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Overview of complications in sinus elevation surgery

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ABSTRACT: Sinus elevation is a common procedure to increase bone volume in the posterior maxilla for dental implants. While effective, complications can arise, the most frequent being Schneiderian membrane perforation, which can lead to sinus infections, graft failure, or the need for revision surgery. Other complications include postoperative infections, sinusitis, graft migration, and, in rare cases, oroantral fistula formation or excessive bleeding. Proper patient selection, thorough preoperative assessment, and careful surgical technique are key to reducing these risks and ensuring successful outcomes.
KEYWORDS: Maxillary Sinus; Dental Implants; Membrane Perforation; Bone Grafting; Postoperative Complications

I. INTRODUCTION:

The placement of dental implants has become a cornerstone in modern dentistry, particularly for restoring functionality and aesthetics in patients with missing teeth. Among the various sites for implantation, the posterior maxilla presents unique challenges due to its anatomical complexities, including limited bone quality and proximity to vital structures such as the maxillary sinus. As the demand for successful implant outcomes rises, understanding the potential complications associated with sinus augmentation procedures is essential.[1]

Inadequate treatment planning, insufficient bone density, and surgical techniques can lead to intraoperative issues like membrane perforation, bleeding, and implant displacement, as well as postoperative complications such as swelling, graft failure, and infections.[1]

This highlights the necessity for effective management strategies, including thorough preoperative assessments and precise surgical interventions, to enhance patient outcomes and mitigate risks. Through a comprehensive exploration of these factors, this topic aims to provide insights into the complexities of dental implant placement in the posterior maxilla and the importance of meticulous planning and execution in achieving successful results.[2]

Etiology:
The etiologies of sinus elevation complications are,[3]

Pre-existing systemic diseases and medications related
- Uncontrolled diabetes
- Osteoporosis
- Bisphosphonate medication
- Immunocompromised patients
- Cigarette smoking

Anatomy and surgical procedure-related
- Perforation of membrane
- Sinus septa
- Onlay graft and residual bone height
- Bleeding
- Displacement of implants into sinus
- Obliteration of sinus cavity

Sinus pathology related
- Pseudo-cysts
- Retention cysts
- Mucocele

Infection-related
- Infection
- Swelling/hematoma
- Incision line opening/ wound dehiscence
- Bone sequestrum/ fragments
- Sinusitis
- Oroantral fistula

Prosthetic related
- Postoperative temporary prosthesis
- Implant length and diameter
- Insufficient number of implants
- Increased occlusal table
- Nonsplinted implants

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Pre-existing systemic diseases and medications related:

Uncontrolled diabetes increases susceptibility to complications due to a weakened immune response, affecting graft turnover and increasing infection risk after sinus elevation. While studies show no significant impact of diabetes control on implant outcomes, sinus proximity makes infection more likely[3].

Osteoporosis, especially in patients on bisphosphonate therapy, leads to higher implant failure rates (40-46%). Prolonging healing time before implant placement is recommended—8 months in the maxilla and 6 months in the mandible. Immunocompromised patients are often contraindicated for sinus augmentation due to impaired healing. Smoking significantly raises implant failure (7-17%) and infection rates, with smokers having a higher prevalence of complications. Common complications in sinus lifts include perforation (60%), infection (21%), bleeding (9%), and rare issues like implant dislocation or benign vertigo.[4-8]

