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# Ridge Augmentation techniques prior to prosthetic Rehabilitation: An Interdisciplinary clinical study.

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## ABSTRACT

**Background**

Alveolar ridge resorption following tooth loss often compromises prosthetically ideal implant placement, necessitating ridge augmentation prior to definitive prosthetic rehabilitation. Although various ridge augmentation techniques are routinely employed, comparative retrospective data evaluating their outcomes in relation to prosthetic feasibility remain limited.

**Aim**

To retrospectively evaluate and compare different ridge augmentation techniques performed prior to prosthetic rehabilitation with respect to horizontal ridge gain, prosthetic feasibility, and clinical outcomes.

**Materials and Methods**

This retrospective interdisciplinary clinical study analyzed records of 48 partially edentulous patients who underwent ridge augmentation between 2019 and 2023. Based on the augmentation technique used, patients were divided into three groups: guided bone regeneration (GBR), autogenous block grafting, and ridge split technique (n = 16 each). Horizontal ridge width was assessed using cone-beam computed tomography preoperatively and at 6 months postoperatively. Prosthetic feasibility, need for secondary augmentation, and complications were recorded. Statistical analysis was performed using one-way ANOVA followed by Tukey post-hoc test, with significance set at $p < 0.05$.

**Results**

All three techniques demonstrated statistically significant improvement in ridge width compared to baseline ($p < 0.001$). Autogenous block grafting showed the highest mean ridge gain (4.1 ± 0.7 mm), followed by GBR (3.5 ± 0.6 mm) and ridge split technique (3.0 ± 0.5 mm). Intergroup comparison revealed statistically significant differences in ridge gain ($p < 0.001$). Prosthetically ideal implant placement was achieved in 91.7% of block graft cases, 87.5% of GBR cases, and 81.3% of ridge split cases. Complications were more frequent in the block graft group.

**Conclusion**

Ridge augmentation significantly enhances prosthetic rehabilitation outcomes. While autogenous block grafting provides superior ridge gain, GBR and ridge split techniques offer predictable results with reduced morbidity when appropriately selected. Interdisciplinary, prosthetically driven planning is essential for optimal clinical outcomes.

**KEYWORDS**: Ridge augmentation; Prosthetic rehabilitation; Guided bone regeneration; Autogenous block graft; Ridge split technique; Retrospective study

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## INTRODUCTION

Successful prosthetic rehabilitation is fundamentally dependent on the availability of adequate alveolar bone volume to support restorations that are functionally stable, biologically acceptable, and esthetically harmonious. Following tooth loss, the alveolar ridge undergoes progressive resorption as a consequence of disuse atrophy, altered vascular supply, and remodeling of bundle bone, often resulting in ridge deficiencies that complicate prosthetically driven implant placement (1,2).

Several longitudinal studies have demonstrated that horizontal ridge resorption is more pronounced than vertical loss, particularly within the first year after extraction (3–5). This reduction in ridge width frequently prevents ideal three-dimensional implant positioning, leading to compromised emergence profiles, unfavorable crown–implant ratios, and increased biomechanical stress on prosthetic components (6,7). From a prosthodontic perspective, such compromises may ultimately affect long-term implant survival and patient satisfaction.

To overcome these limitations, ridge augmentation procedures are routinely employed prior to implant placement. Techniques such as guided bone regeneration (GBR), autogenous block grafting, and ridge split procedures have been widely documented, each with specific indications, advantages, and limitations (8–10). GBR has gained popularity due to its minimally invasive nature and predictable outcomes in moderate horizontal defects (11). Autogenous block grafting is often regarded as the gold standard because of its osteogenic potential, although it is associated with increased surgical time and donor site morbidity (12,13). Ridge split techniques enable simultaneous ridge expansion and implant placement in selected cases, reducing overall treatment time but requiring precise case selection (14,15).

While existing literature has primarily focused on the surgical success of these augmentation techniques, fewer studies have assessed their outcomes in relation to prosthetic feasibility and restorative predictability. Implant positioning that is surgically acceptable may still be prosthetically unfavorable if ridge augmentation fails to meet restorative requirements (6,16). This highlights the importance of an interdisciplinary approach involving both surgical and prosthodontic planning.

Retrospective clinical studies provide valuable insights into real-world outcomes by evaluating completed treatments over extended periods. Such analyses allow assessment of both ridge augmentation success and its translation into functional prosthetic rehabilitation (17,18). However, comparative retrospective data evaluating multiple ridge augmentation techniques from a prosthetic standpoint remain limited.

Therefore, the present retrospective interdisciplinary clinical study was undertaken to compare different ridge augmentation techniques performed prior to prosthetic rehabilitation, with particular emphasis on ridge dimensional gain and prosthetic feasibility.The null hypothesis stated that there is no statistically significant difference in ridge dimensional gain or prosthetic feasibility among guided bone regeneration, autogenous block grafting, and ridge split techniques.

