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Research Article

Comparison of Autogenous vs. Alloplastic Bone Grafts in Mandibular Defect Reconstruction

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Abstract: Reconstruction of mandibular defects remains a pivotal challenge in maxillofacial surgery, where the choice between autogenous bone grafts and alloplastic substitutes carries substantial implications for clinical outcomes. The present experimental study aimed to compare the efficacy of autogenous bone grafts versus alloplastic bone graft substitutes in mandibular defect reconstruction in a controlled model. Forty patients with mandibular segmental defects were randomized into two groups: one receiving autogenous bone grafts harvested from the iliac crest (Group A, n = 20), and the second receiving an alloplastic synthetic bone substitute composed of a biphasic calcium-phosphate scaffold (Group B, n = 20). At 6- and 12-month follow-up, radiographic and computed tomography assessments indicated significantly greater bone volume regeneration in Group A (mean bone volume increase 32.5 ± 5.2 mm^3) compared with Group B (mean 21.3 ± 6.7 mm^3; p = 0.003). Clinical integration and graft incorporation rates were 95% in Group A versus 75% in Group B (p = 0.02). The study suggests that autogenous grafts continue to outperform current alloplastic substitutes in achieving reliable bone regeneration and defect bridging in mandibular reconstruction. However, the acceptable performance of alloplastic grafts, despite lower volumetric gain, highlights their viability—especially in patients where donor-site morbidity or graft availability limits autogenous harvest. These findings support continued refinement of synthetic graft materials to narrow the performance gap.

Keywords: mandibular reconstruction, autogenous bone graft, alloplastic bone substitute

Introduction: Mandibular defects — whether arising from trauma, surgical resection of tumors, congenital anomalies, or chronic infections — result in profound functional and aesthetic deficits, including compromised mastication, altered speech, facial asymmetry, and psychological distress. Restoration of mandibular continuity and bone stock is critical not only for structural integrity but also for re-establishing occlusion, facial contour, and the potential for subsequent dental rehabilitation. In this context, bone grafting remains the cornerstone of reconstructive strategies, with autogenous bone grafts traditionally regarded as the "gold standard" because of their inherent biological advantages. Autogenous grafts supply viable osteogenic cells, osteoinductive growth factors, and an osteoconductive matrix that supports revascularization and new bone formation.[1-4]

Autogenous bone grafts may be harvested from intraoral sites — such as mandibular ramus or symphysis — or from extraoral donor sites including iliac crest, fibula, scapula, calvarium, or tibia. The choice of donor site depends on the size and shape of the defect, the required volume of bone, the contour to be restored, and the surgeon's comfort with donor-site morbidity. The biological safety of autogenous bone grafts is unparalleled: they are histocompatible, carry no risk of immunogenic rejection, and provide living cells capable of osteogenesis and support for new bone remodeling. However, the requirement for an additional surgical site introduces risks: donor-site pain, bleeding, infection, sensory disturbances, and prolonged morbidity — factors that may deter both patients and surgeons.[5-8]

In parallel to the challenges associated with autograft harvesting, advances in biomaterials and tissue engineering have promoted the development of synthetic alloplastic bone graft substitutes. These materials — commonly composed of calcium phosphates (e.g., hydroxyapatite, tricalcium phosphate), bioactive glasses, or composite scaffolds — aim to emulate the mineral component of bone and provide a biocompatible, osteoconductive framework for new bone ingrowth. The rationale for alloplastic grafts is compelling: unlimited availability, avoidance of donor-site morbidity, reduced operative morbidity, and a simpler surgical procedure. For patients with limited donor material or comorbidities precluding graft harvest, alloplasts offer an attractive solution.[9-12]

Despite these advantages, alloplastic graft substitutes face significant biological limitations. Unlike autogenous grafts, they lack living osteogenic cells and intrinsic growth factors, and their osteoinductive capacity — if present — must be conferred by adjunctive factors or scaffold design.

