MedNEXT
Journal of Medical an Health Sciences

REVIEW ARTICLE

DOI: 10.54448/mdnt25S215

Significance and clinical highlights of bone augmentation using fibrin-rich plasma and Bio-Oss®: a systematic review

Lívia de Paula Ferrari[1*], Fabiana Correia Teixeira[1], Gabriel Henrique Pignata Lopes[1], Janaina Cardoso Moreira[1]

[1] UNORTE - University Center of Northern São Paulo, Dentistry department, São José do Rio Preto, São Paulo, Brazil.

*Corresponding author: Lívia de Paula Ferrari.
UNORTE - University Center of Northern São Paulo,
Dentistry department, São José do Rio Preto,
São Paulo, Brazil.
E-mail: depaulaferrarilivia@gmail.com
DOI: https://doi.org/10.54448/mdnt25S215
Received: 02-10-2025; Revised: 04-15-2025; Accepted: 05-10-2025; Published: 05-12-2025; MedNEXT-id: e25S215

Editor: Dr. Abiodun Oyinpreye Jasper MD, MHP.

Abstract

Introduction: The number of dental implant procedures has been increasing worldwide, reaching about one million yearly. In Brazil, in the last decades, there has been a very rapid evolution in implant dentistry with high success rates. The development of biomaterials for use in dental clinics in recent years has represented a powerful therapeutic tool in the correction of bone defects**. Objective:** This study aimed, through a systematic literature review, to show the processes that involve bone formation for dental implants, with the use of biomaterials such as fibrin-rich plasma and Bio-Oss®. **Methods:** The PRISMA Platform systematic review rules were followed. The search was carried out from November 2024 to January 2025 in the Scopus, PubMed, Science Direct, Scielo, and Google Scholar databases. The quality of the studies was based on the GRADE instrument, and the risk of bias was analyzed according to the Cochrane instrument. **Results and Conclusion:** A total of 175 articles were found, and 65 articles were evaluated in full, and 56 were included and developed in the present systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 10 studies with a high risk of bias and 20 that did not meet the GRADE and AMSTAR-2 criteria. According to the GRADE instrument, most studies presented homogeneity in their results, with X^2=89.5%>50%. Literary findings have shown that Bio-Oss® and PRF work are essential for bone formation processes for dental implants, mainly in joint action.

Keywords: Bone regeneration. Bone augmentation. Bio-Oss®. Fibrin-Rich Plasma. Implant dentistry.

Introduction

The number of dental implant procedures has been increasing worldwide, reaching about one million yearly [1,2]. In the last decades, there has been a very rapid evolution in implant dentistry with high success rates. The development of biomaterials for use in dental clinics in recent years has represented a powerful therapeutic tool in the correction of bone defects [3-5]. However, despite the proven benefits, its use requires the professional to take care of clinical and ethical criteria in the analysis of the risks and benefits that each biomaterial can present [6,7].

A study with 123 dental surgeons using biomaterials showed that professionals are not aware of the risks and benefits of biomaterials, nor their biological principles since 45.0 % believe there is no risk to the patient and 56.0 % do not consider biomaterial as medicine. About 70.0 % felt safe concerning the origin. Despite this, 96.0 % of the interviewees said that there should be greater control of health authorities. More than half of the interviewees (51.0 %) reported little or no patient participation in the process of therapeutic choice [8].

Many patients, elderly or not, sought implant-supported rehabilitation, but there is a need for some adjustments that lead to the consequent demand for regenerative procedures for maxillary reconstructions.

These patients can often present pathological changes, or make use of medications, which may alter bone healing [9,10]. Several materials can be used as a bone graft, each with different properties; for example: for neovascularization, materials such as hydroxyapatite and calcium phosphate showed the highest expression rates of vascular growth factors (VGF) and microvascular density; while the grafts of polymer, showed the lowest rates [11-13].

The search for a solution for large bone defects has begun studies based on guided tissue regeneration therapy or guided bone regeneration. These studies promote the use of fillers and epithelial barriers that aid in treatment as an adjunct to bone grafting techniques. Thus, they favor greater predictability in alveolar and peri-implant reconstructions and present a good prognosis [2,3,9].

The main problem is with non-absorbable membranes because they require a second surgical act, they provide infections if there is any type of exposure; and have a firm consistency, which makes it difficult to adapt to the bone defect and thus impairs blood supply and can cause dehiscence and tissue necrosis [10-12]. Guided bone regeneration (GBR) favors the formation of new bone tissue and prevents the gingival tissue from invaginating into the space between the bone and the implant [10,11]. Covani et al [14], in a prospective 10-year study comparing patients who received the GBR technique with patients who did not receive indicated the possibility of gingival retraction in the group that did not receive the technique when compared to the group that received.

The filling biomaterials can be fibrin-rich plasma (FRP), hydroxyapatite, lyophilized and milled demineralized bone marrow, and autogenous bone, which is considered the gold standard, among others. In conjunction with the fillers, it is often necessary to use features to isolate the implant by using biological membranes, which are epithelial barriers that guide tissue regeneration, and function as a mechanical barrier separating the periodontal tissues from the bone surface or implant, thus promoting a new bone formation, a containment of the filling material and a stability of the graft [11,13].

The present study aimed, through a systematic literature review, to show the processes that involve bone formation for dental implants, with the use of biomaterials such as fibrin-rich plasma and Bio-Oss®.

Methods

Eligibility and Study Design

This study followed the international systematic review model, following the PRISMA (preferred reporting items for systematic reviews and meta-analysis) rules. Available at: http://www.prisma-statement.org/?AspxAutoDetectCookieSupport=1. Accessed on: 01/16/2025. The AMSTAR 2 (Assessing the methodological quality of systematic reviews) methodological quality standards were also followed. Available at: https://amstar.ca/. Accessed on: 01/16/2025.