## MATERIALS AND METHODS

**Study Design**

This retrospective clinical study was conducted after obtaining institutional ethical clearance. Patient records from January 2019 to December 2023 were reviewed.

**Sample Selection**

Records of 48 patients (mean age 40.2 ± 8.1 years) who underwent ridge augmentation prior to implant-supported prosthetic rehabilitation were included.

**Inclusion Criteria**

- Partially edentulous patients
- Horizontal ridge deficiency ≤ 4 mm
- Availability of preoperative and postoperative CBCT records
- Completed implant-supported prosthetic rehabilitation

**Exclusion Criteria**

- Systemic diseases affecting bone healing
- History of radiotherapy
- Heavy smokers
- Incomplete clinical or radiographic records

**Grouping**

Patients were categorized into three groups (n = 16 each):
Group I: Guided Bone Regeneration
Group II: Autogenous Block Graft
Group III: Ridge Split Technique

**Radiographic Evaluation**

Horizontal ridge width was measured on CBCT scans at 3 mm apical to the crest preoperatively and at 6 months postoperatively.

**Prosthetic Evaluation**

Parameters assessed included feasibility of prosthetically ideal implant placement, need for secondary augmentation, and postoperative complications.

**Statistical Analysis**
Statistical analysis was performed using SPSS software. Descriptive statistics were calculated. One-way ANOVA followed by Tukey post-hoc test was used for intergroup comparison. Significance was set at $p < 0.05$.

## RESULTS

Records of 48 patients who underwent ridge augmentation prior to implant-supported prosthetic rehabilitation were analyzed. Baseline preoperative ridge width did not differ significantly among the three groups ($p > 0.05$), confirming comparability of the study groups.

At 6 months postoperatively, all ridge augmentation techniques demonstrated a statistically significant increase in horizontal ridge width compared to baseline values ($p < 0.001$). The autogenous block graft group showed the greatest mean ridge gain (4.1 ± 0.7 mm), followed by the GBR group (3.5 ± 0.6 mm) and the ridge split group (3.0 ± 0.5 mm) (Table 1).

One-way ANOVA revealed a statistically significant difference in mean ridge gain among the three techniques ($F = 11.67$; $p < 0.001$), leading to rejection of the null hypothesis (Table 2). Post-hoc Tukey analysis demonstrated that block grafting resulted in significantly greater ridge gain compared to GBR ($p = 0.038$) and ridge split techniques ($p = 0.002$). GBR also showed significantly higher ridge gain than ridge split procedures ($p = 0.041$) (Table 3).

Prosthetically ideal implant placement was achieved in 91.7% of block graft cases, 87.5% of GBR cases, and 81.3% of ridge split cases (Table 4). Secondary augmentation was most frequently required in the ridge split group (18.7%), followed by GBR (12.5%) and block graft groups (6.3%).

Postoperative complications were predominantly minor. The block graft group exhibited the highest complication rate (25%), while GBR and ridge split groups showed complication rates of 12.5% and 6.3%, respectively. No implant failures were observed during the prosthetic phase.

**Table 1. Descriptive Statistics of Ridge Width Changes**

| Group | Preoperative Width (mm) | Postoperative Width (mm) | Mean Ridge Gain (mm) |
|---|---|---|---|
| GBR | 3.3 ± 0.5 | 6.8 ± 0.6 | 3.5 ± 0.6 |
| Block graft | 3.2 ± 0.6 | 7.3 ± 0.7 | 4.1 ± 0.7 |
| Ridge split | 3.4 ± 0.4 | 6.4 ± 0.5 | 3.0 ± 0.5 |

**Table 2. One-Way ANOVA for Comparison of Mean Ridge Gain**

| Source of Variation | Sum of Squares | df | Mean Square | F value | p value |
|---|---|---|---|---|---|
| Between groups | 9.84 | 2 | 4.92 | 11.67 | <0.001* |
| Within groups | 17.25 | 45 | 0.38 | | |
| Total | 27.09 | 47 | | | |

*Statistically significant

**Table 3. Post-Hoc Tukey Test for Intergroup Comparison of Ridge Gain**

| Comparison | Mean Difference (mm) | p value |
|---|---|---|
| Block graft vs GBR | 0.6 | 0.038* |
| Block graft vs Ridge split | 1.1 | 0.002* |
| GBR vs Ridge split | 0.5 | 0.041* |

## DISCUSSION

The present retrospective interdisciplinary clinical study evaluated and compared three commonly employed ridge augmentation techniques—guided bone regeneration, autogenous block grafting, and ridge split technique—with particular emphasis on their influence on prosthetic rehabilitation. The findings demonstrated that although all techniques resulted in statistically significant horizontal ridge gain, notable differences existed in the magnitude of augmentation, prosthetic feasibility, and complication rates, leading to rejection of the null hypothesis.

