

**PREDICTABILITY OF LATERAL AND TRANSCRESTAL MAXILLARY SINUS  
ELEVATION TECHNIQUES: AN INTEGRATIVE REVIEW**

**PREVISIBILIDADE DAS TÉCNICAS DE ELEVAÇÃO DO SEIO MAXILAR  
LATERAL E TRANSCRESTAL: UMA REVISÃO INTEGRATIVA**

**PREDICTIBILIDAD DE LAS TÉCNICAS DE ELEVACIÓN DEL SENO MAXILAR  
LATERAL Y TRANSCRESTAL: UNA REVISIÓN INTEGRATIVA**

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**ABSTRACT**

Bone loss in the posterior segment of the maxilla is one of the main challenges for oral rehabilitation with dental implants, due to alveolar resorption associated with progressive pneumatization of the maxillary sinus. Maxillary sinus elevation, using lateral and transcresal techniques, is a widely used strategy to enable the placement of implants in these conditions. This integrative review aimed to analyze the scientific evidence on the clinical and radiographic predictability of these two techniques. The search was conducted in PubMed, SciELO, and Google Scholar databases from 2019 to 2025, including randomized clinical trials, prospective and retrospective studies, and systematic reviews. Outcomes related to bone height gain, implant survival rates, and incidence of complications were analyzed. After applying the eligibility criteria, 15 studies comprised the final sample. The synthesis of the findings demonstrated that the lateral technique provides greater bone height gain but presents greater morbidity and a higher risk of sinus membrane perforation. The transcresal technique proved to be less invasive, with a lower complication rate and implant survival rates similar to those of the lateral approach. It is concluded that both

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techniques are highly predictable when correctly indicated, and it is essential to consider sinus anatomy, residual bone height, and individual patient conditions when making clinical decisions.

**Keywords:** Maxillary Sinus Elevation. Bone Graft. Dental Implant.

## RESUMO

A perda óssea no segmento posterior da maxila é um dos principais desafios para a reabilitação oral com implantes dentários, devido à reabsorção alveolar associada à pneumatização progressiva do seio maxilar. A elevação do seio maxilar, utilizando as técnicas lateral e transcrestal, é uma estratégia amplamente utilizada para possibilitar a instalação de implantes nessas condições. Esta revisão integrativa teve como objetivo analisar as evidências científicas sobre a previsibilidade clínica e radiográfica dessas duas técnicas. A busca foi realizada nas bases de dados PubMed, SciELO e Google Scholar no período de 2019 a 2025, incluindo ensaios clínicos randomizados, estudos prospectivos e retrospectivos e revisões sistemáticas. Foram analisados desfechos relacionados ao ganho de altura óssea, às taxas de sobrevivência dos implantes e à incidência de complicações. Após a aplicação dos critérios de elegibilidade, 15 estudos compuseram a amostra final. A síntese dos achados demonstrou que a técnica lateral proporciona maior ganho de altura óssea, porém apresenta maior morbidade e maior risco de perfuração da membrana do seio. A técnica transcrestal mostrou-se menos invasiva, com menor taxa de complicações e taxas de sobrevivência de implantes semelhantes às da abordagem lateral. Conclui-se que ambas as técnicas são altamente previsíveis quando corretamente indicadas, sendo essencial considerar a anatomia do seio, a altura óssea residual e as condições individuais do paciente na tomada de decisão clínica.

