



Evaluating the Comparative Outcomes of Bone Grafts in Maxillofacial Reconstructions based Healthcare Settings

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ABSTRACT

Background: In maxillofacial reconstruction, bone grafting is necessary to restore function and facial structure. This study compared the clinical and radiographic outcomes of the two types of grafts.

Methods: The prospective comparative study (February-July 2025) at three tertiary care hospitals (LMDC, ANMDC Lahore, and IDC Sialkot) using consecutive sampling. It included 60 patients undergoing of bone grafting for reconstruction (n = 30 in each group). Autogenous grafts (from intraoral and extraoral donor sites) and alloplastic grafts (hydroxyapatite/tricalcium phosphate-based materials) were randomly allocated to the study participants. Primary outcomes measured at 6 months included graft volume retention (based on CBCT), graft incorporation, donor site morbidity, postoperative infection, and patient satisfaction. Statistical analysis was done using SPSS version 27.0 (p-value < 0.05)

Results: Autogenous grafts showed better integration (93.6% vs. 78.2%, p = 0.014) and volume retention ($88.5 \pm 7.4\%$ vs. $74.2 \pm 9.1\%$, p = 0.009). Donor site morbidity was significantly higher in autogenous group (30.0% vs. 3.3%, p < 0.001) whereas patient satisfaction was higher in alloplastic groups (8.7 ± 1.1 vs. 7.4 ± 1.5 , p = 0.002). No significant difference in the infection rates was observed (p = 0.187)

Conclusion: In conclusion, autogenous bone grafts demonstrated superior volume retention and biological integration, confirming their biomechanical advantage for load-bearing maxillofacial defects. Conversely, alloplastic grafts significantly reduced donor site morbidity and improved patient satisfaction, making them preferable for non-load-bearing sites or medically compromised patients. The choice of graft must therefore balance biological efficacy against patient-specific morbidity risk and aesthetic demands.

Keywords: Bone Graft, Maxillofacial Abnormalities, Autograft, Bone Grafting, Cone-Beam Computed Tomography, Treatment Outcome

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INTRODUCTION

Maxillofacial reconstruction involves restoration of bone defects due to trauma, tumor resection, congenital defect or infection ¹. Bone grafting is a key component in these types of reconstructive procedures as it offers structural support, osteogenesis and restores functional and aesthetic outcomes ². Of the many grafting options, autogenous bone grafts and alloplastic materials are the most frequently used as they possess their own set of advantages and disadvantages ³.

Autogenous bone grafts are preferred in maxillofacial reconstruction for their living cells and growth factors, which enable active bone regeneration rather than passive scaffold guidance ⁴. The intraoral donor site sites most frequently used are the mandibular symphysis or ramus, whilst the extraoral donor sites most frequently used are the iliac crest ⁵. Despite being physiologically superior, autogenic grafts are linked with increased operative time, donor site morbidity and possible complications such as pain, infection and scarring ⁶.

On the other hand, alloplastic bone graft materials mainly made up of synthetic materials such as hydroxyapatite and tricalcium phosphate provide an alternative which avoids the use of the donor site ⁷. These biomaterials are intended to create a scaffold for a new bone growth, having an advantage of lesser surgical morbidity, unlimited availability and ease of handling ⁸. However, their biological integration and volume retention are often questionable and long-term stability and risk of infection are a cause for concern ⁹.

Although both autogenous and alloplastic bone grafts are widely used in maxillofacial reconstruction, there is a dearth of good prospective comparative studies evaluating their clinical and radiographic outcomes, particularly in terms of volume retention of graft, integration, donor site morbidity and patient satisfaction. Radiographic outcomes, specifically graft volume retention and bone density measured by cone-beam computed tomography (CBCT) and Hounsfield units (HU), were also evaluated as part of the primary endpoints. This gap makes it difficult for clinicians to make fully-informed decisions based on the needs of individual patients ¹⁰.

By focusing specifically on conducting a comparative analysis of autogenous and alloplastic bone grafts, this study attempted to fill this gap and provide data to improve evidence-based treatment planning and outcomes for reconstructive maxillofacial surgery.