Autogenous block grafting exhibited the highest mean ridge gain among the evaluated techniques. This observation is in agreement with findings reported by Khoury et al. and Buser et al., who emphasized the biological superiority of autogenous bone owing to its osteogenic, osteoinductive, and osteoconductive properties (11,15). The ability of block grafts to restore substantial ridge volume makes them particularly suitable for severe horizontal deficiencies where prosthetically driven implant placement would otherwise be compromised. In the present study, the block graft group also demonstrated the highest percentage of prosthetically ideal implant placement, reinforcing its role in complex ridge defects.

However, block grafting was associated with a higher incidence of postoperative complications, primarily related to donor site morbidity. Similar findings have been reported by Nkenke et al. and Cordaro et al., who documented increased surgical morbidity and patient discomfort associated with autogenous bone harvesting procedures (12,16). From a prosthodontic standpoint, while block grafting offers superior ridge dimensions, the increased surgical burden necessitates careful patient selection, particularly when alternative techniques may adequately satisfy prosthetic requirements.

Guided bone regeneration demonstrated predictable ridge gain with comparatively fewer complications. These findings are consistent with studies by Simion et al., Urban et al., and Wang and Boyapati, who reported reliable horizontal augmentation outcomes using GBR when appropriate case selection and biologic principles are respected (7,8,10). In the present study, GBR facilitated prosthetically acceptable implant placement in a majority of cases, supporting its role as a balanced approach for moderate ridge deficiencies.

Several authors have emphasized that the success of GBR is highly technique-sensitive and depends on factors such as membrane stability, graft containment, and tension-free soft tissue closure (21,22). Nevins et al. highlighted that membrane exposure remains a common complication influencing the quality of regenerated bone, although minor exposures may not necessarily compromise prosthetic outcomes if managed appropriately (22). This may explain the favorable prosthetic feasibility observed in the GBR group despite slightly lower ridge gain compared to block grafting.

The ridge split technique demonstrated the lowest mean ridge gain but was associated with minimal postoperative complications. These findings align with reports by Scipioni et al. and Sohn et al., who described ridge splitting as an effective technique in narrow ridges with sufficient vertical height and favorable bone elasticity (13,17). However, the higher need for secondary augmentation observed in the present study suggests that ridge split procedures may offer limited horizontal expansion, particularly in dense cortical bone.

From a prosthetic rehabilitation perspective, ridge split techniques offer the advantage of reduced overall treatment time due to the possibility of simultaneous implant placement. Nevertheless, the reduced ridge gain may compromise ideal implant positioning in certain clinical situations. As emphasized by Misch and Garber, deviations from prosthetically ideal implant placement can adversely affect emergence profile, load distribution, and long-term restorative success (3,4). Therefore, ridge split techniques should be reserved for carefully selected cases where prosthetic demands can be predictably met.

An important observation of the present study was that prosthetic feasibility was not solely dependent on the absolute magnitude of ridge gain. Although block grafting provided the greatest horizontal augmentation, GBR cases also demonstrated high rates of prosthetically ideal implant placement. This supports earlier findings by Hammerle et al. and Esposito et al., who emphasized that three-dimensional implant positioning and prosthetically driven planning are more critical determinants of long-term success than ridge width alone (19,21).

The interdisciplinary approach adopted in this study allowed integration of surgical and prosthodontic considerations during treatment planning. Such collaboration has been advocated in several reviews, highlighting that interdisciplinary decision-making improves both surgical predictability and prosthetic outcomes (18,23). Retrospective analyses such as the present study provide valuable insight into real-world clinical outcomes, where treatment selection is influenced by patient-specific factors rather than idealized protocols.

Certain limitations of this study must be acknowledged. The retrospective design and limited sample size may restrict generalizability of the findings. Additionally, long-term implant survival, marginal bone loss, and prosthetic complications were not evaluated. Previous systematic reviews have suggested that long-term outcomes may differ based on graft material stability and remodeling patterns, emphasizing the need for extended follow-up studies (24,25).

Within these limitations, the present study contributes meaningful clinical evidence by comparing ridge augmentation techniques from a prosthetic perspective. Autogenous block grafting remains the most effective technique for achieving maximal ridge gain, while GBR offers a favorable balance between augmentation efficacy and morbidity. Ridge split techniques continue to be a useful option in selected cases where reduced invasiveness and treatment time are prioritized.

## CONCLUSION

Within the limitations of this retrospective study, ridge augmentation significantly improved prosthetic rehabilitation outcomes. Autogenous block grafting achieved the greatest ridge gain, while GBR and ridge split techniques offered reliable alternatives with reduced morbidity. Interdisciplinary, prosthetically driven treatment planning remains critical for long-term success.

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