperative and postoperative measurements demonstrated a statistically significant increase in available bone width (paired Student’s t-test, $p < 0.001$). None of the regenerated sites presented a final width of less than 5 mm, allowing implant placement in all cases without the need for additional horizontal augmentation procedures.

A total of 20 narrow-diameter implants were placed in the regenerated areas. The most frequent implant positions were 16 and 26, accounting for 30% of the implants each. The distribution of the remaining implant positions is shown in Figure 2.

The implant diameters used were 2.5 mm (15.0%), 3.0 mm (40.0%), and 3.5 mm (45.0%). Regarding implant length, 6.5-mm implants were used in

40.0% of cases, 7.5-mm implants in 35.0%, and 8.5-mm implants in 25.0%. The most common implant configuration was 3.0 × 6.5 mm, representing 25.0% of all implants, followed by 3.5 × 7.5 mm implants (20.0%). Implants measuring 2.5 × 8.5 mm were used in sites with the greatest residual horizontal deficiency, whereas 3.5 × 8.5 mm implants were placed in areas where regeneration provided greater bone availability (Figure 3). This distribution allowed treatment to be adapted to the anatomical characteristics of each site while maintaining a minimally invasive approach in all cases. The mean insertion torque was 34.71 ± 18.25 Ncm.

The distribution of implant-supported rehabilitations showed a predominance of splinted partial prostheses. Restorations supported by two implants replacing two teeth accounted for 33.3% of cases, followed by full-arch rehabilitations, which were present in 19.4% of patients. The remaining prosthetic configurations showed frequencies ranging from 8.3% to 16.7%. Definitive loading was performed between 3 and 9 months after the provisional phase. Of the definitive restorations, 80.6% corresponded to metal-ceramic prostheses, while the remaining 19.4% were metal-reinforced resin prostheses.

The mean follow-up period after loading was 80.5 ± 3.6 months, ranging from 60 to 109 months. During this period, no implant failures were recorded, resulting in a cumulative implant survival rate of 100%. No surgical complications associated with the regenerative procedure were observed. Only two prosthetic complications were recorded, both consisting of screw loosening during the definitive prosthetic phase, which were resolved by retightening without the need to replace the restorations. Consequently, prosthetic survival was also 100%.

At the end of follow-up, the mean crestal bone loss was 0.73 ± 0.18 mm on the mesial aspect and 0.85 ± 0.34 mm on the distal aspect, reflecting adequate long-term peri-implant stability.

Figures 4–22 illustrate one of the clinical cases included in the study.

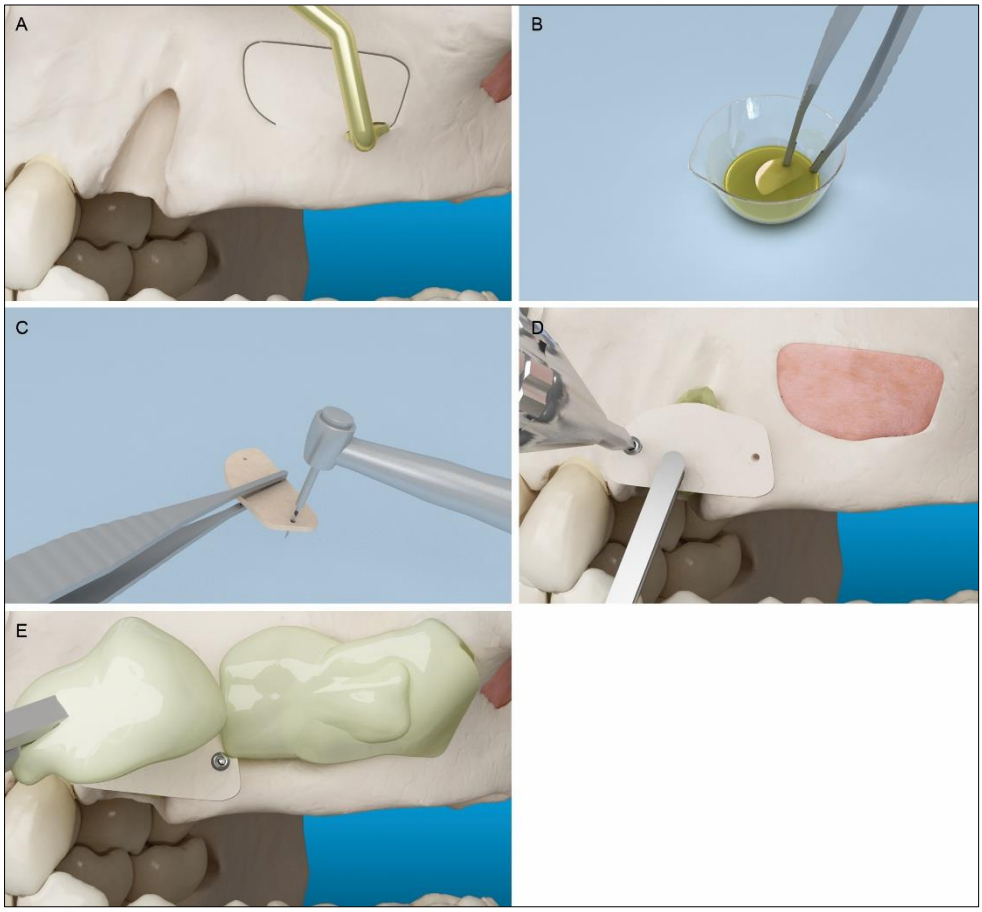



**Figure 1: Technique for using the sinus bone lid as a bone membrane for horizontal regeneration of the maxilla. Harvesting of the sinus bone lid and preservation in non-activated PRGF-Endoret® prior to its use as a cortical membrane. Once fixation is required, perforations are made to accommodate the osteosynthesis screws and the membrane is stabilized in position. Finally, the entire grafted area is covered with autologous fibrin membranes before wound closure**

