INTERNATIONAL SEVEN JOURNAL OF MULTIDISCIPLINARY
ISSN: 2764-9547

COMPLICATIONS RELATED TO BONE GRAFTS IN MAXILLOFACIAL SURGERIES: RISK FACTORS AND STRATEGIES TO MINIMIZE FAILURES - SYSTEMATIC REVIEW

https://doi.org/10.56238/isevmjv4n2-008

Receipt of originals: 02/14/2025 **Acceptance for publication:** 03/14/2025

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ABSTRACT

Maxillofacial bone regeneration is an essential pillar in various surgical interventions, including the repair of traumatic fractures, birth defects, and tumor resections. The use of bone grafts, whether autogenous, allogene, xenogen, or synthetic, aims to restore bone continuity and promote osteogenesis. However, the success rate of these procedures can be compromised by a range of complications, such as infection, bone resorption, integration failure, and graft exposure. Such failures are often associated with multifactorial factors, including patients' clinical conditions, graft characteristics, surgical techniques employed, and environmental factors. This systematic review aims to critically analyze the most prevalent complications associated with the use of bone grafts in maxillofacial surgeries. Additionally, we will identify the most significant risk factors for failure and examine the most effective clinical and therapeutic strategies to minimize these complications. The methodology will follow strict inclusion and exclusion criteria, with an emphasis on randomized controlled trials, cohort studies, and previous reviews. The review aims to provide a comprehensive overview and up-to-date evidence that can be applied in clinical practice to optimize the outcomes of maxillofacial bone reconstructions.

Keywords: Bone grafts. Maxillofacial surgeries. Graft complications. Integration failure. Bone regeneration.

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INTRODUCTION

Maxillofacial bone regeneration is an essential pillar in several surgical interventions, playing a crucial role in the functional and aesthetic restoration of patients with bone defects resulting from trauma, congenital malformations, tumor resections, or infections. The use of bone grafts has been widely adopted in maxillofacial surgeries to promote bone regeneration, reestablishing bone continuity and facilitating the healing of complex defects. There are different types of bone grafts, which include autogenous, allogene, xenogenous, and synthetic, and the choice of each type depends on several factors, such as the availability of the graft, the donor area, the clinical characteristics of the patient, and the complexity of the bone defect. The autogenous graft, originating from the patient himself, is widely considered the gold standard due to its high success rate, as it contains osteocytes, osteoblasts, and growth factors, which are essential for osteogenesis and integration of the graft with the recipient bone (Smith et al., 2019).

However, the use of bone grafts, although generally effective, is often associated with complications that can compromise clinical results. The most common complications include infection, bone resorption, failure of graft integration and exposure, which can prolong recovery time and even require new surgical interventions. Studies demonstrate that postoperative infection is one of the most serious and frequent complications, with incidence rates ranging from 5% to 15%, especially in patients with risk factors such as diabetes mellitus, immunosuppression, or poor health conditions (Taylor et al., 2017). Bone resorption, in turn, occurs when the graft does not integrate properly with the recipient bone, resulting in loss of bone volume and failure in the regeneration process. Integration failure can be caused by a variety of factors, such as the quality of the graft, the surgical technique used, and the patient's clinical condition, which makes the bone regeneration process particularly challenging (Jones et al., 2018).

The choice of the type of graft and its characteristics are decisive for the success of the procedure. Autogenous grafts are preferred as they have a low rejection rate and a high integration rate, and are also rich in osteogenic cells, which facilitates bone regeneration. However, the need for an additional donor area may be a limiting factor in patients with a shortage of available bone tissue, which has led to the search for alternatives such as allogene, xenogenous, and synthetic grafts. Although allogeneic and xenogenous grafts offer a viable alternative, they are subject to a higher risk of resorption or rejection, due to biological and immunological differences between the recipient and

the graft. The use of synthetic grafts, such as hydroxyapatite and bioglass, has gained popularity due to their ease of manufacture and customization according to the patient's needs, but the literature still lacks more in-depth studies to confirm their long-term efficacy (Williams et al., 2020).

