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Maxillary sinus surgery with autologous or allogenic graft with platelet-rich plasma/fibrin for dental implants: a systematic review

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Abstract

Introduction: In the context of bone grafts and regenerative processes, the maxillary sinus acts in the equalization of barometric pressures in the nasal cavity, which is lined by a membrane called Schneider's membrane. When grafting procedures are needed, our focus is often on the type of biomaterial to be used, and the success and predictability of our results do not depend only on the biomaterial. **Objective:** It was to perform a systematic review of the main clinical approaches of maxillary sinus surgery with autologous and/or allogeneic graft, using platelet-rich plasma or fibrin. **Methods:** The systematic review rules of the PRISMA Platform were followed. The search was carried out from December 2022 to January 2023 in the Scopus, PubMed, Science Direct, Scielo, and Google Scholar databases, using articles from 2005 to 2022. 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 125 articles were found, 55 articles were evaluated in full and 27 were included and developed in this systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 25 studies with a high risk of bias and 20 studies that did not meet GRADE. It can be concluded from the present study that there is no statistical superiority observed between platelet-rich plasma, PerioGlas, or Bio-Oss in terms of their use as a grafting material along with the immediate implant placement procedure. Furthermore, the combination of autograft/xenograft and plasma rich in growth factors in the periosteal pocket flap technique is a simpler, cheaper, and faster technique than the guide bone regeneration technique to achieve moderate lateral bone augmentation in implant treatment. Tricalcium β-phosphate is a promising biomaterial for clinical situations that require bone augmentation. However, the addition of platelet-rich plasma results in decreased bone loss around dental implants.

Keywords: Dental implants. Maxillary sinus surgery. Autologous graft. Allogeneic graft. Platelet-rich plasma.

Introduction

In the context of bone grafts and regenerative processes, the maxillary sinus acts in the equalization of barometric pressures in the nasal cavity, which is lined by a membrane called Schneider's membrane [1,2]. The maxillary sinus drains through its ostium into the nasal cavity, which usually takes place in the middle meatus. In around 25% of all maxillary sinuses, there is an accessory bone that is located lower than the main ostium, and all the mucus produced and the particles trapped in this mucus are directed through the ciliary beat to the ostium [3].

In this aspect, when a dental element is lost in the posterior region of the maxilla, there is natural resorption of the alveolar process and at the same time, pneumatization of the maxillary sinus will occur [4,5]. It will increase its volume towards the place where the roots existed and this will often make it difficult or unfeasible to restore implants in place [6]. For this

reason, the maxillary sinus floor elevation procedure should be performed, or short implants when possible. When grafting procedures are required, the focus is often on the type of biomaterial to be used, and the success and predictability of our results do not depend only on the biomaterial [6].

Furthermore, it is also necessary to consider the type of defect (morphology) to be treated. The morphology will have an impact mainly because the defects have different vascularization capacities, different osteogenic cell recruitment capacities, have different natural stabilization capacities of the grafts, therefore, we must consider the characteristics of the biomaterial that we must use, but also the characteristics of the bed and the bone defect that we intend to treat [7].

In addition, several surgical techniques can be used to reconstruct the atrophic alveolar ridge, isolated techniques or associated with autogenous, allogeneic, xenogeneic grafts, and alloplastic biomaterials. The autogenous bone graft is the only one able to present three important biological properties (osteogenesis, osteoinduction, and osteoconduction) guaranteeing a self-regenerative potential [6,7]. As a disadvantage to the autogenous bone graft, the need for second surgical access in the donor area is highlighted, resulting in longer surgical time, morbidity, and a consequent greater resistance of the patient to the proposed treatment [6].

In this context, allogeneic, xenogeneic, and alloplastic bone grafts are an alternative for the treatment of bone deficiencies in the jaws, since they avoid the need for a second surgical approach. But due to the need for processing to eliminate antigenic components, these grafts are uniquely osteoconductive with a lower bone formation potential compared to autogenous bone grafts [8]. To increase the bone formation potential of these grafts, combinations have been proposed to obtain better regenerative conditions by preserving volume and inducing cell migration differentiation [8].

In this sense, platelet-rich plasma (PRP) is a concentration of platelets generated autogenously within a given volume of plasma. PRP is an abundantly rich source of growth-based factors found autogenously [9]. Traditionally, allografts are obtained from donors belonging to identical species. These are available as fresh or frozen, freeze-dried, and freeze-dried demineralized bone tissues [10]. These allograft materials act as osteoconductive scaffolds with osteoinductive properties due to proteins, eg bone morphogenetic protein [11]. On the other hand, xenografts are derived from different species [9].

