

**The importance of maxillary sinus lifting for the installation of dental implants**  
**A importância da elevação do seio maxilar para a instalação de implantes dentários**  
**La importancia de la elevación del seno maxilar para la instalación de implantes dentales**

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**Wladimir Fernandes Filho**

ORCID: <https://orcid.org/0000-0001-8524-1353>

Faculdade Sete Lagoas, Brazil

E-mail: [wladimirfilho@hotmail.com](mailto:wladimirfilho@hotmail.com)

**Daniel Felipe Fernandes Paiva**

ORCID: <https://orcid.org/0000-0003-4186-9856>

Universidade Estadual de Campinas, Brazil

E-mail: [daniel.fernandes.paiva@gmail.com](mailto:daniel.fernandes.paiva@gmail.com)

**Juliana Campos Pinheiro**

ORCID: <https://orcid.org/0000-0001-5687-7635>

Faculdade Sete Lagoas, Brazil

E-mail: [julianapinheiroodonto92@gmail.com](mailto:julianapinheiroodonto92@gmail.com)

**Gabriel Gomes da Silva**

ORCID: <https://orcid.org/0000-0002-1341-7505>

Universidade Federal do Rio Grande do Norte, Brazil

E-mail: [silvagg94@gmail.com](mailto:silvagg94@gmail.com)

**José Sérgio Maia Neto**

ORCID: <https://orcid.org/0000-0002-3740-3562>

Faculdade Sete Lagoas, Brazil

E-mail: [drsergiomaia@yahoo.com.br](mailto:drsergiomaia@yahoo.com.br)

**Saulo Hilton Batista Botelho**

ORCID: <https://orcid.org/0000-0002-5061-0152>

Faculdade Sete Lagoas, Brazil

E-mail: [saulohbbatista@hotmail.com](mailto:saulohbbatista@hotmail.com)

## **Abstract**

In the face of maxillary atrophy, the sinus floor tends to exhibit only a thin cortical bone wall, imposing limitations on the placement of dental implants. The purpose of this literature review was to evaluate the scientific performance on the importance of lifting the maxillary sinus for the installation of dental implants. A literature review was conducted using the PubMed/Medline, Scielo and Science direct databases. Articles published between 2014 and 2020 were selected based on the following inclusion criteria: Availability of the full text, publication in English and clarity on the methodological details used. Studies have shown that the anatomy of the maxillary sinus must be investigated before planning the implants in the posterior region of the maxilla, in order to diagnose the presence of sinus pathologies, the presence of septa and pneumatization. It is important to note that the lifting of the maxillary sinus is a procedure that has good results, showing few complications in the postoperative period. In addition, cone beam computed tomography should be the imaging exam of first choice when this procedure is indicated for the installation of dental implants.

**Keywords:** Maxillary sinus; Osseointegration; Dental implantation.

## **Resumo**

Diante da atrofia maxilar, o assoalho do seio tende a apresentar apenas uma fina parede óssea cortical, impondo limitações para a colocação de implantes dentários. O objetivo desta revisão de literatura foi avaliar o desempenho sobre a importância da elevação do seio maxilar para a instalação de implantes dentários. Foi realizada uma revisão da literatura nas bases de dados PubMed / Medline, Scielo e Science direct. Os artigos publicados entre 2014 e 2020 foram selecionados com base nos seguintes critérios de inclusão: disponibilidade do texto completo, publicação em inglês e clareza nos detalhes metodológicos utilizados. Estudos têm demonstrado que a anatomia do seio maxilar deve ser investigada antes do planejamento dos implantes na região posterior da maxila, a fim de diagnosticar a presença de patologias sinusais, a presença de septos e pneumatização. É importante ressaltar que a elevação do seio maxilar é um procedimento que apresenta bons resultados, apresentando poucas complicações no pós-operatório. Além disso, a tomografia computadorizada de feixe cônico deve ser o exame de imagem de primeira escolha quando este procedimento for indicado para a instalação de implantes dentários.