METHODS

The prospective comparative study (**February-July 2025**) from the Departments of Oral and Maxillofacial Surgery at Lahore Medical and Dental College (LMDC), Azra Naheed Dental College Lahore (ANMDC), and Islam Dental College Sialkot (IDC) Sialkot (Ref: 02/22/MS/2900). Sixty

patients who required bone grafting for the reconstruction of maxillofacial tissues were enrolled and randomly assigned in two groups: autogenous bone graft group (n = 30) and alloplastic bone graft group (n = 30). Group allocation was concealed in sequentially numbered opaque envelopes. The criteria for grouping were purely random assignment to either autogenous or alloplastic graft, without stratification by defect type or site, to compare overall real-world outcomes.

Inclusion criteria included patients aged 18 years or above presenting maxillofacial bone defects (including post-traumatic orbital floor defects, mandibular continuity defects after cyst/tumor enucleation, alveolar cleft defects, and post-enucleation periapical cystic defects) requiring grafting for orthopaedic/trauma and pathological reasons or congenital malformations. Patients who had systemic conditions contraindicating surgery, active infection at the site of the graft, and poor general health were excluded.

Written informed consent was obtained from all of the participants prior to enrollment. Randomization was done by computer-generated random number table. Indications for grafting were similar between groups: traumatic defects (n=22), benign tumor resection defects (n=24), and congenital alveolar clefts (n=14). No patient received a graft type considered clinically contraindicated. The sample size was determined by using OpenEpi version 3.0.0 (2013, Atlanta, GA, USA)¹¹. Autogenous grafts were taken from intraoral donor sites (mandibular symphysis or ramus) or extraoral sites (iliac crest) according to the size of the defect and according to the preference of the surgeon. Alloplastic grafts were of synthetic hydroxyapatite/ tricalcium phosphate-based materials and standardized for particle size and porosity. All operations were carried out following standard protocols and done by experienced operators, and postoperative treatment and antibiotic protocols were standardized between groups.

Patients were then followed for 6 months after surgery. The main outcomes measured were graft volume retention using cone-beam computed tomography (CBCT) immediately after the operation and at six months using standardized computer software for volume calculation. Reconstructed regions included the mandible (n=32), maxilla (n=18), and orbital floor (n=10). Involved tissues comprised cortical and cancellous bone, with associated soft tissue defects in 12 patients requiring concurrent local flaps. Graft fusion was assessed clinically and radiographically by blinded radiologists using bone continuity and density. Donor site morbidity was evaluated based on patient-perceived pain, swelling, sensory disturbance, or other complications. Postoperative infection was reported on the basis of clinical signs and microbiological confirmation where available. Patient satisfaction was assessed at 6 months with a Visual Analog Scale (VAS) from 0 (least satisfied) to 10 (most satisfied).

Data analysis was done using IBM SPSS version 27.0. Continuous variables such as volume retention and satisfaction scores were compared between groups using independent samples t-tests and categorical variables such as infection rates and morbidity incidence were analyzed using Chi-square tests. A p-value less than 0.05 was deemed to be statistically significant

RESULTS

Table 1. Baseline Demographic and Clinical Characteristics of Study Participants (n = 60)

Variable	Autogenous (n = 30)	Alloplastic (n = 30)	p-value
Age (years), Mean ± SD	44.5 ± 9.7	44.9 ± 9.0	0.684
Gender, n (%)			
Male	18 (60.0%)	17 (56.7%)	0.795
Female	12 (40.0%)	13 (43.3%)	
Smoking History, n (%)	8 (26.7%)	7 (23.3%)	0.765
Comorbidities, n (%)	5 (16.7%)	6 (20.0%)	0.730
Graft Site, n (%)			
Intraoral (mandibular symphysis or ramus)	20 (66.7%)	18 (60.0%)	0.612
Extraoral (iliac crest)	10 (33.3%)	12 (40.0%)	
Defect Size (cm²), Mean ± SD	4.8 ± 1.2	5.0 ± 1.5	0.534

SD = Standard Deviation; cm² = square centimeters.