Furthermore, PRP can be used alone or in combination with autograft, as well as allograft materials for the treatment of periodontal bone defects, preservation of extraction sockets, augmentation of an alveolar bone ridge, reconstruction of the mandible, the elevation of the sinus floor and repair of maxillary fissures [11]. Plachokova et al. (2008) [12] demonstrated greater volume as well as a denser bone when compared to using autografts alone for bone regeneration. It has been found that PRP is synthesized from the host and is rich in various growth factors that aid in bone formation and the healing process. Autologous platelet concentrates, such as PRP or platelet-rich fibrin, are readily available, inexpensive, and contain high concentrations of a variety of growth factors that play a role in wound healing and tissue regeneration [13].

Accordingly, several bioactive growth factors that are released upon platelet activation are platelet-derived growth factor, transforming growth factor, vascular endothelial growth factor, insulin-like growth factor, and the insulin-like growth factor of epidermal growth. These growth proteins have important properties, which play a role in tissue healing, chemotaxis, cell proliferation, tissue differentiation, removal of tissue-derived debris, angiogenesis, and extracellular matrix production [14-16]. These biomaterials, due to their low morbidity and possible regenerative potential, have been indicated for use in combination with other biomaterials or even alone [17].

Given this, the present study aimed to carry out a systematic review of the main clinical approaches to maxillary sinus surgery with autologous and/or allogeneic grafts, using platelet-rich plasma or fibrin.

Methods

Study Design

This was followed by a systematic literature review model on the main clinical findings of mandible fractures, according to the PRISMA rules (www.prisma-statement.org/).

Data sources, MeSH Terms and research strategy

The literary search process was carried out from December 2022 to January 2023 and was developed based on Scopus, PubMed, Science Direct, Scielo, and Google Scholar, using scientific articles from 2005 to 2022, using the descriptors (MeSH Terms): “Dental implants. Maxillary sinus surgery. Autologous graft. Allogeneic graft. Platelet-rich plasma”, and using the Booleans "and" between the descriptors (MeSH Terms) and "or" between the historical findings.

Study quality and risk of bias

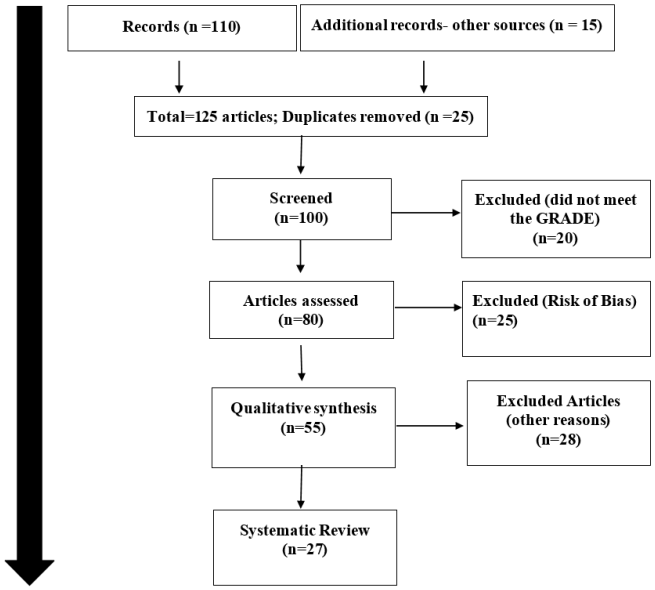
The quality of the studies was based on the GRADE instrument, with randomized controlled clinical studies, prospective controlled clinical studies, and studies of systematic review and meta-analysis listed as the studies with the greatest scientific evidence. The risk of bias was analyzed according to the Cochrane instrument.

Results and Discussion

Summary of Literary Findings

A total of 125 articles were found. Initially, duplication of articles was excluded. After this process, the abstracts were evaluated and a new exclusion was performed, removing the articles that did not include the theme of this article, resulting in 100 articles. A total of 55 articles were evaluated in full and 27 were included and developed in this systematic review study (Figure 1). Considering the Cochrane tool for risk of bias, the overall assessment resulted in 25 studies with a high risk of bias and 20 studies that did not meet GRADE.

Figure 1. Selection of studies.



Main Clinical Findings

Based on literary findings, the use of adequate graft material helps in osseointegration in adequate quantity. A randomized clinical trial compared the effectiveness of platelet-rich plasma (PRP), a synthetic allograft (PerioGlas), and Bio-Oss, a bioabsorbable xenograft in immediate implant procedures. A total of 90 patients were categorized into three groups with 30 samples each Group A: patients who received PRP with immediate implantation; Group B: immediate implants with synthetic allograft (PerioGlas); and Group C: patients with immediate implants placed with bioabsorbable xenograft (Bio-Oss). Intergroup statistical comparisons between gingival and plaque indices at three, six, and 12 months of follow-up in the study groups did not show statistical significance ($p>0.05$). Mean probing depths and bone resorption at three, six, and 12 months of follow-up were not statistically significant ($p>0.05$) in the intergroup comparison [18].

