Complications related to maxillary sinus lift procedures: narrative review

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Abstract

***Aim*: This narrative review aims to synthesize the current evidence regarding complications related to maxillary sinus floor elevation procedures, explicitly focusing on the lateral and transcrestal approaches. The goal is to categorize the main adverse events, assess their frequency, and analyze their etiopathogenic mechanisms and clinical effects.**
***Materials and Methods*: An extensive electronic search was performed using the MEDLINE database (via NCBI PubMed and PMC). The search strategy included MeSH terms and Boolean operators, such as "maxil-lary sinus augmentation," "lateral sinus lift and complications," and "transcrestal sinus elevation." Eligible studies comprised randomized controlled trials, observational clinical studies (prospective and retrospec-tive), narrative and systematic reviews, case series, and case reports published in English or Italian. Addi-tionally, a manual screening of references from selected articles and relevant position papers was conducted to ensure a thorough review.**
***Results*: The review identified a spectrum of complications, including Schneiderian membrane perforation, hemorrhage, graft material displacement, chronic rhinosinusitis, obstruction of the ostiomeatal complex, benign paroxysmal positional vertigo, and implant displacement. The occurrence and severity of these events vary depending on the surgical technique, anatomical factors, and biomaterials used. Recent evi-dence supports the potential benefits of basal bone implant placement in selected cases as an alternative to sinus elevation.**
***Conclusion*: Within the limitations of the current evidence, sinus augmentation procedures, although pre-dictable, are associated with a non-negligible risk of complications. Clinical success depends on accurate case selection, anatomical assessment, and surgical expertise. Further clinical investigations are required to optimize preventive and management strategies.**

Keywords: Maxillary Sinus; Sinus Floor Augmentation; Dental Implants; Postoperative Complications; Bone Regeneration; Membrane Perforation.

Introduction

The maxillary sinus is the largest pneumatic cavity among the paranasal sinuses and exhibits a pyramidal morphology. Its average dimensions are approximately 2.5 cm in width, 3.75 cm in height, and 3.0 cm in depth, although these values can vary

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significantly between individuals (1). Following the loss of posterior maxillary teeth, a dual anatomical alteration typically occurs in the edentulous segment: on one hand, a centripetal resorption of the alveolar ridge due to the physiological post-extraction bone remodeling; on the other, a progressive expansion of the sinus cavity, referred to as pneumatization, which predominantly proceeds in a caudal direction toward the edentulous alveolar crest (2).

The synergistic interaction of sinus pneumatization and alveolar bone resorption often leads to a critical re-duction in the residual bone volume, compromising the feasibility of implant placement using conventional surgical protocols. Under such clinical conditions, sinus floor elevation represents one of the most validated and widely adopted regenerative procedures. It aims to restore sufficient vertical and horizontal bone vol-ume to ensure proper implant positioning in three dimensions and achieve adequate primary stability (3,4).

Tatum reported the first documented attempt at maxillary sinus floor elevation in 1977, and Boyne and James formalized the subsequent scientific description in 1980 (5,6). Currently, sinus lift techniques are classified into two main approaches—lateral access and transrectal access—each selected based on the avail-able residual bone.

The lateral window technique involves the creation of an osteotomy on the lateral wall of the maxillary si-nus, allowing direct visualization and access to the Schneiderian membrane, which is adherent to the lat-eral wall and the superior aspect of the alveolar process. Atraumatic membrane elevation is performed us-ing an infero-medial and subsequently distal detachment, forming a compartment into which grafting ma-terials can be placed—autogenous, allogenic, xenogenic, or synthetic. This allows for vertical bone augmen-tation. Implant placement may be performed simultaneously when residual bone volume ensures sufficient primary stability, or in a delayed approach, following the maturation and osseointegration of the graft (7–9).

The transrectal approach, which is less invasive, is indicated when the residual bone height is at least 5 mm. This technique involves using progressively wider osteotomes to induce lateral and apical bone con-densation while facilitating controlled fracture of the sinus floor and elevation of the Schneiderian mem-brane through the implant site. Implant placement is performed in the same surgical session, configuring the procedure as a one-stage protocol (10).

Although both techniques are extensively documented in the literature for their clinical effectiveness, they are not devoid of potential complications. The most frequently reported intraoperative complication is per-foration of the Schneiderian membrane. Other adverse events include graft material infection, acute or chronic sinusitis, intra- or postoperative bleeding, surgical wound dehiscence, graft failure, and, in more severe cases, early or late implant loss (12–14).