**Palavras-chave:** Elevação do Seio Maxilar. Enxerto Ósseo. Implante Dentário.

## RESUMEN

La pérdida ósea en el segmento posterior del maxilar es uno de los principales desafíos para la rehabilitación oral con implantes dentales, debido a la reabsorción alveolar asociada con la neumatización progresiva del seno maxilar. La elevación del seno maxilar, utilizando técnicas lateral y transcrestal, es una estrategia ampliamente utilizada para permitir la colocación de implantes en estas condiciones. Esta revisión integrativa tuvo como objetivo analizar la evidencia científica sobre la predictibilidad clínica y radiográfica de estas dos técnicas. La búsqueda se realizó en las bases de datos PubMed, SciELO y Google Scholar en el período de 2019 a 2025, incluyendo ensayos clínicos aleatorizados, estudios prospectivos y retrospectivos y revisiones sistemáticas. Se analizaron resultados relacionados con el aumento de la altura ósea, las tasas de supervivencia de los implantes y la incidencia de complicaciones. Después de aplicar los criterios de elegibilidad, 15 estudios conformaron la muestra final. La síntesis de los hallazgos demostró que la técnica lateral proporciona mayor ganancia de altura ósea, pero presenta mayor morbilidad y mayor riesgo de perforación de la membrana sinusal. La técnica transcrestal resultó ser menos invasiva, con menor tasa de complicaciones y tasas de supervivencia de implantes similares a las del abordaje lateral. Se concluye que ambas técnicas son altamente predecibles cuando están correctamente indicadas, siendo esencial considerar la anatomía del seno, la altura ósea residual y las condiciones individuales del paciente en la toma de decisiones clínicas.

**Palabras clave:** Elevación del Seno Maxilar. Injerto Óseo. Implante Dental.

## 1 INTRODUCTION

Oral rehabilitation with implants in the posterior region of the maxilla represents one of the greatest challenges in implant dentistry, especially in patients with extensive tooth loss associated with chronic inflammatory processes resulting from periodontal disease. The combination of progressive alveolar ridge resorption and maxillary sinus pneumatization results in a significant reduction in residual bone height, compromising the primary stability of implants and increasing the risk of biomechanical and biological failures when appropriate reconstructive strategies are not adopted (Lyu, 2023)

In this context, maxillary sinus floor elevation has become established as a fundamental procedure to enable the placement of implants in areas with insufficient bone volume. The lateral window technique stands out for allowing ample access to the sinus cavity, direct detachment of Schneider's membrane, and accommodation of large volumes of graft material, being indicated mainly in situations of severe atrophy and rehabilitation with multiple implants (Barros, 2023).

As a less invasive alternative, the transcresal elevation technique emerged with the aim of reducing surgical morbidity. Performed through the implant bed itself, this approach uses instruments that promote controlled fracture of the cortical bone and progressive displacement of the sinus membrane, with a smaller flap extension and potential reduction in postoperative discomfort. However, its application has limitations in cases of extremely reduced residual bone height (Decker, 2024).

In recent years, scientific literature has broadened the debate beyond the simple effectiveness of maxillary sinus elevation, focusing on the comparison between lateral and transcresal approaches in terms of vertical bone gain, implant survival rate, and the incidence of surgical complications. Recent reviews indicate favorable results for both techniques, but show great methodological heterogeneity among studies, making it difficult to define the absolute superiority of one technique over the other in different clinical conditions (Cobo-Vázquez, 2025).

Among the complications associated with the procedure, perforation of the Schneider membrane is described as one of the most relevant complications, both in the lateral and transcresal approaches. Evidence from meta-analyses indicates that, when properly managed with the use of barrier membranes and refined surgical technique, perforation does not always compromise the success of implants, although it may be associated with an increased risk of sinusitis and partial graft loss (Schiavo-Di Flaviano, 2024).

Anatomical aspects of the maxillary sinus directly influence the risk of complications and the predictability of techniques. The presence of bone septa, variations in lateral wall thickness, and irregularities in the sinus membrane are associated with a higher probability of rupture during the procedure, reinforcing the need for careful planning using computed tomography and individualization of the surgical access route (Yang, 2024).

The behavior of grafted materials over time also directly impacts the predictability of results. Radiographic studies show that autogenous, allogenic, and xenogenic grafts have distinct patterns of bone remodeling and volumetric maintenance, and it has been described that combinations of these materials may favor greater bone height stability in the medium term, although they do not completely eliminate physiological resorption (Bouwman, 2025).

Despite the high implant survival rates reported in areas undergoing maxillary sinus elevation, uncertainties remain about which technique offers the best balance between bone gain, surgical morbidity, and implant longevity in different clinical scenarios. Clinical trials suggest that the lateral approach is preferably indicated for bone heights less than 4 mm, while the transcrestal technique is more applicable for intermediate values, a hypothesis that requires consolidation through systematic literature reviews (Bacevic, 2021).

