E-ISSN 2250-0944

ISSN 2250-1150
doi: 10.48047/ijprt/15.02.478

Research Article

Clinical Evaluation of Ridge Preservation Techniques Following Tooth Extraction in Pakistani Patients

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ABSTRACT

Alveolar ridge remodeling following tooth extraction often compromises future restorative options, highlighting the need for predictable ridge preservation protocols. This experimental clinical study evaluated two ridge preservation techniques in Pakistani patients to determine their comparative effectiveness in minimizing post-extraction dimensional loss. Forty patients requiring single-rooted tooth extraction were enrolled and randomly allocated to Group A, receiving a xenograft with collagen membrane, or Group B, receiving alloplastic biphasic calcium-phosphate granules without membrane. Standardized extraction and grafting procedures were followed. Ridge dimensions were assessed immediately post-extraction and at 16 weeks using calibrated digital calipers and cone-beam computed tomography. Results demonstrated significantly greater horizontal ridge preservation in Group A (mean reduction 1.12 ± 0.41 mm) compared with Group B (2.03 ± 0.57 mm; $p = 0.001$). Vertical height loss was similarly lower in Group A (0.84 ± 0.28 mm) than Group B (1.58 ± 0.46 mm; $p = 0.002$). Soft-tissue healing scores favored Group A, with fewer postoperative complications ($p = 0.03$). These findings indicate that xenograft with membrane provides superior preservation of ridge dimensions, supporting its value in optimizing future implant-prosthetic outcomes. The study highlights clinically relevant differences between commonly used materials within the Pakistani population and demonstrates the importance of membrane-supported grafting for predictable ridge maintenance.

Keywords: ridge preservation, extraction socket, bone graft

INTRODUCTION: Alveolar ridge resorption following tooth extraction represents one of the most frequently encountered challenges in contemporary dental practice. The biological response to extraction involves rapid remodeling processes that significantly alter the three-dimensional architecture of the alveolar bone. These dimensional changes can jeopardize implant placement, compromise esthetics, and limit prosthetic options, particularly in regions of high cosmetic demand. Despite advances in implant dentistry, the prevention or reduction of post-extraction ridge loss continues to be an essential component of treatment planning. Ridge preservation techniques, incorporating bone grafting materials with or without barrier membranes, have been developed to mitigate these dimensional alterations and enhance the predictability of subsequent rehabilitation procedures.[1-3]

The alveolar bone is unique in its structure, as it exists primarily to support teeth, and its maintenance is dependent on functional loading transmitted through the periodontal ligament. Once the tooth is removed, the bundle bone lining the socket undergoes rapid osteoclastic activity, initiating a cascade of resorptive changes. The majority of ridge reduction occurs during the first three months and may amount to more than half of the original width in some individuals. Notably, horizontal changes tend to exceed vertical ones, but even minor dimensional losses may create localized defects that require additional augmentation procedures at the time of implant placement. For this reason, ridge preservation has become an integral part of clinical practice for clinicians aiming to enhance long-term restorative outcomes.[4-7]

Bone grafting materials used in ridge preservation vary widely in composition, biological behavior, and clinical effectiveness. Xenografts, derived from bovine or porcine sources, have been extensively studied and exhibit slow resorption, stable volume maintenance, and favorable osteoconductive properties. Their use, commonly in combination with collagen membranes, has shown promising outcomes in diverse populations. Conversely, alloplastic materials such as biphasic calcium-phosphate have gained popularity as they offer controlled resorption rates, biocompatibility, and unlimited availability, while eliminating any risk of disease transmission. However, their performance remains heterogeneous and may depend on particle size, composition ratio, architectural properties, and host factors.[8-10]

The clinical significance of ridge preservation extends beyond dimensional stability; it encompasses soft-tissue healing, patient comfort, and the reduction of subsequent surgical interventions. Membrane-supported grafting has been suggested to enhance graft stability and promote guided bone regeneration by preventing soft-tissue collapse into the defect. However, the cost, handling characteristics, and potential complications associated with membranes—such as exposure—must also be considered. These variables make the selection of ridge preservation protocols highly relevant to clinical success.[11-12]

In Pakistan, the prevalence of compromised dentition, delayed dental consultations, and high rates of extractions underscores the importance of predictable post-extraction management strategies. Furthermore, limited access to advanced reconstructive procedures makes effective ridge preservation particularly valuable. Despite widespread use of xenografts and alloplastic substitutes in the region, limited locally generated evidence exists to compare their effectiveness in this population. Variations in bone density, systemic health patterns, dietary factors, and genetic influences may affect graft response, creating a need for population-specific research.

The present study therefore aimed to provide clinical evidence from Pakistani patients regarding the comparative effectiveness of two widely used ridge preservation techniques. By focusing on single-rooted extraction sockets, standardizing surgical procedures, and employing calibrated three-dimensional measurements, the study sought to generate robust data on ridge dimension changes and postoperative healing. The inclusion of cone-beam computed tomography allowed precise evaluation of bone height and width, enhancing the reliability of outcomes. Moreover, the study aimed to examine soft-tissue healing characteristics and complication rates, which remain essential indicators of clinical success.

Given the ongoing demand for implants and the critical importance of sufficient bone volume for successful placement, generating evidence on ridge preservation techniques used in Pakistan contributes meaningfully to clinical practice. A comparison of xenograft with membrane versus alloplastic graft without membrane provides insights into whether the additional cost and procedures associated with membrane placement translate into measurable improvements in clinical outcomes. Ultimately, the findings aim to guide practitioners toward evidence-based

decision making, improve patient outcomes, and reduce the need for secondary augmentation procedures.

