Polo del Conocimiento

Pol. Con. (Edición núm. 108) Vol. 10, No 7
Julio 2025, pp. 707-719
ISSN: 2550 - 682X
DOI: https://doi.org/10.23857/pc.v10i7.9922

CC BY NC SA

Aplicaciones de injertos óseos en rebordes atróficos. Revisión de la literatura

Applications of bone grafts in atrophic ridges. Literature review

Aplicações do enxerto ósseo em cristas atróficas. Revisão de literatura

Juan Carlos Cabrera-Yánez [I]
jcarlos.cabrera@ucuenca.edu.ec
https://orcid.org/0009-0008-0483-552X

Joselyne Nayelly Jara-Sangurima [II]
nayelly.jara@ucuenca.edu.ec
https://orcid.org/0009-0005-4878-9156

David Pineda-Álvarez [III]
david.pineda@ucuenca.edu.ec
https://orcid.org/0000-0002-6395-7702

Correspondencia: jcarlos.cabrera@ucuenca.edu.ec

Ciencias de la Educación
Artículo de Investigación

*** Recibido:** 20 de mayo de 2025 ***Aceptado:** 04 de junio de 2025 *** Publicado:** 08 de julio de 2025

I. Students at the Faculty of Dentistry, University of Cuenca, Ecuador.
II. Students at the Faculty of Dentistry, University of Cuenca, Ecuador.
III. Faculty member at the Faculty of Dentistry, University of Cuenca, Ecuador.

Resumen

Objetivo: El objetivo es realizar un mapeo mediante la revisión de la literatura existente para determinar el tratamiento para la aplicación de injertos óseos, ya sea vertical, horizontal o una combinación de ambos. Materiales y métodos: La revisión se apegó a las directrices PRISMA y empleó una estrategia de búsqueda exhaustiva utilizando las principales bases de datos, palabras clave para este estudio y operadores booleanos. Los criterios de inclusión consistieron en ensayos controlados aleatorizados y series de casos que informaran sobre el uso y la aplicación de injertos óseos. Como resultado, la búsqueda identificó 30 estudios centrados en la aplicación de injertos óseos en rebordes alveolares atróficos.

Resultado: Tras identificar 2129 documentos, incluyendo artículos, monografías, etc., se revisaron los artículos, se excluyeron varios y, finalmente, solo se seleccionaron 30, ya que abordaban la aplicación de injertos óseos y cumplían con los criterios propuestos para esta revisión.

Conclusión: Los autoinjertos son el estándar de oro en la regeneración ósea debido a sus excelentes características, pero presentan altas tasas de reabsorción y complicaciones. Los xenoinjertos ofrecen alta biocompatibilidad y estabilidad volumétrica, aunque presentan riesgos asociados. Los injertos aloplásticos también han demostrado resultados muy satisfactorios. Por lo tanto, no existe una técnica única; la integración ósea y la estabilidad volumétrica son clave para elegir el procedimiento adecuado, y la selección del material debe basarse en las necesidades clínicas del paciente.

Palabras clave: Injertos óseos naturales; Xenoinjerto y autoinjerto en el maxilar; Injerto óseo maxilar; Aumento de la cresta maxilar; Aloinjerto maxilar.

Abstract

Objective: The objective is to perform a mapping through a review of the existing literature to determine the treatment for bone graft application, either vertically, horizontally, or in a combination of both. Materials and methods: The review adhered to PRISMA guidelines and employed an exhaustive search strategy using major databases, keywords for this study, and Boolean operators. Inclusion criteria consisted of randomized controlled trials and case series reporting on the use and application of a bone graft. As a result, the search identified 30 studies focused on the application of bone grafts in atrophic alveolar ridges.

Result: After identifying 2,129 documents including articles, monographs, etc., the articles were reviewed, several were excluded, and finally, only 30 were selected, as they addressed the application of bone grafts and also met the proposed criteria for this review.