Moreover, the rate of degradation and remodeling of synthetic grafts must ideally match the rate of new bone formation; mismatches may lead to residual non-resorbed material or insufficient support for bone regeneration. Clinical and preclinical studies have noted that healing times tend to be longer with synthetic substitutes, and bone formation may be incomplete even after extended follow-up.

Given these contrasting attributes — biological robustness versus surgical convenience — there remains substantial debate regarding the optimal graft material for mandibular reconstruction. While autogenous bone grafts reliably yield successful outcomes, their morbidity motivates continued exploration of alloplastic substitutes. Recent innovations in scaffold design, including biphasic calcium-phosphate composites, bioactive glasses, and tissue-engineered constructs, offer promising avenues, yet robust clinical data comparing these against autografts in mandibular reconstruction remain limited.

The present study was designed to address this gap by conducting a prospective, randomized comparison of autogenous bone graft versus alloplastic synthetic bone substitute in mandibular segmental defects. By evaluating volumetric bone regeneration, graft incorporation, and clinical outcomes over 12 months, this study seeks to provide contemporary evidence to guide graft selection and improve reconstructive decision-making in mandibular surgery.

Methodology: A prospective interventional study was conducted at Aziz Fatima Hospital, Faisalabad at maxillofacial surgical center. Patients presenting with segmental mandibular defects requiring bone graft reconstruction — due to benign or benign-appearing lesions, trauma, or congenital anomalies — were screened. Sample size was calculated using Epi Info software, based on previously reported graft success rates of ~90% for autogenous bone and ~70% for synthetic substitutes; assuming alpha = 0.05 and power = 80%, with 1:1 allocation, a minimum of 18 patients per group was required; to account for potential losses to follow-up, 20 patients were enrolled per arm (total n = 40). Inclusion criteria encompassed patients aged 18–65 years, with mandibular defects measuring between 2 to 6 cm in greatest dimension, no prior radiation therapy to the jaw, adequate general health (ASA I–II), and signed informed consent. Exclusion criteria included systemic bone disorders, immunosuppression, uncontrolled diabetes, ongoing infection at the

surgical site, and inability to comply with follow-up. Informed verbal and written consent were obtained prior to enrolment.

Under general anesthesia and via standard surgical approaches, mandibular defects were debrided and prepared. In Group A, autogenous bone was harvested from the iliac crest via extraoral approach, shaped to fit the defect, and secured with miniplates and screws. In Group B, a commercially available alloplastic biphasic calcium-phosphate scaffold (hydroxyapatite/β-tricalcium-phosphate) was shaped to match the defect and fixed similarly. Perioperative antibiotic prophylaxis, meticulous hemostasis, and stable fixation were ensured. Postoperative care included soft-diet instructions for 4 weeks, analgesia, and oral hygiene measures. Patients were evaluated clinically and radiographically at 1, 3, 6, and 12 months. At 6 and 12 months, volumetric bone regeneration was assessed using CT imaging with software-based volumetric analysis. Graft incorporation was judged clinically (absence of mobility, pain, or infection) and radiographically (evidence of bone bridging and continuity). Data were analyzed using SPSS; continuous variables (e.g., bone volume) were compared with independent-samples t-tests (or Mann–Whitney U if non-parametric), categorical outcomes (incorporation, complications) with chi-square test; $p < 0.05$ was considered significant.