Given this scenario, an integrative review is essential to gather, analyze, and integrate the available scientific evidence on the predictability of lateral and transcrestal maxillary sinus elevation techniques, contributing to evidence-based clinical decision-making and the definition of safer and more effective protocols in rehabilitation with dental implants.

## **2 METHODOLOGY**

This study is characterized as an integrative literature review, conducted with the purpose of gathering, critically evaluating, and synthesizing the available evidence on the predictability of lateral and transcrestal maxillary sinus elevation techniques. The method followed the steps proposed by Whitemore and Knafl, allowing the integration of studies with different designs for a broader understanding of the phenomenon investigated (Whitemore & Knafl, 2005; Decker, 2024).

The guiding question was structured based on the PICO strategy, considering the population composed of patients undergoing maxillary sinus elevation, with the lateral technique as the intervention, the transcrestal technique as the comparison, and bone height gain, implant survival, and the occurrence of complications as the outcomes. Based on this formulation, the central question was established: which maxillary sinus elevation technique

has greater clinical and radiographic predictability in different anatomical conditions? (Bacevic, 2021; Cobo-Vázquez, 2025).

The bibliographic search was conducted in the PubMed, SciELO, and Google Scholar databases, including publications up to May 2025, using descriptors combined by Boolean operators (“sinus lift,” “lateral window,” “transcrestal,” “osteotome,” “hydraulic,” “osseodensification,” “dental implant”). Studies published in the last five years in English, Portuguese, and Spanish were selected, ensuring scientific currency and clinical relevance for the final synthesis (Lyu, 2023; Barros, 2023).

Eligibility criteria were established in advance to standardize the selection of studies. Randomized clinical trials, prospective and retrospective studies, and systematic reviews analyzing lateral or transcrestal techniques were included. Case reports, letters to the editor, studies with fewer than five participants, and articles without clear clinical data on bone gain, implant survival, or surgical complications were excluded (Schiavo-Di Flaviano, 2024; Elfar, 2024).

### Table 1

#### *Inclusion and exclusion criteria for studies*

Inclusion Criteria	Exclusion Criteria
Randomized clinical trials	Case reports
Prospective/retrospective studies	Letters to the editor
Systematic reviews	Samples < 5 patients
Evaluation of lateral/transcrestal techniques	Absence of clinical data
Data on bone gain, survival, complications	Full text unavailable

Source: Prepared by the authors, 2025.

The selection of studies took place in two stages, involving initial screening by titles and abstracts, followed by a complete reading of potentially eligible articles. Two independent reviewers participated in the process, and disagreements were resolved by consensus, ensuring methodological rigor and minimizing bias. The process followed the PRISMA recommendations for scientific reviews (Yang, 2024; Jiménez-Guerra, 2025).

Data extraction was performed using a standardized instrument, covering information related to participants, residual bone height, technique used, biomaterials employed, follow-up time, and clinical outcomes. This standardization allowed for greater reliability and comparability between the studies included in the integrative review (Gaspar,

The final stage consisted of qualitative and quantitative data analysis. In cases of high heterogeneity, a narrative synthesis was chosen, highlighting convergences, divergences, and gaps in the literature on the predictability of maxillary sinus elevation techniques (Mazor, 2024).

### **3 RESULTS**

The initial search conducted in the PubMed, SciELO, and Google Scholar databases resulted in the identification of 300 records. After removing duplicates and applying the previously established eligibility criteria, 15 studies were considered suitable for inclusion in the final sample of this integrative review. The included studies comprised randomized clinical trials, prospective clinical studies, and systematic reviews that analyzed lateral and transcrestal maxillary sinus elevation techniques in isolation or comparatively. Most publications focused on the period between 2021 and 2025, reflecting the topicality of the subject and the growing interest in minimally invasive approaches in implant dentistry (Bacevic, 2021; Lyu, 2023; Cobo-Vázquez, 2025).