The present narrative review critically examines the complications associated with maxillary sinus floor ele-vation surgical techniques, particularly the lateral and transrectal approaches. This analysis seeks to identi-fy the main types of adverse events reported in the literature, assess their incidence, and describe the po-tential etiopathogenetic mechanisms and clinical implications.

Materials and methods

The MEDLINE database (accessed through the NCBI PubMed and PMC platforms) was used to find rele-vant bibliographic sources. An electronic search was performed to identify scientific articles discussing complications related to maxillary sinus floor elevation procedures.

The search strategy involved the use of controlled MeSH terms and Boolean combinations of keywords such as: “maxillary sinus augmentation and complications,” “sinus floor elevation,” “lateral sinus lift and com-plications,” “transcrestal sinus lift and complications,” “dental implants and complications,” “Schneiderian membrane perforation,” and “sinus augmentation complications.”

Eligible studies included randomized controlled trials (RCTs), prospective and retrospective observational studies, narrative and systematic reviews, case series, and case reports that provided data on the incidence, classification, and management of intraoperative and postoperative complications related to sinus lift proce-dures.

Only articles published in English or Italian were considered. Additionally, a manual analysis of the bibli-ographies of the selected articles and references cited in reviews and position papers was conducted to broaden and strengthen the literature relevant to the topic under investigation.

Results

Complications Associated with Maxillary Sinus Floor Elevation Using the Lateral Approach

Schneiderian Membrane Perforation

Perforation of the Schneiderian membrane is the most frequently reported intraoperative complication dur-ing sinus floor elevation procedures via the lateral window approach. It typically occurs during osteotomy of the lateral sinus wall or detachment of the membrane from the underlying bony surface. Reported inci-dence in the literature varies widely, ranging from 6% to 42%, with a mean incidence generally between 20% and 25% (15). Perforations can be classified based on morphological criteria (size and location), temporal criteria (surgical phase during which they occur), and clinical relevance (manageability and impact on the surgical out-come).

Key predisposing anatomical factors include a severely resorbed alveolar ridge (<3.5 mm in height), narrow sinus morphology, bony septa, and the membrane’s thickness. The latter is one of the most significant de-terminants: the Schneiderian membrane typically has a physiological thickness of about 1 mm, although this may vary due to inflammatory, systemic, or pharmacological factors. Preoperative assessment with computed tomography can theoretically estimate membrane thickness, although image resolution may not always be sufficient for a reliable measurement (16).

A particularly relevant finding from recent studies is the correlation between gingival phenotype and sinus membrane thickness. Patients with a thin gingival phenotype (<1.5 mm) tend to present with thinner and more vulnerable sinus membranes. A retrospective study on 44 patients reported that 17% of procedures involving thin membranes resulted in membrane

perforation, suggesting a statistically significant associa-tion among gingival phenotype, membrane thickness, and residual bone height (17).

Intraantral bony septa—bone structures that partially divide the sinus cavity—represent another risk factor for membrane perforation. Their incidence ranges from 16% to 58% (18), and their location may complicate membrane elevation, particularly near sharp septal edges. Thus, preoperative CT evaluation is essential to identify their presence and guide surgical planning, possibly including multiple antrostomies to avoid them.

Clinically, membrane perforation may lead to loss of graft material stability, prolonged surgical time, in-creased risk of postoperative infections, and a higher incidence of early and late implant failures (19). Man-agement depends primarily on perforation size. Small perforations in naturally folded membrane areas may heal spontaneously due to tissue tension. However, even minor defects can enlarge due to intra-sinus negative pressure, so sealing with fibrin glue or sutures—if accessible—is recommended (20).

Larger defects are typically managed with resorbable collagen membranes placed inside the sinus cavity to cover the tear. Some authors have successfully employed autogenous cortical bone plates as mechanical bar-riers between the membrane and graft material. In severe cases involving extensive or complete mem-brane tears, it is advisable to abort the procedure and reattempt after a healing period of at least 6–8 weeks (21).