Furthermore, implant rehabilitation of posterior mandibular defects is often associated with horizontal bone loss. There are several regenerative techniques to overcome this bone deficiency, one of them is the Periosteal Pocket Flap Technique (PPF) proposed by Steigmann et al. to treat small horizontal bone defects. In this sense, a prospective clinical study proposed a modification of this technique based on the concomitant use of PPF with the use of xenogeneic and autologous bone and Plasma Rich in Growth Factors (PRGF), to evaluate the clinical and radiographic results of PPF with the use of xenogeneic and autologous bone and PRGF compared to conventional Guided Bone Regeneration (GBR) procedures. A total of 9 patients were included in the study (7 women and 2 men, mean age: 53 ± 2.74 years) and allocated to PPF or GBR. In both groups, implant placement was performed simultaneously with bone regeneration. Nine surgeries were performed: 6 PPF and 3 GBR. Regarding clinical results, operative time was significantly longer in the GBR group than in the PPF group (51.67 ± 3.51 min vs. 37 ± 5.69 min; $p = 0.008$). Postoperative pain was greater in the GBR compared to the PPF ($p=0.011$). Regarding radiographic results, there were no significant differences in horizontal bone gain (PPF: 9.43 ± 1.8 mm; GBR: 9.28 ± 0.42 mm), surface area (PPF: 693.33 ± 118, 73 mm2; GBR: 655.61 ± 102.43 mm^2) and volume (PPF: 394.97 ± 178.72 mm^3; GBR: 261.66 ± 118 mm^3) between groups [19].

Moreover, the study developed by the authors Uppala et al, 2020, evaluated and compared crestal bone loss around implants placed with particulate β-tricalcium phosphate bone graft and platelet concentrates. A total of 50 subjects received 100 dental implants. Each individual received a dental implant in the edentulous area filled with β-tricalcium phosphate (β-TCP) bone graft with platelet-rich plasma (PRP) (Group A) and another in the edentulous area filled only with β-tricalcium phosphate bone graft (Group B) in the posterior edentulous region. All 100 implants were prosthetically loaded after a three-month healing period. Crestal bone loss was measured on the mesial, distal, buccal, and lingual sides of each implant using periapical radiographs 3 months, 6 months, and 9 months after implant placement. Mean crestal bone loss 9 months after implant placement in Group A and Group B was 2.75 mm and 2.23 mm, respectively, a statistically significant value ($P < 0.05$). In both Group A and Group

B, mean crestal bone loss was greatest on the lingual side, followed by the buccal, distal, and mesial sides [20].

In this regard, implant dentistry has stood out as a modern method of oral rehabilitation for total or partially edentulous patients. For this method to develop properly, it is necessary for bone integration of the implant to occur in the recipient bone tissue, since bone integration is the key to clinical surgical success, which will be completed after the end of the prosthetic phase [4].

Thus, dental implants are being used more and more due to their high success rates. However, a large number of patients do not have enough minimum bone conditions for the installation of implants, therefore, previous reconstructive bone surgeries are necessary. Fundamentally, the dental surgeon dominates the knowledge in the healing process of post-extraction sockets, to provide correct planning of the cases [2,21].

Furthermore, fibrin-rich plasma (FRP) as an autologous biomaterial for use in oral and maxillofacial surgery presents most of the leukocytes, platelets, and growth factors, forming a fibrin matrix with three-dimensional architecture. The Bio-Oss® (Geistlich) biomaterial, as it is biodegradable, biocompatible, non-toxic, and has low immunogenicity and bio stimulators, can act in the regeneration of bone tissue, as it establishes with adenomatous mesenchymal stem cells the appropriate biological niche for bone growth and, thus allowing the dental implant to be performed with the greatest possible efficiency [22].

Based on this, two important studies reported results on the combined use of Bio-Oss® and FRP. Thus, the first study clinically and histologically investigated the potential of FRP as a grafting material in pre-implant reconstructive surgery for severe maxillary atrophy after sinus lift procedures at 106-120-180 days, to determine whether the use of FRP is capable of accelerating the bone regeneration process, which is essential to promote implant stability. This study also includes a control group, in which only deproteinized bovine bone (Bio-Oss®) was used as the reconstructive material. As a result, the use of FRP optimized bone formation [22,23].