Quantitative analysis of studies that directly compared both techniques showed that the lateral approach promotes greater vertical bone height gain, with variations between 3 and 7 mm, while the transcrestal approach showed more modest gains, ranging from 2 to 4 mm. Despite this difference in vertical augmentation, implant survival rates were high in both groups, ranging from 94% to 98% after follow-up periods of 12 to 60 months. Moderate heterogeneity was observed between studies, mainly attributed to differences in the instruments used, the biomaterials employed, and the experience of the operators (Elfar, 2024; Jiménez-Guerra, 2025; Decker, 2024).

**Table 2**

*Summary of the main results of the studies included in the integrative review*

Author/Year	Type of Study	Technique Evaluated	Sample	Average Bone Gain	Implant Survival	Main Complications
Bacevic(2021)	Randomized clinical trial	Lateral vs. Transcrestal	60	6,2 mm vs. 3,1 mm	96%	Membrane perforation
Barros (2023)	Literature review	Lateral	—	5–7 mm	>95%	Edema and bleeding
Jiménez-Guerra (2025)	Prospective study	Transcrestal	48	3,5 mm	97%	Transient sinusitis
Mazor(2024)	Multicenter study	Transcrestal with osseodensification	72	3,8 mm	98%	Reduced perforation
Bouwman(2025)	Radiographic study	Lateral	40	6,5 mm	95%	Bone remodeling

Source: Prepared by the authors, 2025.

With regard to complications associated with maxillary sinus elevation techniques, perforation of Schneider's membrane was the most frequently reported complication. In the lateral technique, the incidence ranged from 10% to 30%, while in the transcrestal approach, the rates ranged from 5% to 15%. Other complications described included intraoperative bleeding, facial edema, transient sinusitis, and early implant failure. Recent studies have indicated that the adoption of modern techniques, such as bone densification and hydrodynamic irrigation, contributes significantly to reducing the risk of sinus membrane perforation (Mazor, 2024; Yang, 2024; Schiavo-Di Flaviano, 2024).

The overall summary of the studies shows convergence regarding the high clinical predictability of both techniques, provided they are correctly indicated according to the residual bone height and anatomical characteristics of the maxillary sinus. The lateral technique stood out for its greater potential for bone gain in cases of severe atrophy, while the transcrestal technique presented lower morbidity rates and more favorable postoperative recovery, without significant impairment in implant survival rates. These findings reinforce the importance of individualized surgical planning (Bouwman, 2025; Gaspar, 2024; Gherlone, 2022).

The analysis of the studies also showed that anatomical factors, such as the presence of bony septa, the thickness of the lateral sinus wall, and morphological variations of the sinus membrane, have a direct influence on both the choice of technique and the occurrence of complications. Computed tomography was identified as an indispensable tool for surgical planning, allowing for greater predictability of results and reduction of operative risks (Yang, 2024; Lyu, 2023).

Overall, the results of this review demonstrate that both techniques have high rates of clinical and radiographic success, with well-defined differences in terms of bone gain potential and surgical morbidity. The lateral approach is more suitable for situations of marked bone resorption, while the transcrestal approach stands out as a conservative alternative for intermediate cases, with comparable clinical results in terms of implant survival (Bacevic, 2021).

## **4 DISCUSSION**

### **4.1 GENERAL INTERPRETATION OF CLINICAL FINDINGS**

The findings of this integrative review show that both the lateral and transcrestal maxillary sinus elevation techniques have high clinical predictability when applied within their indication limits. The literature shows that implant survival rates are consistently above 94%, reinforcing that the central issue is not the effectiveness of the technique, but rather the appropriate selection based on the patient's anatomical aspects, prosthetic planning, and the experience of the surgical team. Early implant loss is rare and is usually attributed to primary stability failure, local infection, or significant sinus membrane rupture, and not necessarily to the method used (Bacevic, 2021; Cobo-Vázquez, 2025).

Analysis of long-term follow-up studies reveals satisfactory functional stability of implants placed in areas undergoing sinus elevation. Clinical reports highlight that, with proper planning, chewing performance, phonetic comfort, and overall patient satisfaction remain high over the years. Behavioral factors, such as poor oral hygiene and smoking, have been shown to have a more significant impact on implant longevity than the choice between lateral or transcrestal techniques, reinforcing the role of clinical follow-up in rehabilitation success (Jiménez-Guerra, 2025; Barros, 2023).

