MEDICAL SCIENCES

SHELL TECHNIQUE WITH CORTICAL BONE FROM THE LATERAL BUCCAL WALL FOR HORIZONTAL RIDGE AUGMENTATION IN ASSOCIATION WITH SINUS AUGMENTATION: A CASE REPORT WITH A 10 YEARS FOLLOW-UP

Berberi A.
BDS, MSc, PhD, HDR. Professor, Dean, Faculty of Dental Medicine, Lebanese University Orcid: https://orcid.org/0000-0002-7658-1361
https://doi.org/10.5281/zenodo.19292665

Abstract
The objective of this case report is to describe a clinical situation in which an external sinus lift was required to facilitate implant placement, and the buccal bone wall was used as a 2D scaffold to reconstruct a mesial bone defect with AM. Three Astra Tech EV implants were subsequently placed and restored three months later, with a 10-year follow-up.

Keywords: Sinus Lift, Bone reconstruction, Dental Implants, Buccal wall.

Introduction

Maxillary sinus augmentation (MSA) procedures are widely recognized as highly reliable and safe methods, often selected when the remaining alveolar bone height in the maxillary premolar-molar region measures less than 2–4 mm [1]. This surgical technique involves osteotomy of the buccal bone using the outfracture technique [1] or removal of the bone wall [2], followed by elevation of the Schneiderian membrane and placement of grafting materials between the crestal bone and the membrane [1–3]. Numerous studies have explored sinus augmentation using various materials, including autogenous bone (AB) [4,5], allograft materials (AM) [6–8], synthetic grafts (SG) or xenografts (XG) [8,9], combinations [9], or even graft-less techniques [10,11].

This procedure facilitates subsequent dental implant placement, either simultaneously or in a delayed approach [11,12]. The long-term stability of implants is closely linked to the viability and integration of grafting materials with newly formed bone, which gradually develops from the residual maxillary bone [13,14].

Various guided bone regeneration (GBR) techniques and grafting protocols are employed to reconstruct alveolar bone defects, depending on the defect's morphology [15]. Minor horizontal defects may be corrected through a single-stage augmentation procedure [16]. The use of barrier membranes resorbable or non-resorbable combined with tenting screws helps preserve the gained volume and prevent resorption [17]. Consequently, restoring substantial defects requires horizontal and/or vertical augmentation using AB grafts or bone substitutes [15,16]. AB grafts are considered the "gold standard" for bone grafting due to their osteogenic, osteoinductive, and osteoconductive properties [18]. However, harvesting AB necessitates an additional surgery, increasing patient morbidity [19]. To mitigate these risks, various SG, XG biomaterials, or AM have been employed as bone substitutes because of their osteoconductive scaffold and bone-forming capacity [6–9].

For two-dimensional (2D) bone defects, grafts harvested from the chin or retromolar regions have been utilized [20]. Pikos [21] introduced the inlay technique, which involves the precise placement of block grafts that fit the defect. The shell technique has also been described for 2D bone reconstruction [22,23]. Thin cortical bone shells can be harvested from the retromolar region using a specialized diamond disk and positioned to reconstruct the cortical plate, shielding the harvested bone placed between the shells and the defect from resorption [22,23]. These procedures require both augmentation of the recipient site and harvesting from an intraoral donor site, necessitating two surgeries [22,23].

An alternative MSA technique involves the outfracture osteotomy, where a complete 360-degree osteotomy is performed, and the lateral window bone is separated from the membrane [24–26]. The bony window can replace an absorbable membrane or be crushed and mixed with graft material [24,26]. If the lateral bone wall is thick (>2 mm), cortical bone can be harvested and used as graft material [27,28].

The objective of this case report is to describe a clinical situation in which an external sinus lift was required to facilitate implant placement, and the buccal bone wall was used as a 2D scaffold to reconstruct a mesial bone defect with AM. Three Astra Tech EV implants were subsequently placed and restored three months later, with a 10-year follow-up.

