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Maxillary Sinus Floor Elevation in Implant Dentistry: A Comprehensive Review of Surgical Techniques, Classifications, Biomaterials, and Complications.

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ABSTRACT

Implant rehabilitation in the posterior maxilla poses critical clinical difficulties due to alveolar ridge resorption following tooth loss and progressive pneumatization of the maxillary sinus. Maxillary sinus floor elevation (SFE) is the established, highly predictable surgical modality utilized to reconstruct deficient vertical subantral bone height. This comprehensive review synthesizes the full scope of SFE, including maxillary sinus anatomy, histophysiology of the Schneiderian membrane, diagnostic imaging (panoramic, periapical, and CBCT), and established classification systems (Misch, Wang & Katrangi ABC, Davarpanah 3D, and Tavelli presurgical risk index). The manuscript provides an in-depth comparative analysis of the lateral window antrostomy versus transcrestal/osteotome approaches, along with graft-free osteogenic tenting and diverse biomaterials (autogenous, allografts, xenografts, alloplasts). Technological advancements—including piezoelectric surgery, balloon elevation, hydraulic/gel pressure systems, calcium phosphosilicate putty (MITSA), and osseodensification—are systematically explored. Furthermore, intraoperative and postoperative complications (Schneiderian membrane tears, vascular injury to the alveolar antral artery, sinus infections, graft/implant displacement) and evidence-based management strategies are detailed alongside comprehensive postoperative regimens and prosthetic considerations..

Keywords: Sinus Floor Elevation, Schneiderian Membrane, Lateral Window Osteotomy, Osteotome Technique, Bone Grafting Biomaterials, Alveolar Antral Artery, CBCT Preoperative Planning, Implant Osseointegration

Introduction

Rehabilitation of the partially or completely edentulous posterior maxilla with implant-supported restorations remains one of the most technically demanding disciplines in dental implantology. Tooth loss in this region precipitates rapid and progressive alveolar bone atrophy in both horizontal and vertical vectors. Centripetal resorption of the buccal cortical plate, combined with the lack of functional masticatory stimulation and positive intra-antral pressure, triggers progressive pneumatization of the maxillary sinus. Consequently, the residual vertical bone height (RBH) is frequently reduced to a thin subantral cortex (<1–4 mm), precluding the standard placement of dental implants (≥10 mm) without prior or simultaneous bone augmentation.-....:

The concept of elevating the maxillary sinus floor was pioneered by Hilt Tatum in the mid-1970s, who utilized autogenous rib grafts via a modified Caldwell-Luc lateral approach. In 1980, Boyne and James published the classic lateral window technique utilizing autogenous marrow cancellous bone grafts, establishing a reproducible surgical protocol with reported success rates exceeding 95%. In 1994, Robert Summers introduced a minimally invasive crestal approach using tapered osteotomes with increasing diameters (Osteotome/Crestal Sinus Membrane Elevation - OCSME), allowing localized floor infracture and bone condensation for sites with moderate bone height (≥5–6 mm). Over the ensuing three decades, sinus augmentation has transitioned from invasive open surgeries requiring distant extraoral donor sites to highly refined, minimally invasive interventions supported by xenogeneic bone substitutes, synthetic putty systems, piezoelectric osteotomies, and hydraulic elevation devices.

2. Anatomy and Physiology of the Maxillary Sinus

The maxillary sinus (antrum of Highmore) is a pyramidal, air-filled cavity representing the largest of the paranasal sinuses, with an average adult volume of 12–15 mL. It is bounded medially by the lateral nasal wall, superiorly by the orbital floor (incorporating the infraorbital canal), posteriorly by the maxillary tuberosity and pterygopalatine fossa, anterolaterally by the facial/vestibular wall, and inferiorly by the alveolar process.