a) Surgical

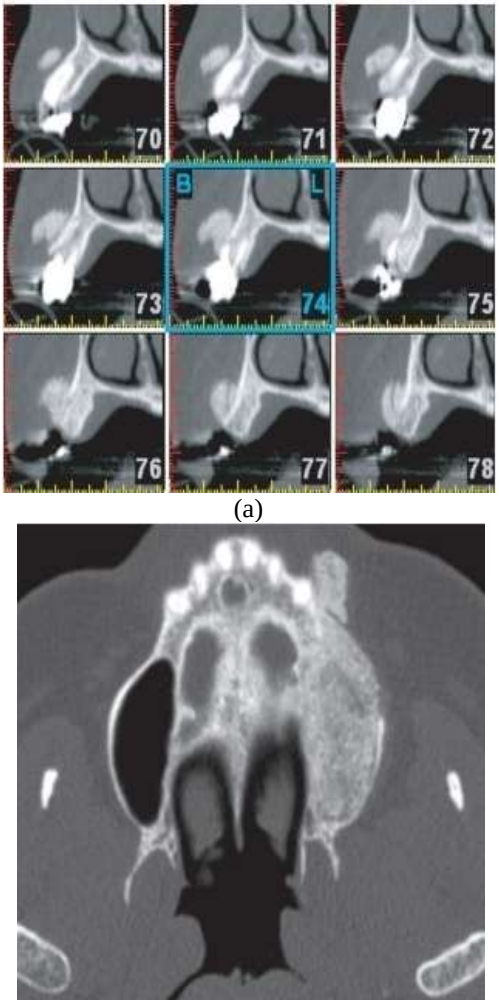
Scniederain membrane perforation:

The most common complication during sinus augmentation is the perforation of the Schneiderian membrane, which protects the maxillary sinus. Tears in the membrane allow direct contact between graft material and the sinus cavity, leading to infection and chronic sinusitis, potentially reducing graft volume. Collagen membranes are typically used to repair perforations, with larger tears (2-3 cm) being more challenging than smaller ones (2-5 mm).[11]

Repair methods include folding the membrane, covering it with collagen tape, or using resorbable membranes. Perforations occur frequently in lateral wall sinus augmentation, with incidence rates between 20% and 44%, though they generally do not affect long-term implant survival. Endoscopic evaluation is accurate but clinical observation is more commonly used to detect perforations during surgery.[12]

Dislodgement of graft material into sinus

Bone graft particles can sometimes be forced into the sinus cavity during augmentation. To prevent this, the graft material should be packed sequentially against the anterior, posterior, and medial walls of the lateral window, avoiding pressure into the sinus, with the vestibular wall filled last. For small Schneiderian membrane perforations, a collagen membrane can be placed over the tear to contain the graft. Mixing the graft with calcium sulfate is also recommended, as it acts as a binder when set, preventing the graft material from migrating into the sinus.[13] (Fig. 1)



(a)

(b)

Figure 1: (a) Displaced graft material following intrasinus bleeding (cross-sectional view). (b) Displaced graft material following intrasinus bleeding (axial computed tomography view)

Dislodgement of implant into sinus

This complication is more common with cylindrical implants in the posterior maxilla and can still occur with screw-form implants when biological boundaries are pushed. It is typically caused by inadequate or early loss of primary stability, or bone loss due to infection. Many clinicians reserve simultaneous implant placement for patients with at least 4-5 mm of crestal bone, though success has been reported with as little as 1-2 mm. However, placing implants in 1-3 mm of crestal bone carries risks. If primary closure is not maintained, early biologic width formation may lead to significant bone loss before the graft has fully matured.[14,15] (Fig. 2)

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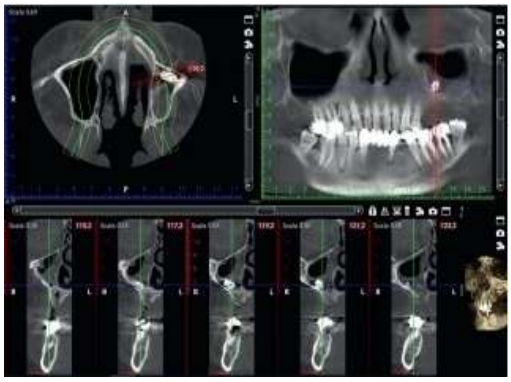

Figure 2: Migration of implant into the sinus cavity

Contamination of site/graft trauma to adjacent tooth:

Bone graft particles can sometimes enter the sinus cavity during augmentation. To prevent this, the graft should be packed sequentially against the anterior, posterior, and medial walls of the lateral window, avoiding pressure into the sinus, with the vestibular wall filled last. For small Schneiderian membrane perforations, a collagen membrane can be placed over the tear to contain the graft. Mixing the graft with calcium sulfate is also recommended, as it acts as a binder when set, preventing displacement of the graft into the sinus.[16]