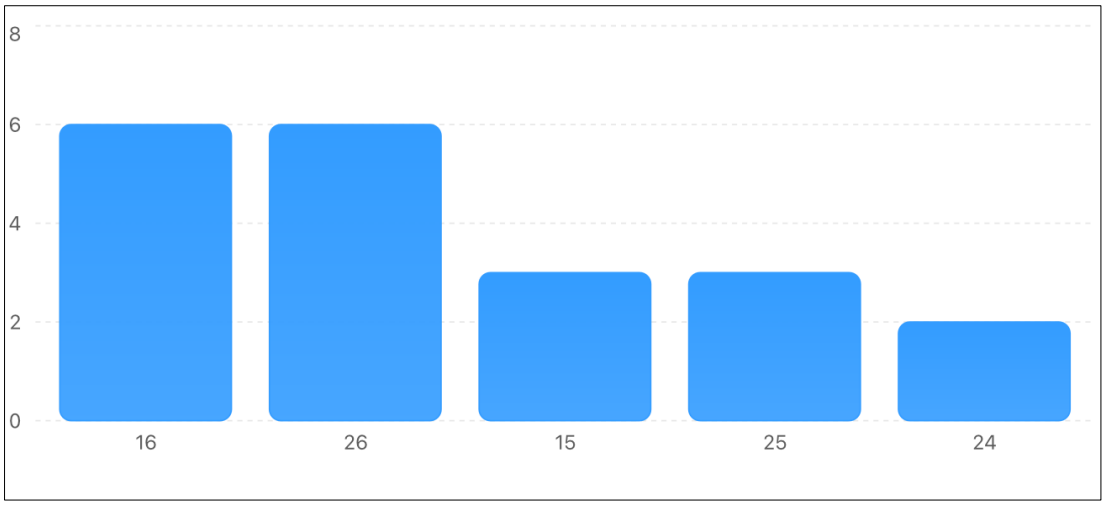



**Figure 2: Distribution of implant positions included in the study**

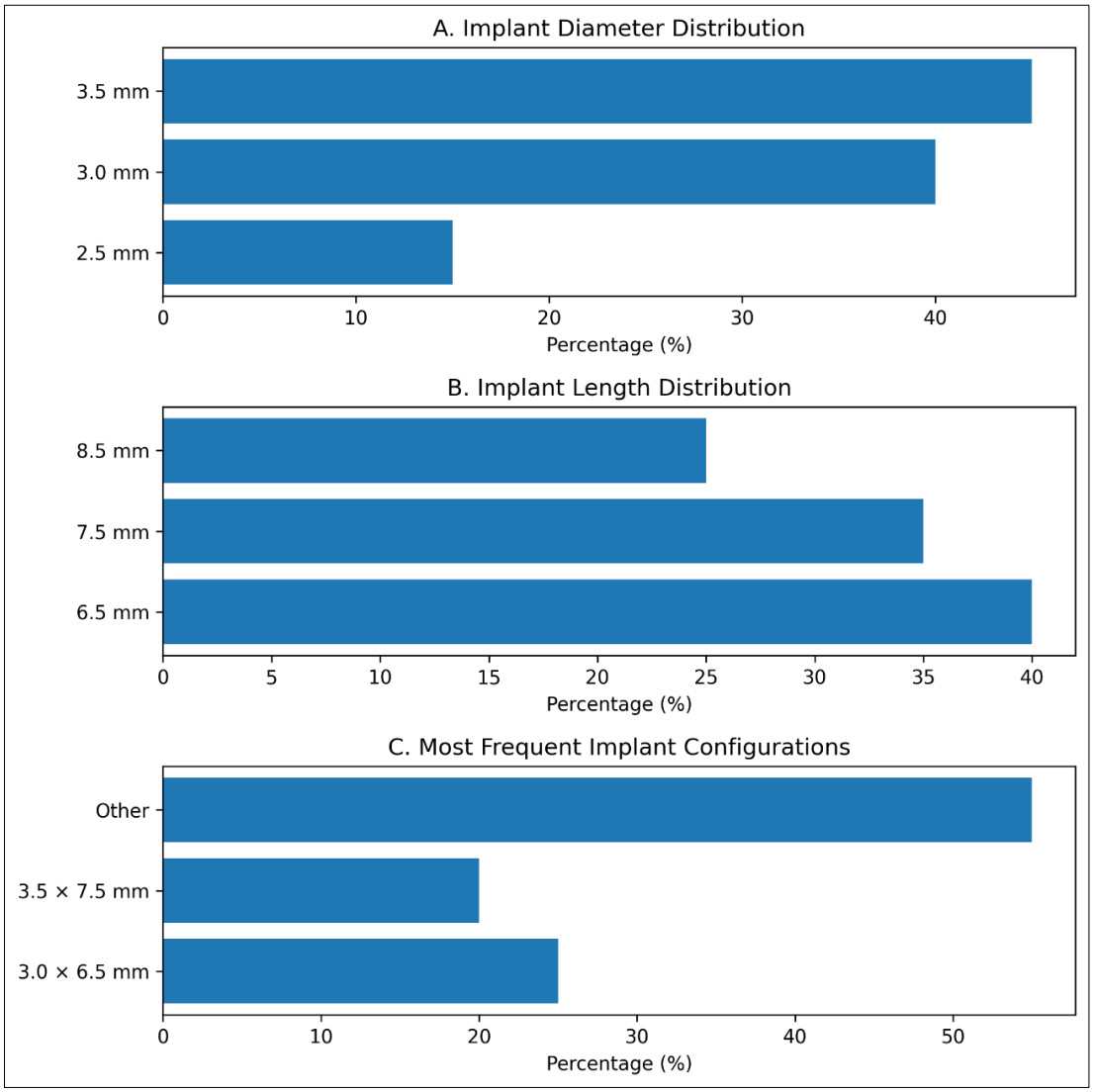



**Figure 3: Distribution of implant dimensions used in the study. (A) Distribution of implant diameters. (B) Distribution of implant lengths. (C) Most frequent diameter–length combinations. The 3.0 × 6.5 mm implant was the most commonly used configuration (25.0%), followed by the 3.5 × 7.5 mm implant (20.0%)**