**Palavras-chave:** Seio maxilar; Osseointegração; Implante dentário.

## Resumen

Ante la atrofia maxilar, el suelo del seno tiende a presentar sólo una fina pared ósea cortical, lo que impone limitaciones a la colocación de implantes dentales. El propósito de esta revisión de la literatura fue evaluar el desempeño científico sobre la importancia de la elevación del seno maxilar para la instalación de implantes dentales. Se realizó una revisión de la literatura utilizando las bases de datos directas PubMed / Medline, Scielo y Science. Los artículos publicados entre 2014 y 2020 fueron seleccionados en base a los siguientes criterios de inclusión: Disponibilidad del texto completo, publicación en inglés y claridad sobre los detalles metodológicos utilizados. Los estudios han demostrado que la anatomía del seno maxilar debe investigarse antes de planificar los implantes en la región posterior del maxilar, con el fin de diagnosticar la presencia de patologías sinusales, la presencia de septos y neumatización. Es importante señalar que el levantamiento del seno maxilar es un procedimiento que tiene buenos resultados, presentando pocas complicaciones en el postoperatorio. Además, la tomografía computarizada de haz cónico debe ser el examen de imagen de primera elección cuando este procedimiento está indicado para la instalación de implantes dentales.

**Palabras clave:** Seno maxilar; Osteointegración; Implantación dental.

## 1. Introduction

To provide an effective solution to tooth loss, dentistry has been experiencing new and significant technological advances, the proof of which is that a tooth can be successfully replaced by a crown retained in an implant. Therefore, the effectiveness and longevity of interventions using dental implants depend on bone quality, implant type and stress distribution at the bone-implant interface (Bataineh & Al-Janaideh, 2019). In addition, alveolar resorption after tooth extraction can be highlighted as a challenge for oral rehabilitation in the posterior maxilla, since it results in the sinus pneumatization process (Amine, Slaoui, Kanice & Kissa, 2020). Pneumatization of the maxillary sinus, although characterized by a physiological process that occurs in all paranasal sinuses during the growth period, also occurs due to the remodeling of the maxillary floor after tooth removal (Amine et al, 2020; Schriber, Bornstein & Suter, 2019).

It is known that the maxillary sinus is the largest of the paranasal sinuses containing 12 to 15 ml of air. It is a pyramidal structure with a base close to the nasal cavity, the upper portion forms the lower wall of the orbit and has its apex towards the zygomatic bone. While

the sinus floor extends anteriorly to the canine and premolars and posteriorly to the maxillary tuberosity (Danesh-Sani, loomer & Wallace, 2016). It is worth mentioning that the size and shape of the maxillary sinus is influenced by breathing patterns, dental problems, anatomical characteristics, sex, age, ethnicity and climatic factors (Giacomini et al, 2018). In addition, the sinuses has several functions, such as heating and humidifying the air stored in the area, ventilation and reduction of the cranial weight, in addition to acting in the defense of the organism against microbial agents (Barbosa Junior, 2019).

In the face of maxillary atrophy, the sinus floor tends to exhibit only a thin cortical bone wall, imposing limitations on the placement of dental implants (Cobiàni et al,2017; Schriber, Bornstein & Suter, 2019; Amine et al, 2020). To overcome this type of anatomical alteration, the use of interventions such as bone augmentation and the use of short or inclined implants appear as some alternatives(Dragan et al,2017; Amine et al, 2020).

With regard to the increase in the volume of the sinus floor for the installation of implants in partially or totally edentulous patients, it may be associated with some complications such as perforation and bleeding of the sinus membrane, post-operative risks of wound infection and sinusitis, as well as graft exposure and flap dehiscence (Dragan et al, 2017). Other complications are related to the migration of the implant to the maxillary sinus, formation of oroantral fistula and loss of vitality of the adjacent teeth(Cobiàni et al, 2017; Danesh-Sani, loomer & Wallace, 2016).

In view of this, the importance of anatomical knowledge of the maxillary sinus is confirmed by the use of techniques such as the use of panoramic radiographs and cone beam computed tomography, as well as it is important to know the surgical technique and types of biomaterials used in this procedure(De-Habory, 2019; Dragan et al, 2017; Amine et al, 2020). The purpose of this literature review was to evaluate the scientific evidence on the importance of lifting the maxillary sinus for the installation of dental implants.

## **2. Methodology**

This is a literature review article, developed through a bibliographic survey in the PubMed/Medline, Scielo and Science direct databases. The search strategy used was "Sinus Lift" and "Osseointegration" and "Oral" and "Maxillofacial" and "Surgery" and "Implantodology". Articles published between 2014 and 2020 were selected, including literature reviews, systematic reviews and controlled clinical trials, based on the following inclusion criteria: availability of the full text, publications in the English language, clarity in

the methodological details used and articles that focus on the importance of lifting the maxillary sinus to installing dental implants.

This methodology is based on qualitative aspects and follows the principles proposed by Pereira, Shitsuka, Parreira & Shitsuka (2018). Having a descriptive and observational character of the integrative type.