Case Report

A 55-year-old female patient, classified as ASA I and in good health, was referred to our clinic by her dentist for evaluation of her edentulous maxillary area. Clinical examination revealed edentulism extending from the canine to the second molar in the left maxilla, with minor pain in the right anterior and left posterior maxillary regions.

Preoperative radiographic evaluation using panoramic radiographs and cone beam computed tomography (CBCT) revealed insufficient bone volume for standard implant placement and a horizontal bone defect in the premolar region. Consequently, sinus bone elevation via the lateral approach and 2D reconstruction were deemed necessary (Figure 1a, b, c, d).

The procedure was discussed thoroughly with the patient, explaining all available treatment options.

MSA was performed under local anesthesia (4% articaine with 1:100,000 adrenaline). Preventive antibiotic therapy (2 g amoxicillin-clavulanic acid or 600 mg clindamycin for penicillin-allergic patients) was administered one hour preoperatively, followed by 1 g/300 mg twice daily for five days. Analgesics (600 mg ibuprofen) were prescribed preoperatively and as needed postoperatively, along with instructions for daily 0.12% chlorhexidine gluconate oral rinses for one week.

A crestal incision was made in the edentulous area, with two vertical incisions mesially and distally. Access to the maxillary buccal bone was achieved through a full-thickness mucoperiosteal flap. Osteotomy of the buccal bony window was performed using a piezo-ultrasonic device as planned on CBCT. The rectangular bone was detached from the sinus membrane and elevated with the membrane tip of the piezo unit, followed by sinus curettes.

A solvent-dehydrated mineralized cortical-cancellous bone allograft (MCBA) (Puros Cortical-Cancellous particulate 0.25–1.0 mm; ZimVie, Carlsbad, USA) was hydrated in sterile saline and condensed into the sinus cavity, then sealed buccally with a collagen membrane (CollaTape; ZimVie, Carlsbad, USA) (Figure 2a, b, c, d, e, f, g, h).

Small perforations were made in the bone defect using a round bur to stimulate vascularization from the bone to the MCBA. The removed cortical bone wall was repositioned and fixed with two bone screws (Profix, Osteogenics, Lubbock, USA, 1.5 mm × 12 mm). The space between the cortical bone and the defect was packed with MCBA. A bovine pericardium membrane (CopiOs Pericardium Membrane, ZimVie) covered the graft site and was fixed with four tacks. The flap was closed with simple sutures (Monocryl 3/0, Ethicon, Johnson & Johnson, Somerville, NJ, USA).

Weekly clinical and radiographic follow-up was conducted. After six months, panoramic radiographs and CBCT revealed complete healing of the defect and sinus cavity. Four Astra Tech EV implants were placed in the augmented areas using a similar flap design. (Figure 3 a, b, c, d, e, f).

Eight weeks later, healing abutments were placed through a limited crestal incision. Two weeks afterward, impressions were taken using polyvinyl siloxane, and final crowns were fabricated using glass ceramic and cemented onto Ti Design abutments with glass ionomer cement (Figure 4 a, b).

Clinical assessments and standardized intraoral radiographs were obtained during follow-up visits up to ten years using the long-cone paralleling technique (Figure 5 a, b).

Discussion

MSA and GBR have demonstrated favorable results clinically, radiographically, and histologically for bone reconstruction in dental implants [6–8,16,18]. Maxillary sinus membrane elevation and grafting is widely recognized as the preferred treatment for implant placement in edentulous posterior maxilla with bone height deficiency [14,27,28].

GBR enhances alveolar bone volume in defects of varying shapes and dimensions [16,18]. Several techniques manage the lateral sinus bony window in MSA, including elevating it into the sinus cavity, crushing and mixing with particulate bone grafts, or repositioning it [25]. The lateral window bone can serve as an autogenous graft when horizontal or vertical crestal defects adjacent to the augmented sinus require reconstruction [22–24,26].

