

Research Article**Comparative Evaluation of Autogenous and Alloplastic Bone Grafts on Marginal Bone Loss Around Dental Implants: A Retrospective Clinical Study.**

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Abstract: Preservation of marginal bone levels is a critical determinant of long-term dental implant success, particularly in sites requiring bone augmentation. This retrospective clinical study evaluated marginal bone loss around dental implants placed in sites augmented with autogenous bone grafts compared to alloplastic bone graft materials, with additional analysis of implant restoration-related factors. The objective was to assess whether graft type influences peri-implant bone stability following prosthetic loading and to examine the impact of restoration timing and prosthetic design on marginal bone changes. Clinical and radiographic records of patients receiving implants with prior bone grafting were analyzed over a minimum follow-up of three years after functional loading. Marginal bone levels were measured radiographically at prosthetic loading and at subsequent follow-up intervals. The results demonstrated statistically significant lower marginal bone loss in autogenous graft sites compared to alloplastic graft sites ($p < 0.01$). Early

restoration timing and screw-retained restorations were associated with increased bone stability across both groups. Multivariate analysis identified graft type, prosthetic loading interval, and crown-implant ratio as independent predictors of marginal bone loss. This study provides novel retrospective evidence that graft material selection, in conjunction with restoration-related factors, plays a significant role in maintaining peri-implant bone health, underscoring the importance of integrated surgical-prosthetic planning in implant dentistry.

Keywords: Dental implants, Marginal bone loss, Autogenous bone graft, Alloplastic graft, Implant restoration

Introduction: Dental implant therapy has become a predictable and widely accepted treatment modality for the replacement of missing teeth, offering high long-term survival rates and favorable functional and esthetic outcomes. Despite advances in

implant design and surface technology, preservation of marginal bone around implants remains a critical determinant of long-term success. Progressive marginal bone loss has been associated with peri-implant disease, esthetic compromise, and eventual implant failure, emphasizing the importance of understanding factors that influence peri-implant bone stability.¹⁻³

Alveolar bone deficiencies are frequently encountered in clinical practice as a result of periodontal disease, trauma, congenital anomalies, or post-extraction resorption. In such cases, bone augmentation procedures are often required to establish sufficient bone volume for optimal implant placement. A wide range of grafting materials has been employed for this purpose, broadly categorized into autogenous, allogeneic, xenogeneic, and alloplastic grafts. Among these, autogenous bone grafts have long been considered the reference standard due to their osteogenic, osteoinductive, and osteoconductive properties.⁴⁻⁷

Autogenous bone grafts, harvested from intraoral or extraoral donor sites, offer biological advantages that facilitate rapid revascularization and integration with host bone. However, their use is limited by donor site morbidity, increased surgical time, and limited availability. These limitations have driven interest in alternative grafting materials, particularly alloplastic bone substitutes, which are synthetic materials designed to provide an osteoconductive scaffold for bone regeneration without the need for a donor site.⁸⁻¹²

Alloplastic graft materials, such as calcium phosphates and bioactive ceramics, have gained popularity due to their availability, biocompatibility, and reduced surgical morbidity. While these materials demonstrate satisfactory volumetric stability, concerns

remain regarding their long-term remodeling behavior and their influence on peri-implant bone maintenance after implant loading. Differences in graft resorption patterns and bone maturation may influence marginal bone responses once implants are restored and subjected to functional forces.

Marginal bone loss around dental implants is a multifactorial phenomenon influenced by surgical, biological, mechanical, and prosthetic factors. While the impact of grafting materials on initial bone regeneration has been extensively studied, fewer investigations have focused on their long-term influence on marginal bone stability following prosthetic rehabilitation. This is clinically relevant, as bone behavior may change after implant loading and restoration.

Implant restoration-related factors, including timing of prosthetic loading, type of restoration, crown-implant ratio, and occlusal scheme, have been shown to affect peri-implant bone remodeling. Early or immediate loading protocols may alter stress distribution at the bone-implant interface, while prosthetic design influences plaque accumulation, load transmission, and maintenance accessibility. The interaction between graft material and prosthetic variables remains insufficiently explored in retrospective clinical studies.

Understanding whether the choice of graft material influences marginal bone loss after prosthetic loading, and how restoration-related parameters modify this effect, is essential for evidence-based treatment planning. Retrospective analyses of well-documented clinical cases offer valuable insights into real-world outcomes and long-term trends that may not be captured in short-term prospective trials.

Therefore, this retrospective clinical study aimed to compare marginal bone loss around dental implants placed in sites augmented with autogenous bone grafts versus alloplastic grafts and to evaluate the influence of implant restoration-related factors on peri-implant bone stability during functional loading.

Methodology: This retrospective clinical study was conducted at Department of Periodontology, Sharif Medical and Dental College using patient records from a university-affiliated dental clinic. Ethical approval was obtained prior to data collection, and all patient information was anonymized. The study included patients who received dental implants in grafted sites using either autogenous or alloplastic bone graft materials and who completed a minimum of three years of follow-up after prosthetic loading.

Sample size calculation was performed using Epi Info software, assuming a mean difference of 0.4 mm in marginal bone loss between groups, a standard deviation of 0.8 mm, a power of 80%, and a confidence level of 95%. The minimum required sample size was calculated as 60 implants per group; to compensate for incomplete records, a total of 150 implants were included.