METHODOLOGY: This prospective experimental study was conducted at a maxillofacial surgery department over 12 months at MTH, Faisalabad. Patients requiring extraction of a single-rooted tooth were screened, and sample size was calculated using Epi Info based on mean horizontal ridge loss reported in earlier trials (difference of 1 mm between groups, SD 0.9 mm, power 80%, alpha 0.05). The calculated minimum sample size was 18 per group; to compensate for attrition, 20 patients were included in each group (total n = 40). Patients aged 18–55 years with non-infected, non-mobile teeth requiring extraction were included. Exclusion criteria consisted of systemic diseases affecting bone metabolism, smokers consuming >10 cigarettes/day, active periodontal infection, pregnancy, bisphosphonate therapy, and inability to comply with follow-up. Verbal and written informed consent was obtained from all participants.

Patients were randomized into Group A (xenograft + collagen membrane) and Group B (alloplastic biphasic calcium-phosphate without membrane). Atraumatic extraction was performed using periotomes and elevators. In Group A, the socket was filled with xenograft particles and covered with a resorbable collagen membrane trimmed to fit the defect. In Group B, the socket was filled with alloplastic granules only. Primary closure was achieved where possible using 4-0 sutures. Postoperative care included antibiotics for 5 days, analgesics as needed, and chlorhexidine rinses. Follow-ups occurred at 1, 2, 4, 8, and 16 weeks.

Baseline ridge width and height were recorded immediately after extraction using digital calipers and CBCT. Final measurements were taken at 16 weeks. Soft-tissue healing was assessed using a validated healing index. Data were analyzed using SPSS; independent-samples t-tests compared continuous variables, while chi-square test assessed categorical outcomes. Significance was set at $p < 0.05$.

RESULTS

TABLE 1: Demographic Distribution of Patients

Variable	Group A (n=20)	Group B (n=20)	p-value
Mean age (years ± SD)	34.2 ± 9.1	33.6 ± 8.8	0.81
Gender (M/F)	11/9	12/8	0.75
Tooth type (incisor/canine/premolar)	8/4/8	7/5/8	0.88

Explanation: Both groups demonstrated comparable baseline demographics, ensuring homogeneity for valid comparison of clinical outcomes.

TABLE 2: Horizontal and Vertical Ridge Reduction at 16 Weeks

Measurement	Group A Mean ± SD (mm)	Group B Mean ± SD (mm)	p-value
Horizontal width reduction	1.12 ± 0.41	2.03 ± 0.57	0.001
Vertical height reduction	0.84 ± 0.28	1.58 ± 0.46	0.002

Explanation: Group A exhibited significantly less ridge reduction horizontally and vertically, indicating superior dimensional preservation.

TABLE 3: Soft-Tissue Healing and Complications

Outcome	Group A (n=20)	Group B (n=20)	p-value
Mean healing score (1–5)	4.62 ± 0.33	4.12 ± 0.41	0.03
Postoperative complications (%)	1 (5%)	5 (25%)	0.04

Explanation: Group A demonstrated better soft-tissue healing and fewer complications, illustrating improved biological performance.

DISCUSSION: The findings of this study highlight a clear clinical advantage of xenograft combined with a collagen membrane over alloplastic grafting alone for ridge preservation in Pakistani patients. The significantly lower horizontal and vertical bone loss in Group A underscores the biological superiority of membrane-supported xenografts in maintaining socket

architecture. The membrane likely contributed by stabilizing the graft, preventing soft-tissue collapse, and facilitating guided bone regeneration, contributing to more favorable outcomes.[13-14]

The greater dimensional stability observed with xenograft may also be attributed to its slower resorption and persistent scaffold integrity, providing structural support during the critical early healing phase. The alloplastic material, while osteoconductive, may have undergone partial resorption before sufficient host bone infiltration occurred, resulting in greater dimensional loss. These outcomes align with current biomaterial principles emphasizing the importance of synchronized resorption and bone formation to preserve ridge morphology.[15-17]

Soft-tissue healing scores further supported the superiority of Group A. The collagen membrane probably promoted a more stable clot environment, reduced early micromovement, and enhanced vascularity of the overlying tissues. In contrast, the absence of a membrane in Group B may have predisposed the graft to particle mobility and reduced soft-tissue support, reflected in the higher complication rate. These findings are consistent with broader clinical trends indicating that membrane use contributes positively to healing quality.[18-20]

The reduced complication rate in Group A reinforces the protective value of the membrane. Membrane exposure, often considered a risk, was not observed in this study due to atraumatic flap manipulation and appropriate case selection, demonstrating that predictable outcomes can be achieved with proper surgical technique. The higher complication rate in Group B may reflect the instability of unprotected particulate grafts in the early phase of healing.

The data from this Pakistani cohort contribute valuable population-specific evidence. Bone density, systemic patterns of oral health, and healing characteristics in this population may influence graft behavior, making localized research essential. The results indicate that xenograft with membrane is a more reliable choice for practitioners working within similar demographic and biological contexts.

Although alloplastic materials remain attractive due to availability and cost considerations, the demonstrated dimensional losses may necessitate secondary augmentation at implant placement, potentially negating initial economic advantages. Thus, long-term cost-effectiveness may favor xenograft-membrane protocols despite higher upfront material costs.

Overall, the study reinforces the role of membrane-supported xenografts as a predictable ridge preservation strategy capable of optimizing future implant placement and reducing the need for additional surgical interventions. The findings also emphasize the importance of individualized material selection based on clinical objectives, patient characteristics, and desired restorative outcomes.

CONCLUSION: Xenograft combined with a collagen membrane provides superior ridge preservation compared with alloplastic grafting alone in Pakistani patients. The technique demonstrates reduced dimensional loss, improved soft-tissue healing, and fewer complications. This study fills a regional evidence gap and supports membrane-supported xenografts as the preferred method for predictable post-extraction ridge maintenance.

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