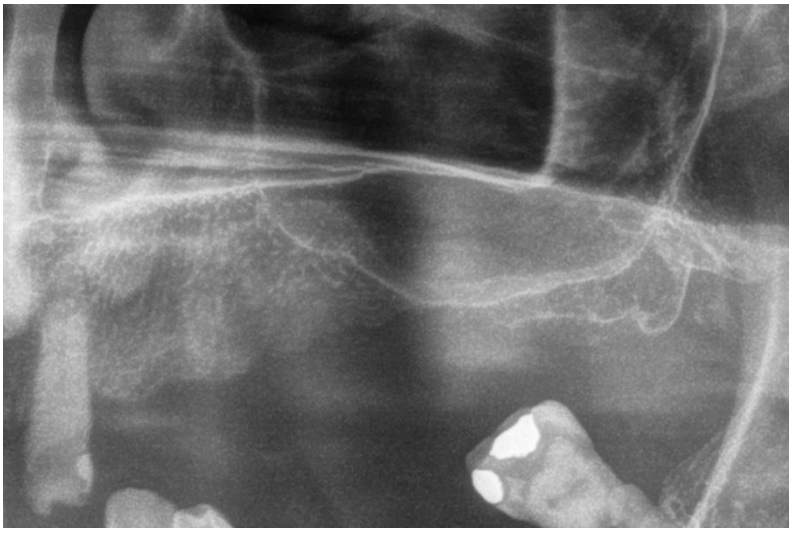


**Figure 4: Initial radiographic image of the patient showing severe mixed atrophy in the second