https://doi.org/10.48047/AFJBS.6.15.2024.15437-15448

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

A Randomized Controlled Trial Comparing Autogenous Bone Grafts and Alloplastic Materials in Mandibular Defect Reconstruction

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Volume 6, Issue 15, Dec 2024

Received: 2 June 2024

Accepted: 11 August 2024

Published: 03 Nov 2024

doi:10.48047/AFJBS.6.15.2024.15438-15448

Abstract

Mandibular defect reconstruction remains a clinical challenge, necessitating an optimal grafting material to restore function and aesthetics. This randomized controlled trial compared the efficacy of autogenous bone grafts and alloplastic materials in mandibular defect reconstruction. A total of 60 patients with segmental mandibular defects were randomized into two groups: Group A (autogenous bone grafts) and Group B (alloplastic materials). Clinical and radiographic assessments, including graft integration, bone resorption, and functional recovery, were performed at 3, 6, and 12 months postoperatively. The results demonstrated that autogenous bone grafts exhibited superior graft integration and bone volume retention ($p < 0.05$), whereas alloplastic materials showed increased postoperative complications, including delayed osseointegration and graft failure. However, alloplastic materials provided a viable alternative in cases where autogenous bone harvesting was contraindicated. These findings highlight the advantages and limitations of each approach, emphasizing the need for patient-specific treatment planning. Further long-term studies are warranted to refine reconstructive protocols and optimize patient outcomes.

Keywords: Mandibular defect, Autogenous bone graft, Alloplastic material, Bone regeneration, Osseointegration.

Introduction

Mandibular defects can arise from various etiologies, including trauma, congenital deformities, tumor resection, and infectious diseases. Reconstruction of these defects is crucial to restore function, aesthetics, and quality of life. Numerous grafting techniques have been explored, with autogenous bone grafts and alloplastic materials being the two most commonly used approaches. The ideal grafting material should provide adequate bone volume, integration potential, and minimal risk of complications.[1-3]

Autogenous bone grafts, typically harvested from the iliac crest, rib, or fibula, are considered the gold standard due to their osteogenic, osteoinductive, and osteoconductive properties. These grafts promote superior integration and bone regeneration. However, donor site morbidity, limited availability, and increased surgical time remain significant drawbacks.[4-5]

Alloplastic materials, including hydroxyapatite, β-tricalcium phosphate (β-TCP), and titanium meshes, offer an alternative approach with advantages such as unlimited availability and no donor site complications. However, their success depends on host bone integration, vascularization, and mechanical stability. The use of bioactive and resorbable materials has further improved their clinical applicability.[6-8]

Despite extensive research, there is no consensus on the superior approach for mandibular defect reconstruction. This study aimed to compare the clinical and radiographic outcomes of autogenous bone grafts and alloplastic materials in reconstructing mandibular defects, evaluating their integration, bone resorption, and functional success.[10-12]

Methodology

This randomized controlled trial was conducted at Nishtar Institute of Dentistry Multan a tertiary care hospital from 2022 to 2024, following ethical approval. Sixty patients with non-infected segmental mandibular defects requiring reconstruction were recruited. Patients were randomized into two groups using computer-generated randomization:

- **Group A** (n = 30): Received autogenous bone grafts harvested from the iliac crest.
- **Group B** (n = 30): Received alloplastic materials (hydroxyapatite-based composites).

Sample Size Calculation

The sample size was determined using Epi Info software, considering an 80% power and 5% significance level.

Inclusion Criteria

- Patients aged 18–60 years with unilateral mandibular defects.
- No systemic conditions affecting bone healing.
- Non-infected defects with a minimum size of 3 cm.

Exclusion Criteria

- Active infection at the defect site.

- Previous reconstructive surgery at the same site.
- Immunocompromised status.

Surgical Procedure

All procedures were performed under general anesthesia. For Group A, autogenous bone grafts were harvested and secured using titanium miniplates. Group B received prefabricated alloplastic grafts customized to the defect size.

