Long term bone volume maintenance

Transcrestal sinus lift with autologous bone and PRGF-Endoret

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In recent decades, the maxillary sinus lift technique has undergone a significant evolution, leading to a paradigm shift in the surgical approach to the atrophic posterior maxilla.[1–3] Traditionally, the lateral window sinus lift was considered the method of choice for increasing subantral bone volume, particularly in cases with minimal residual bone height. However, the development of less invasive techniques, coupled with advances in implant design and a deeper understanding of osseointegration processes, has positioned the transcrestal sinus lift as a predictable, safe, and clinically efficient alternative.[1–5]

Currently, the transcrestal approach is considered the first-line technique in most clinical situations, especially when a residual bone height of at least 4–5 mm is available to ensure adequate primary implant stability. In contrast, the lateral window approach remains the technique of choice in more complex cases, such as when residual bone height is less than 2 mm, when broad sinus visualisation is required, in the presence of antral septa, or when primary implant stability via the crestal approach is not achievable.[6–11] Implant survival rates are comparable between both techniques: long-term survival rates range from 90 to 98% for the lateral approach and from 92 to 98% for the transcrestal technique.[9–18]

Regarding grafting materials, a wide range of options is available, including allografts, xenografts, synthetic biomaterials (e. g. hydroxyapatite, β-tricalcium phosphate), and combinations with platelet-rich plasma.[17–20] Nevertheless, autologous bone remains the gold standard due to its osteogenic, osteoconductive, and osteoinductive properties, which promote faster and more biologically integrated regeneration.[21–24] Comparative studies on transcrestal elevation have demonstrated success rates over 95% with biomaterials and 100% with autologous bone grafts within 12 months of follow-up, with no significant differences in marginal bone levels or subantral volume maintenance.[8–11,25–28]

In this context, the combination of autologous bone harvested during implant site drilling with plasma rich in growth factors (PRGF-Endoret®) represents a biologically advantageous strategy for bone regeneration in transcrestal sinus elevation. This mixture maximises the osteogenic potential of freshly harvested autologous bone, enhancing its handling and cohesion thanks to the biocompatible binding effect of PRGF. Moreover, the bioactive proteins and cytokines present in PRGF-Endoret® promote angiogenesis, cell proliferation, and early bone remodeling, all key factors for predictable osseointegration. Several studies have shown that the combined use of PRGF-Endoret® and autologous bone not only improves graft handling but may also accelerate the regeneration process and enhance the quality of newly formed bone, with implant survival rates comparable to or even exceeding those achieved with conventional biomaterials.[29–32]

This study presents a series of cases in which transcrestal sinus elevation was performed using PRGF-Endoret combined with particulate autologous bone obtained during drilling. The study evaluates the bone height achieved through this technique, the long-term maintenance of bone volume after loading, and implant survival rates.

Materials and methods

A retrospective selection was made of patients who had undergone transcrestal sinus elevation using autologous bone obtained during implant site drilling and combined with PRGF-Endoret as grafting material, with a minimum follow-up period of ten years after implant loading. All patients were evaluated preoperatively through diagnostic study models, intraoral examinations, and cone-beam CT scans analysed with dedicated software (BTI-Scan III). The preoperative medication protocol included 2 g of oral amoxicillin administered one hour prior to surgery and 1 g of paracetamol for analgesia. Postoperatively, patients continued oral amoxicillin, 500–750 mg every eight hours depending on weight, for a total of five days.

