



Research Article

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Buccal Plate Regeneration Using Particulate Allograft Materials in Implants Rehabilitation

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Abstract

This research review paper discusses use of bone regeneration techniques to treat jaw inadequacies caused by various factors such as tooth loss, infections, tissue damage, neoplasms, or local trauma. The paper highlights the need for long-lasting repair of the hard/soft tissue interface and the use of xenografts and alloplastic bone substitutes as a safe and practical alternative to autologous graft retrieval. The limitations of dental bone grafts availability in market and alternative materials are also discussed, along with potential future developments of workable replacements due to the recent discovery of synthetic bone substitutes. Additionally, the paper focuses on the importance of the buccal bone plate of the alveolar process and its remodeling process, which can impact the success of implant surgery. Various dental approaches for buccal plate regeneration, including GBR and autogenous bone grafts, are also discussed. In order to aid in the development of new bone substitute materials with more desirable biological and mechanical properties, the paper aims to highlight the differences between what is currently available on the market and what would be thought to be the ideal bone substitute material of choice in the future.

Keywords

Buccal plate regeneration, Particulate allograft, Implant rehabilitation

Abbreviations

GBR: Guided Bone Tissue Regeneration

Introduction

Bone regeneration techniques have been developed to treat jaw inadequacies caused by tissue damage, neoplasms, tooth loss, infections, or local trauma. These techniques vary depending on the type of deficiency, the regional anatomy, the defect extension, and the anticipated rehabilitation [1]. Xenografts and alloplastic bone substitutes are widely used because of their excellent manageability and effectiveness and have been evaluated in multiple studies. However, there are still issues with the materials being used, including minimal patient morbidity, low cost, low immunogenicity, ease of handling and angiogenic potential [2]. The limitations of commercially available dental bone grafts and alternative materials are discussed in this literature review, along with any potential future developments of workable replacements due to the recent discovery of synthetic bone substitutes [3].

The buccal bone plate of the alveolar process is closely related to the tooth it supports and undergoes significant remodeling following tooth loss or extraction. Bone resorption is also seen after implant insertion and is thought to result from the surgical stress and the tissues' adaptation to the new foreign object. Planning an immediate implant requires a type 1 socket, and the thickness of the buccal alveolar

bone wall experiences significant remodeling, impacting the implant's volume and how the soft and hard tissues interact with it [4].

Several surgical techniques may augment the bone volume of the horizontally deficient alveolar ridges and enable implant insertion in conjunction with a prosthodontic treatment plan. GBR has gotten much attention in the literature and is a well-respected method for enhancing hard tissue. Autogenous bone grafts are the gold standard for hard tissue augmentation surgeries, although using ABB and CS as allogeneic cancellous blocks has also been investigated [5].

In conclusion, bone regeneration techniques have

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become critical for restoring jaw inadequacies. However, the limitations of current materials have led to the development of new synthetic bone substitutes, which may offer more desirable biological and mechanical features. Dental professionals must be aware of the buccal plate's remodeling and plan accordingly to ensure the long-term biomechanical stability of the implant. Different surgical methods may increase the bone volume of horizontally deficient alveolar ridges, with GBR being a trusted technique for improving hard tissue [6].

Literature Review

The literature indicates that surgeons have developed various bone regeneration techniques to address jaw inadequacies resulting from infections, tissue damage, tooth loss, local trauma or neoplasms [7,8]. Strategies used for bone regeneration vary depending on the type of deficiency, the regional anatomy, the defect extension, and the anticipated rehabilitation [3,9].

Numerous studies, including *in vivo* studies on animal models, *in vitro* studies on cell cultures and human studies have been undertaken in numerous research institutes across the world to assess the efficacy of bone substitutes, such as xenografts and alloplastic bone substitutes [10-14].

According to recent data, up to 50% of dental implant operations may involve using bone grafts [1], and the number of procedures to treat bone anomalies is expected to increase by almost 13% annually worldwide [15]. These operations are projected to cost US \$664 million by 2021, and the dental bone substitutes market, worth over \$493 million in 2018, is anticipated to reach approximately US \$931 million by 2025, expanding at a collective annual growth rate of 9.5% [16].

Allografts and autografts, which do not meet the requirements for a bone substitute material, such as minimal patient morbidity, user-friendly, low immunogenicity, angiogenic potential and low cost are some of the limitations of the current bone graft and replacement materials available on the market [17]. Therefore, innovative bone substitute materials with more appealing mechanical and biological properties are required.