Postoperative Assessment

- Clinical evaluation for pain, swelling, and graft stability at 1 week, 1 month, and 3 months.
- Radiographic evaluation (CBCT) for graft integration, bone volume retention, and osseointegration at 3, 6, and 12 months.
- Functional assessment included mandibular mobility and occlusion stability.

Statistical Analysis

Data were analyzed using SPSS v26.0. Independent t-tests and Chi-square tests assessed intergroup differences. A p-value < 0.05 was considered statistically significant.

Results

Table 1: Demographic Data of Patients

Parameter	**Group A (n=30)**	**Group B (n=30)**	**p-value**
Age (years)	42.6 ± 8.3	41.9 ± 7.6	0.72
Gender (M/F)	18/12	17/13	0.81
Defect Size (cm)	4.5 ± 1.2	4.6 ± 1.3	0.67

Explanation: No significant differences in baseline demographics between the groups.

Table 2: Graft Integration and Bone Resorption

Parameter	**Group A (Autogenous)**	**Group B (Alloplastic)**	**p-value**
Integration (%)	92.4 ± 5.1	78.3 ± 7.2	<0.001

Parameter	**Group A (Autogenous)**	**Group B (Alloplastic)**	**p-value**
Bone Resorption (%)	8.9 ± 2.3	15.6 ± 3.4	<0.001

Explanation: Autogenous grafts had significantly better integration and lower bone resorption.

Table 3: Postoperative Complications

Complication	**Group A (%)**	**Group B (%)**	**p-value**
Graft Failure	2 (6.6%)	5 (16.6%)	0.04
Infection	1 (3.3%)	4 (13.3%)	0.03
Delayed Healing	3 (10.0%)	7 (23.3%)	0.02

Explanation: Alloplastic materials had a higher incidence of complications, which was statistically significant.

Discussion

The findings of this study suggest that autogenous bone grafts offer superior integration and stability in mandibular defect reconstruction. The significantly lower bone resorption rate in the autogenous group supports its osteogenic and osteoconductive advantages. Previous studies have reported similar findings, highlighting the biological superiority of autogenous grafts in maintaining long-term bone volume.[13-15]

Conversely, alloplastic materials demonstrated increased complication rates, including higher rates of graft failure and infections. The lack of intrinsic osteogenic potential and reliance on host bone integration contribute to these limitations. Although bioactive modifications in alloplastic

grafts have improved their performance, their efficacy remains inferior to autogenous bone in load-bearing mandibular reconstruction.[16-18]

The results align with recent clinical trials indicating that autogenous grafts provide better long-term stability, although their use is limited by donor site morbidity. Future research should focus on optimizing synthetic grafts to enhance their biointegration, possibly through the incorporation of growth factors and mesenchymal stem cells.The findings of this randomized controlled trial provide strong evidence supporting the superiority of autogenous bone grafts in mandibular defect reconstruction. The significantly better integration rate and lower bone resorption percentage ($p < 0.001$) in the autogenous group highlight the inherent biological advantages of this approach. Autogenous grafts provide osteogenic, osteoinductive, and osteoconductive properties, leading to improved healing and stability. This is consistent with previous studies that have demonstrated enhanced new bone formation when autogenous bone is used for reconstructive procedures[16–18].

Despite these benefits, the use of autogenous grafts is associated with donor site morbidity, including pain, infection, and limited bone availability. The iliac crest, commonly used for harvesting, can result in significant postoperative discomfort. Recent advances in minimally invasive harvesting techniques have attempted to reduce these complications while preserving the biological efficacy of autogenous grafts[19].

Alloplastic materials, while offering unlimited availability and eliminating donor site morbidity, demonstrated significantly lower integration rates ($p < 0.001$) and higher rates of postoperative complications. The increased rate of infections and delayed healing ($p = 0.02$) in the alloplastic group could be attributed to the lack of intrinsic osteogenic potential, which may slow vascularization and graft acceptance. However, recent modifications in alloplastic materials, including bioactive coatings and composite structures, have improved osseointegration, which could enhance their future clinical use[20–22].