2.1 Histophysiology of the Schneiderian Membrane

The interior sinus cavity is lined by the Schneiderian membrane, a specialized mucoperiosteum with a physiological thickness of 0.13 to 0.5 mm. Histologically, it comprises pseudostratified ciliated columnar epithelium containing four primary cell types: ciliated columnar cells (bearing 50–200 cilia beating at 700–800 strokes/min), non-ciliated columnar microvilli cells (which warm and humidify inspired air), secretory goblet cells (producing mucus glycoproteins), and basal stem cells. The underlying subepithelial layer contains seromucous glands and integrates directly with the periosteum. Mucociliary propulsion transports fluid toward the natural maxillary ostium (MO) located superomedially in the hiatus semilunaris within the ostiomeatal complex (OMC). Perforation or pathological thickening (>2 mm) of this membrane from chronic allergic rhinosinusitis compromises mucociliary clearance and substantially elevates graft infection risks.

2.2 Vascular Supply and the Alveolar Antral Artery

The blood supply to the maxillary sinus mucosa and surrounding bony walls arises from branches of the maxillary artery: the posterior superior alveolar artery (PSAA), the infraorbital artery (IOA), and the posterior lateral nasal artery. In 100% of anatomical specimens, an intraosseous or extraosseous anastomosis between the PSAA and IOA—termed the Alveolar Antral Artery (AAA)—traverses the anterolateral wall. Studies indicate that the AAA is located at an average height of 16–17 mm coronal to the alveolar crest, placing it directly within the path of standard lateral window osteotomies. Identifying this vessel via cross-sectional CBCT is essential to prevent significant intraoperative arterial hemorrhage.

2.3 Underwood's Septa

Bony septa (Underwood's septa) are anatomical projections arising from the sinus floor, observed in 16% to 58% of individuals. They typically develop due to asynchronous tooth loss and differential resorption patterns across alveolar segments. Septa divide the antrum into distinct recesses (Class I: coronal/buccopalatal; Class II: sagittal/anteroposterior; Class III: transverse/shelf-like; Class IV: combination). The presence of septa significantly complicates Schneiderian membrane elevation, substantially increasing the risk of mucosal tearing if the window design is not appropriately modified (e.g., preparing two separate mini-windows on either side of the septum).

3. Diagnostic Classifications and Treatment Decision Matrices

Multiple classification models have been established to standardize surgical decision-making, evaluate residual bone morphology, and select between simultaneous versus delayed implant placement.

Classification System	Diagnostic Categories / Parameters	Recommended Surgical Approach	Implant Timing & Clinical Remarks
Misch Subantral (SA)	SA1: ≥12 mm RBH SA2: 10–12 mm RBH SA3: 5–10 mm RBH SA4: <5 mm RBH	SA1: Conventional placement SA2: Crestal osteotome (OCSME) SA3: Lateral or crestal	SA1-3: Immediate placement possible SA4: Delayed

		approach SA4: Lateral window antrostomy	placement (6–9 mos healing)
Misch Bone Density	D1: Dense cortical (Oak) D2: Porous cortical/coarse trabecular (Pine) D3: Porous cortical/fine trabecular (Balsa) D4: Fine trabecular (Styrofoam)	D1/D2: Excellent primary stability D3: Standard under-drilling D4: Osteotome compaction / osseodensification required	Posterior maxilla is predominantly D3 and D4 bone, requiring careful countersinking avoidance.
Wang & Katrangi (ABC)	Class A: >10 mm RBH Class B: 6–9 mm RBH (h/v/c defects) Class C: ≤5 mm RBH (h/v/c defects)	Class A: Standard protocol Class B: Transcrestal osteotome ± GBR Class C: Lateral wall sinus elevation ± onlay graft	Class A & B: Immediate implant Class C: Immediate only with primary stability; otherwise delayed
Davarpanah 3D Model	Volume in subsinus area across 3D planes: 1: 1–4 mm 2: 4–8 mm 3: >8 mm (Horizontal, Vertical, Combined, Sinus)	Directs surgical trajectory (lateral, crestal, or palatal) based on internal vs external subsinus contour	Delayed placement favored for Class 1 (<4 mm) to ensure osseointegration
Tavelli Presurgical Risk Index	Weighted parameters (Membrane thickness, Septa, Wall angle, Teeth presence, AAA caliber, Oral opening)	Assigns risk grade: Grade I (Favorable: 1.0–1.5) Grade II (Normal: 1.5–2.1) Grade III (Problematic: 2.1–2.6) Grade IV (Risky: 2.6–3.0)	Encourages comprehensive CBCT evaluation and targeted surgical modifications.