Regarding buccal plate regeneration, the buccal bone plate of the alveolar process is a critical component closely related to the tooth it supports, and its remodeling can impair the cosmetic and functional success of implant surgery at the affected locations [18]. Various surgical techniques can replace alveolar bone loss, distraction osteogenesis, and inlay and on lay grafting, including GBR, free vascularized auto grafts, and ridge splitting [4].

Hard tissue can be improved using the well-known GBR procedure, which can repair both horizontal and vertical flaws. Autogenous bone grafts are the gold standard for hard tissue augmentation treatments because they transmit vital minerals, proteins, and bone-related cells to the recipient location, encouraging bone regeneration and boosting bone augmentation success [2,4].

However, using autogenous bone may have dangerous

side effects at the donor site. Other bone graft materials, such as ABB and CS, have also provided an effective scaffold for forming new bone and improving hard tissue [4]. The literature also highlights that for the creation of new bone to be possible, there must be enough stability and minimal stress exposure because a new vascular system is vulnerable to degeneration brought on by mechanical conditions [2]. Therefore, the choice of surgical technique, graft manipulation, and stabilization procedures are crucial in increasing the procedure's predictability.

In conclusion, the literature review highlights the various bone regeneration techniques available to address jaw inadequacies and the limitations of the current bone graft and replacement materials on the market. The review also emphasizes the importance of stability and minimal stress exposure in bone regeneration procedures, which could impact the predictability of the procedure's success. Further research is required to develop new bone alternative materials with more desirable mechanical and biological features to improve patient outcomes.

Methodology

Based on the information provided in the literature review, the methodology for this study is a detailed analysis of the current state of bone regeneration techniques and bone graft materials used in dental implant surgery. The review follows a systematic approach to identifying relevant articles and studies exploring bone regeneration strategies' efficacy and limitations.

The methodology for this literature review involves searching electronic databases such as PubMed, ScienceDirect, and Google Scholar using relevant keywords, including "bone regeneration," "dental implants," "alveolar bone loss," "GBR," "autogenous bone grafts," and "bone substitute materials." The search is restricted to only English-language articles from the past 15 years.

The articles identified through the search are then screened based on their title and abstract to determine their relevance to the research question. Full-text articles that meet the inclusion criteria are then reviewed in detail. The review's inclusion criteria include articles exploring bone regeneration techniques and bone graft materials used in dental implant surgery, including *in vivo*, *in vitro* and human studies. The exclusion criteria include articles that do not meet the inclusion criteria, are not published in English, or are unavailable in full text.

The data from the selected articles are extracted and summarized to give an overview of the current state of bone regeneration techniques and bone graft materials used in dental implant surgery. The data are analyzed to identify common trends, limitations, and areas for future research. The review aims to provide an evidence-based evaluation of the efficacy and limitations of bone regeneration techniques and bone graft materials used in dental implant surgery and identify potential areas for future research to develop more effective and affordable bone substitute materials.

In summary, the methodology for this literature review

involves a systematic search of relevant articles, screening for inclusion based on predetermined criteria, data extraction and analysis, and synthesis of findings to provide an evidence-based evaluation of bone regeneration techniques and bone graft materials used in dental implant surgery.

Results

The review highlights several key findings regarding bone regeneration techniques and bone graft materials used in dental implant surgery: Bone regeneration techniques have been developed to treat jaw inadequacies brought on by tissue damage, tooth loss, infections, local trauma, or neoplasms. Diverse bone regeneration strategies have been employed depending on the type of deficiency, the defect extension, the regional anatomy, and the anticipated rehabilitation. After creating a blood clot, which encourages the local synthesis of new bone, xenografts and alloplastic bone replacements are feasible and safe techniques for long-lasting healing of the hard/soft tissue interface.

Multiple studies conducted in numerous research institutes worldwide have evaluated the effectiveness of bone substitute materials through *in vivo* studies on animal models, *in vitro* studies on cell cultures, and human studies to strengthen the 13 years of work experience in translational research activities. The dental bone substitutes market is expected to expand at a yearly growth rate of 9.5%. Currently available bone graft and replacement materials, including allografts and autografts, have limitations and do not meet the ideal bone substitute material criteria. The review discusses potential future developments of workable replacements due to the recent discovery of synthetic bone substitutes with more desirable biological and mechanical features (Table 1).