### 3. Results

Dental osseointegration is defined as the rigid fixation of the implant to the bone tissue, this is influenced by the distribution of forces at the bone-implant interface, which is closely related to the magnitude of the load, material properties and implant geometry (diameter and length) (Bataineh, Al-Janaideh, 2019; El-Anwar, Motfy, Awad, El-Sheikh, 2014). Therefore, because they have good physical-chemical characteristics, mechanical properties, biocompatibility and high resistance to stress due to fatigue and corrosion, titanium and its alloys have been used in implantology since the 1960s (Rahmitasari, Ishida, Kurahashi, Matsuda, Watanabe & Ichikawa, 2017). In addition to titanium, other materials have been studied, such as zirconia, which has a high elasticity module and low temperature degradation. Also noteworthy are the polymeric compounds, such as polyetheretherketone, a semi-crystalline linear polycyclic thermoplastic that can be used as an implant body or abutment, causing less hypersensitivity reactions or allergies, being versatile and being able to undergo adaptation through mass or surface changes (Rahmitasari et al, 2017).

The anatomy of the maxillary sinus must be investigated before planning the placement of implants in the posterior region of the maxilla, in order to diagnose the presence of sinus pathologies, presence of septa and pneumatization. The average dimensions of the maxillary sinus in adults vary from 25 to 35 mm in width and 36 mm to 45 mm in height, with an estimated volume of 14.71 cm<sup>3</sup>, varying according to age. The importance of measurement is also verified when it is necessary to analyze the result of procedures such as lifting the maxillary sinus (Hameed, Santawy & Almeshri, 2020; Zheng, Teng, Zhou, Ye, Li & Mo, 2016).

The rehabilitation of partial or total edentulous patients, using dental implants today, presents lasting results. However, it is necessary to obtain an adequate bone volume and density, so that the stability of the implants occurs. The presence of edentulism, especially in the posterior region of the maxilla, causes the resorption of the alveolar bone crest, resulting in the pneumatization of the maxillary sinus, imposing limitations in prosthetic rehabilitation

(Zheng et al, 2016; Bustillo & Zuloaga, 2017). When the bone thickness remaining in the posterior region of the maxilla is less than 4 mm, it is necessary to raise the floor of the maxillary sinus. This surgical approach allows the placement of the implants with the guarantee of bone support and functional stability through the vertical bone increase of the site (Bustillo & Zuloaga, 2017; Duan, Fu, Qi, Du, Pan & Wang, 2017).

Initially described at the end of the 1970s, the sinus elevation procedure creates a surgical access through the lateral opening of the external wall of the maxillary sinus, for the posterior elevation of the sinus membrane, by means of an apical displacement. Subsequently, this space below the sinus membrane is filled with bone graft so that the implants can be installed simultaneously or later on (Zheng et al, 2016; Khaled, Atef & Hakam, 2019).

As a less invasive alternative, elevation of the transcrestal sinus floor can be used, in these cases a small osteotomy is performed through the alveolar crest of the edentulous site at the lower edge of the maxillary sinus, thus the sinus floor is broken and its membrane is elevated resulting in the creation of a space for placing bone graft or formation of blood clots. In addition to reducing patient morbidity, this technique requires less operative time and less financial investment (Zheng et al, 2016; Matern et al, 2015).

The location of the maxillary floor in relation to the alveolar bone is a factor to be considered for planning and achieving long-term success in the placement of dental implants. Given this need, the relevance of the use of imaging tests, such as intra and extra-oral radiographs, in addition to cone beam computed tomography, is attested (Kwon, 2019; Giacomini et al, 2018).

Radiographs are widely used as a diagnostic resource in the oral and maxillofacial region, but because they are two-dimensional (2D) images, they do not display the three-dimensional (3D) anatomy of the structures of interest with such reliability, promoting the overlapping of anatomical structures such as cervical spine, dimensional imprecision and phantom image formation (Pacenko, 2017; Jacobs, Salmon, Codari, Hassan & Bornstein, 2018). These limitations can, in certain situations, impose new challenges to the diagnostic process of clinical manifestations, such as complex extractions, placement of dental implants and surgical procedures involving the elevation and enlargement of the maxillary sinus (Hameed, Santawy & Almeshri, 2020).