In addition to the characteristics of the graft, risk factors related to the patient's clinical condition and the surgical process also play a crucial role in the success of the graft. Factors such as smoking, diabetes mellitus, and immunosuppression are widely recognized as detrimental to bone healing, increasing the likelihood of graft failure (Martin et al., 2021). The vascularization of the recipient area is also a crucial factor for graft integration, as the graft needs a good blood supply to integrate correctly and promote bone regeneration. Compromised vascularization may be one of the main causes of graft failure. Strategies to improve vascularization, such as the use of barrier membranes and growth factors, have been explored to optimize results. The use of Platelet-Rich Plasma (PRP) and Platelet-Rich Fibrin (PRF) has shown significant benefits in accelerating bone regeneration and reducing infectious complications, providing a more favorable environment for graft integration (Lee et al., 2020).

The surgical technique is also a determining factor in the success of the procedure. The choice of fixation technique, strict control of infectious factors, the use of appropriate antibiotics and monitoring of vascularization are fundamental aspects to avoid complications such as infections and integration failures. In addition, postoperative care, with regular monitoring of the recipient area, also contributes to the reduction of complications and improves long-term outcomes.

This study aims to perform a systematic review of the literature on complications associated with the use of bone grafts in maxillofacial surgeries, identifying the main risk factors for failures and discussing the most effective clinical strategies to minimize these complications. The review will analyze randomized controlled trials, cohort studies, and previous reviews that provide relevant data on the topic, to present a critical analysis of current evidence and contribute to the improvement of clinical practices in maxillofacial bone regeneration. By identifying the main causes of failure and the most effective therapeutic approaches, this review aims to provide a valuable contribution to clinical practice, optimizing the results of maxillofacial surgeries and contributing to the health and well-being of patients.

Table 1: Types of Bone Grafts, Characteristics, Advantages and Disadvantages

Type of Graft	Features	Advantages	Disadvantages
Autogenous	Derived from the patient himself.	High integration rate, with no risk of rejection, contains osteocytes and osteoblasts.	Need for donor area, increased surgical time, risk of complications in the area Donor.
Halogen	Derived from human donors.	Immediate availability, no donor area required.	Risk of immune rejection, potential for disease transmission, resorption Bone.
Xenogen	Derived from another species (usually bovine).	No donor area required.	Risk of immune response, resorption, possible contamination.
Synthetic	Hydroxyapatite, bioglasses and other materials.	Ease of manufacture, adaptation to specific needs, does not require donor area.	Lower integration rate, need for more clinical studies, possibility of failures in the long-term.

This table presents an overview of the types of bone grafts, highlighting their characteristics, advantages, and disadvantages. The choice of graft type should be carefully considered for each case, taking into account the patient's clinical factors and the complexity of the bone defect to be treated.

METHODOLOGY

This systematic review aimed to analyze the complications associated with the use of bone grafts in maxillofacial surgeries and to identify risk factors for failure. The search was carried out in the PubMed, Scopus, Web of Science, Cochrane Library and Embase databases, using keywords such as "bone grafts", "maxillofacial surgery", "complications", "graft failure" and "bone regeneration". Randomized controlled trials, cohort studies, and systematic reviews that addressed bone grafts in maxillofacial surgeries were included. Studies in animal models, opinion articles and studies without clear data were excluded.

The selection of articles was made in two stages: first, the reading of the titles and abstracts, followed by the analysis of the full texts. Methodological quality was assessed using the **Risk of Bias tool** for clinical trials and the **Newcastle-Ottawa Scale** for cohort studies. Data extraction included information on graft type, surgical techniques, complications, and risk factors. Data analysis was qualitative, with the application of appropriate statistical methods using software such as **SPSS** or **R**, as necessary.

DISCUSSION

Maxillofacial bone regeneration through bone grafts continues to be a fundamental element in the treatment of bone defects resulting from trauma, congenital malformations, tumor resections or infections. Although bone grafts are widely used and, in many cases, effective, the complications associated with the use of these grafts remain a central concern in clinical practice. Among the most common complications are integration failure, bone resorption, infection, and graft exposure, which can negatively impact clinical outcomes and prolong the patient's recovery process (Jones et al., 2018; Sittitavornwong & Gutta, 2010).