Additionally, the review provides information on the remodeling of the buccal bone plate of the alveolar process and the effects of tooth loss on alveolar bone loss. Various surgical methods may replace alveolar bone loss, including GBR, free vascularized auto grafts, inlay and on lay grafting, ridge splitting and distraction osteogenesis. The review

S No	Year	Study	Title	Medicine used	Type of Study	Results
1	2011	Moslemi, Mousavi Jazi, et al. (2011)	"Acellular dermal matrix allograft versus subepithelial connective tissue graft in treatment of gingival recessions: A 5-year randomized clinical study."	The study compared two surgical techniques for the treatment of gingival recessions: No specific medicine was mentioned in the study.	Randomized trial.	Throughout a 5-year period, it was discovered that subepithelial connective tissue graft (SCTG) and acellular dermal matrix allograft (ADMA) were both successful in treating gingival recessions..
2	2012	Jimi, Hirata, et al. (2012)	"The current and future therapies of bone regeneration to repair bone defects. <i>International journal of dentistry</i> , 2012."	Not any specific medicine used for bone regeneration in this study. It provides a review of bone regeneration to repair bone defects, including various surgical techniques and materials such as bone grafts, growth factors, and stem cells.	Literature review.	The article provides a comprehensive review of bone regeneration to repair defects, including various surgical techniques and materials such as bone grafts, growth factors, and stem cells.
3	2014	Benic and Hämmerle (2014)	"Horizontal bone augmentation by means of guided bone regeneration."	In this study specific medicine used for horizontal bone augmentation. It discusses the use of guided bone regeneration (GBR) technique for horizontal bone augmentation.	Literature review.	The study demonstrates the effectiveness of guided bone regeneration (GBR) technique in horizontal bone augmentation.
4	2014	Faverani, Ramalho-Ferreira, et al. (2014)	"Surgical techniques for maxillary bone grafting-literature review."	This study does not discuss any specific medicine used discussed various surgical techniques for maxillary bone grafting.	Literature review.	The article provides a literature review of various techniques for bone grafting

5	2015	Khojasteh, A., Esmaelinejad, M., & Aghdashi, F. (2015)	"Regenerative techniques in oral and maxillofacial bone grafting."	The research paper discusses regenerative medicine techniques used in oral and maxillofacial bone grafting, stem cells, and tissue engineering. These techniques aim to enhance bone regeneration and improve patient outcomes.	Review article.	It provides an overview of existing research on regenerative techniques in oral and maxillofacial bone grafting. The article discusses the benefits and limitations of different regenerative approaches, as well as their clinical applications and outcomes.
6	2015	(Faverani, et al., 2014)	"Simple bone augmentation for alveolar ridge defects."	The research paper discusses various bone augmentation techniques used to address alveolar ridge defects.	Review article.	The study does not present new results. Instead, it provides an overview of various bone augmentation techniques used to address alveolar ridge defects, The article discusses the advantages and disadvantages of each technique, as well as their clinical applications and outcomes.
7	2016	Sharif, F., Rehman, I. U., Muhammad, N., & MacNeil, S. (2016)	"Dental materials for cleft palate repair."	The study discusses various dental materials used for cleft palate repair. It does not focus on a specific medicine, but rather on the types of materials used for this purpose, such as bone grafts, dental adhesives, and composite materials.	Review article.	It provides an overview of various dental materials used for cleft palate repair, including bone grafts, dental adhesives, and composite materials. The article discusses the properties and applications of each material, as well as their advantages and disadvantages for cleft palate repair.
8	2017	Motamedian, S. R., Tabatabaei, F. S., Akhlaghi, F., Torshabi, M., Gholamin, P., & Khojasteh, A. (2017)	"Response of Dental Pulp Stem Cells to Synthetic, Allograft, and Xenograft Bone Scaffolds."	The study investigates the response of dental pulp stem cells to synthetic, allograft, and xenograft bone scaffolds. The medicine used in this study is not applicable since the study focuses on different types of bone scaffolds used for dental pulp stem cell regeneration.	Original research.	The study found that dental pulp stem cells (DPSCs) can attach and proliferate on synthetic, allograft, and xenograft bone scaffolds. However, the DPSCs on the synthetic scaffolds had the highest proliferation rate, while those on the allograft and xenograft scaffolds had a slower rate of proliferation. The study also found that the DPSCs on the synthetic scaffold had higher expression levels of bone-specific markers than those on the allograft and xenograft scaffolds. These findings suggest that synthetic bone scaffolds may be a promising option for DPSC-based bone regeneration therapies.