Chronic Rhinosinusitis

Chronic rhinosinusitis is a potentially serious, albeit relatively rare, postoperative complication of sinus lift procedures. It is defined as persistent inflammation of the maxillary sinus mucosa lasting more than 12 weeks, often accompanied by chronic bacterial infection. Its multifactorial etiology may involve intraopera-tive contamination with oral flora, membrane perforation, graft overfilling, implant protrusion into the si-nus cavity, or ostiomeatal complex obstruction due to postoperative mucosal edema or reactive hyperplasia (22).

Recent studies suggest that small membrane perforations alone do not cause chronic sinusitis in immuno-competent individuals but may contribute to it in the presence of other predisposing factors. A retrospective study reported that common symptoms in patients with chronic sinusitis post-lift included purulent dis-charge (89%), facial pain or pressure (78%), nasal congestion (56%), halitosis (45%), persistent cough (18%), peri-implant purulent drainage (18%), ocular itching (9%), and postnasal drip (9%) (23). Symptoms typically present within the first three months postoperatively but may also emerge as late as 12 months after surgery.

Reported incidence ranges from 4.2% to 8.4%. Management usually begins conservatively, with systemic broad-spectrum antibiotics, nasal saline irrigation, topical corticosteroid sprays, and oral antihistamines when indicated. Sinus irrigation with antibiotic or anti-inflammatory solutions may be performed in acute cases.

If conservative management fails, surgical revision may be required, either via the Caldwell-Luc approach or endoscopic transnasal surgery. The latter allows direct sinus drainage, removal of infected graft material, and, if necessary, implant explantation (24).

Hemorrhage

Intraoperative bleeding is a relatively common and potentially significant complication during sinus lift procedures. It usually results from accidental injury to arterial vessels along the lateral sinus wall, originat-ing from the maxillary artery. Particular attention is given to the anastomosis between the posterior superi-or alveolar artery and the infraorbital artery, known as the alveolar-antral artery, which supplies the Schneiderian membrane, periosteum, buccal soft tissues, and maxillary teeth (25).

Numerous anatomical and radiographic studies (including CBCT imaging) have documented interindivid-ual variability in these vessels' presence, diameter, and course. Approximately 10.5% of patients have arter-ies with a diameter >0.5 mm in the inferior portion of the anterolateral sinus wall. The average diameter of the alveolar-antral artery is about 1.2 mm (range 0.5–2.5 mm), with a predominantly intraosseous course in 71.4% of cases (26). These vessels may be epiperiosteal (superficial), intraosseous (endosteal), or intramuco-sal. Intraosseous vessels are at the most significant risk during lateral window osteotomy.

Injury to such vessels can result in significant hemorrhage, which impairs visibility and may hinder surgi-cal completion. Hemorrhagic risk is significantly higher when the vessel diameter exceeds 0.5 mm, with some studies reporting incidence rates up to 57% (27).

To minimize risk, detailed preoperative planning with CBCT is essential to identify and localize large-caliber vessels. In the case of superficial vessels, atraumatic dissection and protection are advised. For in-traosseous vessels, the osteotomy site may need to be modified to avoid transection. Intramucosal vessels can often be elevated together with the membrane.

If vascular injury occurs, management depends on location and accessibility. Visible vessels may be clamped and ligated. If located near osteotomy margins, arterial elasticity may cause retraction, complicat-ing control. Hemostatic agents such as bone wax, collagen sponges, or bioactive topical agents are recom-mended until complete hemostasis is achieved.

Obstruction of the Ostiomeatal Complex

Migration of graft material into the maxillary sinus may lead to clinically significant obstruction of the osti-omeatal complex (OMC), the anatomical drainage point between the sinus and nasal cavity. The ostium is located apically on the medial sinus wall and is essential for mucosal drainage and sinus ventilation.

Due to its superior location, ostium obstruction by graft overfilling is rare but can severely compromise mu-cociliary clearance, promote bacterial proliferation, and predispose to chronic sinusitis (28). Increased sinus pressure may lead to facial pain, heaviness, nasal congestion, and persistent postnasal drip.

Preoperative CBCT is strongly recommended to assess the ostium's location, patency, and anatomy. CBCT also identifies structural anomalies—such as septal deviation, turbinate hypertrophy, or sinus septa—that may impair postoperative drainage.

Intraoperatively, excessive grafting should be avoided to preserve OMC function, particularly in the super-omedial sinus region.

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If clinical signs of obstruction develop, initial treatment is conservative: isotonic saline nasal irrigation, topi-cal decongestants, corticosteroid sprays, and antibiotics if needed. Refractory cases or confirmed obstructive sinusitis may require surgical intervention—typically functional endoscopic sinus surgery (FESS)—to re-store ostium patency (29).