Conclusion: Autografts are the “gold standard” in bone regeneration due to their excellent characteristics, but they have high rates of resorption and complications. Xenografts offer high biocompatibility and volumetric stability, although they show associated risks. Alloplastic grafts have also shown very successful results. Therefore, there is no single technique; osseous integration and volumetric stability are key in choosing the appropriate procedure, and material selection should be based on the patient's clinical need.

Keywords: Natural bone grafts; Xenograft and autograft in the maxilla; Maxillary bone graft; Maxillary ridge augmentation; maxillary allograft.

Resumo

Objectivo: O objectivo é realizar um mapeamento através de uma revisão da literatura existente para determinar o tratamento para a aplicação de enxerto ósseo, seja vertical, horizontal ou numa combinação de ambos. Materiais e métodos: A revisão seguiu as diretrizes PRISMA e empregou uma estratégia de pesquisa exaustiva utilizando as principais bases de dados, palavras-chave para este estudo e operadores booleanos. Os critérios de inclusão consistiram em ensaios clínicos randomizados e séries de casos relatando a utilização e aplicação de enxerto ósseo. Como resultado, a pesquisa identificou 30 estudos focados na aplicação de enxertos ósseos em rebordos alveolares atróficos.

Resultado: Após a identificação de 2129 documentos, incluindo artigos, monografias, etc., os artigos foram revistos, vários foram excluídos e, por fim, apenas 30 foram selecionados, uma vez que abordavam a aplicação de enxertos ósseos e também cumpriam os critérios propostos para esta revisão.

Conclusão: Os enxertos autógenos são o "gold standard" na regeneração óssea devido às suas excelentes características, mas apresentam elevadas taxas de reabsorção e complicações. Os xenoenxertos oferecem uma elevada biocompatibilidade e estabilidade volumétrica, embora apresentem riscos associados. Os enxertos aloplásticos também apresentam resultados muito bem-sucedidos. Portanto, não existe uma técnica única; a integração óssea e a estabilidade volumétrica

são fundamentais na escolha do procedimento adequado, sendo que a seleção do material deve ser baseada na necessidade clínica do paciente.

Palavras-chave: Enxertos ósseos naturais; Enxerto xenogénico e autógeno na maxila; Enxerto ósseo maxilar; Aumento da crista maxilar; enxerto alogénico maxilar.

Introduction

Bone grafting is defined as a tissue capable of promoting bone healing when implanted into a bone defect, either independently or in combination with other materials. On the other hand, a bone replacement refers to a material, either natural or artificial, generally consisting of a mineralized bone matrix without viable cells, but which can serve functions similar to those of a graft (1).

The use of bone grafts and substitutes in medicine has a long history, with the first documented use of bone grafts dating back to 1682 when a cranial defect was successfully restored using a bone graft from a deceased dog (2). In dentistry, one of the most common situations requiring bone graft application is the lack of bone tissue after dental loss. This phenomenon is due to the rapid resorption of the alveolar bone, a consequence of the lack of intraosseous stimulation that is normally exerted through the fibers of the periodontal ligament (2).

The success of dental implant placement depends on the adequate dimensions of the alveolar bone, which should be at least 10 mm in height and between 3 and 4 mm in diameter. It is estimated that approximately 50% of all dental implant procedures currently performed require the application of bone grafts. Globally, recent data indicates that approximately 2.2 million bone graft procedures are performed annually, with a projected cost of 664 million dollars for 2021. Furthermore, it is anticipated that the number of surgical procedures for bone defect repair will increase by approximately 13% annually (1).

Bone grafts are frequently used in conjunction with dental implant surgery. There are various types of bone graft materials, such as autologous bone, allogeneic bone, xenogeneic bone, and synthetic materials (2, 3, 4).