Proper immobilization and vascularization are critical for 2D reconstruction success. The lateral window bone used to create the necessary space is secured with two fixation screws [20–23]. Integration of 2D bone reconstruction and barrier membranes minimizes volumetric changes by reducing surface resorption during healing [17].

The described method offers clinical advantages by condensing the procedure into a single session, eliminating a second surgery. Sinus elevation and horizontal augmentation are performed simultaneously, and implants can be placed in the grafted sinus and augmented area [24].

Bone substitutes, such as allografts, provide scaffolds for vascular infiltration and hard tissue regeneration, integrating smoothly into newly formed bone [6,7,9,14,29,30]. MCBA, according to histological studies, is gradually replaced by autogenous bone while demonstrating excellent integration [7,9,29,30].

Isolation of the bone substitute from the oral cavity is crucial to prevent fibrous tissue infiltration [17]. Dense pericardial membranes exhibit stable resorption and effectively support bone regeneration [31]. The increase in bone width from 3.05 to 6.99 mm post-grafting suggests enhanced vascularization, promoting tissue regeneration [17]. Osteogenesis relies on progenitor cells from bone marrow stroma and pericytes from small blood vessels in connective tissue [29,30]. Perforating the underlying compact bone during GBR opens marrow spaces, accelerating vascularization and enhancing bone regeneration [32].

The primary limitation of this technique is the potential risk of sinus membrane perforation during bony wall reflection or fracturing the bony wall during fixation.

Conclusion

The shell technique using cortical bone from the lateral buccal wall, in combination with allograft materials and lateral sinus augmentation, provides a reliable method for horizontal ridge reconstruction. This approach enables simultaneous sinus elevation and horizontal augmentation, reducing surgical interventions while maintaining predictable outcomes for implant placement. Long-term follow-up demonstrates stable bone volume and successful integration of graft materials, confirming the technique's efficacy for managing complex maxillary defects.

Figures:

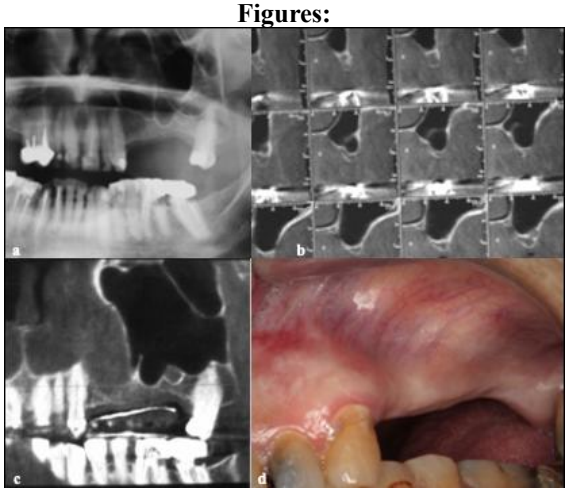

Figure 1:

a: Panoramic radiograph showing the height in the posterior part of the maxilla.
b: para-axial cuts of the CBCT showing the bone defect in the premolar area and the crestal extension of the maxillary sinus.
c: panoramic reconstruction of the CBCT
d: clinical view of the area to be grafted, note the buccal defect in the premolar area.

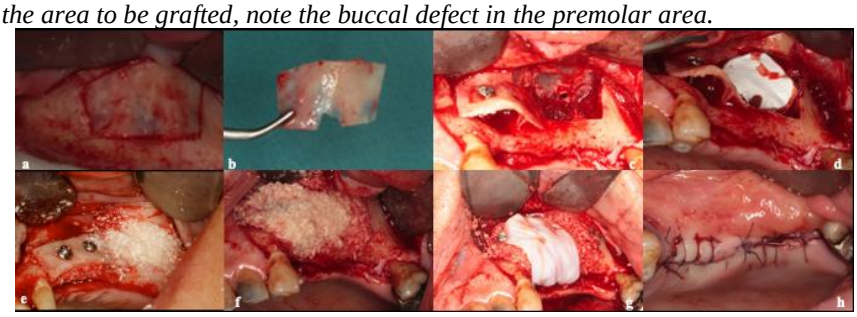

Figure 2:

a: the osteotomy of the buccal wall
b: the buccal wall retrieved in one piece
c: the buccal wall is fixed with screws in the buccal defects, note the small perforation of the sinus membrane
d: the preformation was closed with a collagen membrane
e: the space and the sinus were filled with MCBA
f: collagen membrane covered the augmented area
h: sutures of the flap.