Overfill:

Overfilling the elevated sinus with graft material can lead to perforation of the Schneiderian membrane, loss of graft material into the sinus, and potential sinus infection. Patients may report feeling particles in their throat for several days. Overfilling can also obstruct the ostium, leading to sinus congestion, infection, or increased pressure. In rare cases, increased sinus pressure may cause graft material to leak through the lateral window. Postoperative bleeding, sneezing, and nose blowing can also elevate sinus pressure, risking the displacement of graft material.[17-19]

Incision Line Opening/Wound Dehiscence:

Proper tissue manipulation is essential for wound closure after surgery, and a tension-free flap is crucial for undisturbed healing and reducing the risk of incision line opening. Using membranes over the lateral window can increase the risk of dehiscence and incision line opening due to challenges in achieving tension-free closure and proper flap adaptation. Studies with nonabsorbable membranes have shown a higher risk of dehiscence, which negatively impacts implant survival. Recent literature reports membrane dehiscence rates ranging from 12.5% to 28%, making it the most common postoperative complication.[20,21]

Excessive bleeding

Intraoperative bleeding during sinus surgery often occurs from severing or damaging blood vessels in the lateral wall of the sinus and surrounding tissues (Fig. 3). Typically minor and short-lived, this bleeding can sometimes be profuse and difficult to control. The blood supply to the lateral wall comes from the intraosseous and extraosseous branches of the posterior superior alveolar artery, which forms an arterial arcade with the infraorbital artery. Bleeding may result from soft tissue injury during flap elevation or from the lateral bony wall during lateral window preparation. The medial sinus wall can also bleed if the posterior lateral nasal artery is damaged. These arteries, which include branches of the maxillary artery, play a key role in providing blood for the vascularization of the sinus graft.[23]

Prevention:

While bleeding may not always occur when the posterior superior alveolar artery is damaged, utilizing 3D planning can help avoid its contact. Visualization of the artery during flap elevation allows for a coronal window creation, facilitating internal membrane elevation. However, the artery's path can vary, making it vulnerable to rotary and hand instruments, especially during vertical incisions.[23]

To mitigate bleeding risks, it's crucial to identify the artery's location on cross-sectional CT scans and use instruments that protect vascular and soft tissues. Diamond burs are preferred over carbide burs as they reduce the risk of membrane damage. Piezosurgery®, developed by Vercellotti, employs low-frequency ultrasonic vibrations (24-32 kHz) to safely cut bone while preserving surrounding soft tissues, including the Schneiderian membrane. This technique has minimized soft-tissue complications in various oral surgeries since its U.S. introduction in 2005 and is particularly effective in reducing bleeding during lateral window preparation. A recent systematic review noted similar membrane perforation rates between rotary and piezoelectric methods, emphasizing that operator experience is a more critical factor than the surgical technique itself.[23,24]

Treatment:

Many techniques exist to control vascular bleeding in sinus elevation surgery.

These include:

• Direct pressure on the bleeding point.

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• Use of a localized vasoconstrictor.
• Bone wax.
• crushing the bone channel around the vessel (hemostat).
• Use of electrocautery (with care near membranes).
• suturing the vessel proximal to the bleeding point.

Using a vasoconstrictor (1:50,000 epinephrine) is more effective than electrocautery for managing soft tissue bleeding during flap elevation. Electrocautery is preferred for bone bleeding but should be used cautiously near the Schneiderian membrane to avoid damage.

To control bleeding, compressing an intrabony vascular channel can help, but care must be taken to prevent membrane perforation. Surgeons can prevent perforation by carefully releasing the membrane and using suction for visibility before clamping the vessel. Although bleeding during sinus elevation is usually mild, it can sometimes be pulsating.