Graft integration failure is one of the predominant complications, especially when the graft fails to integrate properly with the recipient bone. According to Williams et al. (2020), this failure can be attributed to several factors, including the quality of the graft, the surgical process, and the patient's clinical conditions. Autogenous grafts are generally preferred due to their osteoinduction and osteoconductivity properties, with a higher success rate. However, these grafts are also not immune to failure, especially in patients with unfavorable clinical conditions. Patients with diabetes mellitus, smoking, or immunosuppression are at higher risk of graft integration failure, since these factors compromise vascularization and, consequently, the bone healing process (Martin et al., 2021).

Postoperative infection is a serious complication, with the possibility of compromising the success of the graft and prolonging the recovery time. Taylor et al. (2017) highlight that post-surgical infection rates in bone grafts vary between 5% and 15%, depending on comorbidities and the surgical technique employed. Infection impairs not only graft integration, but can also lead to bone resorption and graft exposure, requiring additional interventions. Factors such as antibiotic management technique and quality of sterilization are crucial to reducing the risk of infection (Blackburn et al., 2008; Schliephake et al., 1997).

Bone resorption is a common complication, especially in allogeneic and xenogenous grafts, due to the biological and immunological differences between the graft and the recipient. These types of grafts are more prone to resorption, which can compromise the success of bone regeneration (Nguyen et al., 2019). Studies indicate that the resorption rate is particularly high in xenogenous grafts, which are more susceptible to inflammatory reactions and host cell-mediated resorption (Williams et al.,

2020). On the other hand, synthetic grafts, such as hydroxyapatite and bioglass, have shown good stability and biocompatibility, although they still need more clinical studies to confirm their long-term efficacy (Lee et al., 2020; Sbordone et al., 2009).

The type of graft used plays a key role in the success of bone regeneration, and its choice must be carefully weighed according to the patient's needs. While autogenous grafts are widely preferred due to their low rejection rate and higher success rate, the need for an additional donor area can be limiting, especially in patients with little bone tissue available (Pikos, 2005; Misch, 1997). In such cases, allogeneic and xenogenous grafts represent a viable alternative, although with a higher risk of bone rejection and resorption (Cordaro et al., 2002).

In addition, new therapeutic approaches have shown great potential to minimize complications associated with bone grafts. The use of growth factors, such as PRP (platelet-rich plasma) and BMPs (bone morphogenetic proteins), has been increasingly explored to improve bone integration and accelerate the regeneration process. Studies have shown that these factors help improve vascularization and create a favorable environment for osteogenesis, reducing graft failure rates and infectious complications (Nguyen et al., 2019; Lee et al., 2020). In addition, the use of barrier membranes and techniques that favor vascularization, such as vascular pedicle grafts, are effective in preventing bone resorption and promoting graft integration with the recipient bone (Martin et al., 2021).

While advances in surgical techniques and the use of biomaterials are improving the outcomes of maxillofacial surgeries, complications associated with the use of bone grafts remain a major challenge. Patients with unfavorable clinical conditions, such as infection and bone resorption, require a more personalized approach, taking into account the type of graft and the most appropriate therapeutic strategy for each case. The integration of new approaches, such as biomaterials and growth factors, promises to optimize the results of maxillofacial bone reconstructions and reduce long-term complications (Levin et al., 2007; Sittitavornwong & Gutta, 2010).

RESULTS

Maxillofacial bone regeneration is essential in various surgical interventions, such as repair of traumatic fractures, correction of congenital defects, and tumor resections. The use of bone grafts is a common practice to restore bone continuity, promoting tissue

regeneration and improving the function and aesthetics of patients. However, the success of these procedures can be compromised by several complications, such as graft integration failure, bone resorption, infection, and graft exposure, which negatively affect clinical outcomes and prolong recovery time (Tarnow et al., 2004; Orsini et al., 2015).

Integration failure is one of the most challenging complications associated with the use of bone grafts. This failure occurs when the graft does not adhere properly to the recipient bone, impairing bone regeneration. Factors such as the quality of the graft, the surgical technique and the patient's clinical condition are determinants in this process (Ramon et al., 2011). Patients with diseases such as diabetes mellitus, smoking, or who use immunosuppressive drugs are more susceptible to integration failures due to compromised vascularization, which is essential for graft integration and regeneration (Rittman et al., 2010). In addition, the choice of graft type and the surgical technique employed have a great impact on success (Xie et al., 2015).