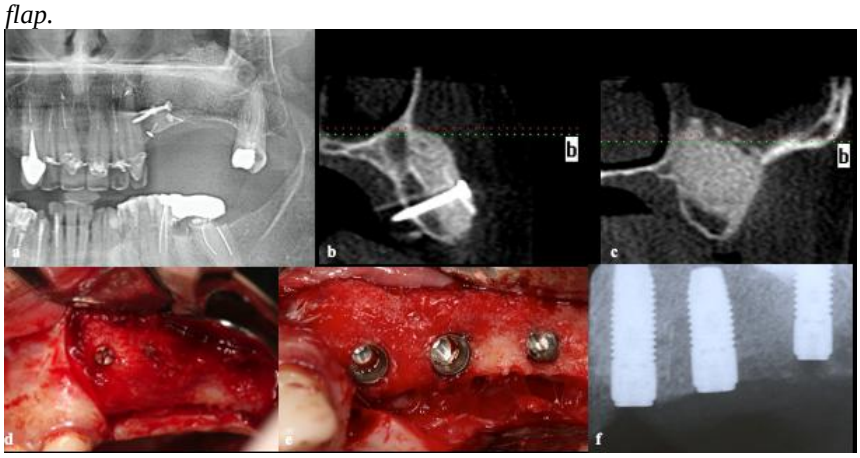

Figure 3:

a: post-operative panoramic radiograph
b: Para-axial cut of the CBCT showing the augmented area
c: Para-axial cut of the CBCT showing the augmented sinus with respect to the sinus cavity
d: 4 months later a clinical view showing the augmented area, note that the new bone is covering the screw.
e: 3 Eve implants were placed in the augmented area.
f; Intra-oral radiograph showing the 3 implants.

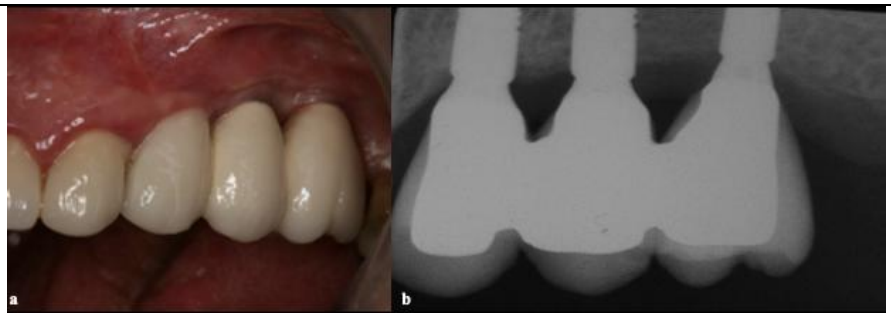

Figure 4:
a: clinical view with fixed crowns on the implants.
b: intra oral radiograph of the implants and crowns.