Search Strategy and Search Sources

The literature search process was carried out from November 2024 to January 2025 and developed based on Web of Science, Scopus, Embase, PubMed, Lilacs, Ebsco, Scielo, and Google Scholar, covering scientific articles from various periods to the present day. The following descriptors (DeCS /MeSH Terms) were used *Bone regeneration. Bone augmentation. Bio-Oss®, Fibrin-Rich Plasma. Implant dentistry*, and using the Boolean "and" between MeSH terms and "or" between historical findings.

Study Quality and Risk of Bias

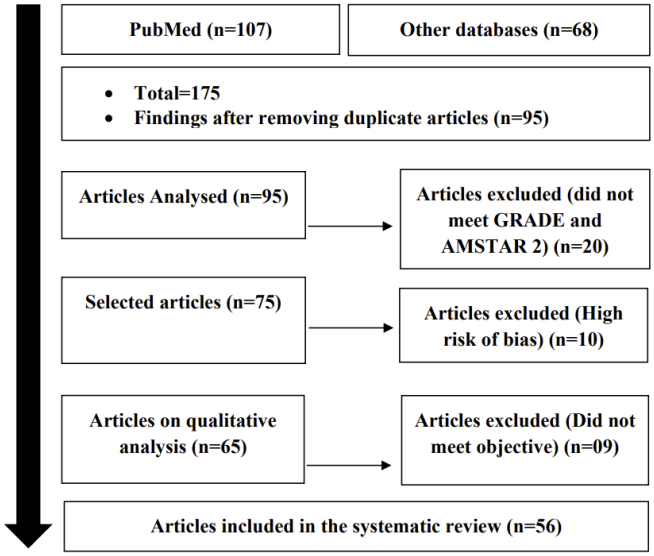
Quality was classified as high, moderate, low, or very low regarding the risk of bias, clarity of comparisons, precision, and consistency of analyses. The most evident emphasis was on systematic review articles or meta-analysis of randomized clinical trials, followed by randomized clinical trials. Low quality of evidence was attributed to case reports, editorials, and brief communications, according to the GRADE instrument. The risk of bias was analyzed according to the Cochrane instrument by analyzing the Funnel Plot graph (Sample size versus Effect size), using Cohen's d test.

Results and Discussion

Summary of Findings

As a corollary of the literature search system, a total of 175 articles were found that were submitted to eligibility analysis, 65 articles were evaluated in full and 56 final studies were selected to compose the results of this systematic review. The studies listed were of medium to high quality (Figure 1), considering the level of scientific evidence of studies such as meta-analysis, consensus, randomized clinical, prospective, and observational studies. Biases did not compromise the scientific basis of the studies. According to the GRADE instrument, most studies presented homogeneity in their results, with X^2=89.5%>50%. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 10 studies with a high risk of bias and 20 studies that did not meet GRADE and AMSTAR-2.

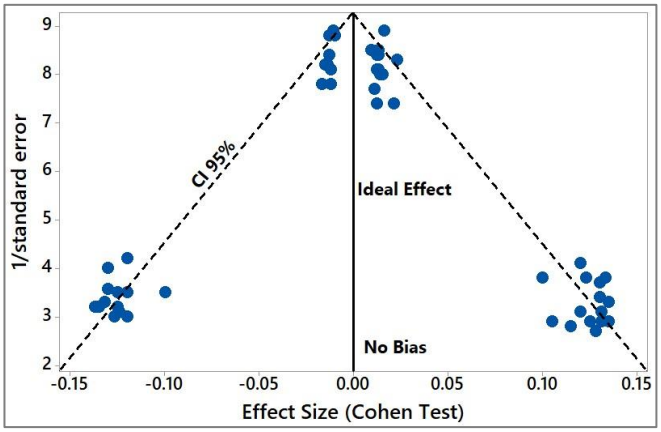
Figure 1. Flowchart showing the article selection process.



Source: Own Authorship.

Figure 2 presents the results of the risk of bias of the studies using the Funnel Plot, showing the calculation of the Effect Size (Magnitude of the difference) using Cohen's Test (d). Precision (sample size) was determined indirectly by the inverse of the standard error (1/Standard Error). This graph had a symmetrical behavior, not suggesting a significant risk of bias, both among studies with small sample sizes (lower precision) that are shown at the base of the graph and in studies with large sample sizes that are shown at the top.

Figure 2. The symmetrical funnel plot does not suggest a risk of bias among the studies with small sample sizes that are shown at the bottom of the graph. Studies with high confidence and high recommendation are shown above the graph (n=56 studies).



Source: Own Authorship.

Significance - Clinical Results

The lack of bone in the alveolar ridges has been a major problem in functional aesthetic recovery in patients who have suffered dentoalveolar trauma, traumatic dental extractions, congenital dental absence, maxillary and mandible pathologies, as well as infections due to the emotional and the possibility of deformity and also the economic impact they cause in the National Health System (NHS) [1-5]. Bone loss can also occur due to periodontal disease, traumatic surgeries, or even physiological reasons due to lack of adequate or inadequate prosthetic load. The trauma in the face region can reach both the soft tissues (skin, muscles, nerves) and hard tissues (bones, teeth), so these lesions can affect the quality of life as well as the health of the victim [15-19].

Trauma maxillofacial injury can be considered one of the most devastating aggressions found in traumatology and oncology due to the emotional consequences and the possibility of deformity and also the economic impact they cause on the National Health System (NHS) [20-23]. The face, more than any other region of the body, is affected by aesthetic changes, since it is always visible, and damages are perceived immediately. For this reason, the trauma of the face deserves to be highlighted in the treatment of polytrauma due to its high incidence and severity [24].

The microscopic bone structure consists of osteoprogenitor cells, support cells (osteoblasts and osteocytes), remodeling cells - osteoclasts - and a non-mineralized extracellular matrix called the osteoid, composed of type I collagen and non-collagen proteins such as osteonectin, osteocalcin, bone morphogenetic protein (BMP), glycosaminoglycans and bone sialoproteins [25]. The osteoprogenitor cells are small spindle cells found on all non-resorbable bone surfaces, derived from primitive mesenchymal cells, and form a population and precursor cells that can differentiate into more specialized cells such as osteoblasts and osteocytes [1,20].