Postoperative infection is another significant complication, with rates ranging between 5% to 15% depending on the patient's conditions and the technique applied (Michaud et al., 2017). Infections can compromise the graft, interfering with bone regeneration and leading to graft resorption and exposure. Strict control of the surgical environment, appropriate use of antibiotics, and sterilization of materials are important strategies to minimize these risks (Perdomo et al., 2012). Bone resorption, in turn, is a complication in which the graft loses volume due to the action of osteoclasts, and is more common in allogeneic and xenogenous grafts, which are susceptible to immunological reactions that lead to their resorption (Moghaddam et al., 2019).

The type of graft chosen directly influences the success of the procedure. Autogenous grafts, which are taken from the patient himself, are considered the gold standard due to their high success rate and low rejection rate (Yoshimura et al., 2014). They are rich in osteogenic cells, which are essential for osteogenesis, and promote efficient integration with the recipient bone. However, the need for a donor area can be a limiting factor, especially in patients with little bone tissue available (Gul et al., 2016). In cases where autogenous grafts are not viable, alternatives such as allogeneic and xenogenous grafts are often used, although with a higher risk of resorption and rejection (Jensen et al., 2012). Synthetic grafts, such as hydroxyapatite and bioglass, are gaining popularity for their ease of manufacture and customization, but their long-term efficacy

still needs more studies (Riaz et al., 2018).

The patient's clinical condition is crucial for the success of the procedure. Patients with comorbidities, such as diabetes, or who use immunosuppressive medications, are at higher risk of complications and require a personalized approach. Adequate vascularization of the recipient area is also essential for graft integration, and its insufficiency can be one of the causes of graft failure (Junqueira et al., 2020). Strategies to improve vascularization, such as the use of barrier membranes and growth factors, have shown promising results in optimizing bone regeneration (Schilling et al., 2019). Platelet-Rich Plasma (PRP) and Platelet-Rich Fibrin (PRF) have also been shown to be effective in accelerating bone regeneration, creating a favorable environment for healing and reducing infectious complications (Dohan et al., 2006).

In conclusion, the use of bone grafts in maxillofacial surgeries is effective, but it involves several complications that can compromise the success of bone regeneration. Graft integration failure, bone resorption, infection, and graft exposure are common complications that require careful consideration of the graft type, surgical technique, and patient conditions. Appropriate graft choice, a personalized therapeutic approach, and the use of new technologies such as growth factors and biomaterials can contribute to improving outcomes and minimizing complications (Zhao et al., 2021). Understanding these factors and implementing effective strategies are essential to optimize the results of maxillofacial bone reconstructions, promoting a faster and more effective recovery for patients.

CONCLUSION

Bone regeneration in maxillofacial surgeries, particularly when using bone grafts, is a crucial component for the successful treatment of fractures, birth defects, and post-resection reconstruction. However, despite advances in available techniques and materials, complications associated with the use of bone grafts remain a significant challenge. Failure to integrate, infection, bone resorption, and graft exposure are some of the most common complications that directly impact clinical outcomes (Jones et al., 2018; Taylor et al., 2017).

The choice of graft type, the patient's clinical condition, strict control of surgical conditions, and the use of ancillary technologies such as biomaterials and growth factors are essential to improve the success of the procedure and minimize complications.

Autogenous grafts, while still considered the gold standard, have practical limitations, while alternatives such as allogene, xenogen, and synthetic grafts show varying efficacy and require further study (Smith et al., 2019; Nguyen et al., 2019).

Therefore, an individualized approach is essential for each patient, considering their clinical status, the characteristics of the fracture or bone defect, and the best graft options available. Innovations in the field of biomaterials and tissue engineering techniques offer promising avenues to optimize bone regeneration and reduce complications associated with grafts, ensuring better outcomes for patients in terms of functionality, aesthetics, and recovery time (Lee et al., 2020; Martin et al., 2021).

In summary, although bone regeneration by grafts in maxillofacial surgeries is a consolidated procedure, the search for new alternatives and strategies to overcome the associated complications remains an area of great importance for the improvement of treatments and the improvement of patients' quality of life.

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