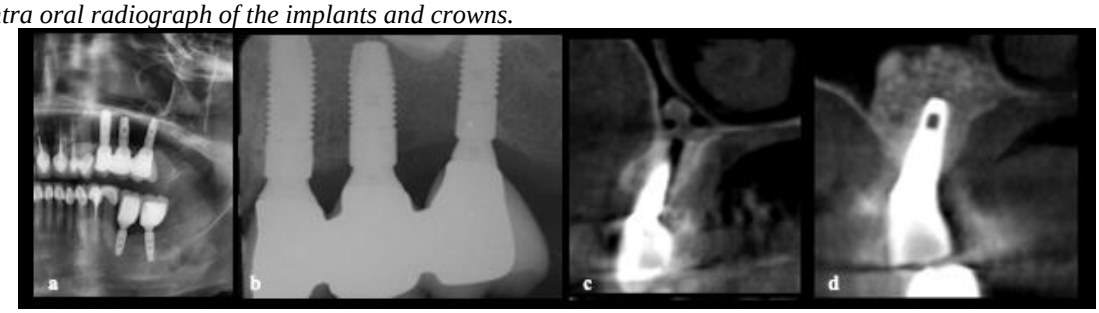

Figure 5: Post-Operative radiographs at 10 years
a: Panoramic radiograph
b: Intra oral radiograph of the implants and crowns, note that there is no bone loss around the neck of the implants.
c: Para-axial CBCT of the premolar area reconstructed in 2D.
d: Para-axial CBCT of the molar region with sinus grafting the continuity of the grafted materials with respect to the sinus membrane is well noted.

References:

1. Boyne PJ, James RA. Grafting of the maxillary sinus floor with autogenous marrow and bone. J Oral Surg. 1980 Aug;38(8):613-6. PMID: 6993637.
2. Lee JK. Outfracture osteotomy on lateral maxillary wall as a modified sinus graft technique. J Oral Maxillofac Surg. 2010 Jul;68(7):1639-41. doi: 10.1016/j.joms.2009.07.067. Epub 2010 Apr 22. PMID: 20417015.
3. Guerrero JS, Al-Jandan BA. Lateral wall sinus floor elevation for implant placement: revisiting fundamentals and the surgical technique. J Calif Dent Assoc. 2013 Mar;41(3):185-7, 190-5. PMID: 23600161.
4. Camargo Filho GP, Corrêa L, Costa C, Pannuti CM, Schmelzeisen R, Luz JG. Comparative study of two autogenous graft techniques using piezosurgery for sinus lifting. Acta Cir Bras. 2010 Dec;25(6):485-9. doi: 10.1590/s0102-86502010000600005. PMID: 21120278.
5. Klijn RJ, Meijer GJ, Bronkhorst EM, Jansen JA. Sinus floor augmentation surgery using autologous bone grafts from various donor sites: a meta-analysis of the total bone volume. Tissue Eng Part B Rev. 2010 Jun;16(3):295-303. doi: 10.1089/ten.TEB.2009.0558. PMID: 19958168.
6. Schmitt CM, Doering H, Schmidt T, Lutz R, Neukam FW, Schlegel KA. Histological results after maxillary sinus augmentation with Straumann® BoneCeramic, Bio-Oss®, Puros®, and autologous bone. A randomized controlled clinical trial. Clin Oral Implants Res. 2013 May;24(5):576-85. doi: 10.1111/j.1600-0501.2012.02431. x. Epub 2012 Feb 13. PMID: 22324456.
7. Berberi A, Nader N. Subantral Augmentation with Mineralized Cortical Bone Allograft Material: Clinical, Histological, and Histomorphometric Analyses and Graft Volume Assessments. Implant Dent. 2016 Jun;25(3):353-60. doi: 10.1097/ID.0000000000000391. PMID: 26866847.
8. Guruprasad M, Kulloli A, Mehta V, Fiorillo L, Cicciu M. Maxillary Sinus Floor Augmentation with Allograft Alone Compared With Alternate Grafting Materials: A Systematic Review and Meta-Analysis. J Craniofac Surg. 2023 Nov 22. doi: 10.1097/SCS.0000000000009913. Epub ahead of print. PMID: 37991404.
9. Schmitt CM, Moest T, Lutz R, Neukam FW, Schlegel KA. Anorganic bovine bone (ABB) vs. autologous bone (AB) plus ABB in maxillary sinus grafting. A prospective non-randomized clinical and histomorphometrical trial. Clin Oral Implants Res. 2015 Sep;26(9):1043-50. doi: 10.1111/clr.12396. Epub 2014 Apr 15. PMID: 24730602.
10. Berberi A, Nader N, Bou Assaf R, Fayyad-Kazan H, Khairalah S, Moukarzel N. Sinus Floor Augmentation with Ambient Blood and an Absorbable Collagen Sponge: A Prospective Pilot Clinical Study. Implant Dent. 2017 Oct;26(5):674-681. doi: 10.1097/ID.0000000000000631. PMID: 28696960.
11. Parra M, Atala-Acevedo C, Fariña R, Haidar ZS, Zaror C, Olate S. Graftless Maxillary Sinus Lift Using Lateral Window Approach: A Systematic Review. Implant Dent. 2018 Feb;27(1):111-118. doi: 10.1097/ID.0000000000000695. PMID: 29210825.
12. Bhandari S, Thomas R, Kumar T, Shah R, Mehta DS. Maxillary Sinus Augmentation Using Hydraulic Pressure by Lateral Approach and Simultaneous Implant Placement: Clinicoradiographic Study. Implant Dent. 2019 Oct;28(5):514-519. doi: 10.1097/ID.0000000000000911. PMID: 31205271.