Although it is known, to this day, there is no ideal graft material, which continues to represent a challenge for implantology as the ideal material should meet seven principles: 1) unlimited supply without compromising the donor area; 2) promote osteogenesis; 3) not show an immune response from the host; 4) revascularize rapidly; 5) stimulate osteoinduction; 6) promote osteoconduction;7) be completely replaced by bone in quantity and quality similar to that of the host (5).

The objective of this article is to carry out a mapping through a review of the existing literature to determine the most appropriate treatment for cases requiring bone augmentation, whether vertically, horizontally, or in combination of both.

Methodology

This article is written in accordance with the PRISMA checklist for narrative reviews (PRISMA-ScR).

Inclusion Criteria:

1. Articles published in scientific journals from the digital databases PubMed, SciELO, and Springer Link.
2. Articles published in the last 10 years: 2015-2025.
3. The accepted languages will be Spanish and English.
4. Randomized clinical trials.
5. Cases reporting the use and application of a bone graft in an atrophic ridge.

Exclusion Criteria:

1. Articles for which the full text cannot be obtained.
2. Duplicate articles.
3. Articles not directly related to the study topic.
4. Studies conducted on animals.

Search Strategy:

The following keywords were used: "Natural and synthetic bone substitutes," "Xenograft and autograft in maxillary," "Maxillary bone graft," "Ridge maxillary augmentation," "Maxillary allograft." These keywords were employed in the PubMed, SciELO, and Springer Link databases using the Boolean operators AND and OR, which facilitated the search strategy, especially in excluding irrelevant articles.

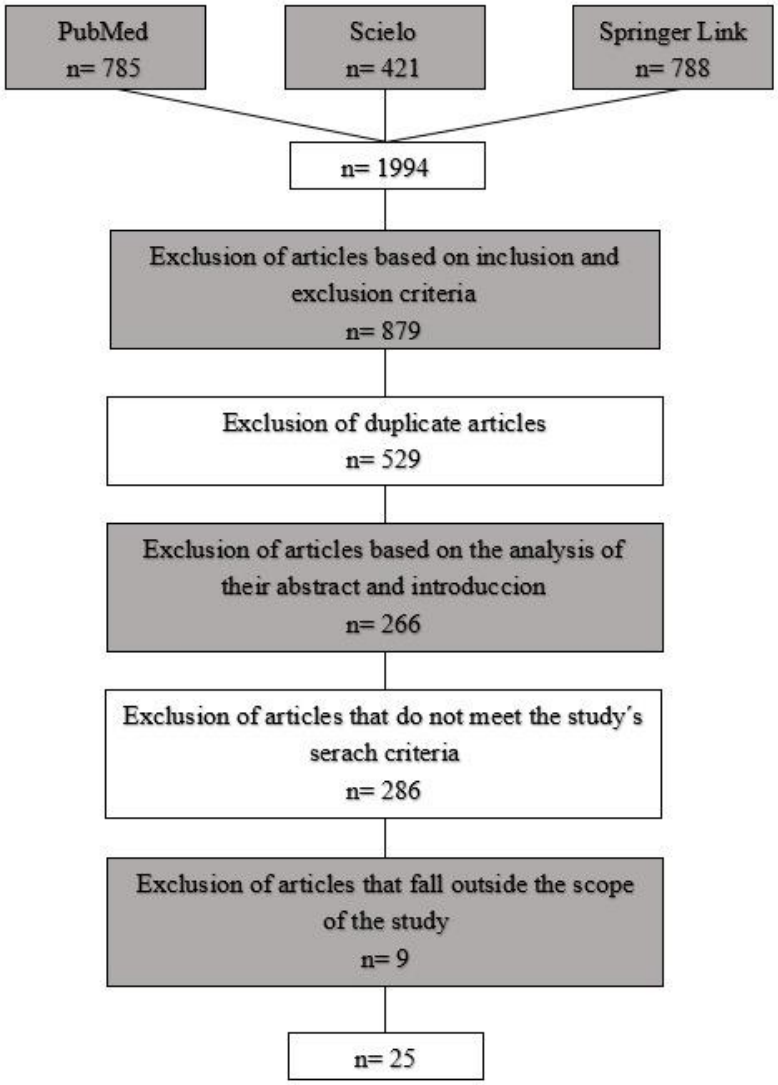
Organization and Analysis of Information:

To organize the selected information, a database was created in Excel. Subsequently, each scientific article was analyzed according to the inclusion and exclusion criteria, ensuring its compatibility with the study topic in order to discard those that were not suitable for use in the research.