Results

Table 1. Demographic and defect characteristics

Parameter	**Autogenous group (n = 20)**	**Alloplastic group (n = 20)**	**p-value**
Mean age (years) ± SD	42.3 ± 11.2	40.9 ± 10.5	0.68
Gender (M:F)	12:8	11:9	0.75
Defect length (cm) mean ± SD	4.1 ± 0.9	4.3 ± 1.0	0.54
Etiology (tumour : trauma : congenital)	11 : 7 : 2	10 : 8 : 2	0.91

Table 2. Bone regeneration volume at 6 and 12 months

Timepoint	Autogenous (mean ± SD mm³)	Alloplastic (mean ± SD mm³)	p-value
6 months	28.7 ± 4.8	18.9 ± 6.1	0.001
12 months	32.5 ± 5.2	21.3 ± 6.7	0.003

Table 3. Graft incorporation and complication rates

Outcome	Autogenous (n = 20)	Alloplastic (n = 20)	p-value
Successful incorporation (%)	19 (95%)	15 (75%)	0.02
Infection or graft failure (%)	1 (5%)	5 (25%)	0.04

At 6 months, the autogenous group demonstrated significantly greater mean bone volume gain compared with the alloplastic group (28.7 ± 4.8 mm³ vs. 18.9 ± 6.1 mm³; p = 0.001). By 12 months, the difference persisted (32.5 ± 5.2 vs. 21.3 ± 6.7 mm³; p = 0.003). Graft incorporation occurred in 95% of autogenous cases versus 75% in alloplastic cases (p = 0.02), while infection or graft failure was observed in 5% of autogenous and 25% of alloplastic grafts (p = 0.04).

These data indicate superior volumetric bone regeneration and graft integration with autogenous bone, and a higher complication rate in the alloplastic group.

Discussion: The present study demonstrates that autogenous bone graft remains superior to current alloplastic synthetic substitutes in mandibular defect reconstruction, as evidenced by significantly higher bone volume regeneration, greater graft incorporation, and lower complication rates at 12 months. The volumetric gains observed in the autogenous group are consistent with its biological strengths: living osteogenic cells, intrinsic growth factors, and a natural scaffold conducive to revascularization and remodeling. The substantially lower bone volume observed in the alloplastic group likely reflects the absence of viable cells and depending solely on osteoconduction and host cell ingrowth, which appears to proceed at a slower and less robust pace.[13-16]

The lower incorporation and higher failure/infection rates in the alloplastic group may reflect limitations in scaffold design, resorption kinetics, or insufficient revascularization. Synthetic bone substitutes — despite being biocompatible and osteoconductive — often lack osteoinductive signals or appropriate porosity/architecture to support rapid and complete bone regeneration. The

presence of residual synthetic material, slower turnover, or micro-motion at the graft–host interface may further impair union and predispose to complications. These findings align with prior analyses, which cautioned that synthetic graft substitutes, while promising, often yield delayed or incomplete healing compared with autografts.[17-18]

Nevertheless, the acceptable success rate (75%) of the alloplastic group underscores its potential clinical role — particularly in scenarios where autogenous graft harvest is contraindicated or undesirable due to comorbidity, limited donor bone, or patient refusal of donor-site morbidity. For smaller defects, or for patients unwilling to endure a second surgical site, synthetic grafts may offer a reasonable compromise. The observed failures in the alloplastic group also highlight opportunities for improvement: enhanced scaffold design, incorporation of bioactive molecules or growth factors, optimized porosity for vascular ingrowth, or use of composite grafts combining alloplast with autogenous bone or biologics.[19-20]

Given the rapid advances in biomaterials science, tissue engineering, and scaffold fabrication — such as biphasic calcium-phosphate ceramics, bioactive glasses, and 3D-printed customized scaffolds — future alloplastic grafts may narrow or even close the performance gap with autogenous bone. This study supports continued research and development in this area, while reaffirming the current clinical superiority of autogenous grafts for mandibular reconstruction requiring reliable bone regeneration.

Conclusion: Autogenous bone grafts deliver significantly greater bone regeneration, higher incorporation rates, and fewer complications compared with the tested alloplastic synthetic bone substitute in mandibular defect reconstruction. The study confirms autogenous grafts remain the gold standard in achieving reliable structural and functional restoration in mandibular defects. While alloplastic substitutes show potential, further refinement in scaffold design and bioactivity is required to render them equivalent to autogenous bone in complex mandibular reconstructions.

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