Osteoblasts are responsible for the production of bone matrix, rich in collagen (mainly type I) and essential for subsequent mineralization, by adherence of calcium hydroxyapatite crystals, magnesium, potassium, sodium, and carbonate ions in collagen fibrils [25]. Osteoblasts are also rich in alkaline phosphatase, which has a high value in periods of bone formation. The process of formation of new bone mediated by osteoblasts is called osteogenesis [15]. It is known that osteoblasts bind directly to collagen through integrin-RDG (-Arg-Gly-Asp-) sites of interaction.

The osteoinduction process is influenced by several factors, requiring the presence of inducers, which include β-glycerolphosphate, ascorbic acid and dexamethasone. In the presence of these substances mesenchymal cells acquire the morphology and components of osteoblast membranes and begin to express alkaline phosphatase, to deposit extracellular

matrix rich in calcium and certain proteins, such as osteopontin and osteocalcin [26].

Organic phosphates, such as β-glycerolphosphate, promote osteogeny by their function in mineralization and modulation of osteoblast activity [20]. Thus, free phosphates can induce mRNA and protein expression, exemplified by the osteopontin protein. If organic phosphate, for example β-glycerolphosphate is present, the formation of a mineral content occurs, hydroxyapatite that is formed between the collagen fibers [26]. Other compounds such as phosphoric ascorbic acid are also used in osteogenic induction, in the involvement of increased alkaline phosphatase activity, and the promotion of the production of osteocalcin and osteopontin [27-32].

Bone morphogenetic proteins (BMP) function as growth factors with a specific role in the proliferation and differentiation of mesenchymal stem cells present in the lesion niche [22,29]. BMP-4 is involved in the early stages of osteogenesis; in addition, it has been demonstrated that the differentiation of human mesenchymal stem cells into the osteogenic lineage requires the presence of BMP-4 in the first days of culture and that these cells after 21 days express specific proteins of the osteogenic lineage such as osteonectin, osteocalcin and osteopontin. There are three fundamental parameters in bone tissue engineering that will determine the ability of osteoinduction are the presence of soluble osteoinductive signals, the viability of the undifferentiated mesenchymal stem cells to respond, the ability to differentiate into bone-forming cells and the production of extracellular matrix adequate [29].

Tissue engineering encompasses numerous advantages that meet the needs of the injured tissue or organ for the regeneration process [17,22]. For this, it is necessary the understand chemical, physical, and biological processes both biological material and the biological niche of the host [18]. The cross-referencing of compatible information between the microenvironments allows cellular recognition and signaling cascades for neovascularizations [19]. Another advantage is the minimally invasive surgical intervention, that is, it allows the use of surgical techniques that are faster and cause less risk to the patient [24].

Also, tissue engineering is a tool that makes possible through a suitable biological niche the construction and regeneration of any tissues and organs [23,32]. For this, xenografts, autografts, and allografts are used, with and without the use of cells [18,19]. According to the Conference of the National Institute for the Development of Health Consensus in 1982, biomaterials are beneficial organic compounds, or combinations thereof, that can be used for some time, wholly or partially as part of a system that treats, replace any tissue, organ or function of the human body. The great challenge is to understand that the science of biomaterials is multidisciplinary and its application needs adjustments of its processing, sterilization, and structural modifications to favor the interaction with the tissue of interest [32-35].

Bioengineering and cell therapy act jointly for Regenerative Medicine, favoring and improving biological conditions to accelerate repair and tissue regeneration and thus maintaining tissue homeostasis [21]. This condition is maintained because the required cellular elements, cell proliferation and differentiation factors, and supramolecular structures are provided which guarantee the functional stereochemical organization of the generated tissues and their systemic integration [32,35].

Mechanism for Bone Remodeling

Normal bone formation and tissue reestablishment involve coordinated interaction between bone-forming cells and biological signals. The main force in this process are the osteoblasts and their precursors [34]. Osteoblasts can produce new bone along with biomaterials, and can initiate the release of biological signals that guide the formation and remodeling of bone. These biological signals attract bone-forming cells to the receptor site. Growth factors and other proteins are some biological signs that may be involved in new bone formation and tissue remodeling. Moreover, through chemotaxis, there is migration of bone-forming cells to the application area, as stimulation of cell migration occurs in response to chemical stimuli [29].

Monocytes, macrophages, and endothelial cells contribute to bone remodeling, either by contact with osteogenic cells or by the release of soluble factors such as cytokines and GF [34-37]. In the skeletal system, TNF-α stimulates bone and cartilage reabsorption and inhibits the synthesis of collagen and proteoglycans. IL-1 induces the expression of a wide variety of cytokines. LIF and IL-6 are two of these molecules that are known to stimulate the differentiation of mesenchymal progenitor cells into the osteoblastic lineage and are also potent anti-apoptotic agents of osteoblasts. In bone, the main sources of IL-6 are osteoblasts and not osteoclasts. Prostaglandin E2 (PGE2) is also directly related to the expression of cytokine IL-6 [29].

Biomaterial - FRP

Fibrin-rich plasma (FRP) as an autologous biomaterial was developed in France by Choukroun et al. (1993) [38] for specific use in oral and maxillofacial surgery. This biomaterial presents the majority of

leukocytes, platelets and growth factors, forming a fibrin matrix, with three-dimensional architecture. It is the second generation of platelet concentrate with a high potential for repair of lesions.

In addition, obtaining FRP follows an easy and simple protocol. A blood sample is obtained without anticoagulant in 10.0 mL tubes that are immediately centrifuged at 3000 rpm (approximately 400.0 g) for 10.0 minutes [37]. After initiation of centrifugation in the absence of an anticoagulant, the activation of most of the collected blood platelets begins, from the contact with the walls of the tube and the release of the coagulation cascades. As the end product of this process, we have fibrinogen, which is a soluble protein, transformed into fibrin insoluble by thrombin. The fibrin gel constitutes the first scar matrix of the injured sites. The fibrinogen is concentrated in the upper part of the tube before the circulating thrombin converts it into fibrin. A fibrin clot is then obtained in the middle of the tube, between the red blood cells at the bottom and acellular plasma at the top.