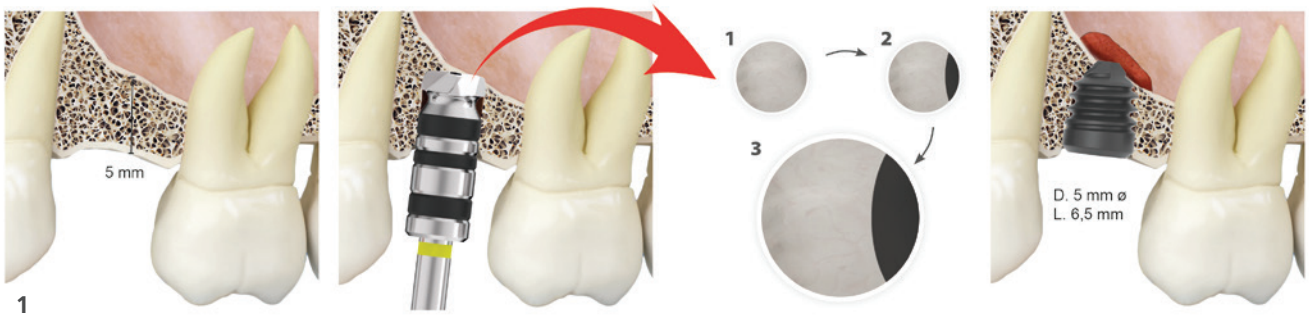


Fig. 1: Drilling technique for implant placement with transcrestal sinus lift using a frontal-cutting drill, which allows progressive removal of the sinus floor. The sequence demonstrates the gradual removal—partial to complete—as performed in the present cases, followed by implant placement and the insertion of autologous graft.

All patients were treated in a private clinical center in Vitoria, Spain, by a single surgeon using the same surgical protocol. The implant site was prepared using low-speed, sequentially larger diameter drills without irrigation (biological drilling). A frontal-cutting drill was used in the final phase to gently access the sinus floor and expose the Schneiderian membrane without perforation. Drilling was adapted based on bone density and residual volume to ensure optimal primary stability.

Once the membrane was exposed, it was carefully elevated through the osteotomy site, the graft was placed, and the implant inserted using a surgical motor set at 25 Ncm and 25 rpm, with final insertion torque measured using a torque wrench (Fig. 1).

After implant placement, a healing period of four to five months was allowed for osseointegration, depending on bone density and final torque. During second-stage surgery, multi-unit transmucosal abutments (Multi-im) were placed for screw-retained prosthetic rehabilitation. All definitive prostheses were screw-retained and splinted, connecting two or more implants via bridges to provide biomechanical stability and optimise load distribution, while maintaining a sealed interface to minimise bacterial infiltration.

Postoperative follow-up included scheduled clinical and radiographic evaluations every six months using standardised panoramic and periapical imaging to monitor implant stability and maxillary sinus morphology. Bone resorption and potential apical bone gain attributable to neoformation were assessed. Periapical radiographs were standardised using specific positioners. Panoramic radiographs were taken using a guided acquisition system with anatomical references and consistent foot positioning to reduce angular variations.

Digital images were calibrated using ImageJ software (NIH), with implant length as the reference to correct for radiographic magnification. Marginal bone loss was measured from the implant shoulder to the first visible bone–implant contact. Apical bone gain was measured perpendicularly from the implant apex to the new sinus floor at a 90° angle to the implant axis, enabling accurate volume estimation.

The primary variable was vertical bone growth in the apical region induced by the transcrestal technique. Secondary variables included implant survival, mesial and distal marginal bone loss, and long-term bone volume stability. Survival analysis was performed using the Kaplan-Meier method, and statistical processing was conducted using SPSS v15.0 (SPSS).

Results

A total of 22 patients met the inclusion criteria, receiving 31 implants. Of these, 64.5% were female, with a mean age of 69 years (±4.6). Most implants were placed in the position of tooth #27 (19.4%), with placements ranging from the second premolar to the second molar. Implant locations are illustrated in Figure 2. The mean