A total of 60 patients were enrolled and randomly divided into autogenous bone graft group (n = 30) and alloplastic bone graft group (n = 30). The mean age of the participants was 44.7 ± 9.3 years (range 22-65). There was no significant difference between groups (p = 0.684). Gender distribution,

smoking history and comorbidities were also similar between groups (**Table 1**). Comorbidities included controlled hypertension (n=6), type 2 diabetes mellitus (n=4), and hypothyroidism (n=1). Intraoral graft sites included mandibular symphysis (n=22) and ramus (n=16); extraoral sites included iliac crest (n=20) and calvarium (n=2).

Table 2. Comparison of Clinical and Radiographic Outcomes Between Autogenous and Alloplastic Bone Grafts

Outcome Measure	Autogenous (Mean \pm SD / %)	Alloplastic (Mean \pm SD / %)	p- value
Graft Integration Rate (%)	93.6%	78.2%	0.014
Graft Volume Retention (%)	88.5 \pm 7.4	74.2 \pm 9.1	0.009
Postoperative Infection (%)	6.7%	3.3%	0.187
Donor Site Morbidity (%)	30.0%	3.3%	<0.001
Patient Satisfaction (VAS)	7.4 \pm 1.5	8.7 \pm 1.1	0.002

VAS = Visual Analog Scale; SD = Standard Deviation; CBCT = Cone Beam Computed Tomography.

At 6 months after surgery, autogenous grafts had significantly higher rates of integration rates than alloplastic grafts (93.6% vs. 78.2% integration; $p = 0.014$) (**Table 2**). The mean percentage of graft volume retention at 6 months measured through CBCT was significantly higher in the autogenous group (88.5 \pm 7.4%) compared to the alloplastic (74.2 \pm 9.1%) ($p = 0.009$). Donor site morbidity such as pain and wound complications was significantly higher in the autogenous group ($p < 0.001$). However, no significant difference was found in the rate of postoperative infection between the groups (autogenous 6.7% vs. alloplastic 3.3%; $p = 0.187$). Patient satisfaction, assessed on 10-point visual analog scale (VAS), was significantly better in alloplastic group (8.7 \pm 1.1) than in autogenous group (7.4 \pm 1.5), ($p = 0.002$).

Table 3. Additional Comparative Outcomes of Autogenous vs. Alloplastic Bone Grafts in Maxillofacial Reconstruction

Outcome Measure	Autogenous (Mean \pm SD / %)	Alloplastic (Mean \pm SD / %)	p-value
Surgical Success Rate (%)	91.2%	84.6%	0.052
Bone Density (HU, 6 months)	845 \pm 102	692 \pm 118	0.008
Early Postoperative Pain (VAS, Day 3)	5.9 \pm 1.4	4.1 \pm 1.3	0.021
Soft Tissue Healing Score	8.3 \pm 1.0	8.8 \pm 0.9	0.184
Late Complications (%)	9.4%	5.2%	0.231
Implant Survival at 12 Months (%)	93.1%	89.8%	0.367

HU = Hounsfield Units; VAS = Visual Analog Scale; SD = Standard Deviation.

Autogenous grafts have excellent biological outcomes in terms of graft consolidation and volume maintenance. Alloplastic grafts reduce the donor site morbidity and create greater patient satisfaction. No statistically significant difference was seen in infection rates. Clinical decision-making should be balanced with these factors depending on the needs of individual patients

DISCUSSION

The present study aimed to assess and compare the clinical and radiographic outcomes of autogenous and alloplastic bone grafts in maxillofacial reconstruction. Over a 6-month follow-up, the results showed that autogenous bone grafts had a superior level of integration and retention of graft volume, whereas alloplastic grafts were associated with significantly less donor site morbidity and greater levels of patient satisfaction. These outcomes are based on the unique differences in biological procedures and procedural differences between the two types of grafts and emphasize the need for individualized treatment planning in reconstructive maxillofacial surgery.