FRP has the characteristic of polymerizing naturally and slowly during centrifugation. The fibrin network thus formed presents, in particular, a homogeneous three-dimensional organization, more coherent than natural fibrin clots [39-42]. In this context, with progressive polymerization, the incorporation of circulating cytokines increases in the fibrin network, implying a longer life for these cytokines, because they will be released and used only when remodeling the initial cicatricial matrix, which is long-term. Cytokines are thus kept available in situ for a convenient period when the cells begin scar remodeling of the matrix [42,43].

FRP is based on the protection of proteolysis growth factors that can maintain its activity for a longer period and stimulate bone regeneration more efficiently [43-45]. The most critical phase of the sinus membrane elevation procedure after osteotomy of the lateral wall of the maxillary sinus is its detachment [46]. In this phase, Schneider membrane ruptures can occur, in around 15.0 % of the cases, which depending on the size of the perforation, can make the grafting unfeasible, mainly due to the containment character of the grafting material that the membrane exerts. The most frequent causes of these perforations are: inadequate osteotomies; incomplete membrane detachments with a lack of bone support for lifting curettes, exertion of excessive pressure on the membrane, and the presence of septa [47,48].

If sinus membrane perforations are present, this should be quantified, since small perforations do not require treatment, since the membrane folds themselves obliterate the perforation. In the case of ruptures greater than 5.0 mm, the use of collagen membranes is indicated. Another study indicates the use of fibrin membranes obtained from the FRP for the sealing of the perforations. In the presence of perforations greater than 10.0 mm, surgery should be aborted and reentry performed after 60 to 90 days [49].

The development of optimized implant surfaces is a reason for great research to accelerate the osseointegration process, leading to a reduction in the waiting period before loading, as well as making the immediate loading of the implant safer. Moreover, Lynch et al. (1991) [45] documented for the first time that the combination of biomaterial and FRP significantly improved bone regeneration in the peri-implant zone. Placement of the implant with the simultaneous use of FRP creates a good relationship between hard tissue and soft tissue beyond the advantage of the psychological relationship to the patient.

Migration, adhesion, and cell proliferation on the surface of the implants are required to initiate the tissue regeneration process, whereas modifications in the surface of the implants incorporating biological mediators of growth and differentiation may potentiate tissue regeneration at implant placement. The balance between fibrin formation and platelet activation is responsible for the FRP process and performance [50,51].

Biomaterial – Bio-Oss®

Tissue engineering is a tool that makes possible through the creation of a suitable biological niche the construction and regeneration of any tissues and organs [1-3]. For this, xenografts, autografts, and allografts are used, with and without the use of cells [25,27]. Thus, the Bio Oss® (Geistlich) biomaterial, because they are biodegradable, biocompatible, nontoxic, and present low immunogenicity and biostimulators can act in the regeneration of bone tissue since they establish with the adenomatous mesenchymal stem cells the appropriate biological niche (favorable microenvironment) for the bone growth [2,3,5].

Some data show that Guided Tissue Regeneration (GTR) is better for the treatment of periodontal intra-bony defects and furcation defects [52-57]. In general, RTG is more efficient than DRA in reducing:> horizontal open furcation depths,> horizontal and vertical insertion levels, and> alveolus depths for class II furcation defects in the mandible or maxilla. With the use of Bio-Oss®, it is possible to achieve orthodontic movement in patients after treatment with GTR [58,59]. Moreover, the resorbable membranes proved to be superior to the non-resorbable membranes concerning the generation of vertical bone filling [4,5].

Major Results - Bio-Oss® and PRF

Authors such as Zhang and his colleagues analyzed the combined effect of FRP on a xenograft-deproteinated bovine bone at the maxillary sinus elevation, promoting bone regeneration [60,61]. Ten patients with atrophic maxilla were selected for this study; the test group consisted of six maxillary sinus elevations that were treated with Bio-Oss® mixed with FRP and the control group consisted of five atrophic sinuses treated with Bio-Oss® alone [61].

In this context, the following six months, healing occurred without complications, for all patients; the postoperative radiographs revealed the presence of mineralized tissue in adequate quantity and density in all cases. Biopsies were performed and bone characteristics were analyzed histologically both FRP and control biopsies showed very similar composition and distribution of histological structures and no significant signs of inflammatory reaction. Also, regarding the formation of new bone, the percentage in the group that used FRP was 1.4 times higher when compared to the control group. Regarding the amount of Bio-Oss® residual present, as well as the contact size between the Bio-Oss® and the new bone formed, there was no significant statistical difference [61].

The maxillary sinus survey, using bone grafts, has become one of the most frequent procedures of implantology and also the most investigated by the use of platelet concentrates. Another reason is that it is a good model of evaluation of bone remodeling being a closed and protected cavity where the interferences with the oral environment are minimal [50].

Many studies have reported that the addition of FRP to a bone graft is associated with positive clinical results and is a good method of handling the bone graft during insertion in the maxillary sinuses and stimulates bone regeneration around implants placed in the graft. However, it is difficult to emphasize the conclusions of the studies carried out due to the large variables present in the in vivo models. However, in general, the authors affirm that the quality of the bone formed and that the surgical technique used does not have any advantages in the therapy [50,51].

A study of 60 patients clinically and histologically investigated the potential use of FRP associated with Bio-Oss® deproteinized bovine bone for sinus grafting with severe maxillary atrophy compared to a control group with only Bio-Oss ®. Thus, the use of PRF, along with the technique of "piezosurgery", reduced the healing time to before 150 days, as described in the literature, favoring bone regeneration. Thus, in 106 days it was already possible to achieve good primary stability of the endosteal implants [62].

