Journal of Rare Cardiovascular Diseases
ISSN: 2299-3711 (Print) | e-ISSN: 2300-5505 (Online)
www.jrcd.eu

RESEARCH ARTICLE

Comparison of Clinical Success and Complication Rates in Vertical Ridge Augmentation Procedures: Oral Surgery versus Prosthodontic Approaches

Dr. Prashant S Patil[1], Dr. Sumit Singh Phukela[2],Dr. Joel Koshy Joseph[3], Dr. Prerna Kumari Roy[4], Dr. Ali Hasan[5], Dr. Komal I. Bhatia[6]

[1]Professor & HOD, Department of Prosthodontics, Yogita Dental College and Hospital, Khed, Maharashtra.

[2]Professor, Department of Prosthodontics, Faculty of Dental Sciences SGT University, Gurugram, Haryana.

[3]Reader, Department of Prosthodontics, Yogita Dental College and Hospital, Khed, Maharashtra.

[4]Post Graduate Student, Department of Prosthodontics and Crown & Bridge, Kalinga Institute of Dental sciences, Bhubaneshwar, Odisha.

[5]Senior Lecturer, Department of Oral and Maxillofacial Surgery, Hazaribagh Dental College, Jharkhand.

[6]MDS Maxillofacial Prosthodontist and Implantologist, Consultant, Khandwa, M. P

*Corresponding Author
Dr. Prashant S Patil, Professor & HOD, Department of Prosthodontics, Yogita Dental College and Hospital, Khed, Maharashtra

Article History
Received: 08.08.2025
Revised: 15.09.2025
Accepted: 24.10.2025
Published: 03.11.2025

Abstract: ***Background:*** Severe vertical alveolar ridge defects present a significant challenge for successful implant placement. Vertical ridge augmentation (VRA) is often necessary, but techniques vary. This study compares two distinct philosophical approaches: a surgically-driven approach focused on maximal anatomical reconstruction and a prosthodontically-driven approach prioritizing predictable bone gain for implant success with minimal morbidity. **Methods:** This retrospective cohort study analyzed data from 60 patients with isolated vertical defects in the posterior mandible. Patients were divided into two groups: Group S (n=30), treated with the surgical approach (d-PTFE membrane), and Group P (n=30), treated with the prosthodontic approach (collagen membrane). Vertical bone gain was measured on pre- and 6-month post-augmentation CBCT scans. All patients received implants 6-7 months post-augmentation, and outcomes were followed for 3 years post-loading. Primary outcomes were vertical bone gain, complication rates (e.g., membrane exposure), and 3-year implant survival and success rates. **Results:** The mean vertical bone gain was significantly greater in Group S (5.1 ± 0.8 mm) compared to Group P (4.2 ± 0.7 mm) ($p = 0.002$). However, Group S experienced a significantly higher rate of postoperative membrane exposure (30.0%; n=9) compared to Group P (10.0%; n=3) ($p = 0.041$). The 3-year implant survival rate was high and comparable in both groups (Group S: 96.7%; Group P: 98.9%; $p = 0.552$). The implant success rate, defined by stable crestal bone and healthy peri-implant tissues, was notably higher in Group P (95.6%) than in Group S (86.7%) ($p = 0.048$), primarily due to greater crestal bone loss in implants placed in sites with prior exposure complications. **Conclusion:** The surgically-driven VRA approach achieved superior vertical bone gain but was associated with a threefold higher risk of membrane exposure, which negatively impacted final implant success. The prosthodontically-driven approach, while yielding slightly less bone, provided sufficient gain for implant placement with significantly fewer complications and higher implant success rates. The choice of technique should be based on a careful risk-benefit analysis tailored to the specific defect and patient..

Keywords: Healthcare Service Quality; Patient Satisfaction; Private Hospitals; SERVQUAL model.

