

BONE AUGMENTATION IN IMPLANT DENTISTRY; COMPARATIVE EVALUATION OF LATERAL WINDOW VERSUS CRESTAL APPROACH FOR MAXILLARY SINUS FLOOR AUGMENTATION — A SYSTEMATIC REVIEW

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Abstract

Insufficient bone volume in the posterior maxilla remains one of the principal challenges in implant dentistry. Progressive alveolar bone resorption and maxillary sinus pneumatization frequently compromise implant placement, necessitating sinus floor augmentation procedures. The lateral window and crestal (transcrestal) approaches are the most commonly utilized surgical techniques for maxillary sinus augmentation. Despite their high clinical success rates, controversy persists regarding indications, surgical morbidity, implant survival, and complication rates between these methods.

The purpose of this systematic review was to comparatively evaluate the lateral window and crestal approaches for maxillary sinus floor augmentation in implant dentistry, focusing on implant survival, bone gain, surgical complications, postoperative morbidity, and long-term clinical outcomes.

An electronic search of PubMed, Scopus, Web of Science, Cochrane Library, and ScienceDirect databases was conducted for articles published between January 2020 and March 2026. Thirty-six studies fulfilled the inclusion criteria. The lateral window approach demonstrated superior vertical bone augmentation in severely atrophic maxillae with residual bone height below 5 mm, achieving implant survival rates between 92% and 98%. The crestal approach showed lower postoperative morbidity, reduced surgical trauma, and shorter healing time, with implant survival rates ranging from 94% to 99% in moderately resorbed posterior maxillae. Membrane perforation represented the most common complication and was more frequently associated with the lateral approach.

Both techniques are clinically predictable and highly successful when appropriately indicated. The lateral window technique remains the gold standard in severe maxillary atrophy requiring extensive bone augmentation, whereas the crestal approach offers a minimally invasive alternative with lower patient morbidity in cases with adequate residual bone height. Appropriate case selection and surgical expertise remain fundamental determinants of long-term success.

Keywords Bone augmentation; sinus lift; lateral window; crestal approach; dental implants; maxillary sinus augmentation; implant dentistry

Introduction

Bone augmentation is a fundamental surgical procedure in contemporary implant dentistry aimed at increasing the quantity and quality of alveolar bone in areas where insufficient bone volume prevents ideal implant placement. Successful osseointegration and long-term implant stability depend heavily on adequate bone height, width, density, and vascularity. However, after tooth extraction, traumatic injury, periodontal disease, congenital defects, cystic lesions,

or prolonged edentulism, the alveolar ridge undergoes progressive physiological resorption that may significantly compromise implant rehabilitation.

The posterior maxilla represents one of the most anatomically challenging regions in implant dentistry due to rapid alveolar bone resorption combined with pneumatization of the maxillary sinus. Following tooth loss, the sinus progressively expands inferiorly, resulting in reduced vertical bone height and poor bone density, frequently classified as type III or IV bone quality according to Lekholm and Zarb classification. Consequently, implant placement in this region often becomes impossible without prior augmentation procedures.

Bone augmentation therefore plays a crucial role in restoring adequate bone architecture necessary for predictable implant-supported rehabilitation. The primary objective of augmentation procedures is to regenerate sufficient hard tissue volume capable of supporting osseointegrated implants under long-term functional loading. In addition to increasing bone quantity, augmentation procedures aim to improve bone quality, vascularization, biological stability, and biomechanical support around implants.

The importance of bone augmentation extends beyond implant placement alone. Adequate bone volume is essential for:

- Achieving primary implant stability

- Ensuring long-term osseointegration

- Improving biomechanical load distribution

- Enhancing peri-implant tissue stability

- Optimizing esthetic outcomes

- Reducing implant failure risk

- Preventing prosthetic complications

Several augmentation techniques have been developed in modern implantology, including:

- Guided bone regeneration (GBR)

- Onlay grafting

- Ridge splitting

- Block grafts

- Sinus floor augmentation (lateral window approach and crestal approach)

Distraction osteogenesis

Among these procedures, maxillary sinus floor augmentation has become one of the most predictable and extensively studied techniques for rehabilitation of the atrophic posterior maxilla.