4. Preoperative Clinical and Radiographic Evaluation

A thorough medical and dental assessment is mandatory prior to sinus floor elevation. Patients presenting with active allergic rhinitis, chronic rhinosinusitis (CRS), nasal polyposis, or ostiomeatal obstruction must receive clearance from an otorhinolaryngologist (ENT). Screening questionnaires such as the Sinonasal Outcome Test (SNOT-22) and the Nasal Obstruction Symptom Evaluation (NOSE) provide reliable outpatient assessments of sinonasal patency and the likelihood of postoperative complications.

Radiographic assessment has evolved significantly:

• **Intraoral Periapical (IOPA) Radiographs:** Offer high spatial resolution (12–22 line pairs/mm) for localized root-to-sinus proximity and crestal bone assessment, but lack 3D dimensional accuracy.

• **Panoramic Radiography (OPG):** Provides a useful broad initial screening modality, but exhibits high geometric distortion and an established 21.3% to 26.5% false-negative rate in detecting Underwood's septa.

• **Cone Beam Computed Tomography (CBCT):** Considered the gold standard. CBCT provides cross-sectional 3D evaluation of subantral bone height and width, Schneiderian membrane thickness, lateral wall thickness, the trajectory and caliber of the alveolar antral artery, septal morphology, and ostiomeatal complex patency.

5. Surgical Techniques: Lateral Window vs. Transcrestal Approach

5.1 Lateral Window Technique (Direct Approach)

Indicated primarily for Misch SA4 and Wang Class C sites where residual bone height is <4–5 mm. The procedure involves:

1. Incision and Flap Reflection: A horizontal beveled incision 1–2 mm palatal to the crest with anterior and posterior divergent vertical releasing incisions, creating a wide full-thickness mucoperiosteal flap exposing ≥3 mm of vital bone around the intended window.

2. Antrostomy Preparation: An oval or rectangular osteotomy is outlined 3–5 mm coronal to the sinus floor using diamond round burs (#4, 6, 8) under copious irrigation or piezoelectric tips. Bone is carefully thinned until the grayish/blue hue of the underlying membrane becomes visible.

3. Management of the Bony Island: The central bone island is either infractured inwardly to act as the subantral roof (Tatum approach) or completely excised (wall-off technique) to enhance visualization and provide particulate autogenous graft material.

4. Membrane Reflection & Graft Condensation: Using specialized angled curettes (Tarnow-Eskow, Kramer-Nevins, #710), the membrane is gently peeled from the floor, anterior, and medial walls. Particulate graft material is loosely packed into the cavity, and a resorbable collagen membrane is positioned over the lateral window prior to tension-free primary closure.

5.2 Transcrestal Osteotome Technique (Indirect Approach)

Indicated for sites with ≥5–6 mm of residual bone (Misch SA2/SA3, Wang Class B). The osteotomy is established using sequential pilot drills terminating 1 mm short of the antral floor. Concave-tipped osteotomes with depth stops are inserted and tapped with a mallet to create a controlled green-stick up-fracture of the subantral cortex. Bone-Added Osteotome Sinus Floor Elevation (BAOSFE) introduces graft granules into the osteotomy, utilizing hydraulic pressure from the bone plug as a cushion to atraumatically elevate the membrane 2–5 mm.