Complications associated with maxillary sinus floor elevation using the transcrestal approach schneiderian membrane perforation

The most common complication associated with the transrectal approach is perforation of the Schneiderian membrane, typically occurring during the osteocondensation phase involving osteotomes. The incidence reported in the literature ranges from 0% to 17% (15). Membrane integrity may be compromised by various factors, including the anatomical configuration of the sinus floor, the surgical technique applied, and the intrinsic properties of the membrane itself.

Perforations are more frequently observed in cases where the sinus floor is oblique or sloped, and when membrane elevation exceeds 3 mm. Additionally, thin Schneiderian membranes are more susceptible to tearing under the axial forces exerted by the osteotomes (16).

Perforation management during the transcrestal approach is inherently more challenging due to the lack of direct visual access. Some authors advocate using autologous platelet derivatives to achieve biological seal-ing of the communication between the sinus cavity and the implant site (17). Others have proposed intro-ducing small fragments of resorbable membrane through the crestal osteotomy to separate the sinus cavity from the apical portion of the implant, especially in cases where simultaneous implant placement is per-formed. When residual bone height allows, an additional treatment option is using shorter implants to avoid protrusion through the membrane defect (18).

Benign Paroxysmal Positional Vertigo (BPPV)

Benign paroxysmal positional vertigo (BPPV) is a rare but documented neurological complication associated with sinus elevation via the crystal approach. It manifests as brief but intense episodes of vertigo and nau-sea, typically triggered by sudden changes in head position. The etiology is multifactorial—idiopathic, post-traumatic, post-infectious, or vascular in origin. The pathogenesis is attributed to the dislodgement of otoliths from the utricular macula into the semicircular canals, disrupting balance perception (30).

A prospective cohort study involving 146 patients undergoing transcrestal sinus lift reported a BPPV inci-dence of 5.84% (31). Symptoms generally appeared within 1–2 days postoperatively and more often affect-ed the side opposite to the surgical intervention. In all cases, symptoms were successfully resolved through canalith repositioning maneuvers, particularly the Epley maneuver—a series of controlled and progressive head movements intended to return the otoliths to their physiological position. Trained professionals must perform this procedure to ensure efficacy and safety (32).

It has been hypothesized that the use of osteotomes, in conjunction with the percussive trauma from the surgical mallet, may be the primary trigger for otolith dislodgement. Furthermore, patient positioning dur-ing the procedure—typically with hyperextension and contralateral inclination of the head—may contrib-ute to otolith migration into the posterior semicircular canal. Prevention involves gentle and progressive surgical maneuvers, minimizing percussive force, and frequently adjusting the patient's head position throughout the procedure.

A randomized clinical trial comparing BPPV incidence in two patient groups treated with conventional os-teotomes versus non-percussive systems found an incidence of 3.06% in the former and 0% in the latter, confirming that reducing vibrational cranial trauma may significantly lower the risk of this complication. Although BPPV often resolves spontaneously, patients should be informed preoperatively of this risk and included in the informed consent documentation (33).

Implant Displacement

Another less frequent but potentially severe complication is displacement of the implant into the maxillary sinus. This may occur intraoperatively due to inadequate assessment of primary stability or excessive apical pressure, or postoperatively due to failed osseointegration or functional overload. Even in the absence of clinical symptoms or radiographic signs of active sinus pathology, dislocated implants should always be removed to prevent future complications, such as infections, chronic sinusitis, or migration of the foreign body into adjacent anatomical regions, including the pterygopalatine fossa, nasal cavity, ethmoid sinuses, sphenoid sinus, or, in extreme cases, the cranial fossa (34).

Three main surgical approaches are described for implant retrieval. The first is the transnasal route, usually performed via functional endoscopic sinus surgery (FESS), which accesses the maxillary sinus through the middle meatus. The second is the transoral approach, involving a canine fossa antrostomy that provides di-rect visualization of the sinus cavity. The third approach consists of reusing the original implant site to access and retrieve the implant, although this is only feasible when no structural damage or infection is present.

The literature recommends using conical implants with reduced apical diameter, which enhances mechani-cal stability, and under-preparation of the implant site to minimize the risk of implant displacement. This technique increases the density of the surrounding cancellous bone and improves primary stability (35).