Results

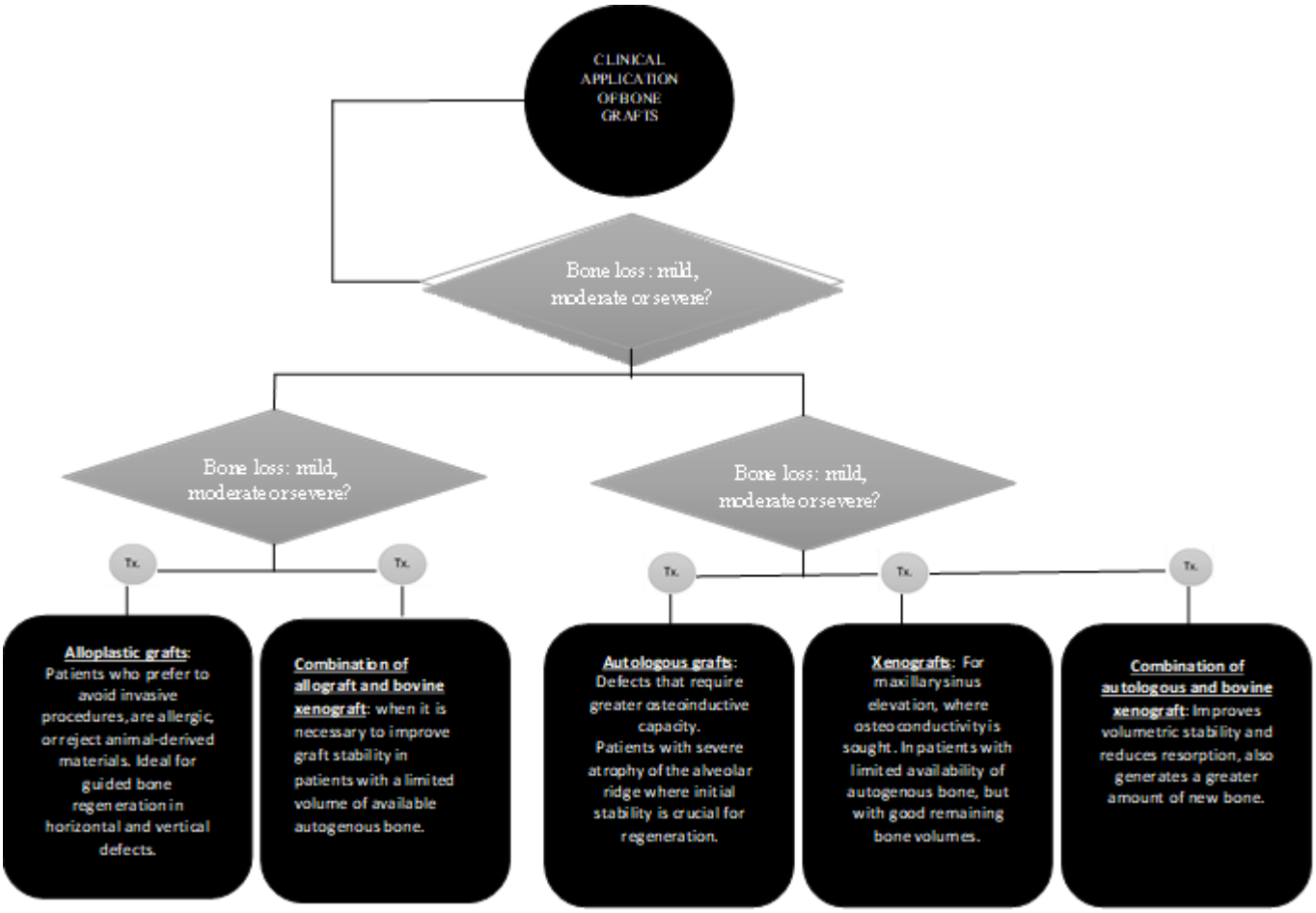
After conducting the searches, 1994 documents were identified, including articles, monographs, etc. After reviewing the articles, 878 were excluded based on inclusion and exclusion criteria, and an additional 529 were excluded due to duplication. A further 266 were excluded after analyzing their abstracts and introductions, 287 were discarded because they did not meet the study's search criteria, and finally, 9 articles were excluded as they were outside the scope of the study. Only 25 articles were selected, as they addressed the application of bone grafts in atrophic ridges and met the criteria set for this review.