Still another study with 82 patients analyzed the biomechanical stability of the increased sites in the maxillary bone when a new class of self-hardening calcium phosphate formable biomaterials is used with and without the addition of FRP in the subperiosteal, also with the use of "piezosurgery". There were significant improvements, with almost double mechanical stability, with the addition of FRP [63].

A retrospective study with 16 patients evaluated the short-term performance of modified maxillary sinus osteotomy with FRP application compared to placing a short implant in cases with residual bone height of 2-4 mm. All implants were stable, with a 100.0 % survival rate. The follow-up of six months showed a significant reduction of alveolar bone height (2.90 ± 0.22 mm), with $p < 0.05$, without the use of FRP. Also, after the second follow-up of six months, there was still more bone resorption (0.14 ± 0.11 mm) ($p < 0.05$). Therefore, with application of FRP and implant placement yielded stable clinical results for severely atrophic maxilla with 2-4 mm [64].

Another study with 50 patients, aged 36-69 years, evaluated changes in alveolar bone height, using radiographic examination and Straumann implant, with survival rate after maxillary height increase and sinus elevation using autogenous bone in combination with platelet-rich plasma versus venous blood, with n = 25 for each group. Panoramic radiographs were performed preoperatively, immediately, at 6 months, and 1 year post-operatively. The results showed a difference in mean values of bone height between groups, with $p=0.001$. Thus, significant differences were also observed between the "immediate", "postoperative" and "six months" phases, $p < 0.01$, for FRP use. In the venous blood group, there were also significant differences ($p=0.0280$), between "postoperative", "immediate" and "six months". Therefore, both groups presented a reasonable increase in the height of the alveolar bone after the sinus enlargement, showing no significant difference. However, in the one-year postoperative period, the FRP group had a significant difference compared to the SV group, with more predominant results [65].

In this scenario, implant dentistry stands out as a modern method of oral rehabilitation for total or partial edentulous patients. In order for this method to develop properly it is necessary that osseointegration of the implant occurs in the recipient bone tissue, since bone integration is the key to surgical clinical success, which will be completed after the end of the prosthetic phase [41].

To improve osseointegration and bone anchoring, surface modifications may be chemical such as calcium phosphate (Ca-P) or physical impregnation, being related to implant microtopography. Several variables

affect the biological activity of FRP preparations such as the number of centrifuges used, the speed of centrifugation, and other protocols that result in preparations with various volumes, platelet numbers, amount of growth factors, and concentration of white blood cells, and fundamental erythrocytes [46,47].

Some investigators recommend avoiding tissue exposure to FRP containing leukocytes by arguing that an inflammatory reaction may occur [44,52]. On the other hand, other authors have described beneficial effects due to the increase in immunological and antibacterial resistance, although there is no clinical evidence supporting its effect [43,48].

It is also observed that FRP has gained attention in the scientific community since it does not require the addition of an activator or anticoagulant, making the product more autologous, presenting a fibrin network that protects the growth factors, maintaining them during more time on site. It also shows other forms of application making its use simpler [42,43]. The bioactivation of the surface of the dental implant with FRP has been described and discussed by the scientific community as surface treatment for the stimulation and acceleration of the osseointegration process, as well as to achieve greater primary stability to implant [41].

The need to rehabilitate edentulous areas that have undergone major resorptions is a current necessity and the maxillary sinus lift maneuver is a viable way of anchoring implants for implant-supported oral rehabilitation [37-40]. One of the relatively frequent complications (around 15.0 %) of the procedures is the rupture of the sinus membrane during displacement of the sinus membrane. The main intercurrence of this disruption is related to graft containment. In this context, small perforations with extension of 1.0 to 2.0 mm are contoured with the own folds of the membrane in their elevation, but when they reach lengths greater than these, membranes must be added for the closure of the same, and tears greater than 10.0 mm. Surgery should be aborted and re-entered after a period of re-epithelialization of the antral cavity, that is, between 60 and 90 days [42].

The use of an autologous fibrin membrane, obtained by centrifugation of the venous blood of the patient, without the addition of anticoagulants, provides a quick and efficient repair of the surgical wounds. The fibrin gel constitutes the first scar matrix of lesioned sites [40]. The FRP is the second generation of fibrin concentrates, succeeding FRP that had limited the release of growth factors and cytokines in a very short time [39-43].

The FRP presents progressive polymerization and the incorporation of circulating cytokines increases in the fibrin mesh. Such a configuration implies a longer life for these cytokines because they are released and used only when remodeling the initial scar matrix. Cytokines are thus kept available in situ for a convenient period when cells start scarring the matrix, i.e., when they have to be stimulated to reconstruct the injured site [41].

According to some authors, the FRP acts in the protection of the growth factors of the proteolysis that, in this way, can maintain their activity for a longer period and stimulate tissue regeneration. The use of autogenous bone, especially osteoinduction capacity, has been recommended for the filling of the antral cavity. However, the use of autogenous bone alone presents a rapid reabsorption time, giving rise to a neoformed bone of lower quality, compared to that used in association with hydroxyapatite [41,42].

Bovine hydroxyapatite (Bio-Oss®) is considered a suitable bone substitute. The combination of FRP and Bio-Oss® has been studied with good clinical results, reducing the healing time from 180 days to approximately 106 days. Another study, with a clinical follow-up of 6 years, used FRP as the only filling material during maxillary sinus elevation and implant placement, promoting bone regeneration [33].

Conclusion

It was concluded that literary findings have shown that work with Bio-Oss® and FRP is essential for bone formation processes for dental implants, mainly in joint action.