quadrant**

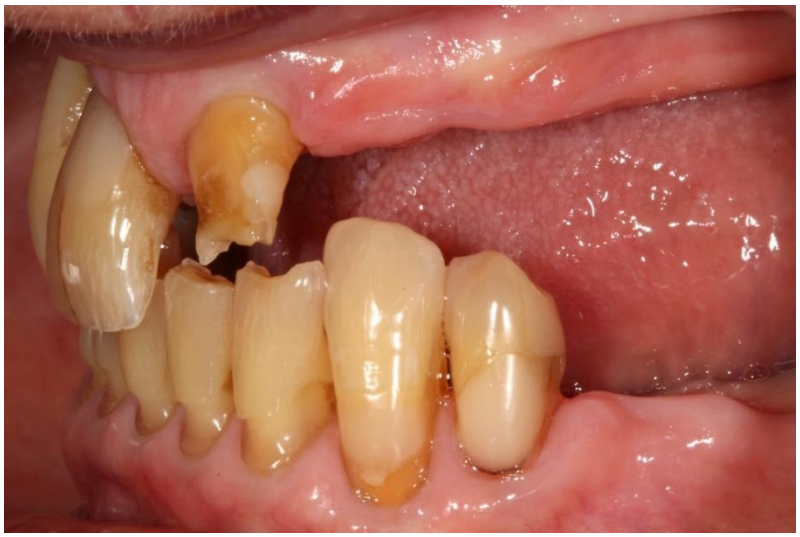
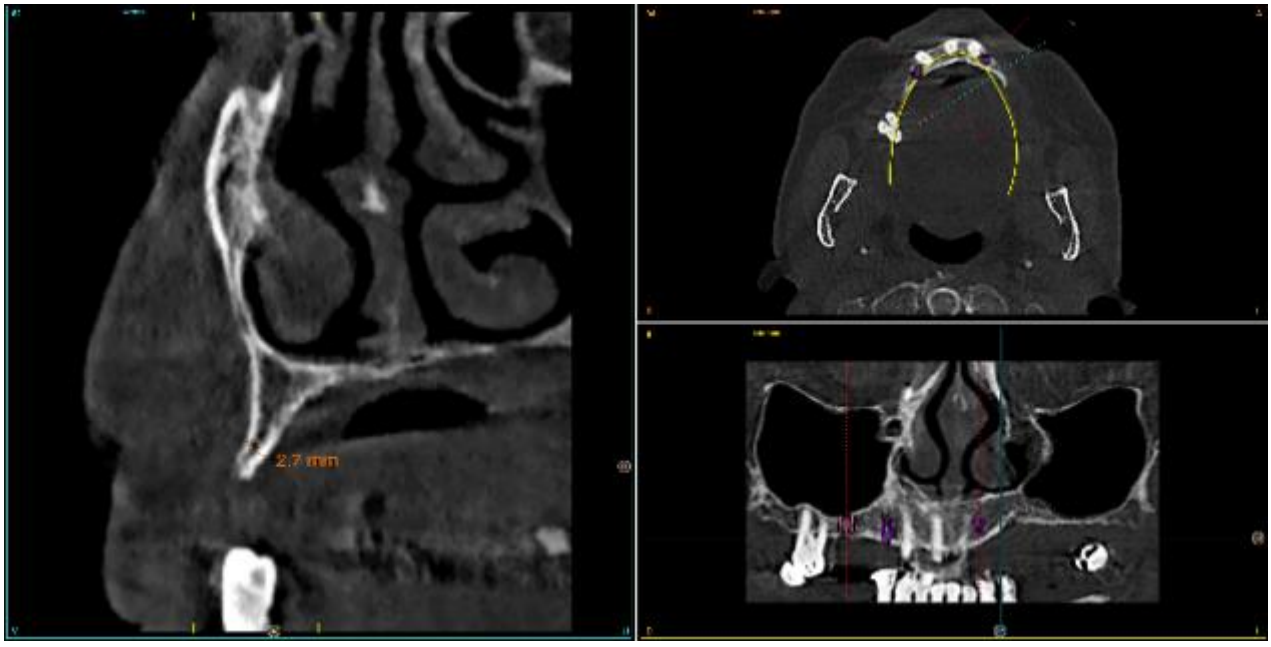
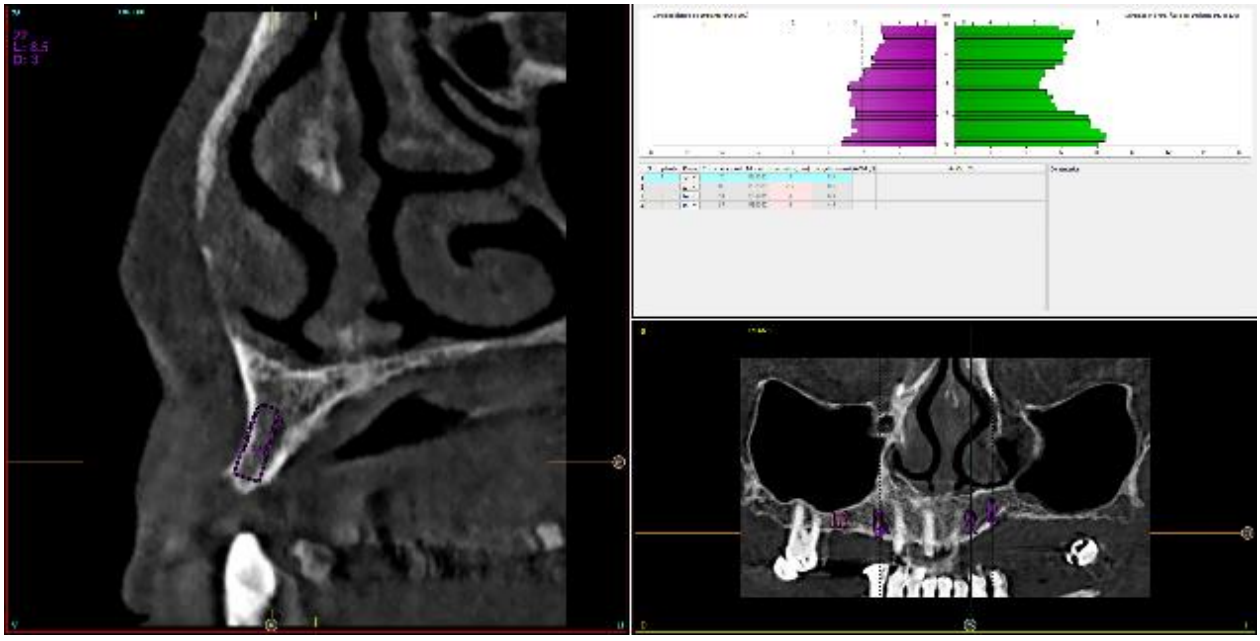