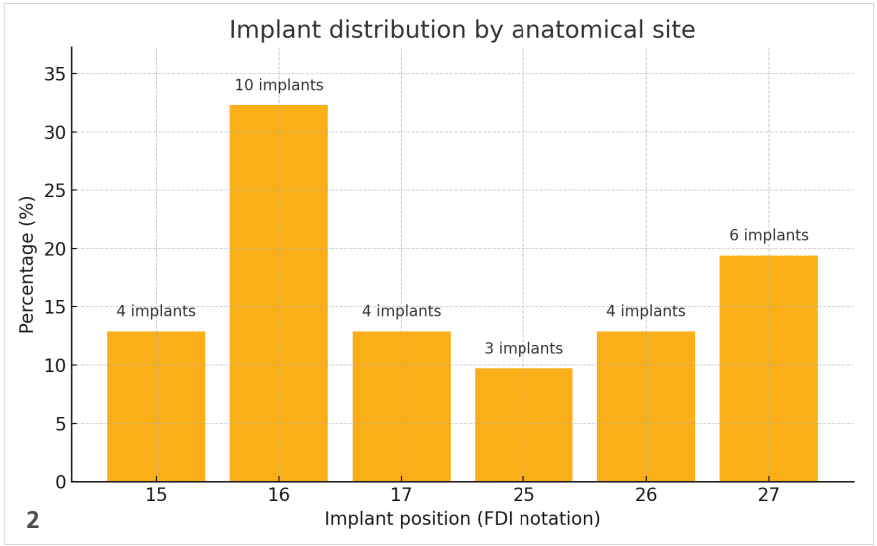
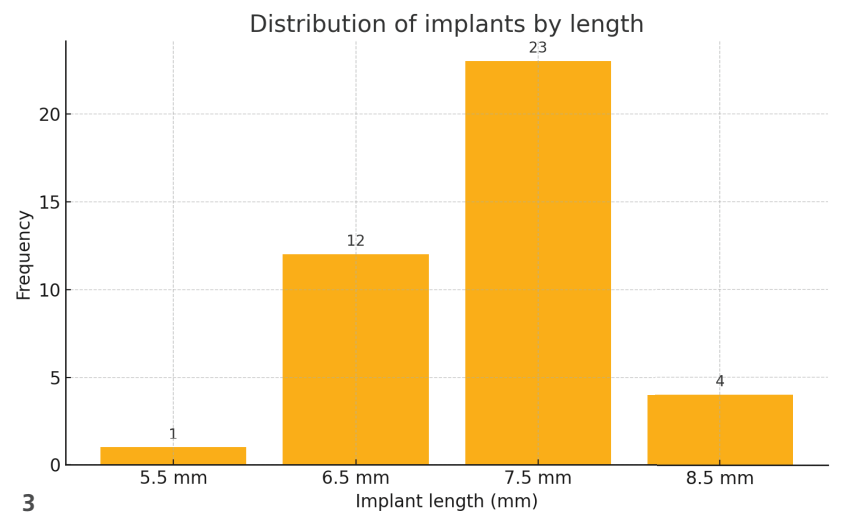
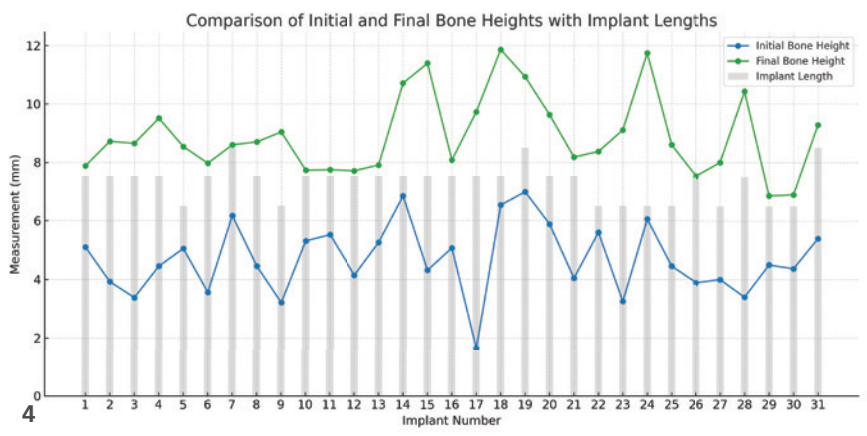
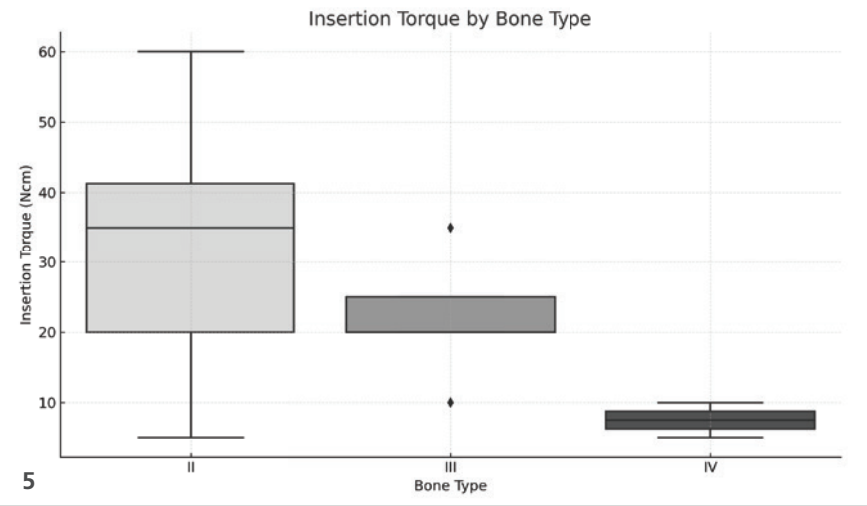