The second study compared the use of Bio-Oss® mixed with FRP and Bio-Oss® with Tisseel® to improve bone regeneration. After elevating the sinus membrane in both sinus cavities, an implant was placed in the sinus cavity. In one of the sinus cavities, the FRP/Bio-Oss® composite was grafted and the Tisseel® / Bio-Oss® composite was grafted in the other sinus cavity. After a 6-month healing period, bone formation at the graft sites and bone-implant contact were evaluated. The mean rate of osseointegration was 43.5 ± 12.4% and the rate of new bone formation was 41.8 ± 5.9% in PRF/Bio-Oss® composite sites. In Tisseel® / Bio-Oss® composite sites they were 30.7 ± 7.9% and 31.3 ± 6.4%. There were statistically significant differences between groups. The findings of this study suggested that when FRP is used as an adjunct to Bio-Oss® particles for bone augmentation in the maxillary sinus, bone formation at the graft sites is significantly greater than when Tisseel® is used [24].

For a successful dental implant practice, osseointegration is essential. However, it is a complex process with many factors interfering in the formation and maintenance of bone tissue around the implant, such as topography and surface roughness, biocompatibility, and loading conditions. In addition, it is necessary to have a host bone layer that is healthy, compatible, and allows primary stability [25].

In this sense, after a tooth extraction, the repair process occurs in the inner region of the alveolus together with the formation of a clot rich in cells and growth factors, promoting neoformation, bone remodeling, and epithelialization of soft tissues. During this process, the alveolar ridge undergoes significant changes, both in height and thickness, which influence the possibility of installing implants. Thus, the optimized processes of implant dentistry and biomaterials allow the installation of implants in areas of low bone thickness, width, and height, with simpler surgeries and a higher success rate and patient comfort [25].

Still, the lack of bone in the alveolar crests has been a major problem in functional aesthetic recovery in patients who have suffered dentoalveolar trauma, traumatic tooth extractions, congenital tooth absence, and maxillary and mandibular pathologies. For the filling of large bone defects, the development of bone regeneration improves epithelial barriers to bone grafting, favoring greater predictability in alveolar and peri-implant reconstructions and presenting a good prognosis. In this sense, filling biomaterials can be FRP, Bio-Oss®, hydroxyapatite, lyophilized and ground demineralized bone marrow, and autogenous bone, which is considered the gold standard, among others [25].

To improve osseointegration and bone anchorage, surface modifications can be chemical, such as calcium phosphate (Ca-P), or physical impregnation, being related to the microtopography of the implant. Several variables affect the biological activity of FRP preparations, such as the number of centrifuges used, centrifugation speed, and other protocols that result in preparations with various volumes, platelet numbers, amount of growth factors, and concentration of white blood cells, and critical erythrocytes [26].

Added to this, the need to rehabilitate edentulous

areas that have suffered significant resorptions is a current need and the maxillary sinus lift maneuver is a viable way to implant anchorage for implant-supported oral rehabilitation [1]. One of the relatively frequent complications (15.0%) of the procedures is sinus membrane rupture during sinus membrane displacement. The main intercurrence of this rupture is related to graft containment [1].

In this context, small perforations with an extension of 1.0 to 2.0 mm are contoured with the folds of the membrane in their elevation, but when they reach lengths greater than these, the membranes must be added to close the same, and larger tears than 10.0 mm. The surgery must be aborted and reinserted after a period of re-epithelialization of the antral cavity, that is, between 60 and 90 days [2].

Thus, the use of an autologous fibrin membrane, obtained by centrifugation of the patient's venous blood, without the addition of anticoagulants, provides a fast and efficient repair of surgical wounds. Fibrin gel constitutes the first healing matrix of injured sites [6]. FRP is the second generation of fibrin concentrates, succeeding FRP, which had the limitation of releasing growth factors and cytokines in a very short time [7,27].

In addition, PRF shows progressive polymerization and the incorporation of circulating cytokines increases in the fibrin mesh. Such a configuration implies a longer life for these cytokines, as they are released and used only in the remodeling of the initial matrix of the scar. Cytokines are thus kept available in situ for a convenient period when cells begin to heal the matrix, that is, when they need to be stimulated to rebuild the injured site [8].

According to some authors, FRP acts to protect growth factors from proteolysis which, in this way, can maintain their activity for a longer period and stimulate tissue regeneration. The use of autogenous bone, especially the capacity of osteoinduction, has been recommended for filling the antral cavity [9].

Conclusion

It can be concluded from the present study that there is no statistical superiority observed between platelet-rich plasma, PerioGlas, or Bio-Oss in terms of their use as a grafting material along with the immediate implant placement procedure. Furthermore, the combination of autograft/xenograft and plasma rich in growth factors in the periosteal pocket flap technique is a simpler, cheaper, and faster technique than the guide bone regeneration technique to achieve moderate lateral bone augmentation in implant treatment. Tricalcium β-phosphate is a promising biomaterial for clinical situations that require bone augmentation. However, the addition of platelet-rich plasma results in decreased bone loss around dental implants.

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Ethics approval

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Informed consent

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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@.

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