Figure 1: *Flowchart for obtaining the bibliographic base.*



Pol. Con. (Edición núm. 108) Vol. 10, No 7, Julio 2025, pp. 707-719, ISSN: 2550 - 682X

Figure 2: *Flowchart for clinical application of bone grafts.*



Discussion

Mahardawi et al. mentions that autografts remain the "gold standard" due to their excellent osteoconductivity, osteogenicity, and osteoinductivity. However, they present higher rates of resorption and complications at the donor site. Despite their potent ability to enhance new bone formation, limitations such as additional surgical time, costs, limited supply, and increased morbidity or bacterial contamination risks are noted. According to Istvan A. Urban et al. (2023) and Correia et al. (2021), xenografts from pigs (MOP3) are comparable to autografts in maxillary sinus lift procedures, with bone levels of 8.7 ± 2.2 mm (xenograft) versus 7.8 ± 2.4 mm (autograft). The absence of adverse reactions and their excellent osteoconductivity are highlighted (6, 7, 8, 9, 10).

Xenografts, such as those derived from bovine and porcine bone, offer high biocompatibility and volumetric stability with lower resorption rates which is why it is said that combining autografts

with bovine xenografts enhances the volumetric stability of the regenerative material. Xenografts provide a stable osteoconductive matrix, while autografts contribute osteogenic cells and growth factors. Similarly, Thomas Starch-Jensen et al. (2021) assert in their study that this combination leads to a greater amount of new bone compared to the use of autografts alone and reduces resorption rates (11, 12).

Authors Francisco Correia et al. (2024) and Cosme García et al. (2020) agree that autografts present the highest resorption rates (45%), followed by allografts (21.7%). Xenografts show greater stability, with resorption rates under 10% in many studies. Combinations of autografts with xenografts significantly reduce resorption, ensuring greater long-term stability (8, 13).

Buser D, Urban I, Monje A, Kunrath MF, and Dahlin C. (2023) mention that since no single bone graft material can meet all the requirements, the best of both worlds should be combined: autologous bone with its great osteoconductive, osteoinductive, and osteogenic potential, stimulating bone formation during the early healing phase; and a low-resorption filler that maintains the gained bone volume stable over the long term (14).

According to Francisco Correia et al. (2024), xenografts derived from bovine bone carry associated risks such as foreign body reactions and chronic infections. Other risks include soft tissue dehiscence, exposure of the graft, and partial or total material loss. Although these complications are rare, long-term monitoring is required. On the other hand, Cosme García (2020) mentions that alloplastic materials have a lower incidence of complications, but their osteoconductivity is inferior to autografts and xenografts (8, 13). Martinez Alvarez et al. (2018) indicate that, compared to autografts or xenografts, alloplastics show similar success rates in both vertical and horizontal bone regeneration (15). In their study, Rusin Zhao et al. (2021) state that to overcome potential immunogenicity and donor site morbidity, synthetic materials for bone substitutes are being developed to closely mimic the biological properties of natural bone (1). Additionally, Essam Al Moraissi et al. (2022) suggest that autografts, the current gold standard bone graft, showed a high resorption rate and less volumetric gain compared to alternative graft combinations. AG (allograft) and XG (xenograft) also showed significant differences with less volumetric gain than AP (alloplastic) and its combinations. No difference was detected between AP and AG+AP. However, there was significantly less volumetric gain for AP alone compared to the combinations of AG+XG and XG with growth factors. These findings suggest significant advantages for new bone formation when using graft materials in combination (16). Florin Onișor-Gligor et al. (2015) also emphasizes