Fig. 2: Implant positions included in the study.

residual bone height at implant sites was 4.79 mm (± 1.27), ranging from 1.65 to 7.05 mm. Implant lengths ranged from 5.5 to 8.5 mm, with 7.5 mm being the most common (57.5% of cases). Implant diameters are shown in Figure 3. Postoperative analysis revealed a mean vertical bone gain of 3.09 mm (± 1.58 mm). Specifically, mean apical bone formation beyond the implant apex was 1.54 mm (± 1.42 mm). Initial and final bone heights, as well as implant lengths, are graphically represented in Figure 4.







Most implants were placed in type II bone (77.4%), followed by type III (16.1%) and type IV (6.5%). Mean insertion torque was 29.03 Ncm (± 14.68). Torque analysis by bone type showed lower values in types III and IV compared to type II: 45 Ncm (± 5.8) for type II, 36.8 Ncm (± 6.2) for type III, and 30.5 Ncm (± 7.1) for type IV (Fig. 5). All implants were rehabilitated within five to six months post-placement, with screw-retained, splinted prostheses using Multi-im abutments in 93.5% of cases. Only one case used a cemented bridge (the case with the longest follow-up: 14 years). Mean follow-up time was 10.71 years (± 1.18 years), ranging from ten to 14 years. No implant failures were observed, resulting in a cumulative survival rate of 100%.

Mean mesial bone loss was 0.63 mm (± 0.39), and distal loss was 0.68 mm (± 0.41). At ten-year follow-up, bone volume was stably maintained, with a mean difference of only 0.23 mm (± 0.26 mm) between final and ten-year measurements. Total cumulative bone gain from baseline to ten years was 4.44 mm (± 1.59 mm), confirming long-term stability. Figure 6 shows individual bone height changes over time: initial, postoperative, and at ten years. Figures 7–14 illustrate one of the included cases.

Discussion

The findings of this study confirm the efficacy and predictability of the transcrestal sinus lift using milled autologous bone graft and PRGF-Endoret® for the rehabilitation of the atrophic posterior maxilla. This surgical approach demonstrated significant vertical bone gain and long-term volume stability, with a 100% implant survival rate at ten years.[30–32] These results support the reliability of this minimally invasive and biologically optimised protocol.

Fig. 3: Lengths of the implants included in the study. – **Fig. 4:** Initial and final bone height for each implant, along with the length of the implant inserted in each case. – **Fig. 5:** Insertion torque values according to bone type.

