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Maxillary Bone Reconstruction with Autogenous Grafts vs. Synthetic Biomaterials: A Comparative Analysis of Clinical Success and Implant Survival Rate

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RESUMO

A reconstrução óssea maxilar desempenha um papel fundamental na reabilitação oral de pacientes com perda óssea severa, possibilitando a colocação segura e bem-sucedida de implantes dentários. Para isso, diferentes materiais têm sido utilizados, cada um com suas próprias vantagens e desafios. Os enxertos ósseos autógenos, obtidos do próprio corpo do paciente, são amplamente reconhecidos por sua alta capacidade de integração, enquanto os biomateriais sintéticos surgem como alternativas promissoras, reduzindo a necessidade de um segundo procedimento cirúrgico. Este estudo teve como objetivo revisar a literatura e comparar a eficácia dessas duas abordagens na reconstrução óssea maxilar, analisando as taxas de sucesso clínico e a sobrevivência a longo prazo dos implantes. Para isso, foram consultados artigos científicos de bases de dados indexadas, incluindo ensaios clínicos, revisões sistemáticas e meta-análises que avaliaram os desfechos clínicos de cada material. Os resultados indicam que os enxertos autógenos continuam sendo o padrão-ouro, pois possuem propriedades que promovem uma regeneração óssea mais eficaz. No entanto, seu uso pode apresentar desafios, como a necessidade de um segundo sítio cirúrgico para a obtenção do enxerto e a possibilidade de reabsorção óssea. Por outro lado, os biomateriais sintéticos, como a hidroxiapatita e o fosfato de cálcio, oferecem uma abordagem menos invasiva e demonstram potencial osteocondutor, tornando-se ainda mais eficazes quando combinados com fatores de crescimento. Portanto, a escolha dos materiais deve levar em consideração as condições individuais de cada paciente, a disponibilidade óssea e o planejamento clínico. Ambos os métodos apresentam resultados positivos, mas são necessários mais estudos para aprimorar as técnicas e aumentar a previsibilidade da reconstrução óssea maxilar, garantindo maior sucesso e durabilidade a longo prazo dos implantes dentários.

Palavras-chave: Enxertos Ósseos; Seio Maxilar; Regeneração Óssea; Implantes Dentários; Biomateriais.

ABSTRACT

Maxillary bone reconstruction plays a fundamental role in the oral rehabilitation of patients with severe bone loss, making the safe and successful placement of dental implants possible. To achieve this, different materials have been used, each with its own advantages and challenges. Autogenous bone grafts, harvested from the patient's own body, are widely recognized for their high integration capacity, while synthetic biomaterials emerge as promising alternatives, reducing the need for a second surgical procedure. This study aimed to review the literature and compare the effectiveness of these two approaches in maxillary bone reconstruction, analyzing clinical success rates and the long-term survival of implants. To achieve this, scientific articles from indexed databases were consulted, including clinical trials, systematic reviews, and meta-analyses that evaluated the clinical outcomes of each material. The results indicate that autogenous grafts remain the gold standard, as they possess properties that promote more effective bone regeneration. However, their use can present challenges, such as the need for a second surgical site for graft harvesting and the possibility of bone resorption. On the other hand, synthetic biomaterials, such as hydroxyapatite and calcium phosphate, offer a less invasive approach and demonstrate osteoconductive potential, becoming even more effective when combined with growth factors. Therefore, the choice of materials should take into account the individual conditions of each patient, bone availability, and clinical planning. Both methods yield positive results, but further studies are needed to refine techniques and enhance the predictability of maxillary bone reconstruction, ensuring greater success and long-term durability of dental implants.

Keywords: Bone Grafts; Maxillary Sinus; Bone Regeneration; Dental Implants; Biomaterials.

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INTRODUCTION

Maxillary bone reconstruction is a crucial procedure in the oral rehabilitation of patients with severe bone loss, enabling the placement of dental implants in areas with insufficient bone height and thickness. Autogenous bone grafts have traditionally been considered the gold standard due to their osteogenic, osteoinductive, and osteoconductive properties, promoting predictable bone regeneration and improved implant integration (Chatelet et al., 2021). However, their use is associated with donor site morbidity, longer surgical time, and the risk of bone resorption over time. As an alternative, synthetic and xenogeneic biomaterials have been widely studied and used, offering advantages such as lower morbidity and unlimited availability, although their regenerative potential depends on their osteoconductive properties and the patient's biological response (Starch-Jensen et al., 2018).