Visual severity often exceeds the actual condition, as pulsating bleeding often stops on its own or with direct pressure. Positioning a high-volume, narrow-tipped evacuator near the bleeding site minimizes blood flow into the surgical field, allowing the procedure to continue. Typically, bleeding ceases by the end of grafting, and postoperative bleeding is rare after closure. Suction is mainly for visibility rather than bleeding control, which it can hinder.[25]

Best clinical practice includes:
• obtain preoperative computed tomography images to locate the vessel.
• visualize the vessel clinically.
• avoid the vessel, if appropriate, when designing the window.
• use piezoelectric surgery to avoid trauma to the vessel.
• have materials on hand to control bleeding (electrocautery, local with 1:50 000 epinephrine, bone wax, resorbable suture material).[25]

Figure 3: Artery visualized in the lateral wall after flap reflection

b) Post operative complications

Postoperative complications have been reported in up to 20% of cases and may include sinus infections, hemosinus, oro-antral fistulae, and loss of grafts or implants. Treatment for infections generally consists of antibiotics and careful patient monitoring. If a graft becomes infected during healing or is exposed post-surgery, it should be removed, and the area should be allowed to heal for at least six months before considering regrafting.[26]

Infection:

Infection is a rare but significant complication of surgical procedures, including sinus augmentation, where it can adversely affect graft and implant survival. A study by Peleg et al. found that 61.4% of failed implants in augmented sinuses were associated with postoperative infections, making it the primary cause of implant failure. If a graft becomes infected, complete removal may be necessary to prevent further damage. [27-30]

After the infection is resolved, the sinus can be regrafted. An antibiotic regimen along with nasal decongestants is initiated before and continued during the healing process. Literature reviews indicate that acute sinusitis is often caused by Haemophilus influenzae, followed by Moraxella catarrhalis, Streptococcus pneumoniae, and methicillin-sensitive Staphylococcus aureus. This suggests that amino-penicillins like amoxicillin may be the preferred antibiotic for treating acute sinus infections following augmentation procedures.[31]

Bone Sequestrum/Fragments:

Simultaneous dental implant placement during sinus augmentation is a viable option for patients with sufficient crestal bone. However, it's crucial to avoid dislodging bone fragments into the sinus cavity during osteotomy preparation, as the migration of cancellous bone fragments has been linked to sinusitis. In such cases, endoscopic removal or debridement may be required to resolve the issue.[32]

Bleeding/ Nose Bleeding/ Hemosinus:

Postoperative bleeding can occur if flap management and closure are inadequate. Applying pressure to the surgical area immediately after closure may help reduce this risk. Prolonged bleeding might also be due to medications or undiagnosed bleeding disorders, such as hemophilia B or liver disease, necessitating physician consultation. Membrane perforations can lead to postoperative nosebleeds, as they create direct communication between the nasal cavity and

the sinus graft. During healing, increased vascularity in the graft area can cause blood to seep into the maxillary sinus ostium and exit through the nose. Patients should be treated with nasal decongestants and antibiotics, and close monitoring for infection is essential.[33-35]

Proper tissue manipulation is crucial for successful wound closure. A tension-free flap is necessary to promote undisturbed healing and minimize the risk of incision line opening or dehiscence. The use of membranes over the lateral window can complicate achieving tension-free closure and may increase the likelihood of dehiscence. Studies indicate that the use of nonabsorbable membranes can raise the risk of postoperative dehiscence, which has been reported between 12.5% and 28% and is a common complication affecting implant survival.[36,37]

Hematoma:

Postoperative complications following invasive surgery may include swelling, purulent discharge, and hematoma formation. Due to the vascular nature of the sinus cavity, achieving hemostasis can be challenging; swelling and hematomas have been reported in 65% of sinus augmentation procedures clinically and in 89% endoscopically. To reduce postoperative swelling, protocols typically include non-steroidal anti-inflammatory drugs and steroids.[38]

Purulent discharge often indicates an active infection, requiring close monitoring during the postoperative phase. If graft infection is suspected, complete removal of the graft or secondary graft placement may be necessary. Otherwise, managing purulent discharge involves ensuring complete drainage and administering antibiotic therapy.[39]

Sinusitis (Nasal Congestion, Purulent Discharge, Headaches):