Bone grafting materials and associated complications in maxillary sinus augmenta-tion

Bone regeneration during maxillary sinus augmentation procedures is typically achieved by placing graft-ing materials that act as scaffolds to facilitate new bone formation and support long-term implant stability. Various graft materials have been used in lateral and transrectal approaches, including autogenous bone, allografts, xenografts, and alloplastic materials—each with distinct biological characteristics and clinical in-dications.

Autogenous bone is considered the gold standard due to its intrinsic osteogenic, osteoinductive, and osteoconductive properties. It can be harvested intraorally from the mandibular ramus or symphysis, or ex-traorally from donor sites such as the iliac crest. However, the use of autologous bone is associated with in-creased surgical morbidity, limited availability, unpredictable resorption, and extended surgical time, which may improve patient discomfort and postoperative complications such as donor site infection, hema-toma, or nerve injury (36).

Allografts, such as demineralized freeze-dried bone allograft (DFDBA), are osteoconductive and variably osteoinductive, depending on the processing techniques. Although they eliminate donor site morbidity, concerns remain regarding immunogenicity, potential disease transmission, and variable biological activi-ty. In rare cases, delayed graft resorption or inflammatory foreign body reactions may occur (37).

Xenografts, particularly deproteinized bovine bone mineral (DBBM), are among the most commonly used materials in sinus floor augmentation due to their excellent volume stability and low resorption rate. How-ever, the persistence of residual graft particles for prolonged periods has been implicated in certain compli-cations, such as chronic sinusitis, particularly when the graft is inadvertently displaced into the sinus osti-um, or in cases of overfilling near the medial wall (38). Additionally, DBBM's purely osteoconductive na-ture requires more extended healing periods before implant placement and has been linked to occasional incomplete bone remodeling.

Alloplastic materials, including synthetic hydroxyapatite, beta-tricalcium phosphate (β-TCP), and biphasic calcium phosphate, are biocompatible, osteoconductive, and free of disease transmission risk. Nevertheless, their clinical performance highly depends on material composition, porosity, and degradation rate. Rapidly resorbing grafts may result in insufficient bone volume at implant placement, while nonresorbing materi-als may impede proper vascularization or lead to fibrous encapsulation (39).

In both lateral and transcrestal sinus lift procedures, complications associated with grafting materials in-clude:

- Graft migration into the sinus cavity or ostiomeatal complex, potentially resulting in obstructive si-nusitis, especially in overfilled sinuses or in cases with Schneiderian membrane perforation. This is more commonly reported in lateral window techniques but has also been described in transcrestal procedures (40).
- Graft infection is a common condition, particularly when membrane perforation occurs or in im-munocompromised patients. Infected grafts may lead to chronic sinus inflammation, peri-implantitis, or require surgical removal (41).
- Foreign body reaction or chronic inflammation, more frequently observed with xenografts and al-loplasts, may compromise the quality of bone regeneration or impair implant osseointegration.
- Inadequate or delayed graft remodeling, particularly with slowly resorbing xenografts or synthetic materials, can delay or prevent optimal implant stability at placement (42).

Recent strategies aim to mitigate these complications through the use of composite grafts, combining differ-ent biomaterials (e.g., xenograft with autogenous chips), or by enriching grafts with biological enhanc-ers such as platelet-rich fibrin (PRF), bone morphogenetic proteins (BMPs), or mesenchymal stem cells, which can promote faster vascularization and enhance bone regeneration (43).

Whenever feasible, an alternative strategy to sinus augmentation procedures is placing implants in basal bone structures, particularly in the anterior or lateral regions of the maxilla, where the cortical bone is denser, more stable, and less subject to resorptive remodeling. Basal bone offers superior mechanical re-sistance, high primary stability, and reduced susceptibility to pneumatization-related volume loss over time. Implant placement in basal bone eliminates sinus lifting and associated complications, such as Schneiderian membrane perforation, graft-related infections, and obstructive sinusitis, simplifying the sur-gical workflow (44).

Discussion

Managing complications associated with maxillary sinus augmentation procedures requires a multifactorial and phase-specific approach, as each adverse event—whether intraoperative or postoperative—carries dis-tinct clinical implications and therapeutic challenges. This section discusses the main therapeutic strategies described in the literature, highlighting clinical evidence and consensus-based recommendations.