the combination of materials and mentions that the 1/1 mixture of alloplastic and autologous materials used for maxillary sinus augmentation leads to an improvement of the characteristics each material has when used alone (17).

Cárdenas et al. (2024), Correia et al. (2023) note that autografts are ideal for complex cases, while xenografts and biomaterials offer less invasive alternatives with comparable results in procedures such as maxillary sinus lift. They agree that long-term results show that there is no one-size-fits-all technique. Initial bone integration and volumetric stability are key factors in selecting the most appropriate procedure for each patient (8, 18). Finally, AlGhamdi AS et al. says that the selection of graft material depends on the operator's preference, the defect type and size, the resorbability of the graft material, cost, and patient acceptance (19). According to a study by Rodríguez et al., long-term safety of xenografts and their potential association with disease are valid concerns. Bovine bone xenografts are not biodegradable. Complications found included bone pathologies of the paranasal and maxillary sinuses, displacement of graft materials, implant failure, foreign body reactions, encapsulation, chronic inflammation, soft tissue fenestration, and associated cysts. The resolution or improvement of associated lesions was achieved by removing the bone graft materials. Clinical evaluations over the long term are required to identify the biological complications of xenografts used (20).

Chatelet et al. (2021) and SpyridonN (2016) reports that the implant survival rate does not differ between guided bone regeneration or autologous block grafts. The choice of treatment always depends on various factors related to the patient and the anatomy of the existing defects, with classifications such as Chipasco's (2008) for the posterior maxilla and Cawood and Howell's (1988) for the posterior mandible (21). They mention that using the shell technique results in greater bone gain compared to GBR, with a gain of 2.10 ± 0.87 mm for GBR and 2.18 ± 0.79 mm for the shell technique (22). Additionally, in a study by Starch-Jensen et al., no differences in implant treatment outcomes were noted after horizontal ridge augmentation with allogenic bone block compared to autologous bone block. They emphasize that rigorous donor selection and proprietary aseptic processing programs have made the use of human allografts a safe and effective therapeutic option (23).

Sapoznikov et al. (2024) highlight that dentin-derived graft material has properties that allow it to meet many of the criteria for an optimal graft material. However, unlike bone material, dentin grafts are slowly resorbed as the bone and repair area remodel, which does not negatively affect long-

term bone strength. Furthermore, dentin material stimulates bone growth and establishes close connections with bone, providing relatively early strength and mechanical resistance at the graft site (24). According to Oguić et al., their study on dentin-derived grafts demonstrated that these grafts are biocompatible and have osteoconductive and osteoinductive properties (25).

Chiliquinga et al. (2024) mentions that bone grafts play an important role in dental implantology, especially in cases of severe atrophy of alveolar ridges that prevent the use of dental implants for high-quality, long-lasting rehabilitation. In these situations, bone grafts are necessary to prevent the negative effects of bone loss after dental loss. Together with implant rehabilitation, bone grafts will improve the patient's quality of life (19).

Conclusions

Autografts are the "gold standard" in bone regeneration due to their excellent osteoconductivity and osteogenicity but have high resorption rates and donor site sequelae. In contrast, porcine xenografts are comparable in maxillary sinus elevation, with no adverse reactions and good osteoconductivity.

Bovine and porcine xenografts offer high biocompatibility and volumetric stability with lower resorption rates. The combination of autografts and bovine xenografts improves volumetric stability and generates more new bone compared to autografts alone.