Sinusitis is characterized by a triad of symptoms: nasal congestion, purulent discharge, and headaches. Key clinical indicators for diagnosing sinusitis include mucosal redness and edema, along with purulent discharge around the ostium. To minimize the risk of sinusitis following augmentation, preoperative screening is essential for patients with predisposing factors. Studies indicate that patients with chronic sinusitis and congestion are more likely to experience postoperative sinusitis after sinus augmentation. [40]

Preoperative administration of antibiotics, steroids, and decongestants is recommended to reduce the risk of ostial obstruction after surgery. In cases of transient postoperative sinusitis, decongestants and antibiotics should be used, with close monitoring for any worsening symptoms. If sinusitis persists beyond two weeks and becomes chronic, surgical endoscopy may be required.[40]

Oroantral Fistula:

Communication between the sinus and oral cavity can result from molar extractions, loss of implants placed in the sinus, or inadequate wound healing after sinus augmentation. If this communication remains open, epithelialization can lead to the formation of an oroantral fistula.[41] Chronic sinusitis is often associated with oroantral fistulas and can hinder implant therapy related to sinus augmentation.[42]

Various techniques are recommended in the literature for mobilizing a flap or using free soft tissue grafts to cover the oroantral fistula effectively.[43]

Prosthetic-related complications:

Prosthetic-related complications following sinus augmentation can arise from inadequate engineering, particularly when overloading softer bone. The strength of the maxillary posterior region can be up to ten times weaker than denser areas in the mandible. Therefore, restorations in these areas must ensure proper biomechanics to maintain health and prevent excessive crestal bone loss during loading.[44]

b) Postoperative Temporary Prosthesis:

Complications related to prosthetics often involve the use of postsurgical temporary prostheses, making effective wound management crucial for successful augmentation procedures. Patients typically require interim prostheses during the healing phase before final implant placement or prosthetic treatment. Full or partial dentures may be used in the absence of transitional implants, but they can exert excessive force on the incision line, maturing bone grafts, or integrating implants.[45]

To ensure undisturbed healing and prevent premature loading or displacement of dental implants, proper relief around augmented or implanted areas is essential. There have been reports of dental implants dislodging into the sinus cavity following loading. Retrieval of these implants often necessitates endoscopy or the Caldwell-Luc procedure, which can generally be avoided with careful planning and patient monitoring.[45]

Implant Length and Diameter:

Osseointegration of implants placed in the posterior mandible is less predictable than in other areas, primarily due to the softer bone found in this

region. Misch classified the bone in the posterior maxilla as Type IV, and studies indicate that implants in these areas have a higher likelihood of failure.[44]

To enhance the predictability of osseointegration, increasing the surface area and bone-to-implant contact by enlarging the implant's length and width is effective. Increasing the diameter of the implant significantly impacts surface area more than length does, leading some implant manufacturers to focus on this aspect in their designs. Moreover, increasing the size of the implant in either dimension, along with adding more threads, has been shown to reduce the strain transmitted to the surrounding bone.[44]

Insufficient Number of Implants:

Increasing the number of implants significantly impacts load distribution and enhances bone-to-implant contact, making it especially important for patients with parafunctional habits. Research on the long-term success of implants placed in the posterior maxilla indicates that a greater number of implants may lead to improved outcomes. Adding more implants can also help decrease strain on the bone and reduce crestal bone loss, particularly after loading. A wider occlusal table can contribute to minimizing bone loss by distributing forces more evenly. Eliminating excursive and non-working contacts has been shown to reduce strain on the bone and decrease the bending of implants.[45]

A study by Cehreli and Iplikcioglu found that reducing bending moments on implants can be achieved through proper implant placement, narrow occlusal surfaces, and ensuring occlusal contacts promote axial loading.[46]

Nonsplinted Implants:

Splinted implants effectively distribute stress evenly across the framework, reducing the total stress transmitted to the alveolar bone. This approach is particularly beneficial for preserving bone levels around implants placed in augmented sinuses and should be considered for implants that are placed off-axially.[47]

Off-axial implants tend to transmit greater crestal strain to the surrounding bone, which can be partially mitigated by splinting them to adjacent implants. However, it's important to note that strain around terminal implants is typically greater than that experienced by middle implants within a splinted trio.[47]

Displacement of dental implants:

Displacement of dental implants into adjacent anatomical structures is a recognized complication that can arise from inadequate treatment planning and lack of initial stability due to insufficient bone height and quality. Such displacement can lead to serious consequences, including sensory disturbances, maxillary sinusitis, and oroantral fistulas.