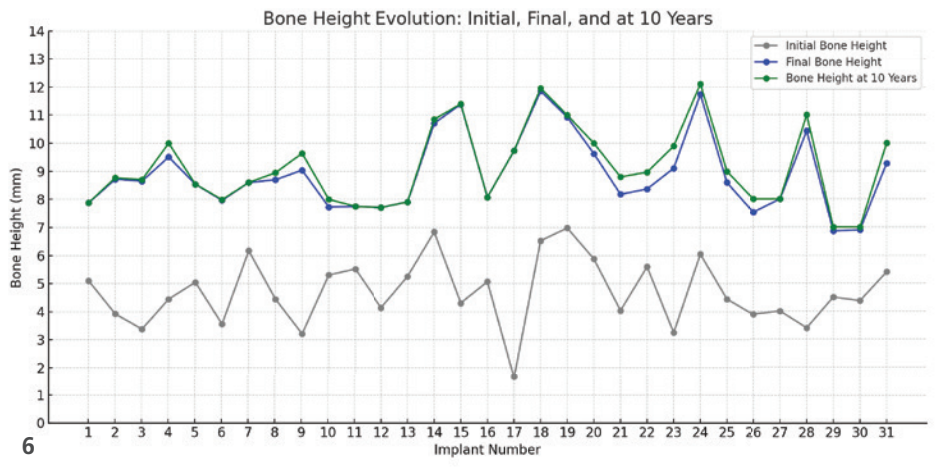
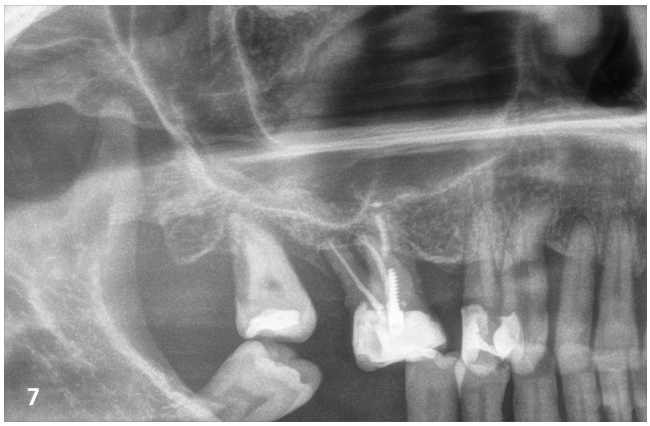
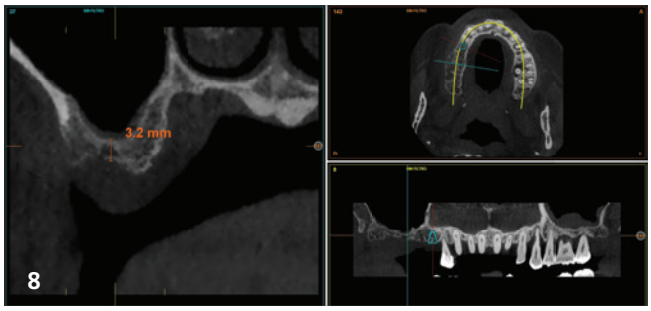
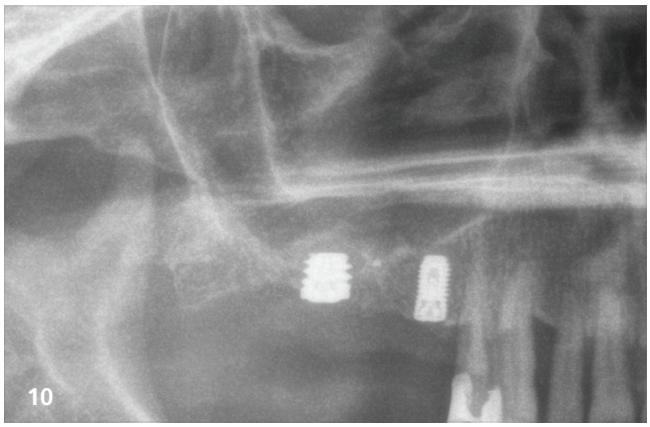
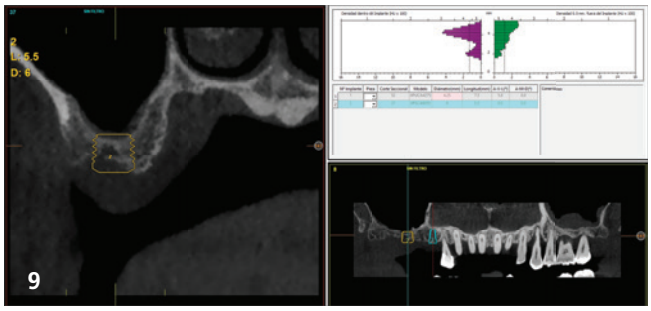