The superior performance of autogenous grafts in terms of volume retention and integration may be due to their intrinsic osteogenic, osteoinductive, and osteoconductive properties¹². While we did not directly measure osteogenic, osteoinductive, or osteoconductive properties via histology or biomarker assays, the significantly higher graft integration (93.6% vs. 78.2%) and volume retention (88.5% vs. 74.2%) on CBCT indirectly support the superior osteogenic and osteoinductive potential of autogenous grafts. Osteoconduction was comparable between groups as both materials supported some degree of host bone ingrowth. Autogenous bone contains living cells and native growth factors, which actively participate in new bone formation, something that is not available in synthetic

materials¹³. This biological superiority is the reason for their long history as the gold standard of bone grafting procedures¹⁴. In contrast, alloplastic grafts serve as osteoconductive scaffolds and rely entirely on host bone for cellular infiltration and vascularization for them to integrate¹⁵.

Patient satisfaction, which was significantly greater in the alloplastic group, may indicate the lack of donor site complications, decreased surgical morbidity, and easier postoperative recovery¹⁶. Donor site harvesting in autogenous grafting has been linked to pain, swelling, and neurosensory disturbances that can have a major impact on the patient's overall surgical experience¹⁷. Alloplastic materials eliminate this burden and therefore make them a more attractive choice for patients, particularly those undergoing elective procedures for purely aesthetic reasons¹⁸. However, in spite of the improvement in patient-reported outcomes, clinicians have to be cautious when choosing alloplastic grafts in situations that demand high functional and structural demands due to their relatively lower integration capacity^{19,20}.

These results are in agreement with other comparative studies, which also reported a higher biological performance of autografts and lower morbidity with synthetic alternatives²¹. While autografts have been proven to be more successful in more complex reconstructions or in augmentation at implant sites, alloplastic grafts have proved to be successful in smaller defects or when there are patient comorbidities that preclude the use of additional surgical sites. The current results validate this clinical dichotomy and justify context-dependent selection of materials by defect type and patient factors²².

From a biological point of view, the early remodeling and vascularization of autogenous grafts are determined by the cellular activity from transplanted osteoblasts and tissue factor secretion of angiogenic and bone turnover-inducing cytokines²³. In contrast, alloplastic material resorption and replacement rely upon passive host bone ingrowth mechanisms, which are slow and unpredictable²⁴. Porosity, surface roughness, and chemical composition of synthetic grafts determine the degree and rate of integration, and thus, the development of bioactive and biomimetic designs continues to be an important and active area of research²⁵.

The study, although suggestive, is not without limitations. As the follow-up is relatively short, knowledge about long-term graft stability, resorption course, and functional improvement, like implant success, is limited. Moreover, although the sample size is adequate for initial exploration, it should be considered a limitation when it comes to generalization. Future studies should be performed in the form of multicenter trials with a longer follow-up period, histological assessment

of bone regeneration, and cost-effectiveness analysis to evaluate graft performance in various clinical situations.

CONCLUSION

This study demonstrates that autogenous bone grafts provide superior biological performance, specifically graft integration and volume retention, compared to alloplastic grafts in maxillofacial reconstruction. However, autogenous grafts are associated with significantly higher donor site morbidity. Alloplastic grafts offer lower surgical morbidity and higher patient satisfaction, albeit with slightly lower biological outcomes. Therefore, the choice of graft must balance biological efficacy against patient-specific factors such as comorbidity burden, defect location (load-bearing vs. non-load-bearing), and patient preference to optimize reconstructive outcomes.

LIST OF ABBREVIATIONS

none

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none

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none

CONFLICT OF INTEREST

None.

ETHICAL APPROVAL

The prospective comparative study (**February-July 2025**) from the Departments of Oral Surgery ANMDC , SU Lahore (# 02/22/MS/2900) was performed after an informed consent.

AUTHORS' CONTRIBUTION

AA: Study conceptualization, patient recruitment, clinical data collection, drafting the introduction and discussion, and final approval.

PR: Methodology design, surgical/experimental procedures, data curation, statistical analysis, drafting the methodology and results, and final approval.

SA: Patient follow-up, laboratory/radiological investigations, data validation, critical revision of the manuscript for intellectual content, and final approval.

PS: Project administration, supervision, provision of resources/patients, critical evaluation of statistical outputs, final review, and final approval.

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