13. Raghoebar GM, Onclin P, Boven GC, Vissink A, Meijer HJA. Long-term effectiveness of maxillary sinus floor augmentation: A systematic review and meta-analysis. J Clin Periodontol. 2019 Jun;46 Suppl 21:307-318. doi: 10.1111/jcpe.13055. PMID: 30624789.

14. Cara-Fuentes M, Machuca-Ariza J, Ruiz-Martos A, Ramos-Robles MC, Martínez-Lara I. Long-term outcome of dental implants after maxillary augmentation with and without bone grafting. Med Oral Patol Oral Cir Bucal. 2016 Mar 1;21(2): e229-35. doi: 10.4317/medoral.21055. PMID: 26827071; PMCID: PMC4788804.

15. Fu JH, Wang HL. Horizontal bone augmentation: the decision tree. Int J Periodontics Restorative Dent. 2011 Jul-Aug;31(4):429-36. PMID: 21837309.

16. Benic GI, Hämmerle CH. Horizontal bone augmentation by means of guided bone regeneration. Periodontol 2000. 2014 Oct;66(1):13-40. doi: 10.1111/prd.12039. PMID: 25123759.

17. Zhang M, Zhou Z, Yun J, Liu R, Li J, Chen Y, Cai H, Jiang HB, Lee ES, Han J, Sun Y. Effect of Different Membranes on Vertical Bone Regeneration: A Systematic Review and Network Meta-Analysis. Biomed Res Int. 2022 Jul 14; 2022:7742687. doi: 10.1155/2022/7742687. PMID: 35872861; PMCID: PMC9303140.

18. Netto HD, Miranda Chaves MD, Aatrstrup B, Guerra R, Olate S. Bone Formation in Maxillary Sinus Lift Using Autogenous Bone Graft at 2 and 6 Months. Int J Morphol. 2016 Sep;34(3):1069-1075. doi: 10.4067/S0717-95022016000300041. PMID: 27867255.

19. Li J, Wang HL. Common implant-related advanced bone grafting complications: classification, etiology, and management. Implant Dent. 2008 Dec;17(4):389-401. doi: 10.1097/ID.0b013e31818c4992. PMID: 19077576.

20. Khoury F, Hanser T. Mandibular bone block harvesting from the retromolar region: a 10-year prospective clinical study. Int J Oral Maxillofac Implants. 2015 May-Jun;30(3):688-97. doi: 10.11607/jomi.4117. PMID: 26009921.

21. Pikos MA. Block autografts for localized ridge augmentation: Part II. The posterior mandible. Implant Dent. 2000;9(1):67-75. doi: 10.1097/00008505-200009010-00012. PMID: 11307236.

22. Kämmerer PW, Tunkel J, Götz W, Würdinger R, Kloss F, Pabst A. The allogeneic shell technique for alveolar ridge augmentation: a multicenter case series and experiences of more than 300 cases. Int J Implant Dent. 2022 Nov 1;8(1):48. doi: 10.1186/s40729-022-00446-y. PMID: 36316597; PMCID: PMC9622968.