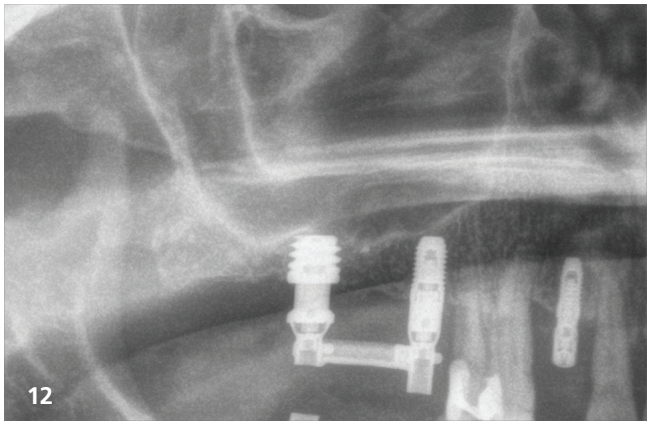
Fig. 6: Evolution of bone height from baseline, the gain achieved through transcrestal sinus elevation, and the maintenance of this augmented volume after ten years. As shown, the grafted height remains stable in all cases, with only minimal, clinically insignificant resorption.











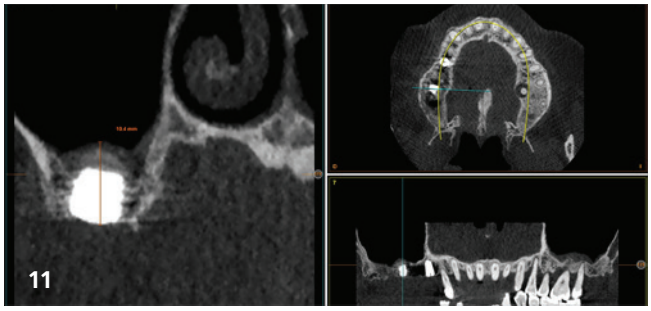
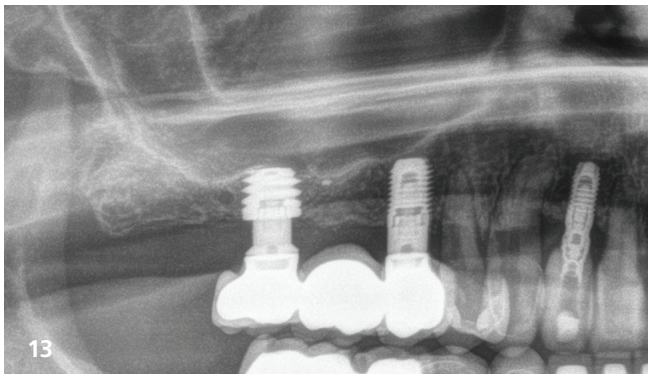


Fig. 7: Baseline radiograph showing teeth 16 and 18 with poor prognosis, indicating the need for extraction. – **Fig. 8:** Cone-beam planning slice showing vertical bone atrophy at the site of tooth 16, with a remaining height of 3.2 mm. – **Fig. 9:** Implant planning image. – **Fig. 10:** Postoperative radiograph showing the positioned implant and the clearly visible vertical bone gain achieved with the transcrestal elevation using autologous bone. – **Fig. 11:** Cone-beam control scan at six months, demonstrating graft consolidation at the time of implant loading. The crestal height increased from less than 4 mm to 10.5 mm. – **Fig. 12:** Radiograph showing the provisional loading prosthesis placed after the second surgical stage.