The biological success of bone augmentation depends greatly on the regenerative capacity and quality of the newly formed bone. Ideal regenerated bone should demonstrate:

- Adequate mineralization

- Sufficient vascular supply

- Mechanical stability

- Favorable remodeling potential

- High osteoconductive and osteoinductive properties

Bone quality significantly influences implant survival and long-term clinical outcomes. Poor bone density may compromise primary stability, delay osseointegration, and increase micromovement at the bone–implant interface. Consequently, achieving high-quality regenerated bone has become a major focus of contemporary regenerative implant dentistry.

Modern regenerative protocols utilize various grafting materials including:

- Autogenous bone grafts

- Allografts

- Xenografts

Alloplastic biomaterials

Growth factors and biologics

Autogenous bone remains the gold standard because of its osteogenic, osteoinductive, and osteoconductive properties. Nevertheless, xenografts and synthetic biomaterials have gained increasing popularity due to reduced donor-site morbidity and favorable long-term volumetric stability. Advances in tissue engineering, biomaterials, piezosurgery, platelet concentrates, and digital surgical planning have substantially improved the predictability and safety of augmentation procedures. Contemporary literature demonstrates implant survival rates exceeding 90–95% in augmented bone when proper surgical protocols and patient selection criteria are respected.

Within sinus floor augmentation procedures, two principal surgical approaches dominate current clinical practice:

The lateral window approach

The crestal (transcrestal) approach

Both methods aim to elevate the Schneiderian membrane and create sufficient vertical bone height for implant placement. However, they differ considerably in surgical invasiveness, achievable bone gain, complication profile, healing dynamics, and clinical indications.

The lateral window approach was initially introduced for severely atrophic maxillae requiring substantial vertical bone gain. It involves preparation of a lateral bony window followed by Schneiderian membrane elevation and graft placement. This approach provides direct surgical visualization and extensive augmentation capacity but is associated with greater surgical invasiveness and postoperative morbidity. Still remains the preferred technique in cases of severe posterior maxillary atrophy requiring substantial augmentation.

Conversely, the crestal approach utilizes osteotomes or osseodensification through the alveolar crest to elevate the sinus membrane indirectly. It is considered minimally invasive, demonstrates lower morbidity, and is generally indicated in cases with moderate residual bone height.

Recent advances in implant surface technology, biomaterials, guided surgery, piezosurgery, and osseodensification techniques have significantly modified the indications and outcomes of both approaches. Contemporary literature suggests excellent implant survival rates with both methods, although significant differences remain regarding complication frequency, patient comfort, surgical indications, and achievable bone gain. Understanding the biological principles, indications, limitations, and clinical outcomes of both augmentation techniques is essential for achieving predictable implant rehabilitation and long-term functional success in modern implant dentistry.

This systematic review critically analyzes recent evidence from relevant medical and dental journals to comparatively evaluate lateral window and crestal sinus augmentation approaches in implant dentistry.

Materials and methods

Focused Question

The review addressed the following PICO question:

“In patients with atrophic posterior maxilla requiring implant rehabilitation, does the lateral window approach provide superior clinical outcomes compared with the crestal approach regarding implant survival, bone augmentation, and complication rates?”

Electronic database searches were conducted in:

PubMed/MEDLINE

Scopus

Web of Science
Cochrane Library
ScienceDirect

The search period included studies published between January 2020 and March 2026.

The following search terms were utilized: “maxillary sinus augmentation” , “lateral window sinus lift” , “crestal sinus lift” , “transcrestal sinus floor elevation” , “bone augmentation in implant dentistry” , “osseodensification sinus lift” , “implant survival sinus augmentation” , “sinus membrane perforation” .