**Figure 5: Intraoral view of the area to be rehabilitated. A fracture of tooth 21 is also evident**





**Figures 6 and 7: CBCT sections corresponding to the left maxillary canine region, showing severe horizontal atrophy with only 2.7 mm of ridge width. For this reason, a 2.5-mm-diameter implant was planned in this area**

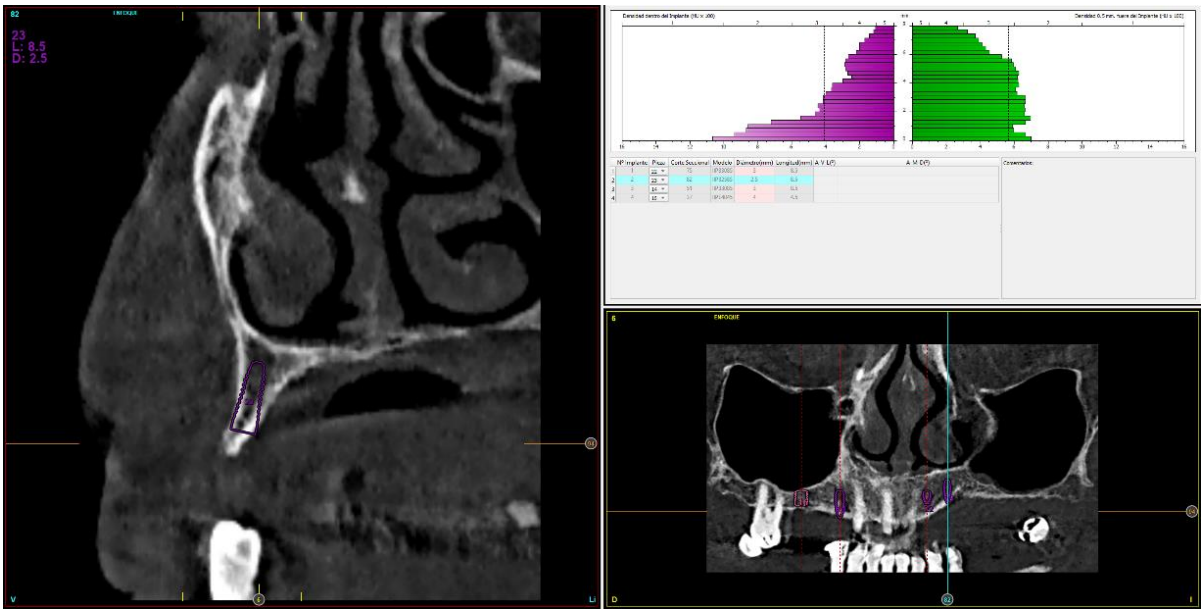
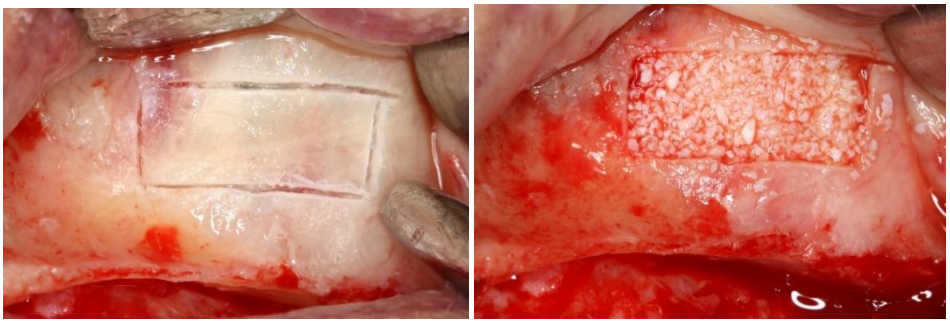
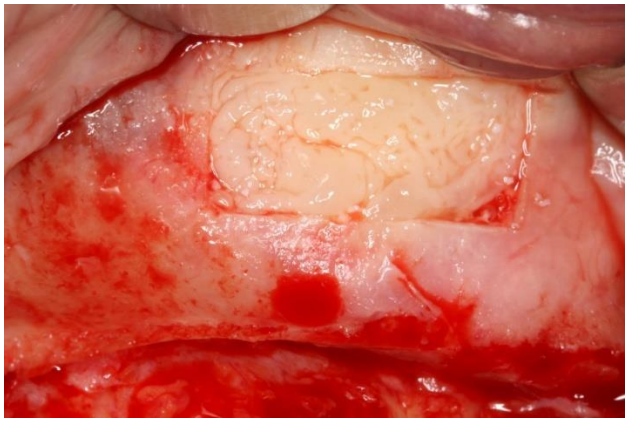
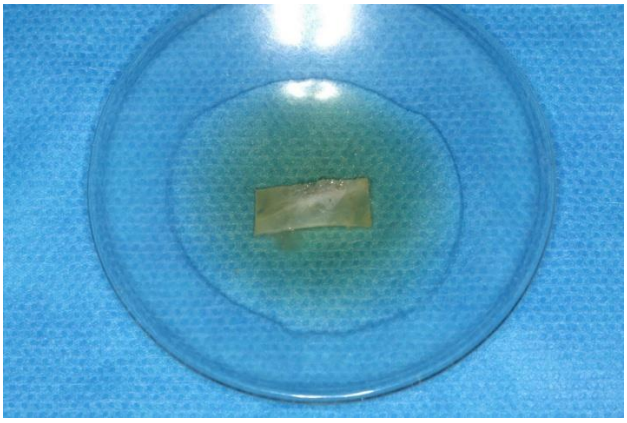


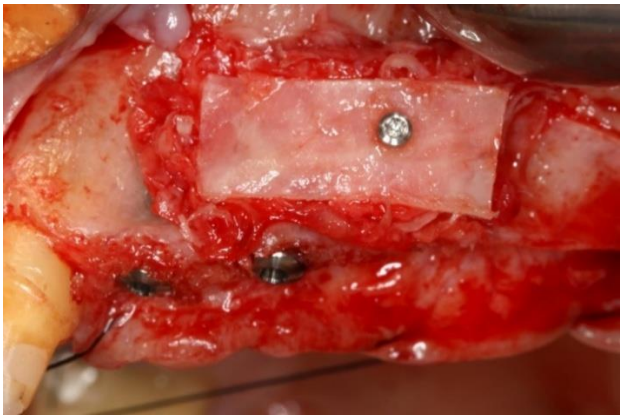
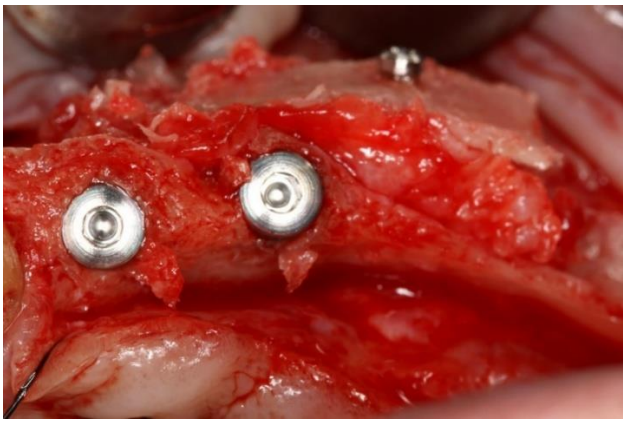

**Figure 8: CBCT section corresponding to the lateral incisor region of the same quadrant, presenting moderate horizontal atrophy and allowing placement of a 3.0-mm-diameter implant**



**Figures 9 and 10: Clinical images showing maxillary sinus floor elevation performed through a lateral window approach in the second quadrant**

**Figures 11 and 12: Completion of the lateral sinus elevation procedure. A freshly activated PRGF-Endoret® clot was placed in the position previously occupied by the sinus bone lid. The bone lid was preserved in PRGF-Endoret® for subsequent use as part of the grafting procedure**

**Figures 13 and 14: Placement of implants in the second quadrant and regeneration of the area presenting the greatest horizontal deficiency, located distal to the implants. The sinus bone lid was used as a cortical bone membrane and particulate bone was used as graft material. The graft was stabilized with an osteosynthesis screw to maintain its position during the integration phase**