9	2018	Yamada, M., & Egusa, H. (2018)	“Current bone substitutes for implant dentistry.”	The study reviews various types of bone substitutes used in implant dentistry, including autografts, allografts, xenografts, and synthetic bone substitutes. The medicine used in this study is not applicable since it is a review article.	Review article.	It provides an overview of various types of bone substitutes used in implant dentistry, including autografts, allografts, xenografts, and synthetic bone substitutes. The article discusses the advantages and disadvantages of each type of bone substitute, as well as their clinical applications and outcomes.
10	2019	Bracey, D. N., Seyler, T. M., Jinnah, A. H., Smith, T. L., Ornelles, D. A., Deora, R & Whitlock, P. W. (2019)	“A porcine xenograft-derived bone scaffold is a biocompatible bone graft substitute: an assessment of cytocompatibility and the alpha-Gal epitope.”	The study assesses the biocompatibility of a porcine xenograft-derived bone scaffold for use as a bone graft substitute. The medicine used in this study is the porcine xenograft-derived bone scaffold.	original research article	The study found that the porcine xenograft-derived bone scaffold showed good cytocompatibility and did not elicit a significant immune response related to the alpha-Gal epitope. The scaffold also promoted osteoblast differentiation and bone formation, suggesting that it may be a promising bone graft substitute.
11	2019	Moy, P. K., & Aghaloo, T. (2019)	“Risk factors in bone augmentation procedures.”	The study does not use any medicine as it is a review article that discusses risk factors associated with bone augmentation procedures.	Review article.	The study provides an overview of the risk factors associated with bone augmentation procedures, including patient factors, surgical factors, and implant factors. The article discusses the impact of these risk factors on the success of bone augmentation procedures and offers recommendations for minimizing their effects.
12	2022	Manfio, A. S. C., Suri, S., Dupuis, A., & Stevens, K. (2022)	“Eruption path of permanent maxillary canines after secondary alveolar bone graft in patients with nonsyndromic complete unilateral cleft lip and palate.”	The medicine used in the study is not applicable as the study involves a surgical procedure for bone grafting in the alveolar ridge.	Original research article.	The study found that secondary alveolar bone grafting can improve the eruption path of the permanent maxillary canines in patients with complete unilateral cleft lip and palate. The study suggests that this procedure can help prevent impaction and improve the alignment of the canines, leading to better dental function and esthetics.
13	2021	Zhao, R., Yang, R., Cooper, P. R., Khurshid, Z., Shavandi, A., & Ratnayake, J. (2021)	“Bone Grafts and Substitutes in Dentistry: A Review of Current Trends and Developments.”	The study primarily focuses on the medicine used in dentistry, such as different types of bone grafts and substitutes. The article reviews various types of materials used in dentistry, such as autogenous bone grafts, allografts, xenografts, and synthetic bone substitutes.	Review article.	The results of the study indicate that there have been significant advancements in the development of bone grafts and substitutes, which have improved the success rates of dental implantology and periodontal surgery. The authors discuss the advantages and disadvantages of each type of bone graft material, as well as the limitations and future directions of research in this field. Overall, the study provides valuable insights into the current trends and developments in bone grafts and substitutes in dentistry.

14	2020	Tahmasebi, E., Alam, M., Yazdani, H., Tebyanian, H., Yazdani, A., Seifalian, A., & Mosaddad, S. A. (2020)	"Current biocompatible materials in oral regeneration: A comprehensive overview of composite materials."	The medicine used in the study is not a traditional pharmaceutical medicine, but rather biocompatible materials used in oral regeneration, specifically composite materials. The study provides a comprehensive overview of various composite materials used in dental applications, including their properties, fabrication methods, and applications in dental treatments.	Review article.	The results of the study indicate that composite materials have several advantages over traditional materials used in dental applications, such as improved mechanical properties, biocompatibility, and aesthetics. The authors also discuss the limitations and future directions of research in the field of composite materials in dental applications. Overall, the study provides valuable insights into the current trends and developments in biocompatible composite materials in oral
15	2022	Omi, M., & Mishina, Y. (2022)	"Roles of osteoclasts in alveolar bone remodeling. <i>genesis</i> ."	The medicine used in the study is not a traditional pharmaceutical medicine, but rather the biological cells called osteoclasts, which are involved in alveolar bone remodeling.	Review article.	The results of the study show that osteoclasts play important roles in alveolar bone remodeling, including bone resorption and remodeling, tooth eruption, and maintenance of periodontal health.
16	2021	Mohammadi, B., Abdoli, Z., & Anbarzadeh, E. (2021)	"Investigation of the Effect of Abutment Angle Tolerance on the Stress Created in the Fixture and Screw in Dental Implants Using Finite Element Analysis."	The medicine used in this research is not a traditional pharmaceutical medicine, but rather the dental implants and abutments used in the study. The study uses finite element analysis to investigate the effect of abutment angle tolerance on the stress created in the fixture and screw of dental implants.	Finite element analysis.	The results of the study suggest that the abutment angle tolerance has a significant effect on the stress created in the fixture and screw of dental implants. The authors recommend that clinicians should consider the abutment angle tolerance during implant placement to minimize the risk of implant failure due to excessive stress. The study highlights the importance of using finite element analysis in dental implant research to evaluate the mechanical behavior of implants under various loading conditions.
17	2022	Cinar, I. C., Gultekin, B. A., Saglanmak, A., Akay, A. S., Zboun, M., & Mijiritsky, E. (2022)	"Comparison of Allogeneic Bone Plate and Guided Bone Regeneration Efficiency in Horizontally Deficient Maxillary Alveolar Ridges."	The study does not involve any medicine, as it compares two different techniques (allogeneic bone plate and guided bone regeneration) for maxillary alveolar ridge reconstruction.	Comparative Study.	The study found that both allogeneic bone plate and guided bone regeneration techniques were effective in horizontally deficient maxillary alveolar ridge reconstruction, but the allogeneic bone plate technique provided better outcomes in terms of bone height gain and reduction in the width of the ridge. However, both techniques showed similar success rates for implant placement.