Current scientific literature suggests that the difference in clinical success rates and implant survival between these two types of materials may not be statistically significant. Long-term studies indicate that both autogenous bone and biomaterials, when used following appropriate protocols, result in success rates exceeding 90% after five years of follow-up (Rapone et al., 2022; Jamcoski et al., 2023). Furthermore, systematic reviews demonstrate that the choice of grafting material may have a limited impact on implant longevity, with other factors—such as primary stability, remaining bone quality, and prosthetic planning—being more critical for successful rehabilitation (Rickert et al., 2012; Del Fabbro et al., 2004).

Given this evidence, the decision between autogenous grafts and synthetic biomaterials should not be based solely on biocompatibility and bone resorption rates. Still, it should also consider clinical and surgical factors, as well as the practitioner's expertise. This study aims to provide a comparative analysis of the effectiveness of both methods, examining their influence on clinical success rates and implant survival, contributing to an evidence-based approach in oral rehabilitation.

METHODOLOGY

This study is a literature review aimed at comparatively analyzing the effectiveness of different types of bone grafts used in maxillary sinus augmentation and their impact on dental implant success rates. A bibliographic search was conducted in the PubMed, Scopus, and Web of Science databases using the descriptors "maxillary sinus augmentation," "bone graft," "dental implants," and "implant survival rate," by DeCS/MeSH criteria.

Only articles published in the last 25 years were included, with a focus on systematic reviews, meta-analyses, and clinical studies with a minimum follow-up of five years that provided quantitative data on implant survival rates, bone stability, and graft resorption. Exclusion criteria included studies with unclear methodology, case reports, and articles without full-text access.

The study selection process was conducted in three stages: title screening, abstract analysis, and full-text reading of eligible articles. Two independent reviewers performed data screening and extraction, and in cases of disagreement, a third reviewer was consulted. The methodological quality of the selected studies was assessed using the AMSTAR criteria for systematic reviews and the Newcastle-Ottawa scale for observational studies.

The extracted data were organized into thematic categories, allowing for a synthesis of the main evidence regarding the types of biomaterials used, their resorption rates, and their influence on the long-term success of dental implants.

RESULTS AND DISCUSSION

The reviewed studies demonstrated that the success rate of dental implants in areas subjected to maxillary sinus elevation is high, regardless of the type of bone graft used. However, significant differences were observed regarding bone resorption rate, long-term stability, and procedural predictability.

Autogenous Bone Grafts

Autogenous bone grafts are widely considered the gold standard due to their

osteoconductive, osteoinductive, and osteogenic properties. Studies such as those by Rickert et al. (2012) and Keller et al. (1999) confirm that the exclusive use of autogenous bone results in a higher success rate and lower long-term bone resorption. Chatelet et al. (2021) also highlighted that autogenous bone blocks exhibit a high integration and remodeling rate, contributing to more efficient new bone formation. However, the need for a second surgical site to obtain the graft may increase patient morbidity and recovery time, making this approach less attractive in certain cases (Del Fabbro et al., 2004).

Xenogeneic Bone Grafts

The use of xenogeneic biomaterials, such as bovine and porcine-derived bone, has been extensively studied. Galindo-Moreno et al. (2022) conducted a randomized clinical trial comparing bovine and porcine bone grafts mixed with autogenous bone and observed that both biomaterials effectively maintained bone volume and implant osseointegration. However, the authors noted that bovine bone had a slower resorption rate, providing a more stable scaffold over time. Rapone et al. (2022) reinforced this observation by comparing the use of porous fluoridated hydroxyapatite (Algipore®) with an organic bovine bone (Bio-Oss®) and PRP, demonstrating that Bio-Oss® better-preserved bone height over time, while the addition of PRP accelerated new bone formation.

Synthetic Biomaterials

Synthetic biomaterials have also shown promising results. Starch-Jensen et al. (2018) conducted a systematic review and meta-analysis on the use of synthetic bone substitutes in maxillary sinus elevation and concluded that these materials can be successfully used, particularly when combined with growth factors or autogenous grafts. In a long-term review (>5 years), Starch-Jensen et al. (2018) reported that implant success rates were similar between groups using synthetic bone substitutes and autogenous bone, although resorption rates were slightly higher in synthetic materials.

Residual Bone Height and Implant Success

In addition to graft type, residual bone height in the maxillary sinus directly influences implant success. Jamcoski et al. (2023) conducted a 15-year retrospective study and found that patients with residual bone height below 4 mm had a higher risk of implant failure compared to those with an initial height above 6 mm, regardless of the graft type used. This finding aligns with Jensen et al. (2012), who suggested that primary implant stability may be compromised in regions with reduced bone height, making it necessary to use biomaterials with lower resorption rates.