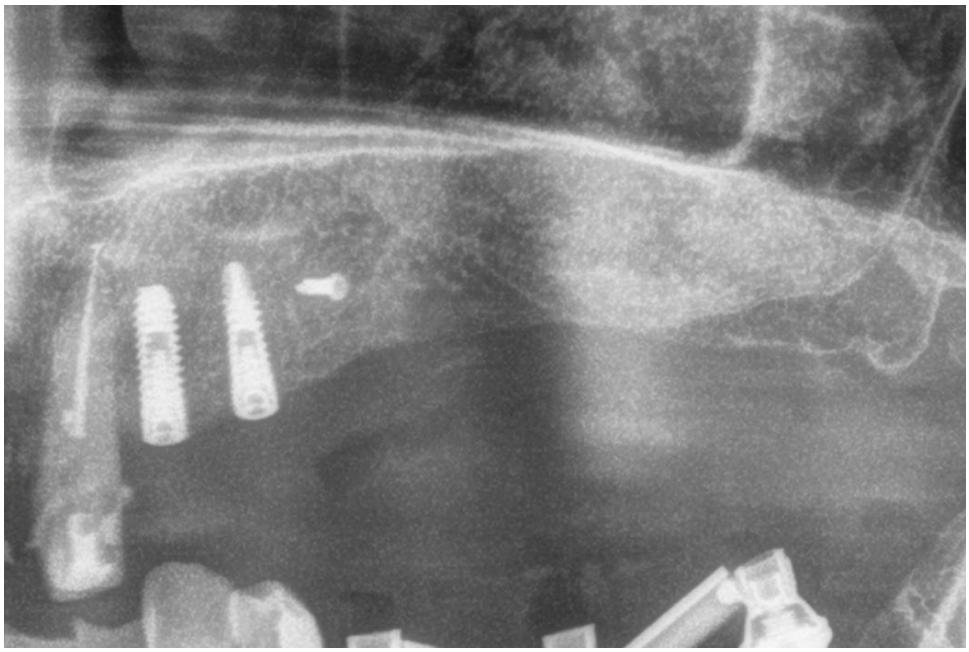
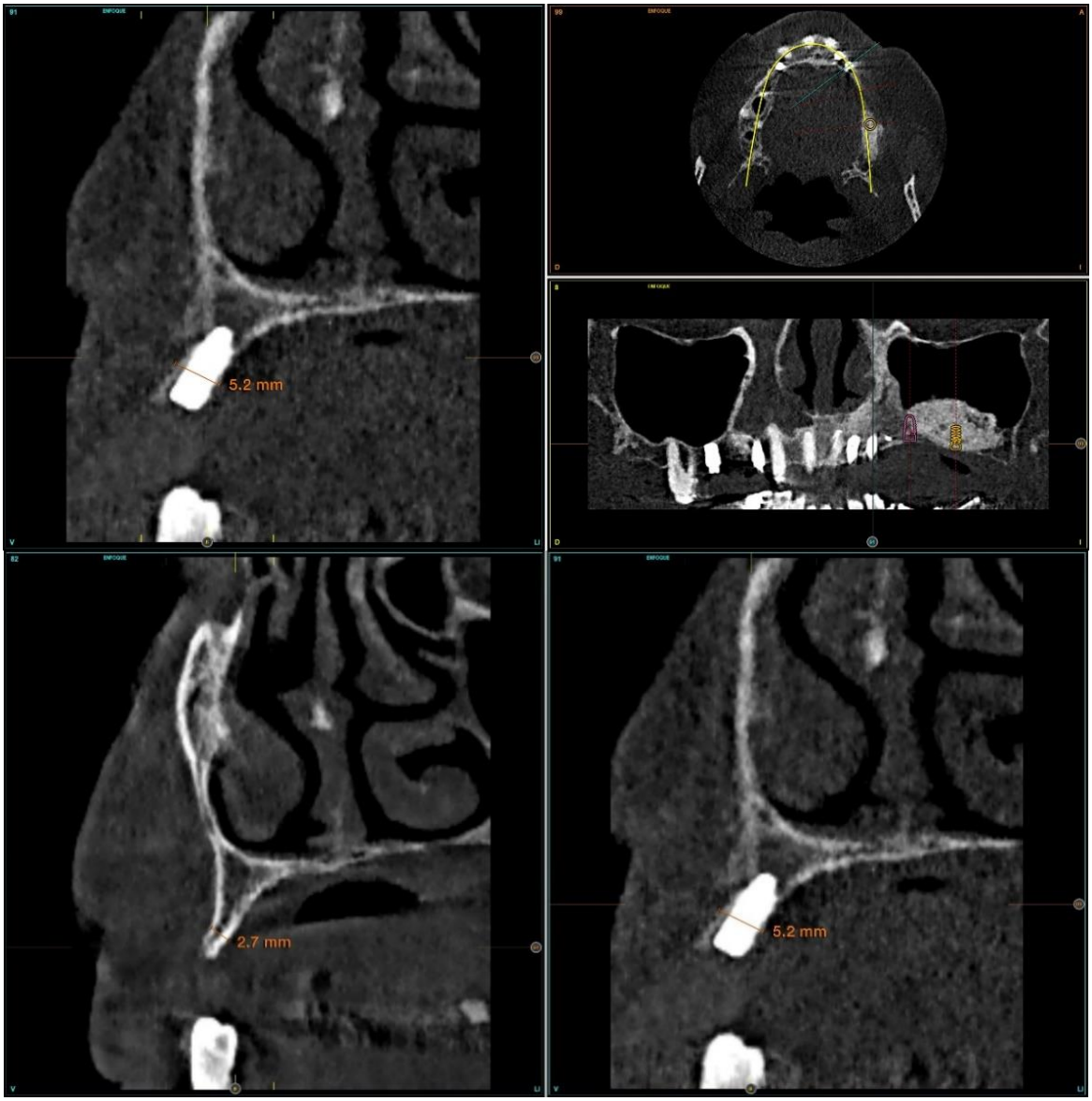