6. Biomaterials and Graft-Free Sinus Augmentation

Successful osseointegration within the augmented sinus requires a scaffold that promotes vascularization and osteogenesis while resisting intra-antral respiratory pressure.

Graft Category	Biological Properties	Common Sources / Examples	Clinical Performance & Resorption Dynamics
Autografts	Osteogenic, Osteoinductive, Osteoconductive	Intraoral: Symphysis, Ramus, Scraper Extraoral: Iliac crest, Tibia	Gold standard for osteoinduction; undergoes higher volumetric resorption (mix with xenograft recommended).
Allografts	Osteoconductive ± Weakly Osteoinductive	FDBA (mineralized), DFDBA (demineralized freeze-dried)	Excellent space maintenance and turnover rate; verified safety through extensive screening.
Xenografts	Purely Osteoconductive	Deproteinized Bovine Bone Mineral (DBBM - Bio-Oss), Equine bone	Very slow resorption rate; provides superior long-term space maintenance and prevents sinus repneumatization.
Alloplasts / Synthetics	Purely Osteoconductive	β-Tricalcium Phosphate (β-TCP), Hydroxyapatite (HA), Biphasic HA/TCP	Biocompatible synthetic scaffold; predictable dissolution and replacement by host bone.
Calcium Phosphosilicate (CPS) Putty	Osteoconductive & Hydrophilic Matrix	Bioactive glass synthetic putty (NovaBone / CPS Putty)	Formable cohesive paste delivering hydraulic pressure for

			membrane lift; rapid cellular infiltration.

6.1 Graft-Free Sinus Floor Elevation (Blood Clot Alone)

Emerging clinical evidence confirms that the Schneiderian membrane possesses intrinsic osteogenic potential, harboring viable osteoprogenitor cells. When the membrane is tented upward by the placed dental implant fixture, a stable blood coagulum forms in the subantral void. In self-contained 3-wall defects with RBH ≥ 4 mm, spontaneous new bone formation of 3.4 to 6.5 mm has been documented with 94–100% implant survival rates (Fornell et al., Capparè et al., Ye et al.). However, in extensive defects (RBH < 3 mm), grafting biomaterials remain indispensable to resist membrane collapse from positive intra-antral pressure.

7. Technological Innovations in Sinus Augmentation

To lower complication rates and reduce patient morbidity, multiple advanced surgical technologies have been introduced:

• **Piezoelectric Surgery (Intralift™ System):** Utilizes modulated ultrasonic micro-vibrations (25–29 kHz) that selectively ablate mineralized bone while sparing soft tissue. Micro-cavitation from the sterile saline spray gently detaches the Schneiderian membrane, drastically minimizing perforation risks.

• **Antral Membrane Balloon Elevation (AMBE):** Pioneered by Soltan and Smiler (2005), a latex balloon catheter is introduced into the subantral space and inflated with 2–4 mL of sterile saline, exerting uniform, atraumatic hydrostatic pressure to elevate the mucosa ≥10 mm.

• **Minimally Invasive Transcrestal Sinus Augmentation (MITSA):** Utilizes cohesive Calcium Phosphosilicate (CPS) putty injected through a narrow-gauge cartridge. The viscous putty functions simultaneously as a hydraulic elevator and an osteoconductive matrix (Kher et al., 2014).

• **Hydraulic Crestal Elevation (CAS Kit):** Employs high-speed water jet pressure via specialized conical reamers with depth stoppers to hydrostatically lift the membrane, achieving >9 mm of vertical gain with exceptional safety.

• **Osseodensification (Densah™ Bur Technology):** Involves multi-fluted tapered burs rotating in reverse (counter-clockwise at 800–1500 rpm) with continuous irrigation. Rather than cutting, it condenses and autotransplants residual bone laterally and apically, facilitating transcrestal elevation while significantly enhancing primary implant stability.