Computed tomography appeared in the 1970s, being a technology capable of offering 3D images and consequently subsidizing diagnoses and surgical planning with better precision, in particular offering a quantitative and qualitative analysis of bone structures for future implant placement (Molon, 2015). Cone beam or cone beam computed tomography has

recently appeared, aimed at dental interests, which in addition to guaranteeing images in different planes, without overlapping, with excellent quality and resolution, also subjects the patient to a relatively low dose of radiation (Jacobs et al, 2018; Souza, 2019). In addition to having a compact size, ease of use and better cost-benefit, given the lower financial investment required to acquire the device, the image quality of cone beam computed tomography devices may vary depending on the exposure protocol when compared to multi-slice medical computed tomography (Jacobs et al, 2018). Another limitation of medical computed tomography is the absence of contrast between soft tissues, which can hinder the pre-surgical planning phase (Pauwels, 2015).

An important resource to enable the correct installation of the implants is bone regeneration, since it allows an adequate prosthetic rehabilitation. Therefore, correct planning is increasingly necessary, especially with regard to the location of unfavorable areas for implant placement (Malheiros & Tavares, 2016). It is also noteworthy that the atrophy of the alveolar ridges, due to a gradual bone resorption, is associated with traumatic, neoplastic, inflammatory or infectious tooth removal. To restore this adequate bone thickness, several biomaterials are used, including autogenous and xenogenous (Malheiros & Tavares, 2016; Mazzone, 2018).

Currently, the use of techniques and biomaterials has been observed to increase the vertical dimension of the maxilla, with the perspective of attributing to this maneuver a better healing prognosis and with regard to the placement of implants (Trinh, Dam, Le, Pittayapat & Thunyakitpisal, 2019). Thus, the use of biomaterials as grafts stands out, for example, autogenous bone and xenograft (Leigton, Weber, Rosas, Pinto & Borie, 2019; Danesh-Sani, Loomer & Wallace, 2016). Considering the pattern between the types of grafts, autogenous bone has osteogenic and osteoinductive properties, in addition to presenting osteoconductive properties. However, the use of this resource is not without disadvantages, since it requires an intraoral supply, morbidity at the donor site, the need for two surgical sites, risk of resorption, longer intervention time, in addition to greater chances of intra and postoperative complications (La- Monaca, Iezzi, Cristalli, Prano, Sfasciotti & Voza, 2018).

Meanwhile, xenografts are biomaterials transferred from one species to another, presenting osteoinductive properties and acting as space maintainers for bone regeneration. However, its osteoinductive capacity can be increased if there is an association of bone morphogenetic proteins (Lewin, Scharager & Picand, 2017; Danesh-Sani, Loomer & Wallace, 2016). Another type of biomaterial used in association with the grafts is the non-resorbable and resorbable collagen biological membranes. Such membranes act as a barrier to promote



bone regeneration (Lewin, Scharager & Picand, 2017; Barbosa Junior, 2019).

#### 4. Discussion

Pacenko et al (2017) in a retrospective study evaluating 100 imaging exams, aimed to assess the prevalence of changes in the maxillary sinuses observed on panoramic radiographs and cone beam computed tomography. Regarding veiling of the maxillary sinus, it was observed that there was a 90% agreement between both diagnostic methods, indicating the ease of identification of this manifestation in panoramic radiographs. Concerning the location of the septa inside the maxillary sinuses, the agreement between the exams was 31%, demonstrating that the panoramic radiograph does not present a complete precision of the maxillary sinus images when compared with cone beam computed tomography, being this the most suitable to assess the changes present in the maxillary sinus.

The study by Amine et al. (2020) examined cone beam computed tomographies of 300 patients filed in a private hospital in Casablanca-Morocco. Among the indications for such an examination, the planning for placing dental implants stood out. As for the imaging findings of these patients, it was observed that the average thickness of the maxillary sinuses in the premolar regions was approximately 1.16 +/- 0.48 mm. Other findings were related to the presence of septa and opacity within the sinus, being compatible with the presence of polyps and/or cysts.

In the study by Terrero-Pérez et al. (2018), 260 tomographic images of maxillary sinuses were analyzed in patients with partial or total edentulism. It was found that 126 maxillary sinuses had a deficient residual bone height, less than 4 mm, followed by 83 maxillary sinuses with a moderately deficient residual bone height between 4 mm and 7 mm. Only 51 maxillary sinuses exhibited a slightly deficient residual bone height, measuring about 7 mm to 10 mm.