CRediT

Author contributions **Conceptualization**- Lívia de Paula Ferrari, Fabiana Correia Teixeira, Gabriel Pignata Lopes; **Formal Analysis-** Lívia de Paula Ferrari, Fabiana Correia Teixeira, Gabriel Pignata Lopes, Janaina Cardoso Moreira; **Investigation-** Lívia de Paula Ferrari, Fabiana Correia Teixeira, Gabriel Pignata Lopes; **Methodology-** Lívia de Paula Ferrari, Fabiana Correia Teixeira, Gabriel Pignata Lopes; **Project administration-** Lívia de Paula Ferrari; **Supervision-** Janaina Cardoso Moreira; **Writing - original draft-** Lívia de Paula Ferrari, Fabiana Correia Teixeira, Gabriel Pignata Lopes, Janaina Cardoso Moreira; **Writing-review & editing-** Lívia de Paula Ferrari, Fabiana Correia Teixeira, Gabriel Pignata Lopes, Janaina Cardoso Moreira.

Acknowledgment

Not applicable.

Ethical Approval

Not applicable.

Informed Consent
Not applicable.

Funding
Not applicable.

Data Sharing Statement
No additional data are available.

Conflict of Interest
The authors declare no conflict of interest.

Similarity Check
It was applied by Ithenticate®.

Application of Artificial Intelligence (AI)
Not applicable.

Peer Review Process
It was performed.

About The License©

References
1. Pereira RDS, de Carvalho MVNB, Hochuli-Vieira E, Statkievicz C, Pereira Santos DL, Augusto Neto RT, Pinto CFS, Bennardo F, Mourão CF. Histomorphometric and Micro-CT Evaluation of Cerabone and Bio-Oss in Maxillary Sinus Lifting: A Randomized Clinical Trial. Medicina (Kaunas). 2024 Nov 8;60(11):1834. doi: 10.3390/medicina60111834.
2. Ouyang L, Li J, Dong Y, Li J, Jin F, Luo Y, Wang R, Wang S. Comparison of clinical efficacy between autologous partially demineralized dentin matrix and deproteinized bovine bone mineral for bone augmentation in orthodontic patients with alveolar bone deficiency: a randomized controlled clinical trial. BMC Oral Health. 2024 Aug 23;24(1):984. doi: 10.1186/s12903-024-04730-8.
3. Krennmair G, Schwarze UY, Weinländer M, Forstner T, Malek M, Krennmair S. Maxillary Sinus Augmentation with Anorganic Bovine Bone Mineral of Different Particle Sizes: A Split-Mouth Study with Histomorphometric, Radiographic, and Clinical Analyses. Int J Oral Maxillofac Implants. 2024 Jun 21;(3):350-364. doi: 10.11607/jomi.10536.
4. Kim H, Han HS, Ghanaati S, Zadeh HH, Kim S, Cho YD. Alveolar Ridge Preservation Using a Collagenated Xenograft: A Randomized Clinical Trial. Int Dent J. 2025 Apr;75(2):1155-1164. doi: 10.1016/j.identj.2024.07.015.
5. Li Y, Zhou W, Li P, Luo Q, Li A, Zhang X. Comparison of the osteogenic effectiveness of an autogenous demineralised dentin matrix and Bio-Oss® in bone augmentation: a systematic review and meta-analysis. Br J Oral Maxillofac Surg. 2022 Sep;60(7):868-876. doi: 10.1016/j.bjoms.2022.03.009.
6. Pye AD, Lockhart DEA, Dawson MP, Murray CA, Smith AJ. A review of dental implants and infection. J Hosp Infect ; 2009, 72:104–110.
7. Bra°nemark PI, Hansson BO, Adell R, Breine U, Lindstrom J, Hallen O et al (1977) Osseointegrated implants in the treatment of edentulous jaw. Experience from a 10-year period. Scand J Plast Reconstr Surg Suppl 16:1–192.
8. Bugarin Júnior JG, GarrafaII V. Bioethics and biosafety: the use of biomaterials in dental practice. Rev Saúde Pública 2007;41(2):223-8.
9. Mazaro JVQ, Godoy PAI, Junior JFS, Mello CC, Pellizzer EP, Zavanelli AC ; Regeneração óssea guiada em implantodontia: relato de caso ; RFO, Passo Fundo, v. 19, n. 1, p. 121-128, 2014.
10. Busetti J; Avaliação histológica e histomorfométrica da regeneração óssea guiada sob membranad]s biológicas não reabsorvíveis em ratas osteoporóticas com e sem tratamento com ácido zoledrônico ; Porto Alegre, 2015.
11. Fernandes TBG. Utilização de membranas absorvíveis e não absorvíveis em técnicas de regeneração óssea na implantodontia ; Uberlândia, 2015.
12. Costa JBZ, Silva F, Dultra CA, Souza LF, Santos MCNE. Uso de membranas biológicas para regeneração óssea guiada em implantodontia – uma revisão de literatura - Revista Bahiana de Odontologia. 2016 Mar;7(1):14-21.
13. Saghiri MA, Asatourian A, Garcia-Godoy F, Sheibani N. The role of angiogenesis in implant dentistry part II: The effect of bone-grafting and barrier membrane materials on angiogenesis. Med Oral Patol Oral Cir Bucal. (2016), doi:10.4317/medoral.21200.
14. Covani U, Chiappe G, Bosco M, Orlando B, Quaranta A, Barone A. A 10-year evaluation of implants placed in fresh extraction sockets: a prospective cohort study. J Periodontol 2012; 83(10):1226-34.
15. Aubin J. E.; Liu F. The osteoblast lineage. In:

Bilizekian, J., Raisz, L., and Rodan, G., editors. Principles of Bone Biology. San Diego, CA: Academic Press: 1996, 39-50.