• **Computer-Guided & AI-Driven Dynamic Navigation:** CAD/CAM surgical templates and AI-assisted 3D planning software enable precise implant angulation, exact window perimeter mapping, and automatic volumetric estimation of required graft volumes.

8. Anterior Maxillary Rehabilitation: Nasal Floor Elevation

In the severely resorbed anterior maxilla, implant placement is frequently restricted by the floor of the nasal cavity (pyriform aperture). Nasal floor elevation (first described by Adell et al., 1990) provides a predictable approach to gain 2–4 mm of vertical height. Via a crestal incision and lateral exposure of the pyriform rim and anterior nasal spine, the thicker, highly vascular nasal mucosa is gently reflected using curved curettes. Autogenous bone or xenografts combined with PRGF/PRF fibrin membranes are condensed into the subnasal space, allowing simultaneous implant placement with 100% long-term survival rates (Lorean et al., 2014).

9. Intraoperative and Postoperative Complications & Management Protocols

A systematic protocol for preventing, recognizing, and managing surgical complications is essential for every clinician undertaking sinus lift procedures.

9.1 Schneiderian Membrane Perforation

The most frequent intraoperative complication, occurring in 7% to 44% of procedures. Perforations are confirmed visually or via the Valsalva maneuver (observing bubbling/air displacement). Small perforations (<5 mm) are managed by placing a fast-absorbing resorbable collagen barrier membrane or PRF matrix extending 3–5 mm beyond the tear borders. Medium perforations (5–10 mm) are stabilized with collagen membranes and resorbable sutures or titanium tack fixation. Large, uncontrollable perforations (>10 mm) require immediate aborting of the procedure, with re-entry scheduled after 6–8 weeks of spontaneous mucosal healing.

9.2 Hemorrhage from the Alveolar Antral Artery

Laceration of the PSAA/IOA intraosseous anastomosis during window osteotomy produces rapid bleeding. Management entails direct pressure with epinephrine-soaked gauze (1:50,000), bone wax burnishing, electrocautery, or ligation. Preoperative identification on CBCT prevents arterial trauma.

9.3 Graft Displacement and Acute/Chronic Maxillary Sinusitis

Over-compaction of graft material or unrecognized membrane tears can force granules into the antral cavity, leading to ostial blockage, mucosal inflammation, and chronic rhinosinusitis. If symptoms persist despite antibiotic and decongestant therapy, surgical debridement or Functional Endoscopic Sinus Surgery (FESS) with an ENT surgeon is indicated.

9.4 Implant Dislodgement into the Sinus

Occurs due to inadequate primary stability, excessive insertion torque in D4 bone, or over-drilling. Dislodged fixtures must be located radiographically (CBCT/panoramic) and retrieved via the lateral antrostomy or transnasal endoscopic approach, followed by graft stabilization or delayed site reconstruction.

10. Postoperative Care Regimens and Prosthetic Considerations

10.1 Postoperative Medical Protocol

To ensure uneventful healing, patients must adhere to strict postoperative guidelines:

• **Antibiotic Coverage:** Amoxicillin/Clavulanate 875 mg BID for 10 days (or Clindamycin 300 mg TID for penicillin-allergic patients).

• **Analgesic/Anti-inflammatory:** Ibuprofen 600 mg QID for 3–5 days, supplemented with Acetaminophen/Codeine as needed.

• **Antimicrobial Rinse:** 0.12% Chlorhexidine gluconate oral rinse BID starting 24 hours post-surgery for 10–14 days.

• **Sinus Precautions:** Strict avoidance of nose-blowing, open-mouth sneezing when unavoidable, avoidance of drinking through straws, and restriction of vigorous physical exertion for 3–4 weeks.

• **Prosthesis Relining:** Removable prostheses (flippers/dentures) must be aggressively relieved over the surgical site to prevent mucosal pressure necrosis and graft dehiscence.