Migration of implants into areas like the ethmoid and sphenoid sinuses, orbit, nose, and anterior cranial fossa is less common. Factors contributing to this displacement include poor surgical technique, unrecognized perforations, excessive tapping of the implant, or applying excessive force. An autoimmune reaction causing peri-implant bone destruction can also result in loss of integration.[48]

The Caldwell-Luc technique has been suggested for retrieving displaced dental implants or foreign bodies from the sinus, but if an implant is embedded near the orbit, retrieval can become challenging, necessitating additional surgeries and incurring extra costs for the patient.[48]

Early postoperative complications such as swelling and slight bleeding are common and typically transient. However, exposure of the underlying membrane due to suture line opening often occurs due to excessive swelling, highlighting the importance of providing clear postoperative instructions to patients. Late complications can include graft loss, leading to implant failure and potential migration to other anatomical structures, as well as the development of oroantral fistulas.[49]

Acute postoperative sinusitis can occur in up to 4.7% of sinus graft procedures. Rhino sinusitis is a well-documented complication associated with sinus lift procedures, sometimes requiring further surgical intervention to manage infection. Typically, infections manifest more than a week after surgery, and patients with predisposing factors for sinusitis face a 3-20% risk of developing postoperative transient sinusitis.[49]

Limitations of sinus augmentation procedures:

The placement of dental implants has become a vital treatment option for missing teeth, with the primary requirement being the presence of adequate bone. Bone grafting is performed where there is a deficiency. Research indicates that the maxillary sinus expands in the absence of teeth, leading to thin bone that is unsuitable for implant placement. In such cases, bone grafting is achieved through direct or indirect sinus lifts to increase bone height in the posterior maxilla. This procedure was first described by Dr. Hilt Tatum at an

Alabama implant conference in 1976, paving the way for new techniques in tooth replacement.[50]

However, the maxillary sinus is a delicate area with several vital structures that must be considered during treatment planning. Failure to account for these factors can lead to significant complications, including:

1. Intraoperative Complications: Bleeding, buccal flap tears, infraorbital nerve injury, and membrane perforation.
2. Early Postoperative Complications: Incision line opening, bleeding, barrier membrane exposure, and infraorbital nerve paresthesia.
3. Late Postoperative Complications: Graft loss or failure, implant failure, oroantral fistula, implant migration, and inadequate graft fill.

Membrane perforation is one of the most common intraoperative complications, occurring in about 7-44% of procedures. This can lead to acute or chronic sinus infections, loss of graft material, and disruption of normal sinus physiology. If perforation occurs, grafting should be postponed for 2-3 weeks until the membrane has healed. Some authors argue that grafting can still be performed even after a membrane tear, as no direct link between perforation and implant survival has been established.[51]

Anatomical factors such as sinus septa, mucosal swelling, mucoceles, narrow sinuses, osteotomy design, or increased lateral wall thickness can increase the risk of membrane perforation. Therefore, the surgical site must be free of pathologies before performing a sinus lift.

Bleeding is another common complication. While slight bleeding is normal, profuse bleeding may indicate damage to the vascular supply of the lateral wall of the sinus or surrounding tissues. Control of bleeding is critical, and bone grafting should only commence once the clinician is confident that hemorrhaging has been addressed.[51]

II. CONCLUSION:

In summary, dental implants in the posterior maxilla are crucial for replacing missing teeth but can lead to complications due to inadequate planning, bone quality, and surgical techniques. Intraoperative challenges include membrane perforation, bleeding, and implant displacement, while postoperative issues may involve swelling, graft loss, and infections, particularly acute sinusitis. To minimize these risks and enhance success, effective management strategies such as thorough preoperative assessments and precise surgical techniques are essential.

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