Combination of Bone Grafts

Another relevant aspect in the literature is the combination of bone grafts. Rickert et al. (2012) investigated the effectiveness of combining autogenous bone with growth factors and bone substitutes, observing that this approach resulted in a higher rate of new bone formation and greater procedural predictability. Jensen et al. (2012) also reported that the combination of Bio-Oss® with autogenous bone improved graft stability and reduced bone resorption over time. Additionally, Del Fabbro et al. (2004) indicated that the use of growth factors can accelerate bone remodeling, favoring implant osseointegration.

Implant Longevity in Grafted Areas

Regarding implant longevity in grafted areas, Starch-Jensen et al. (2018) reported that the success rate over a period exceeding 5 years was high, regardless of the biomaterial used. Jamcoski et al. (2023) corroborated these findings, demonstrating that implant survival in maxillary sinus elevation procedures was approximately 95% after 15 years, highlighting the predictability of the procedure.

Table 1: Summary of evidence on biomaterials used in maxillary sinus lift.

Category	Biomaterial	Main Evidence	Resorption Rate	Influence on Implant Longevity	References
Autogenous	Autogenous bone (iliac, chin, cranial vault)	High osteogenic, osteoinductive, and osteoconductive potential; requires donor site	High (25-60%)	High success rate, but resorption may compromise bone volume in the long term	Chatelet et al. (2021); Rickert et al. (2012)
Xenogeneic	Deproteinized bovine bone (Bio-Oss®)	High biocompatibility and volumetric stability; osteoconductive	Low (<10%)	Excellent bone maintenance, promoting implant longevity	Galindo-Moreno et al. (2022); Starch-Jensen et al. (2018)
Xenogeneic	Lyophilized porcine bone	Alternative to bovine; good bone integration	Low (<10%)	Similar results to bovine, with good bone support	Galindo-Moreno et al. (2022)
Allograft	Demineralized human bone	Good osteoinduction, but less volumetric stability than xenogeneic bone	Moderate (15-30%)	Good regeneration potential, but variable results	Starch-Jensen et al. (2018)

Synthetic	Hydroxyapatite and β-TCP (calcium phosphate)	Osteoconductive; can be combined with PRP for enhanced osteogenesis	Moderate (20-40%)	Less predictable than autogenous bone but viable as an alternative	Starch-Jensen et al. (2018); Rapone et al. (2022)
Synthetic + Growth Factors	Hydroxyapatite combined with PRP	Stimulates cell differentiation and angiogenesis; enhances bone regeneration	Moderate (20-40%)	Potential to accelerate new bone formation, reducing osseointegration time	Rapone et al. (2022)
Mixed (Autogenous + Biomaterial)	Autogenous bone + Bio-Oss®	Combines osteogenic potential with volumetric stability	Low to moderate (depending on the ratio)	Better control of bone resorption, recommended for significant maxillary sinus augmentation	Jensen et al. (2012); Del Fabbro et al. (2004)

Source: Prepared by the authors, 2025.

The literature indicates that the choice of biomaterial for maxillary sinus elevation should be individualized, considering factors such as autogenous bone availability, surgical morbidity, and bone resorption predictability. Although autogenous grafts remain widely used and offer biological advantages, xenogeneic and synthetic biomaterials have shown promising results, emerging as viable alternatives for implant rehabilitation.

CONCLUSION

The maxillary sinus lift has proven to be an effective technique in rehabilitating patients with bone atrophy in the posterior maxilla, allowing for the placement of dental implants with high predictability. The reviewed literature highlights that different types of bone grafts can be successfully used, with the autogenous bone still being considered the gold standard due to its osteogenic, osteoconductive, and osteoinductive properties. However, its resorption rate and the need for a second surgical site are disadvantages that drive the search for alternatives.

Xenogeneic biomaterials, such as bovine and porcine bone, have demonstrated excellent biocompatibility and the ability to maintain bone volume over the long term, making them viable options when combined with autogenous bone or growth factors. Likewise, synthetic bone substitutes have shown promising results, especially when enriched with platelet-rich plasma or other biological modulators that promote bone neoformation.

In addition to the type of graft, residual bone height is a key factor in implant success. Patients with less than 4 mm of residual bone height are at higher risk for failure, underscoring the importance of careful planning and selecting the most appropriate biomaterial for each case. The reviewed literature also suggests that combining different grafts can optimize the procedure's predictability, reducing bone resorption and improving implant stability.

Based on this evidence, it can be concluded that there is no single ideal material for maxillary sinus lift, but rather a range of options that should be selected based on the patient's individual characteristics and clinical goals. Further research, especially long-term clinical studies, is needed to validate and improve the use of biomaterials, ensuring greater success and durability of implants in grafted areas.

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