Perforation of the Schneiderian membrane remains the most common intraoperative complication, with a mean reported incidence of 20–25%, as confirmed by Raghoebar et al. in a 2019 meta-analysis (15). Clinical management is primarily dictated by the size and location of the tear: minor defects, especially in naturally folded areas of the membrane, may heal spontaneously or be sealed with fibrin glue, whereas larger le-sions typically require placement of resorbable membranes or, in severe cases, abortion of the procedure with re-entry after 6–8 weeks (21). Schwarz et al., in a retrospective analysis of 407 sinus lift procedures, emphasized the critical role of CBCT-based preoperative planning to assess membrane thickness, presence of bony septa, and sinus morphology—all known risk factors for perforation (21).

Postoperative complications such as chronic rhinosinusitis are often secondary to infection of the graft mate-rial or obstruction of the ostiomeatal complex. Studies by Hernández-Alfaro et al. (24) and Moreno Vázquez et al. (22) have demonstrated how membrane perforation, graft overfilling, or implant protrusion into the sinus cavity may predispose to persistent mucosal inflammation. Initial management is conservative, in-cluding systemic antibiotics, nasal irrigation, and corticosteroids, but refractory cases often require surgical resolution via functional endoscopic sinus surgery (FESS).

Hemorrhagic events, although less frequent, can significantly hinder surgical outcomes by compromising intraoperative visibility and increasing procedure duration. As described in the cadaveric study by Solar et al., the alveolar-antral artery—formed by the anastomosis between the posterior superior alveolar

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artery and the infraorbital artery—is particularly at risk during lateral wall osteotomy (25). Anatomical variability in vessel size and location, as documented by Güncü et al. (26), necessitates careful CBCT assessment to plan osteotomy design. Hemostasis may be achieved through direct compression, bone wax, or ligation, depending on accessibility and bleeding intensity.

Different studies have highlighted the advantages and limitations of each class of grafting materials used in sinus augmentation. Autogenous bone remains the gold standard due to its osteogenic, osteoinductive, and osteoconductive potential. Still, it is associated with donor site morbidity, limited availability, and increased operative time, as discussed by Aghaloo and Moy (7). Allografts and xenografts eliminate the need for donor harvesting but may elicit foreign body reactions or persistent inflammation, especially in cases of overfilling or when displaced near the sinus ostium. Wallace and Froum (4) reported that deproteinized bovine bone mineral (DBBM), while highly stable volumetrically, may persist unresorbed for years and contribute to delayed or incomplete bone remodeling.

Although rare, benign paroxysmal positional vertigo (BPPV) has been increasingly reported following transcrestal sinus lift using osteotomes. In a randomized controlled trial, Sammartino et al. showed that patients treated with percussive osteotomes exhibited a significantly higher incidence of BPPV than those treated with non-percussive systems (32). The presumed pathogenesis involves otolith dislodgement caused by vibratory trauma during malleting, compounded by patient head positioning. Preventive measures in-clude the use of less traumatic instruments and progressive adjustment of head angulation during the pro-cedure.

Implant displacement into the maxillary sinus represents a severe complication that may occur intraopera-tively, due to inadequate primary stability, or postoperatively, due to failed osseointegration or overload. In a case reported by Xia et al. (34), implant migration occurred without any apparent membrane perforation and was resolved through endoscopic transnasal retrieval. Preventive strategies include using tapered im-plants with narrower apical diameters and under-preparation of the implant bed to maximize bone con-densation and primary stability, as suggested by Ding et al. (33).

Some authors propose strategically placing implants in basal bone as a valid alternative to sinus lift proce-dures, especially when anatomical conditions permit. Basal bone—found in the anterior or lateral maxilla—provides dense cortical anchorage, superior mechanical strength, and minimal resorption over time. This approach eliminates the need for sinus grafting and its associated risks—such as membrane perforation, in-fection, and obstructive sinusitis—streamlining the surgical workflow and improving predictability (44).

Conclusion

Within the limitations of the present study—primarily its narrative design and the heterogeneity of the included sources—it can be concluded that maxillary sinus augmentation procedures, while well-established in clinical practice, are associated with a non-negligible risk of complications. Careful patient selection, thorough preoperative planning, and minimally invasive surgical techniques are essential to mitigate ad-verse events. Further prospective and controlled clinical studies are warranted to establish standardized protocols and effective preventive strategies.

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