Inclusion Criteria

The following studies were included:

Randomized controlled clinical trials

Prospective studies

Retrospective cohort studies

Systematic reviews

Human clinical studies

Publications from the last 5 years

Exclusion Criteria

Excluded studies included:

Animal studies

Case reports

Studies without implant survival data

Publications before 2020

Data Extraction

The following variables were extracted:

Residual bone height (RBH)

Implant survival rate

Vertical bone gain

Schneiderian membrane perforation

Biological complications

Prosthetic complications

Postoperative pain and swelling

Healing period

Follow-up duration

Results

Study Selection

The initial electronic search identified 1,547 studies. After duplicate removal and eligibility screening, 36 studies fulfilled the inclusion criteria for qualitative analysis.

The included literature comprised:

10 systematic reviews

8 randomized clinical trials

11 prospective studies

7 retrospective cohort analyses

Lateral Window Approach

Surgical Characteristics

The lateral window approach, also known as the lateral antrostomy technique or direct sinus lift procedure, is a surgical method used for maxillary sinus floor augmentation in patients with insufficient vertical bone height in the posterior maxilla. It is considered the gold standard technique for severe maxillary atrophy and allows direct visualization and elevation of the Schneiderian membrane with simultaneous placement of grafting material and, in many cases, dental implants.

This technique is generally recommended in:

Severe posterior maxillary atrophy

Residual bone height below 4-5 mm

Extensive vertical augmentation requirements

Prior implant rehabilitation

The fundamental principle of the technique is:

Creation of a bony window in the lateral wall of the maxillary sinus

Careful elevation of the Schneiderian membrane

Formation of a subantral compartment

Placement of bone graft material beneath the elevated membrane

Simultaneous or delayed implant placement depending on primary stability

The elevated sinus membrane acts biologically as a compartment that protects the graft material and facilitates new bone formation.

Clinical importance

The lateral window approach remains one of the most predictable regenerative procedures in implant dentistry. It enables implant rehabilitation in patients who otherwise would not qualify for implant treatment because of severe posterior maxillary bone deficiency. Long-term studies report implant survival rates exceeding 95%,

Implant Survival Rates

Recent systematic reviews reported implant survival rates ranging between 92% and 98% for the lateral approach making this procedure highly reliable when proper surgical principles and patient selection criteria are respected. Long-term implant success appears comparable to implants placed in native bone.

Several studies concluded that lateral sinus augmentation provides excellent primary stability even in severely atrophic maxillae.

Bone Gain

The lateral approach demonstrated the highest vertical augmentation capacity among all sinus lift techniques.

Average vertical bone gain:

8–12 mm

This substantial augmentation makes the technique ideal for complex implant rehabilitation in severely resorbed posterior maxillae.

Complications

The most frequently reported complication was Schneiderian membrane perforation. Recent evidence demonstrated perforation rates between:

10% and 35%

Additional complications included:

Bleeding

Sinus infection

Graft migration

Postoperative edema

Delayed healing

Small residual ridge height was identified as an important risk factor for membrane perforation.

Crestal Approach

Surgical Characteristics

The crestal approach, also known as the transcresal sinus lift, osteotome sinus floor elevation, or indirect sinus lift technique, is a minimally invasive surgical procedure used for maxillary sinus floor augmentation through the alveolar crest. The technique was originally introduced by Robert B. Summers and is widely utilized in implant dentistry for patients with moderate posterior maxillary bone deficiency.

Unlike the lateral window approach, the crestal technique elevates the Schneiderian membrane indirectly through the implant osteotomy site without creating a lateral bony window. The crestal or transalveolar approach elevates the sinus membrane indirectly through the alveolar crest using osteotomes or osseodensification instruments.

This minimally invasive technique is recommended when:

Residual bone height exceeds 5 mm

Limited vertical augmentation is required

Reduced postoperative morbidity is desired

Simultaneous implant placement is planned

The crestal approach has gained increasing popularity due to improvements in osseodensification and minimally invasive implant protocols.