16. Calasans MD., Fernandes GVO.; Granjeiro, JM. Preservação alveolar com enxertos após exodontias e previamente à instalação de implantes. Revista Implantnews, 2011, 6: 583-590.
17. Chan, YL.; King, NM. Use of focused íon bean milling for investigating the mechanical properties of biological tissues: A study of human primary molars. Journal of the Mechanical Behavior of Biomedical Materials 2009, 2 (4) : 375-383.
18. Fardin A.C., et al. Enxerto Ósseo em Odontologia: Revisão de Literatura. Innov Implant J, Biomater Esthet, São Paulo, 2010, 5 (3): 48-52.
19. Fontanari LA; Manne JM; Junior WT. Utilização de enxerto homógenos para reconstrução em áreas atróficas pré-implante: banco de ossos. Revista Implantnews, 2007, 5 (6) : 539-597.
20. Gimble JM.; Katz AJ.; Bunnell BA. Adipose-Derived Stem Cells for Regenerative Medicine. Circ Res; 2013, 100:1249-1260.
21. Hallman M, Cederlund A, Lindskog S, Lundgren S, Sennerby L. A clinical histologic study of bovine hydroxyapatite in combination with autogenous bone and fibrin glue for maxillary sinus floor augmentation. Results after 6 to 8 months of healing. Clin Oral Implants Res 2001 Apr;12(2):135-143.
22. Hing K. A. Bone repair in the twenty-first century: biology, chemistry or engineering? Philos. Trans. R. Soc. Lond. B. Biol Sci., 2004, 362(1825) : 2821-2850.
23. Langer R. ;Vacanti JP. Tissue Engineering. Science 1993; 260 : 920-926.
24. Lima, A F.; Martorelli. Enxertos ósseos: características de alguns materiais. Revista ABO Nacional, 2008, 16(3).
25. Liu, Y.; Clark, RAF.; Huang, L.; Rafailovich, MH. Hyaluronic acid-gelatin fibrous scaffold produced by electrospinning of their aqueous solution for tissue engineering applications. In Advances in Material Design for Regenerative Medicine, Drug Delivery and Targeting/ Imaging 2010; 1140 :131-136.
26. Locke M, Windsor J, Dunbar PR. Human adipose-derived stem cells: isolation, characterization and applications in surgery. ANZ J Surg, 2009, **79:**235-244.
27. Maiorana C, Sommariva L, Brivio P, Sigurtà D, Santoro F. Maxillary sinus augmentation with anorganic bovine bone (Bio-Oss) and autologous platelet-rich plasma: preliminary clinical and histologic evaluations. Int J Periodontics Restorative Dent 2003 Jun;23 (3) : 227-235.
28. Mazzoneto, R. Reconstruções em Implantodontia – Protocolos clínicos para o sucesso e a previsibilidade. Ed. Napoleão, 2009, 1ª Edição. Nova Odessa – SP, Brasil.
29. Mesimäki K, Lindroos B, Törnwall J, Mauno J, Lindqvist C, Kontio R, Miettinen S, Suuronen R: Novel maxillary reconstruction with ectopic bone formation by GMP adipose stem cells. Int J Oral Maxillofac Surg 2009, 38:201-209.
30. Nardi N.B.; Meirelles S.L. Mesenchymal stem cells: isolation, in vitro expansion and characterization. HEP 2006; 174 : 249-82.
31. Planat Bernard V, Silvestre JS, Cousin B., et al. Plasticity of human adipose lineage cells towards endothelial cells: physiological and therapeutic perspectives. Circulation 2004; 109 : 656 -63.
32. Vacanti, JP.; Langer, R. Tissue engineering: The design and fabrication of living replacement devices for surgical reconstruction and transplantation. Lancet,1999; 354: 32–34.
33. Valentini P, Abensur D. Maxillary sinus floor elevation for implant placement with demineralized freeze-dried bone and bovine bone (Bio-Oss): a clinical study of 20 patients. Int J Periodontics Restorative Dent 1997 Jun;17(3):232- 241.
34. Zago, MA.; Covas, DT. Células-tronco: Origens e Propriedades. In: Células-tronco: A nova Fronteira da medicina. Ed. M. Zago e D. T. Covas, pp. 3-20. Editora Atheneu São Paulo, 2006.
35. Zotarelli Filho IJ, Frascino LF, Greco OT, Araujo JDD, Bilaqui A, Kassis EN, Ardito RV and Bonilla-Rodriguez GO. Chitosan-collagen scaffolds can regulate the biological activities of adipose mesenchymal stem cells for tissue engineering. J Regen Med Tissue Eng. 2013; 2:12. http://dx.doi.org/10.7243/2050-1218-2-12.
36. Zuk PA, Zhu M, Mizuno H, Huang J, Futrell JW, Katz AJ, et al. Multilineage cells from human adipose tissue: implications for cell-based therapies. Tissue Eng; 2001, 7(2):211-28.
37. Anitua E, Sanchez M, Nurden AT, Nurden P, Orive G, Andia I. New insights into and novel applications for platelet-rich fibrin therapies. Trends Biotechnol. 2006; 24:227-34.
38. Choukroun J, Diss A, Simonpieri A, Girard M, Schoeffler C, Dohan SL. Plateletrich fibrin (PRF): a second-gereration platelet concentrate. Part V: histologic evaluations of PRF effects on bone allograft maturation in sinus lift. O Surg Oral Med