Inclusion criteria comprised patients aged 20–70 years, implants placed in partially or

completely edentulous sites augmented with either autogenous or alloplastic bone grafts, delayed implant placement protocols, and availability of standardized periapical radiographs at prosthetic loading and follow-up visits. Exclusion criteria included uncontrolled systemic disease, history of radiotherapy to the jaws, untreated periodontitis, peri-implantitis during follow-up, smoking exceeding 10 cigarettes per day, and implants restored with removable prostheses.

Patients were categorized into two groups based on graft material used: autogenous bone graft group and alloplastic bone graft group. Implant characteristics, including implant diameter, length, surface type, and insertion torque, were recorded. Restoration-related variables included timing of prosthetic loading, type of prosthetic retention (screw-retained or cement-retained), crown-implant ratio, and restoration material.

Marginal bone levels were measured on standardized digital periapical radiographs using calibrated software. Measurements were taken from the implant shoulder to the first bone-implant contact on mesial and distal aspects, and mean marginal bone loss was calculated. Statistical analysis included independent t-tests, ANOVA, and multivariate regression analysis, with significance set at $p < 0.05$.

Results

Table 1: Demographic and Implant Characteristics

Variable	Autogenous (n=74 implants)	Alloplastic (n=76 implants)	p-value
Mean age (years)	49.2 ± 8.6	50.1 ± 9.1	0.54
Male (%)	58.1	55.3	0.72
Posterior implants (%)	64.9	67.1	0.78
Mean implant length (mm)	11.2 ± 1.4	11.0 ± 1.6	0.46

Baseline demographic and implant characteristics were comparable between groups.

Table 2: Marginal Bone Loss After Prosthetic Loading

Follow-up Interval	Autogenous (mm)	Alloplastic (mm)	p-value
At loading	0.42 ± 0.21	0.51 ± 0.24	0.04
1 year	0.78 ± 0.34	1.12 ± 0.41	<0.001
3 years	1.02 ± 0.46	1.58 ± 0.53	<0.001

Autogenous graft sites demonstrated significantly lower marginal bone loss over time.

Table 3: Influence of Restoration-Related Factors on Marginal Bone Loss

Variable	β	95% CI	p-value
Alloplastic graft	0.38	0.21–0.55	<0.001
Early loading (<8 weeks)	0.29	0.12–0.46	0.002
Cement-retained restoration	0.33	0.17–0.49	<0.001
Crown-implant ratio >1.5	0.27	0.10–0.44	0.004

Graft type and restoration-related factors independently influenced marginal bone loss.

Discussion: The findings of this retrospective clinical study demonstrate that implants placed in sites augmented with

autogenous bone grafts exhibit significantly lower marginal bone loss compared to those augmented with alloplastic graft materials during long-term functional loading. These results support the biological advantage of autogenous grafts in maintaining peri-implant bone stability after prosthetic rehabilitation.

The superior performance of autogenous grafts may be attributed to their inherent osteogenic and osteoinductive properties, which promote rapid vascularization and bone remodeling. In contrast, alloplastic materials primarily function as osteoconductive scaffolds, and their slower remodeling dynamics may contribute to greater marginal bone changes once implants are subjected to occlusal forces.¹³⁻¹⁵

Importantly, this study highlights the role of implant restoration-related factors in modifying marginal bone outcomes. Early prosthetic loading was associated with increased marginal bone loss, suggesting that grafted sites may require extended healing periods to achieve optimal biomechanical stability before functional loading. This effect was observed across both graft groups but was more pronounced in alloplastic graft sites.¹⁶⁻¹⁸

The type of prosthetic retention emerged as a significant predictor of marginal bone loss. Cement-retained restorations were associated with greater bone loss compared to screw-retained restorations, likely due to the risk of residual cement and its inflammatory effects on peri-implant tissues. This finding reinforces the importance of restoration design in maintaining peri-implant health, particularly in grafted sites.

An increased crown-implant ratio was also associated with higher marginal bone loss, underscoring the influence of biomechanical factors on peri-implant bone remodeling. Excessive leverage forces may exacerbate bone resorption, especially in regenerated

bone that may exhibit different mechanical properties compared to native bone.

The retrospective nature of this study reflects real-world clinical practice and allows evaluation of long-term outcomes following prosthetic loading. However, variability in graft healing time and prosthetic protocols represents an inherent limitation. Despite this, the consistent trends observed across multiple variables strengthen the validity of the findings.¹⁹⁻²⁰

Overall, the results emphasize that marginal bone preservation around implants is not solely dependent on graft material but is strongly influenced by restoration timing and prosthetic design. Integrated surgical and prosthetic planning is therefore essential for optimizing long-term implant outcomes.

Conclusion

Autogenous bone grafts demonstrate superior marginal bone preservation around dental implants compared to alloplastic grafts during long-term follow-up after prosthetic loading. Restoration-related factors, particularly loading timing, prosthetic retention type, and crown-implant ratio, significantly influence peri-implant bone stability. This study fills an important clinical gap by highlighting the combined impact of graft selection and prosthetic planning on implant success and supports a multidisciplinary approach to implant rehabilitation.

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