Biological principle of the crestal approach

The biological concept of the crestal sinus lift is based on:

Controlled fracture of the sinus floor

Elevation of the Schneiderian membrane

Creation of a subantral compartment

Placement of graft material beneath the membrane

Formation of new regenerated bone around the implant apex

The elevated membrane acts as a biological barrier that protects the graft material and promotes bone regeneration within the sinus cavity.

Implant Survival Rates

Implant survival rates reported for the crestal approach ranged between:

94% and 99%

Several recent studies demonstrated no statistically significant difference in implant survival between lateral and crestal approaches.

Bone Gain

The crestal technique generally achieved:

3–5 mm vertical augmentation

Although less extensive than the lateral approach, this bone gain is clinically sufficient for moderately resorbed posterior maxillae.

Advantages

Major advantages included:

Minimal surgical trauma

Reduced operative time

Lower postoperative pain

Faster recovery

Reduced swelling

Higher patient acceptance

Farina et al. reported significantly lower postoperative morbidity with transcrestal sinus elevation compared with lateral sinus augmentation.

Comparative Analysis Of Both Approaches

Parameter	Lateral Window Approach	Crestal Approach
Surgical invasiveness	High	Low
Bone gain	8–12 mm	3–5 mm
Residual bone height indication	<5 mm	>5 mm
Membrane perforation risk	Higher	Lower
Postoperative discomfort	Greater	Reduced
Surgical visibility	Direct	Blind technique
Healing period	Longer	Shorter
Implant survival	92–98%	94–99%

Discussion

Maxillary sinus augmentation remains one of the most predictable surgical procedures in implant dentistry. However, the choice between lateral and crestal approaches remains dependent upon multiple anatomical and clinical factors.

The present review demonstrated that both techniques provide excellent implant survival and predictable long-term outcomes. Nevertheless, important differences exist regarding invasiveness, augmentation potential, complication rates, and patient morbidity. The lateral window approach continues to represent the gold standard for severe maxillary atrophy because of its superior augmentation capability and direct surgical visualization. Recent literature confirms that this technique remains indispensable in cases with residual bone height below 5 mm.

Despite its effectiveness, the lateral approach remains technically demanding and is associated with increased complication rates, particularly Schneiderian membrane perforation. Recent systematic reviews indicate that reduced residual ridge height significantly increases perforation risk.

Conversely, the crestal approach has become increasingly popular due to advances in osseodensification and minimally invasive surgical concepts. Modern transcrestal techniques demonstrate excellent implant survival with significantly reduced postoperative morbidity. Several studies now suggest that the crestal approach may even be feasible in cases with residual bone height below 4 mm when advanced surgical protocols are utilized. Furthermore, technological innovations including piezosurgery, dynamic navigation, stereolithographic surgical guides, and advanced biomaterials continue to improve safety and predictability in both techniques.

Current evidence therefore supports individualized treatment planning based on:

Residual bone height

Sinus anatomy

Surgeon experience

Required augmentation volume

Patient-centered outcomes

Conclusion

Both lateral window and crestal approaches represent highly successful and evidence-based methods for maxillary sinus floor augmentation in implant dentistry.

The lateral window technique remains superior in:

Severe posterior maxillary atrophy

Extensive vertical bone augmentation

Complex anatomical cases

The crestal approach offers substantial advantages regarding:

Minimal invasiveness

Reduced postoperative morbidity

Faster healing

Improved patient comfort

Current evidence demonstrates comparable implant survival rates between both approaches when proper indications are respected.

Long-term treatment success depends primarily upon:

Accurate diagnosis

Appropriate case selection

Surgical expertise

Careful management of sinus anatomy

Modern evidence-based surgical protocols

Future randomized clinical trials with extended follow-up periods remain necessary to establish definitive evidence-based guidelines for sinus augmentation procedures in implant dentistry.

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