Another aspect confirmed by studies is the correlation between residual bone height and the choice of the most appropriate technique. The lateral window technique remains the standard for cases with bone height less than 4 mm, allowing ample access to the sinus and

accommodation of a larger graft volume. The transcrestal technique maintains its position as the least invasive option for heights between 4 and 6 mm, offering good predictability and reduced morbidity. Advances in instruments, biomaterials, and three-dimensional planning methods have contributed to expanding the applicability of the transcrestal technique in recent years (Lyu, 2023; Decker, 2024).

The meta-analyses evaluated reinforce the superiority of the lateral technique in terms of vertical graft bone gain, which is consistent with the extent of the osteotomy and the magnitude of the space created under the membrane. However, the transcrestal technique has proven sufficient in many cases of intermediate atrophy, ensuring adequate biomechanical conditions for implant placement. Thus, the clinical choice should not prioritize only the volume obtained, but the balance between reconstructive need, morbidity, and individual risk of complications (Cobo-Vázquez, 2025; Mazor, 2024).

The behavior of bone height obtained after surgery deserves special attention, since prolonged radiographic studies show that remodeling and slight vertical loss occur over time, a phenomenon inherent to any grafting procedure. Despite this, the results show maintenance of a stable bone plateau that is fully compatible with implant-supported function. The literature points to important differences in the volumetric stability of autogenous, xenogeneic, and allogeneic grafts, suggesting that the combination of materials may favor better remodeling patterns (Bouwman, 2025; Gaspar, 2024).

**Table 3**

*Relationship between residual bone height, indicated technique, and clinical performance*

Residual height	bone	Indicated technique	Average obtained	gain	Morbidity	Main advantages
< 4 mm		Lateral	5–7 mm		Moderate	Wide access and greater graft volume
4–6 mm		Transcrestal	2–4 mm		Low	Less invasive and rapid recovery
> 6 mm		Both	Variable		Low	Technical flexibility

Source: Prepared by the authors, 2025.

The data gathered in this review confirm that both techniques offer high predictability, provided they are applied based on a thorough clinical and radiographic evaluation. Thus, the results suggest that the selection of the most appropriate technique involves not only local anatomy but also a balance between expected bone gain, risk of complications, and patient comfort (Elfar, 2024; Gherlone, 2022).

#### 4.2 COMPLICATIONS, ANATOMICAL FACTORS, AND BIOMATERIALS

Schneider membrane perforation was the most commonly reported complication in the studies evaluated, occurring more frequently in the lateral technique due to wider detachment and more extensive bone access. However, authors point out that small perforations, when properly managed with barrier membranes and delicate techniques, do not necessarily compromise the success of the graft or implant. The stability of results in cases of perforation corroborates the importance of technical training and surgical precision (Mazor, 2024; Schiavo-Di Flaviano, 2024)

Sinus anatomy plays an essential role in the choice of surgical method and the occurrence of complications. Bone septa, variations in lateral wall thickness, and irregularities in the sinus membrane are associated with an increased risk of perforation, making computed tomography indispensable for detailed mapping of the region prior to intervention. Studies reinforce that careful interpretation of images is crucial for individualizing osteotomy and reducing the risk of complications (Yang, 2024; Lyu, 2023).

In addition to intraoperative complications, the studies analyzed also reported differences in postoperative discomfort between the techniques. Pain, facial edema, and ecchymosis were more frequently associated with the lateral technique, especially when performed with large graft volumes and extensive flap elevation. In contrast, patients undergoing the transcrestal technique reported faster recovery and less need for analgesia, favoring treatment adherence and postoperative satisfaction (Iancu, 2023; Elfar, 2024).

Comparative clinical trials have shown that, although the lateral technique is more suitable for severe atrophy, the transcrestal technique can offer important surgical advantages, such as shorter surgical time and lower morbidity. These differences reinforce that the selection of the technique should consider not only anatomical criteria, but also patient expectations and the overall clinical context (Elfar, 2024; Barros, 2023).