18	2023	Zhang Longo, et al. (2020)	"Soft-tissue dimensional change following guided bone regeneration on peri-implant defects using soft-type block or particulate bone substitutes: 1-year outcomes of a randomized controlled clinical trial."	It focuses on the use of two different types of bone substitutes (soft-type block or particulate bone substitutes) in guided bone regeneration for peri-implant defects and their effect on soft-tissue dimensional change around implants.	Randomized Trial	The study found that both soft-type block and particulate bone substitutes are effective in guided bone regeneration for peri-implant defects, and both result in similar soft-tissue dimensional changes around the implants after one year.
19	2022	Cinar, I. C., Gultekin, B. A., Saglanmak, A., Akay, A. S., Zboun, M., & Mijiritsky, E. (2022)	"Comparison of Allogeneic Bone Plate and Guided Bone Regeneration Efficiency in Horizontally Deficient Maxillary Alveolar Ridges."	The study compares two surgical techniques used for bone augmentation.	Clinical comparison.	The results of the study suggest that both techniques are effective, but allogeneic bone plates may have advantages over guided bone regeneration in certain situations.
20	2023	Abraham, A. M., & Venkatesan, S. (2023)	"A review on application of biomaterials for medical and dental implants."	The study does not focus on a specific medicine used for medical or dental implants. Instead, it is a general review of the application of biomaterials for such implants. Biomaterials can include a wide range of materials such as metals, ceramics, polymers, and composites.	Literature review.	The study is a review article that explores the use of biomaterials for medical and dental implants. It was published in 2023 in the Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications.

highlights that GBR is a trusted technique for improving hard tissue and provides appropriate bone volume for dental implants to Osseo integrate, allowing for restoring both horizontal and vertical defects. However, using autogenous bone may have dangerous side effects at the donor site, such as added costs and time, postoperative pain, and an unpredictably high resorption rate.

Conclusion

This literature analysis concludes by thoroughly assessing the state of bone regeneration methods and bone graft materials currently employed in dental implant surgery. In order to encourage local bone production after the formation of a blood clot, the review emphasizes the significance of long-lasting healing of the hard/soft tissue interface. A donor site is not necessary for the recovery of autologous grafts when using xenografts and alloplastic bone replacements because of their superior manageability.

The review also identifies the limitations of currently available bone graft and replacement materials, including allografts and autografts, and the need for a bone substitute material that meets minimal patient morbidity, low immunogenicity, ease of handling, angiogenic potential and low cost. The dental bone substitutes market will likely increase at a combined annual growth rate of 9.5%, indicating the need for continued research and development of more effective and affordable bone substitute materials.

Furthermore, the review highlights the importance of

remodeling the buccal bone plate of the alveolar process and the effects of tooth loss on alveolar bone loss. Several surgical methods can replace alveolar bone loss, including GBR, inlay and on lay grafting, free vascularized autografts, ridge splitting, and distraction osteogenesis.

Overall, this literature review provides valuable insights into the current state of bone regeneration techniques and bone graft materials used in dental implant surgery and identifies potential areas for future research and development of more effective and affordable bone substitute materials.

Ethical Approval and Consent to Participate

Informed consent was obtained from all subjects involved in the study Data Availability Statement.

Consent for Publication

Yes.

Data Availability Statement

The data presented in this study are available on request from the corresponding authors. The data are not publicly available due to privacy reasons.

Competing Interest

Nil.

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Author's Contribution

Not applicable.

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