Pathol Radiol Endod 2006; 101(3):299-303.
39. Simonpieri A., Choukroun J., Del Corso M., Sammartino G., Dohan Ehrenfest D.M. Simultaneous sinus-lift and implantation using microthreaded implants and leukocyte- and platelet-rich fibrin as sole grafting material: a six-year experience. Implant Dent. 2011 Feb;20(1):2-12.
40. Anil, S., et al. Dental Implant Surface Enhancement and Osseointegration. [Em linha]. Disponível em <http://www.intechopen.com/books/implant-dentistry-arapidly-evolving-practice/dental-implant-surface-enhancement-andosseointegration>. [Consultado em 17/7/2016].
41. Anitua, E. Enhancement Of Osseointegration By Generating a Dynamic Implant Surface. Journal of Oral Implantology, 2006; 32:72-76.
42. Del Corso, M., Toffler, M. e Ehrenfest, D. Use of Autologous Leukocyte and Platelet-Rich Fibrin (L-PRF) Membrane in Post-Avulsion Sites: An Overview of Cjoukroun's PRF. The Journal of Implant and Advanced Clinical Dentistry, 2010; 1:27-35.
43. Ehrenfest, D., Rasmusson, L. e Albrektsson, T. Classification of platelet concentrates: from pure platelet-rich plasma (P-PRP) to leucocyte- and platelet-rich fibrin (L-PRF). Cell Press, 2009; 27.
44. Lopez-Vidriero, E., et al. The use of platelet-rich plasma in arthroscopy and sports medicine: optimizing the healing environment. Arthroscopy, 2010; 26:269-278.
45. Lynch S, et al. The Effects of Short-Term Application of a Combination of Platelet-Derived and Insulin-Like Growth Factors on Periodontal Wound Healing. Journal of Periodontology, 1991; 62:458-467.
46. Messora, M., et al. Análise da eficiência do protocolo de dupla centrifugação para o preparo do plasma rico em plaquetas (PRP) – estudo experimental em coelhos. RSBO- Revista Sul-Brasileira de Odontologia, 2010; 6:291-296.
47. Messora, M., et al. A standardized research protocol for plateletrich plasma (PRP) preparation in rats. Revista Sul-Brasileira de Odontologia, 2011; 8:299-304.
48. Moojen, D., et al. Antimicrobial activity of platelet-leukocyte gel against Staphylococcus aureus. Journal of Orthopaedic Research, 2008; 26:404-410.
49. Perez, M., et al. Relevant Aspects of Centrifugation Step in the Preparation of Platelet-Rich Plasma. International Scholarly Research Notices of Hematology, 2014; 8:1-8.
50. Simonpieri, A., et al. Current Knowledge and Perspectives for the Use of Platelet-Rich Plasma (PRP) and Platelet-Rich Fibrin (PRF) in Oral and Maxillofacial Surgery Part 2: Bone Graft, Implant and Reconstructive Surgery Current Pharmaceutical Biotechnology, 2012; 13:1231-1256.
51. Tejero, R., Anitua, E. e Orive, G. Toward the biomimetic implant surface: Biopolymers on titanium-based implants for bone regeneration. Journal of Progress in Polimeral Science, 2014; 39:1406-1447.
52. Tidball, G. Inflammatory cell response to acute muscle injury. Medicine & Science in Sports & Exercise, 1995; 27:1022-1032.
53. Ghezzi et al Clin. The importance of oral health in (frail) elderly people–a review. Oral Impl. Res. 18 (Suppl. 3), 2007 / 15-19.
54. kinaia BM. et al. Quality assessment of systematic reviews on periodontal regeneration in humans. J Periodontol. 2011 Mar; 82 (3):413-428.
55. Murphy kG et Gunsolley JC. Sinus augmentation utilizing anorganic bovine bone (Bio-Oss) with absorbable and nonabsorbable membranes placed over the lateral window: histomorphometric and clinical analyses. Ann Periodontol, Dec, 2003, Vol 8. Number 1, 266-302.
56. Houser BE et al. Treatment of class II molar furcation involvement: meta analyses of reentry results. Int J Periodontics Restorative Dent., 2001 Apr, 21 (2): 161-169.
57. Paolantonio M et al. Autogenous Periosteal Barrier Membranes and Bone Grafts in the Treatment of Periodontal Intrabony Defects of Single-Rooted Teeth: A 12-Month Reentry Randomized Controlled Clinical TrialJ Periodontol. 2010 Nov;81(11):1587-1595.
58. Da Silva, Vanessa Camila, et al. "Orthodontic movement after periodontal regeneration of class II furcation: a pilot study in dogs." Journal of clinical periodontology 33.6 (2006): 440-448.
59. Cardaropoli, Daniele, et al. "Bio-Oss collagen and orthodontic movement for the treatment of infrabony defects in the esthetic zone." International Journal of Periodontics & Restorative Dentistry, 2006, 26.6.
60. Correia F, Almeida RF, Costa AL, Carvalho J, Felino A. Levantamento do seio maxilar pela técnica da janela lateral: tipos enxertos. Revista Portuguesa de Estomatologia, Medicina Dentária e Cirurgia Maxilofacial.2012, 53 (3): 190-196.

61. Zhang Y, Tangl S, Huber CD, Lin Y, Qiu L, Rausch-Fan X. Effects of Choukroun's platelet-rich fibrin on bone regeneration in combination with deproteinized bovine bone mineral in maxillary sinus augmentation: A histological and histomorphometric study. Journal of Cranio-Maxillo-Facial Surgery. 2012 (40) 321-328.
62. Tatullo, M, Marrelli, M, Cassetta M, Pacifici A, Stefanelli LV, Scacco, S, Dipalma,G, Pacifici, L, Inchingolo, F. Platelet Rich Fibrin (P.R.F.) in Reconstructive Surgery of Atrophied Maxillary Bones: Clinical and Histological Evaluations. International Journal of Medical Sciences. 2012; 9(10):872-880. doi: 10.7150/ijms.5119.
63. Angelo T, Marcel W, Andreas, K, Izabela, S. Biomechanical Stability of Dental Implants in Augmented Maxillary Sites: Results of a Randomized Clinical Study with Four Different Biomaterials and PRF and a Biological View on Guided Bone Regeneration. Hindawi Publishing Corporation BioMed Research International, 2015, http://dx.doi.org/10.1155/2015/850340.
64. Chen, Y, Cai,Z, Zheng, D, Lin,P, Cai,Y, Hong, S, Lai & Dong Wu, Y. Inlay osteotome sinus floor elevation with concentrated growth factor application and simultaneous short implant placement in severely atrophic maxilla. Scientific Reports 2016, 6:27348 DOI: 10.1038/srep27348.
65. Kumar, NK, Shaik, M, Rao Nadella,K, Chintapalli, BM. Comparative Study of Alveolar Bone Height and Implant Survival Rate Between Autogenous Bone Mixed with Platelet Rich Plasma Versus Venous Blood for Maxillary Sinus Lift Augmentation Procedure. J. Maxillofac. Oral Surg. (Apr–June 2015) 14(2):417– 422 DOI 10.1007/s12663-014-0643-7.