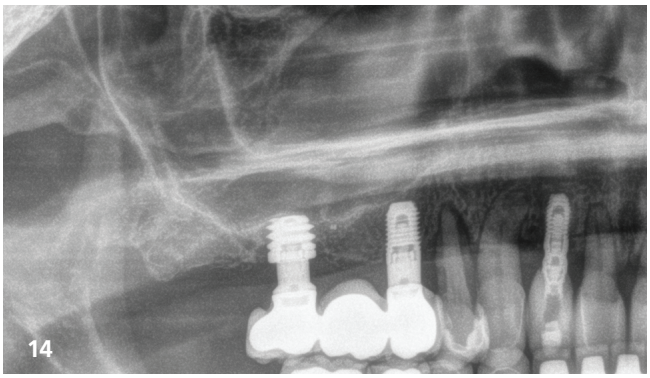


Fig. 13: Radiograph with the definitive prosthesis in place, showing complete graft consolidation and evident bone gain beyond the implant apex. – **Fig. 14:** Radiograph at ten-year follow-up, demonstrating the long-term stability of the treatment, with sustained bone height gain, particularly noticeable in the distal region.

The use of a customised, low-speed drilling protocol and a frontal-cutting drill minimised the risk of Schneiderian membrane perforation, contributing to the high predictability of the technique. Even in challenging cases with low bone volume or density, implants were successfully stabilised and osseointegrated, validating the role of individualised drilling and autologous material in improving outcomes.

The addition of PRGF-Endoret® further enhanced the regenerative potential of the graft. In the sinus environment, where vascularisation is limited, PRGF acts as a biological modulator that accelerates healing and promotes efficient bone consolidation.[33–34] PRGF also acts as a natural binder, improving handling and cohesion of the autologous graft without requiring synthetic or exogenous materials, thus minimising immunogenic risks or fibrous encapsulation.[29,30,35]

The mean vertical bone gain of 3.09 mm, with 1.54 mm beyond the implant apex, is within the upper range reported for transcrestal techniques and surpasses some outcomes achieved with conventional particulate biomaterials or heterologous grafts.[36–38] Long-term volume maintenance was also notable, with minimal loss (0.23 mm) after a decade, indicating stable biological behavior of the graft.

Mean marginal bone loss was only 0.63 mm mesially (±0.39) and 0.68 mm distally (±0.41) after ten years—lower than in previous studies using autologous bone in transcrestal elevation. Zhang et al.[39] reported 0.92 mm of bone loss at five years using autologous grafts. In other long-term studies, transcrestal techniques—even without grafts—did not result in significantly higher marginal bone loss than more invasive procedures. Akin et al.[40] observed 0.93 mm (±0.34) loss after three years without grafting, and Nedir et al.[41] reported 0.94 mm (±0.38) at five years with short implants and no graft. The minimal crestal bone loss in our study likely reflects the biological advantages of biological drilling, autologous grafting, and PRGF-Endoret®, which together promote early healing, enhance local angiogenesis, and reduce long-term bone resorption.

Conclusions

This case series demonstrates that transcrestal sinus elevation with particulate autologous bone harvested through biological drilling, combined with PRGF-Endoret®, is a safe, minimally invasive, and highly effective procedure for treating the atrophic posterior maxilla. Significant vertical bone gain was achieved, with stable long-term volume maintenance after over ten years of follow-up. Implant survival was 100%, and marginal bone loss was minimal, supporting the long-term predictability and stability of the approach. These findings endorse the use of particulate autologous bone combined with PRGF-Endoret® as a biologically efficient alternative to other grafting materials in transcrestal sinus elevation.

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