Autografts have the highest resorption rates (45%), while xenografts are more stable with resorption rates under 10%. This combination not only reduces resorption but also ensures long-term stability.

Nonetheless, bovine xenografts may present risks such as foreign body reactions, although these are rare. Alloplastic materials have fewer complications but are less osteoconductive.

The use of alloplastics with xenografts or autografts improves volumetric stability and reduces resorption. Additionally, the use of titanium membranes and growth factors, such as PRF, is effective for bone regeneration.

Graft selection should be based on the clinical needs of the patient. While autografts are ideal for complex cases, xenografts and biomaterials offer less invasive alternatives with comparable results in procedures such as maxillary sinus lift. There is no single technique applicable to all cases; bone integration and volumetric stability are key when choosing the most appropriate procedure.

References

1. Zhao R, Yang R, Cooper PR, Khurshid Z, Shavandi A, Ratnayake J. Bone Grafts and Substitutes in Dentistry: A Review of Current Trends and Developments. Molecules. 18 de mayo de 2021;26(10):3007.
2. Cha HS, Kim JW, Hwang JH, Ahn KM. Frequency of bone graft in implant surgery. Maxillofac Plast Reconstr Surg. 31 de marzo de 2016;38(1):19.
3. Salmerón Escobar JI. Preprosthetic surgery: A critical analysis. Rev Esp Cir Oral Maxilofac. agosto de 2007;29(4):228-39.
4. Ciszyński M, Dominiak S, Dominiak M, Gedrange T, Hadzik J. Allogenic Bone Graft in Dentistry: A Review of Current Trends and Developments. Int J Mol Sci. enero de 2023;24(23):16598.
5. Matos JDM de, Nakano LJN, Silva SAB da, Nascimento JA do, Aureliano GMG, Andrade VC, et al. Los Injertos Óseos Homogéneos como una Alternativa en los Tratamientos de Rehabilitación Oral con Implantes Dentales. Int J Odontostomatol. diciembre de 2020;14(4):678-84.
6. Mahardawi B, Rochanavibhata S, Jiaranuchart S, Arunjaroensuk S, Mattheos N, Pimkhaokham A. Autogenous tooth bone graft material prepared chairside and its clinical applications: a systematic review. Int J Oral Maxillofac Surg. 1 de enero de 2023;52(1):132-41.
7. Urban IA, Montero E, Amerio E, Palombo D, Monje A. Techniques on vertical ridge augmentation: Indications and effectiveness. Periodontol 2000. octubre de 2023;93(1):153-82.
8. Correia F, Pozza DH, Gouveia S, Felino AC, Faria-Almeida R. Advantages of Porcine Xenograft over Autograft in Sinus Lift: A Randomised Clinical Trial. Materials. 21 de junio de 2021;14(12):3439.
9. Haugen HJ, Lyngstadaas SP, Rossi F, Perale G. Bone grafts: which is the ideal biomaterial? [citado 5 de abril de 2025]; Disponible en: https://onlinelibrary.wiley.com/doi/10.1111/jcpe.13058
10. Miron RJ. Optimized bone grafting. Periodontol 2000. 2024;94(1):143-60.