**Figure 15: Postoperative radiograph showing the placed implants and the regenerated area**




**Figures 16 and 17: Cross-sectional CBCT images corresponding to the canine implant site in the second quadrant, illustrating the comparison between the initial ridge width and the width achieved after implant placement and grafting**

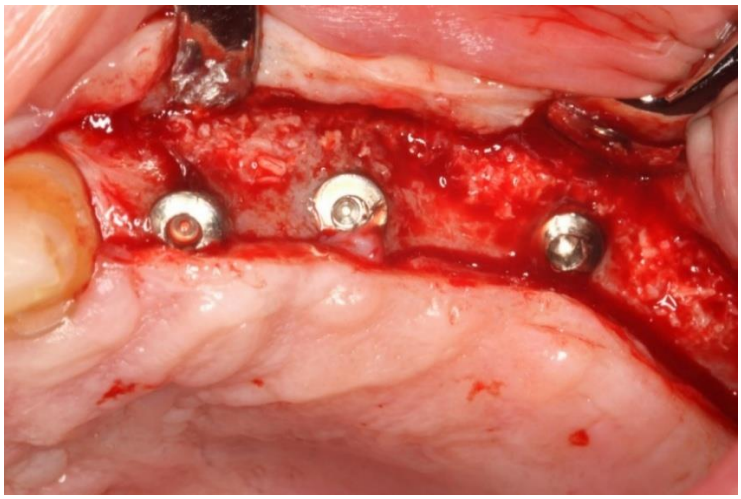


**Figure 18: Re-entry procedure during the second-stage surgery of the last implants placed in the second quadrant, demonstrating successful graft integration and the horizontal ridge gain achieved**

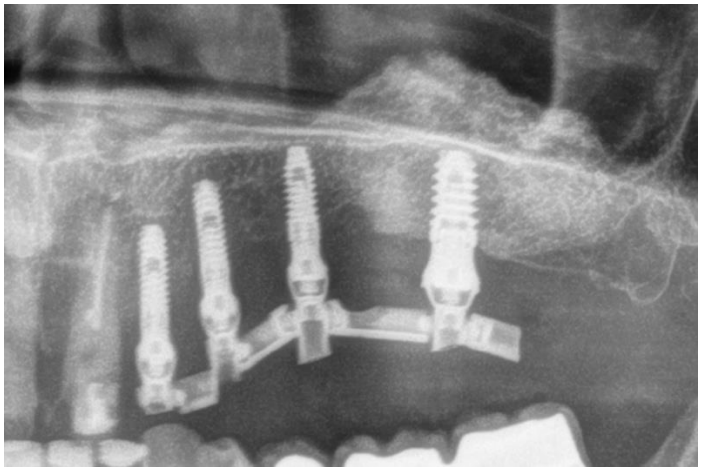


**Figure 19: Progressive loading prosthesis following placement of the implant in the area previously treated with sinus floor elevation**

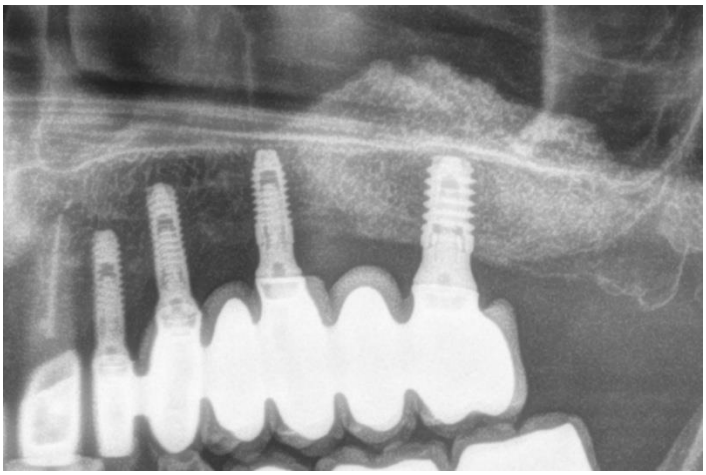
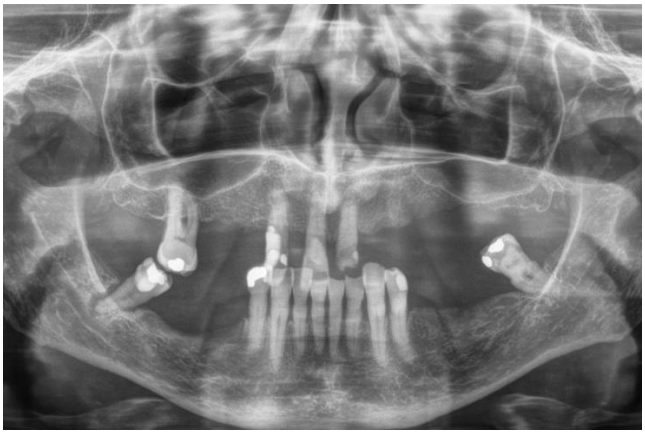
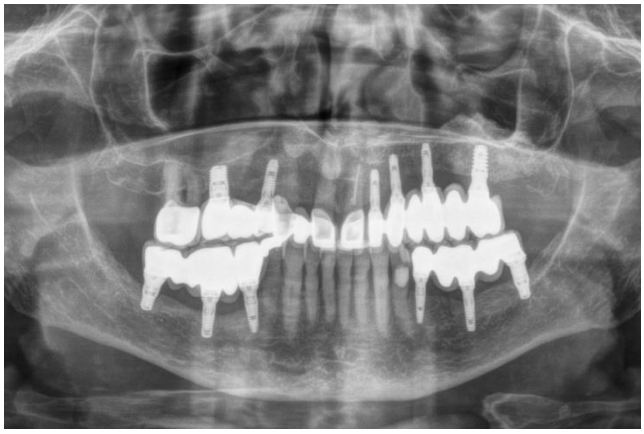