23. Villa G, Rizzacasa A, Bessa L, Spina P, Barootchi S, Tavelli L, Wang HL. Shell Technique with a Xenogeneic Cortical Bone Lamina and Particulate Bone Graft for Horizontal Ridge Augmentation: A Case Series. Int J Periodontics Restorative Dent. 2023 July-Aug;43(4):435-441. doi: 10.11607/prd.5671. PMID: 36520135.

24. Berberi A, Nader N, Noujeim Z, Scardina A, Leone A, Salameh Z. Horizontal and vertical reconstruction of the severely resorbed maxillary jaw using subantral augmentation and a novel tenting technique with bone from the lateral buccal wall. J Maxillofac Oral Surg. 2015 Jun;14(2):263-70. doi: 10.1007/s12663-014-0635-7. Epub 2014 Jun 28. PMID: 26028846; PMCID: PMC4444692.

25. Juzikis E, Gaubys A, Rusilas H. Uses of maxillary sinus lateral wall bony window in an open window sinus lift procedure: literature review. Stomatologija. 2018;20(1):14-21. PMID: 29806654.

26. Park WB, Kang P, Park W, Han JY. Use of a Lateral Sinus Bony Window as an Intraoral Donor Site for Guided Bone Regeneration in Wide Post-Extraction Defects. Medicina (Kaunas). 2022 Dec 4;58(12):1785. doi: 10.3390/medicina58121785. PMID: 36556988; PMCID: PMC9782459.

27. Kim JM, Sohn DS, Heo JU, Park JS, Jung HS, Moon JW, Lee JH, Park IS. Minimally invasive sinus augmentation using ultrasonic piezoelectric vibration and hydraulic pressure: a multicenter retrospective study. Implant Dent. 2012 Dec;21(6):536-42. doi: 10.1097/ID.0b013e3182746c3d. PMID: 23149505.

28. Maridati P, Dellavia C, Pellegrini G, Canciani E, Maragno A, Maiorana C. Histologic and Radiographic Comparison of Bone Scraper and Trephine Bur for Autologous Bone Harvesting in Maxillary Sinus Augmentation. Int J Oral Maxillofac Implants. 2015 Sep-Oct;30(5):1128-36. doi: 10.11607/jomi.3810. PMID: 26394350.

29. Noumbissi SS, Lozada JL, Boyne PJ, Rohrer MD, Clem D, Kim JS, Prasad H. Clinical, histologic, and histomorphometric evaluation of mineralized solvent-dehydrated bone allograf (Puros) in human maxillary sinus grafts. J Oral Implantol. 2005;31(4):171-9. doi: 10.1563/1548-1336(2005)31[171:CHAHEO]2.0.CO;2. PMID: 16145844.

30. Froum SJ, Wallace SS, Elian N, Cho SC, Tarnow DP. Comparison of mineralized cancellous bone allograft (Puros) and anorganic bovine bone matrix (Bio-Oss) for sinus augmentation: histomorphometry at 26 to 32 weeks after grafting. Int J Periodontics Restorative Dent. 2006 Dec;26(6):543-51. PMID: 17243327.

31. Abaza AWAAB, Abbas WM, Khalik DMA, El Din NHK. Horizontal Ridge Augmentation of the Atrophic Maxilla Using Pericardium Membrane Versus Titanium Mesh: A Clinical and Histologic Randomized Comparative Study. Int J Oral Maxillofac Implants. 2023 May, Jun;38(3):451-461. doi: 10.11607/jomi.9715. PMID: 37279212.

32. Danesh-Sani SA, Tarnow D, Yip JK, Mojaver R. The influence of cortical bone perforation on guided bone regeneration in humans. Int J Oral Maxillofac Surg. 2017 Feb;46(2):261-266. doi: 10.1016/j.ijom.2016.10.017. Epub 2016 Nov 16. PMID: 27865631.