11. Starch-Jensen T, Deluiz D, Vitenson J, Bruun NH, Tinoco EMB. Maxillary Sinus Floor Augmentation with Autogenous Bone Graft Compared with a Composite Grafting Material or Bone Substitute Alone: a Systematic Review and Meta- Analysis Assessing Volumetric Stability of the Grafting Material. J Oral Maxillofac Res. 31 de marzo de 2021;12(1):e1.
12. Miron RJ, Zhang Q, Sculean A, Buser D, Pippenger BE, Dard M, et al. Osteoinductive potential of 4 commonly employed bone grafts. Clin Oral Investig. noviembre de 2016;20(8):2259-65.
13. García Martí CD, Pérez Padrón A, Pérez Quiñones JA, Bello Fuentes R, Pérez Padrón A, García Martí CD, et al. Utilización de biomateriales e injertos óseos autólogos en pacientes con atrofia alveolar. Rev Médica Electrónica. octubre de 2020;42(5):2366-77.
14. Buser D, Urban I, Monje A, Kunrath MF, Dahlin C. Guided bone regeneration in implant dentistry: Basic principle, progress over 35 years, and recent research activities. Periodontol 2000. octubre de 2023;93(1):9-25.
15. Martínez Álvarez O, Barone A, Covani U, Fernández Ruíz A, Jiménez Guerra A, Monsalve Guil L, et al. Injertos óseos y biomateriales en implantología oral. Av En Odontoestomatol. junio de 2018;34(3):111-9.
16. Al-Moraissi E, Alhajj WA, Al-Qadhi G, Christidis N. Bone Graft Osseous Changes After Maxillary Sinus Floor Augmentation: A Systematic Review. J Oral Implantol. 1 de octubre de 2022;48(5):464-71.
17. Onişor-Gligor F, Juncar M, Câmpian RS, BăciuŢ G, Bran S, BăciuŢ MF. Subantral bone grafts, a comparative study of the degree of resorption of alloplastic versus autologous grafts. Romanian J Morphol Embryol Rev Roum Morphol Embryol. 2015;56(3):1003-9.
18. Chiliquinga BRC, Cordova BRG, Delgado ERE, Gómez JLT. Injertos óseos para implantología oral, técnicas y protocolos. Polo Conoc. 21 de marzo de 2024;9(3):3307-23.
19. AlGhamdi AS, Shibly O, Ciancio SG. Osseous grafting part II: xenografts and alloplasts for periodontal regeneration--a literature review. J Int Acad Periodontol. abril de 2010;12(2):39-44.
20. Rodriguez AE, Nowzari H. The long-term risks and complications of bovine-derived xenografts: A case series. J Indian Soc Periodontol. 2019;23(5):487-92.

21. Chatelet M, Afota F, Savoldelli C. Review of bone graft and implant survival rate : A comparison between autogenous bone block versus guided bone regeneration. J Stomatol Oral Maxillofac Surg. 1 de abril de 2022;123(2):222-7.
22. De Angelis P, Cavalcanti C, Manicone PF, Liguori MG, Rella E, De Rosa G, et al. A Comparison of Guided Bone Regeneration vs. the Shell Technique Using Xenogeneic Bone Blocks in Horizontal Bone Defects: A Randomized Clinical Trial. Dent J. 9 de mayo de 2024;12(5):137.
23. Starch-Jensen T, Deluiz D, Tinoco EMB. Horizontal Alveolar Ridge Augmentation with Allogeneic Bone Block Graft Compared with Autogenous Bone Block Graft: a Systematic Review. J Oral Maxillofac Res. 31 de marzo de 2020;11(1):e1.
24. Sapoznikov L, Humphrey M. Progress in Dentin-Derived Bone Graft Materials: A New Xenogeneic Dentin-Derived Material with Retained Organic Component Allows for Broader and Easier Application. Cells. 31 de octubre de 2024;13(21):1806.
25. Oguić M, Čandrlić M, Tomas M, Vidaković B, Blašković M, Jerbić Radetić AT, et al. Osteogenic Potential of Autologous Dentin Graft Compared with Bovine Xenograft Mixed with Autologous Bone in the Esthetic Zone: Radiographic, Histologic and Immunohistochemical Evaluation. Int J Mol Sci. 29 de marzo de 2023;24(7):6440.

© 2025 por los autores. Este artículo es de acceso abierto y distribuido según los términos y condiciones de la licencia Creative Commons Atribución-NoComercial-CompartirIgual 4.0 Internacional (CC BY-NC-SA 4.0) (https://creativecommons.org/licenses/by-nc-sa/4.0/).