The results of this study align with previous research indicating that alloplastic materials can serve as an alternative in cases where autogenous bone is not available, but they require additional biological modifications to match the regenerative potential of natural bone grafts[23]. Advanced tissue engineering approaches incorporating stem cells and growth factors, such as bone

morphogenetic proteins (BMPs) and platelet-rich plasma (PRP), are promising strategies to enhance synthetic graft performance[24].

Additionally, patient-specific factors must be considered when selecting the optimal grafting approach. Factors such as defect size, patient comorbidities, and the need for immediate functional restoration should be assessed when determining whether an autogenous or alloplastic graft is the best choice. In clinical scenarios where rapid rehabilitation and shorter surgical time are prioritized, alloplastic grafts may provide a more practical solution despite their slightly lower success rates[25].

While this study provides valuable insights, its limitations include the relatively short follow-up period of 12 months. Future research should include long-term evaluations of graft performance, biomechanical stability, and patient-reported outcomes. Additionally, studies incorporating newer biomaterials and nanotechnology-based scaffolds could provide further improvements in mandibular reconstruction strategies.

The comparison between autogenous bone grafts and alloplastic materials for mandibular defect reconstruction has been extensively studied, yielding valuable insights into their respective advantages and limitations.

Autogenous Bone Grafts

Autogenous bone grafts, harvested from the patient's own body (commonly from the iliac crest, rib, or calvarium), are considered the gold standard in mandibular reconstruction due to their osteogenic, osteoinductive, and osteoconductive properties. These grafts promote effective integration and bone regeneration, leading to favorable functional and aesthetic outcomes. However, the use of autogenous grafts is associated with donor site morbidity, including pain, infection, and limited bone availability. For instance, harvesting from the iliac crest can result in significant postoperative discomfort. Despite these challenges, studies have demonstrated that autogenous bone grafts remain a reliable treatment modality for reconstructing mandibular defects, offering predictable functional and aesthetic results.

Alloplastic Materials

Alloplastic materials, such as titanium meshes, hydroxyapatite, and other synthetic substitutes, offer alternatives to autogenous grafts, eliminating the need for a donor site and reducing associated morbidities. These materials provide structural support and can be shaped to match the defect site. However, their lack of intrinsic osteogenic potential may lead to slower integration and higher rates of infection. A comprehensive review highlighted that while alloplastic materials serve as viable options, their outcomes are often less favorable compared to autogenous grafts, particularly concerning integration and long-term stability.

Hybrid Approaches

Hybrid reconstruction methods, combining autogenous bone with alloplastic materials, have emerged to capitalize on the strengths of both approaches. These techniques aim to enhance structural support while promoting biological integration. A study reviewing various hybrid techniques found that such approaches could achieve acceptable functional and aesthetic outcomes, though the evidence is primarily based on individual case reports, and larger cohort studies are needed to validate these findings.

Patient-Specific Factors

The choice between autogenous and alloplastic materials should consider patient-specific factors, including the size and location of the defect, overall health status, and potential for donor site morbidity. For instance, in cases where patients have contraindications for autogenous graft harvesting, alloplastic materials may be preferred despite their limitations. Conversely, for extensive defects requiring robust vascularization, autogenous grafts may offer superior outcomes.

Advancements and Future Directions

Advancements in tissue engineering and biomaterials are paving the way for improved mandibular reconstruction strategies. The development of biocompatible scaffolds combined with growth factors and stem cells holds promise for enhancing the efficacy of alloplastic materials. A comprehensive review on current biocompatible materials in oral regeneration suggests that such

innovations could lead to more predictable and successful outcomes in mandibular defect reconstruction.

Conclusion

Autogenous bone grafts continue to be the preferred choice for mandibular defect reconstruction due to their superior integration and regenerative capabilities. However, the associated donor site morbidity necessitates the exploration of alternative solutions. Alloplastic materials offer viable options, particularly for patients unsuitable for autogenous grafting, but they come with challenges related to integration and infection risk. Hybrid approaches and advancements in tissue engineering present promising avenues for future research and clinical application, aiming to optimize outcomes while minimizing patient morbidity.

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