Technological advances in bone densification drills have expanded the applicability of the transcrestal technique, offering greater control over membrane displacement and

better primary implant stability. Recent research indicates that, with these instruments, bone heights lower than those traditionally recommended can be safely managed, although technical mastery is essential to minimize risks (Gaspar, 2024; Mazor, 2024).

The type of biomaterial used was also a decisive factor in the outcomes observed. Studies have identified that the combination of autogenous grafts with osteoconductive biomaterials promotes bone formation and reduces resorption over time, although it increases morbidity in the donor area. Allogeneic and xenogeneic biomaterials, often associated with platelet concentrates, showed good volumetric results with less postoperative discomfort, making them viable options for patients who wish to avoid additional procedures (Barros, 2023; Bouwman, 2025).

#### 4.3 CLINICAL IMPLICATIONS, LIMITATIONS OF EVIDENCE, AND FUTURE PERSPECTIVES

In the clinical context, the findings of the review reinforce that the choice between the lateral and transcrestal techniques should be guided by an integrated assessment of anatomical, prosthetic, and systemic factors. Residual bone height, the presence of septa, the availability of prosthetic space, the type of planned rehabilitation, and the patient's systemic conditions influence the therapeutic decision. For patients with a history of sinus disease or previous sinus surgery, less invasive approaches may be preferable, reducing cavity manipulation and the risk of complications (Decker, 2024; Gherlone, 2022).

Methodological limitations were identified in the included studies, such as small samples, lack of blinding, wide variety of biomaterials used, and heterogeneity in follow-up times. These factors call for caution in extrapolating findings and explain the differences observed between meta-analyses and recent systematic reviews. This variability reinforces the need for standardized protocols for future studies (Schiavo-Di Flaviano, 2024; Yang, 2024).

Despite the limitations, the convergence of results provides a solid basis for guiding clinical practice. The literature consistently demonstrates that the lateral technique is more suitable for severe atrophy, while the transcrestal technique offers excellent applicability in intermediate cases, with lower morbidity and equal predictability regarding implant survival. The perspective of managing membrane perforation as a treatable and not necessarily decisive event contributes to the safety of the procedure (Bouwman, 2025; Barros, 2023).

Future prospects include the development of hybrid approaches combining sinus elevation with angled implants, 3D digital planning, customized surgical guides, and immediate or accelerated loading protocols. In addition to radiographic analyses, emerging studies suggest the importance of investigating the impacts of the technique on quality of life, return to work, and overall treatment costs, expanding the understanding of its real effectiveness in clinical practice (Gherlone, 2022; Jiménez-Guerra, 2025).

## **5 CONCLUSION**

The integrated analysis of scientific evidence has shown that both the lateral maxillary sinus elevation technique and the transcrestal technique have high clinical and radiographic predictability to enable the placement of dental implants in the posterior segment of the maxilla. Implant survival rates remain consistently high in both approaches, provided that the indication is made judiciously, considering residual bone height, maxillary sinus anatomical conditions, and individualized prosthetic planning.

The results indicate that the lateral technique remains the approach of choice in cases of severe bone atrophy, as it allows for greater vertical gain and better accommodation of large graft volumes. In contrast, the transcrestal technique stands out for its lower invasiveness, lower surgical morbidity, and more favorable postoperative recovery, being fully indicated in situations of moderate atrophy, with comparable clinical performance in terms of implant longevity.

With regard to complications, perforation of the Schneiderian membrane was the most frequently reported complication, especially in the lateral technique. However, the literature shows that when this occurrence is properly managed with appropriate techniques and the use of barrier membranes, the success of the procedure and the survival of the implants can be preserved. In addition, anatomical factors and the type of biomaterial used have a direct influence on both the occurrence of complications and the volumetric stability of the graft over time.

It can therefore be concluded that the success of maxillary sinus elevation does not depend exclusively on the technique used, but on a set of factors involving careful tomographic planning, correct selection of biomaterial, technical mastery of the professional, and rigorous clinical follow-up. Despite the convergence of findings, there are still methodological limitations in the available studies, which reinforces the need for new

randomized clinical trials, with greater standardization of protocols and long-term follow-ups, to definitively strengthen the scientific evidence on the subject.

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