The study by Kwon et al. (2019) performed the evaluation of 33 patients who underwent surgery to raise the sinus membrane using the transcrestal technique. Six months after the intervention, it was observed that the height of the patients' maxillary sinus varied between 7.88 mm to 21.63 mm, with an average residual bone height of 4.38 mm. As for the height of the apical graft, a gain of 2.85 mm was observed immediately after surgery and 6 months after a gain of 1.29 mm.

In a cross-sectional study by Anbiaee et al. (2019) analyzed 199 image examinations of asymptomatic maxillary sinuses using cone beam computed tomography. This research



aimed to evaluate the relationship between the volume of the maxillary sinus, pneumatization and associated anatomical factors. It was found that the mean value of the maxillary sinus volume and pneumatization were 15.54 mm and 3.54 mm, respectively. The prevalence of nasal septum deviation and maxillary sinus septa were 14.6%, 14.6% and 6%. It is concluded that there were no associations between anatomical factors, including deviation of the nasal septum and septa of the maxillary sinuses with the volume of the maxillary sinuses and pneumatization.

Barbosa et al. (2019) evaluated the importance of using cone beam computed tomography in patients who would later undergo dental implant installation. It was found that of the 226 CT scans analyzed, 25.2% had pneumatization of the maxillary sinus, 12.8% antral pseudocyst and 2.7% polyps. Therefore, the importance of this type of examination is emphasized in the perspective of diagnosing and treating this condition before the installation of dental implants, thus favoring a promising rehabilitation.

The study by Velasco-Torres (2017) analyzed 394 image exams performed using cone beam computed tomography. It was observed that the total volume of the maxillary sinus was significantly smaller in total or partial edentulous patients. In addition, older patients also exhibited a lower volume, regardless of sex and edentulism.

Zhao et al. (2018), studied the elevation of the floor of the transalveolar sinus. 120 patients were selected who needed implant placement in the posterior regions of atrophic jaws. It was observed that the elevation of the floor of the transalveolar sinus achieved ideal clinical results, exhibiting less trauma and complications in the postoperative period.

In the study by Khaled et al. (2019) a study was carried out comparing the elevation of the sinus membrane without using a graft and using nano-hydroxyapatite. It was observed that both groups did not present any complications after the installation of the implants, besides there were no signs of infection or oroantral communication. Furthermore, healing complications were not observed in any operated site. However, regarding the increase in bone volume and density, the group that performed the elevation of the sinus membrane using nano-hydroxyapatite showed better results. Despite this, in relation to implant stability, it is concluded that both techniques showed significant results.

Zheng et al. (2015) in their study analyzed the quality of bone graft after maxillary sinus enlargement using cone beam computed tomography. A decrease in the average volume of the xenograft material was observed in the postoperative period, however, these changes were not statistically significant. Despite this, the structural indexes of the xenograft showed a significant difference in relation to its homogeneity, connectivity, thickness and roughness in

the postoperative follow-up, confirming a positive result of the use of biomaterials during maxillary sinus elevation procedures.

Trinh et al. (2019) made sponges from the gelatinous extraction of the Acemana leaf (Aloe Vera) and they were used in cavities of elevated maxillary sinuses. In short, bone formation was observed in patients who used the bone substitute based on Aloe Vera, showing the effectiveness of this biomaterial. Still in this context, the possibility of using bioactive glass ceramics is highlighted, characterized by the potential for osteoconduction, resistance, biocompatibility and ability to bind to tissues (bioactivity). The bioactive glass forms a layer of silica gel on the surface. It consists of an absorbable synthetic material free from the risk of disease transmission or immune responses and helps with hemostasis, in addition to being useful for filling bone defects and orthopedic applications (Menezes et al, 2018).

## 5. Conclusion

After analyzing the maxillary sinus elevation procedures included in this literature review, it was possible to infer that this is a procedure that has good results and few complications in the postoperative period. It has also been observed that pneumatization of the maxillary sinuses is a frequent finding in partially or totally edentulous patients. Cone beam computed tomography should be the first-choice exam when this procedure is indicated for the installation of dental implants.

Also, clinicians must know and deepen the sinus lift technique to provide greater safety for the patient when understanding its various advantages for the treatment prognosis, as well as the aesthetic advantage provided.

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#### **Percentage of contribution of each author in the manuscript**

Wladimir Fernandes Filho – 20%

Daniel Felipe Fernandes Paiva – 16%

Juliana Campos Pinheiro – 16%

Gabriel Gomes da Silva – 16%

José Sérgio Maia Neto – 16%

Saulo Hilton Batista Botelho – 16%