10.2 Prosthetic Biomechanics & Restoration Design

A minimum of 5–7 mm of interarch restorative space is required. Where vertical alveolar deficiency exists, hard/soft tissue augmentation, vertical osteotomy, or gingivectomy may be necessary. Screw-retained prostheses are preferred for minimal vertical space (≥4 mm) and full retrievability without cement-induced peri-implantitis risks. Cement-retained crowns are reserved for short spans with margins positioned supragingivally. In cases of extreme resorption, the All-on-4 tilted implant concept provides a viable alternative by utilizing anterior and angled posterior fixtures, bypassing the maxillary sinus entirely.

11. Conclusion

Maxillary sinus floor augmentation stands as one of the most reliable and biologically sound surgical interventions in modern implantology. Long-term success is achieved through precise CBCT diagnostic planning, rigorous anatomical risk stratification, appropriate selection between lateral and transcrestal approaches, and the judicious application of bone grafting biomaterials and minimally invasive technologies. Standardized complication management protocols and vigilant postoperative care ensure exceptional implant survival rates, restoring aesthetic harmony and masticatory function in the severely atrophic posterior maxilla.

REFERENCES

[1] Boyne, P. J., & James, R. A. (1980). Grafting of the maxillary sinus floor with autogenous marrow and bone. Journal of Oral Surgery, 38(8), 613–616.

[2] Tatum, H. (1986). Maxillary and sinus implant reconstructions. Dental Clinics of North America, 30(2), 207–229.

[3] Summers, R. B. (1994). A new concept in maxillary implant surgery: the osteotome technique. Compendium, 15(2), 152–156.

[4] Misch, C. E. (1987). Maxillary sinus augmentation for endosteal implants: organized alternative treatment plans. International Journal of Oral Implantology, 4(2), 49–58.

[5] Vercellotti, T., De Paoli, S., & Nevins, M. (2001). The piezoelectric bony window osteotomy and sinus membrane elevation: introduction of a new technique. International Journal of Periodontics & Restorative

Dentistry, 21(6), 561–567.

[6] Soltan, M., & Smiler, D. G. (2005). Antral membrane balloon elevation. Journal of Oral Implantology, 31(2), 85–90.

[7] Wang, H. L., & Katrangi, A. (2008). ABC sinus augmentation classification. International Journal of Periodontics & Restorative Dentistry, 28(4), 383–389.

[8] Davarpanah, M., Martinez, H., Tecucianu, J. F., & Celletti, R. (2001). The modified osteotome technique. International Journal of Periodontics & Restorative Dentistry, 21(6), 599–607.

[9] Tavelli, L., Borgonovo, A. E., Re, D., & Maiorana, C. (2017). Sinus presurgical evaluation: A new classification proposal. Maxillofacial Plastic and Reconstructive Surgery, 39(1), 22.

[10] Kher, U., Tunkiwala, A., & Mazor, Z. (2014). Transalveolar sinus floor elevation using calcium phosphosilicate putty. Journal of Oral Implantology, 40(6), 725–732.

[11] Lorean, A., Mazor, Z., Mijiritsky, E., & Levin, L. (2014). Nasal floor elevation combined with dental implant placement. Clinical Implant Dentistry and Related Research, 16(3), 405–412.

[12] Starch-Jensen, T., Deluiz, D., Bruun, N. H., & Tinoco, E. M. (2021). Maxillary sinus floor augmentation with autogenous bone graft compared with composite grafts: a systematic review and meta-analysis. International Journal of Oral and Maxillofacial Surgery, 50(7), 940–950.

[13] Albash, Z., et al. (2023). Influence of implant protrusion length and initial bone height on intrasinus bone gain in transalveolar sinus floor elevation without bone graft. Journal of Cranio-Maxillofacial Surgery, 51(4), 215–222.

[14] Sulyhan-Sulyhan, K., et al. (2024). Radiographic study of transcrestal sinus floor elevation using osseodensification technique with graft material. International Journal of Implant Dentistry, 10(1), 14.

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