**Figure 20: Definitive prosthetic loading**





**Figures 21 and 22: Eight-year follow-up radiograph demonstrating long-term stability of the treatment, with no peri-implant bone loss associated with any of the implants when compared with the baseline radiograph**

## DISCUSSION

The results of the present case series demonstrate that the use of the sinus bone lid as an autologous bone membrane allows the simultaneous treatment of vertical and horizontal defects of the posterior maxilla with a high degree of predictability. All treated sites achieved sufficient bone volume to allow implant placement without the need for additional regenerative procedures, with a final ridge width greater than 5 mm in all cases.

When the present findings are compared with those reported for conventional reconstructive techniques, the horizontal gain achieved in this series falls within the upper range reported for transverse

augmentation procedures. Reviews evaluating autogenous block grafts and horizontal ridge augmentation techniques have described mean horizontal gains generally ranging between 3 and 5 mm, although considerable variability exists depending on defect morphology, donor site, grafting material, and healing time [14–16,36–40]. In a comparative review evaluating the Khoury technique and guided bone regeneration procedures, reported horizontal gains ranged from approximately 3.9 to 5.0 mm for the Khoury technique and from 3.9 to 5.7 mm for Urban-type approaches, with variable complication rates mainly related to membrane exposure, infection, and soft tissue dehiscence [22]. In the present series, the mean horizontal gain was 5.35 ± 1.75 mm, resulting in a final mean ridge width of 8.46 ± 1.65 mm, with no surgical complications recorded. These findings place the proposed technique within a range of effectiveness comparable to that of established reconstructive procedures while avoiding the need to harvest a cortical block from a second donor site.

The magnitude of the horizontal gain obtained is particularly relevant considering that all sites presented combined vertical and horizontal atrophy and that transverse reconstruction was performed simultaneously with sinus floor augmentation. The mean gain achieved allowed the subsequent placement of implants ranging from 2.5 to 3.5 mm in diameter, adapting treatment to the final anatomical conditions obtained. This observation highlights that the objective of regeneration should not necessarily be the reconstruction of excessively wide ridges, but rather the creation of a stable bone foundation that permits implant placement in a prosthetically driven position while maintaining an adequate peri-implant bone volume.

This difference is clinically relevant. Autogenous block grafts continue to be regarded as an effective option for the treatment of severe horizontal defects; however, their main limitation remains donor-site morbidity, particularly when intraoral donor areas such as the mandibular ramus or symphysis are used [25,41,42]. Additional complications may include graft exposure, infection, wound dehiscence, partial graft resorption, and the need for secondary remodeling procedures [43]. In this regard, the technique described in the present series preserves one of the fundamental biomechanical principles of cortical block grafting, namely the rigid stabilization of the particulate graft volume, while modifying its anatomical origin. The cortical plate employed does not originate from a secondary surgical site but from the lateral window created during sinus surgery itself. This characteristic may reduce overall surgical morbidity while preserving the containment and stabilizing effect of an autologous cortical membrane [26].

These findings suggest that integrating both reconstructive procedures into a single surgical intervention may simplify the treatment of severe mixed atrophies, reducing the number of surgeries required and optimizing the use of biological resources already available within the surgical field.

In the cases included in this study, the use of a cortical structure harvested during sinus access eliminated the need for additional bone harvesting procedures while maintaining the capacity to provide spatial stabilization of the particulate graft. From both a biological and surgical perspective, this represents one of the principal advantages of the evaluated technique.

Another relevant finding was the high level of clinical stability observed throughout follow-up. After a mean follow-up period exceeding six years following functional loading, no implant or prosthetic failures were recorded, resulting in cumulative implant and prosthetic survival rates of 100%. Furthermore, marginal bone loss at the end of follow-up was limited, with values below 1 mm on both the mesial and distal aspects. These results suggest that the regenerated tissue was capable of maintaining its supportive function over the long term, allowing peri-implant behavior comparable to that reported for implants placed in native bone.

The limitations of the present study are mainly related to its retrospective design and relatively small sample size, circumstances commonly encountered in clinical series evaluating complex surgical procedures. In addition, the absence of a control group treated with conventional cortical grafting techniques prevents direct comparison regarding the superiority of one approach over another. Nevertheless, the extended follow-up period and the consistency of the outcomes observed across all cases provide clinically relevant information regarding the feasibility and predictability of this therapeutic alternative.

## CONCLUSIONS

Within the limitations of the present study, the results obtained indicate that the use of the sinus bone lid as an autologous bone membrane represents an effective alternative for the simultaneous reconstruction of vertical and horizontal defects of the posterior maxilla. The technique allowed the achievement of significant horizontal bone gains, avoided the need for a second donor site, facilitated the subsequent placement of narrow-diameter implants, and maintained excellent long-term clinical and radiographic stability.

Furthermore, the integration of horizontal ridge augmentation and sinus floor elevation into a single surgical procedure may reduce treatment morbidity and optimize the use of available autologous biological resources. Additional prospective controlled studies with larger sample sizes are required to confirm these findings and further define the indications and limitations of this therapeutic approach.

**Conflict of Interest:** E.A. is the scientific director of BTI Biotechnology Institute, a dental implant company that investigates in the fields of oral implantology and PRGF-Endoret technology.

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