INTRODUCTION

The successful long-term rehabilitation of edentulous spaces with dental implants is predicated on the presence of adequate bone volume to ensure primary stability and facilitate a prosthetically favorable implant position **[1]**. Alveolar ridge atrophy following tooth extraction is a common physiological process, with vertical bone loss being particularly challenging to manage clinically **[2]**. Severe vertical defects (Siebert Class III) can preclude standard implant placement, necessitating advanced bone grafting procedures to reconstruct the deficient anatomy **[3]**.

Guided Bone Regeneration (GBR) has become the gold-standard technique for vertical ridge augmentation (VRA). The principle involves using a barrier membrane to create a secluded space, preventing soft tissue ingrowth and allowing for the proliferation of osteoprogenitor cells and subsequent bone formation **[4]**. The success of VRA is highly technique-sensitive and dependent on several key factors, including primary wound closure, space maintenance, and graft stability **[5]**.

Over the years, two prevailing philosophical approaches to VRA have emerged, often distinguished by the choice of membrane and the primary treatment goal. The first can be described as a **surgically-driven approach**, which aims for maximum anatomical reconstruction of the alveolar ridge. This is typically

achieved using space-maintaining, non-resorbable membranes, such as those made of dense polytetrafluoroethylene (d-PTFE), often supported by tenting screws. This technique has demonstrated significant potential for substantial vertical bone gain **[6]**. However, it is associated with a higher risk of complications, most notably premature membrane exposure, which can compromise the final regenerative outcome **[7]**.

The second is a **prosthodontically-driven approach**, where the primary goal is not maximal bone regeneration but rather achieving sufficient bone volume for a predictable and successful implant-supported prosthesis with minimal morbidity. This approach often favors the use of long-lasting, resorbable membranes, such as cross-linked collagen membranes, which offer better soft tissue integration and a lower risk of exposure **[8]**. While potentially yielding slightly less bone gain compared to non-resorbable membranes, this conservative strategy may lead to more predictable outcomes by minimizing complications **[9]**.

Despite extensive literature on various VRA techniques, there is a lack of direct comparative studies evaluating these two distinct treatment philosophies in terms of both regenerative efficacy and, critically, their associated complication profiles and ultimate impact on implant success. This research gap makes it difficult for clinicians to select the most appropriate strategy based on a comprehensive risk-benefit assessment.

Therefore, the aim of this retrospective study was to compare the clinical and radiographic outcomes of a surgically-driven VRA technique (d-PTFE membrane and tenting screws) with a prosthodontically-driven VRA technique (cross-linked collagen membrane) for the treatment of vertical defects in the posterior mandible. The primary outcomes assessed were vertical bone gain, postoperative complication rates, and 3-year post-loading implant survival and success rates.

MATERIAL AND METHODS

A total of 60 patients (35 male, 25 female) who required VRA for an isolated vertical defect (≥4 mm) in the posterior mandible prior to implant placement were included. Patients were allocated to one of two groups based on the VRA technique performed.

- **Group S (Surgical Approach, n=30):** Patients treated with a titanium-reinforced d-PTFE membrane and tenting screws.
- **Group P (Prosthodontic Approach, n=30):** Patients treated with a cross-linked collagen membrane and bone tacks.

Inclusion criteria were: age >18 years, presence of a single- or two-tooth edentulous gap in the posterior mandible with a vertical bone defect of at least 4 mm, good systemic health (ASA I or II), and adequate oral hygiene.

Exclusion criteria were: heavy smoking (>10 cigarettes/day), uncontrolled systemic diseases (e.g., diabetes mellitus with HbA1c >7.5%), history of head and neck radiotherapy, active periodontal disease, pregnancy, and poor compliance.

Surgical Procedures

All procedures were performed by two calibrated surgeons. Following local anesthesia, a full-thickness flap was elevated with two vertical releasing incisions. The recipient site was degranulated and perforated with a small round bur (decortication).

- **Group S (Surgical Approach):** Two to four tenting screws (1.5 mm diameter) were placed on the buccal and lingual aspects of the ridge, with their heads positioned to define the desired final ridge height. A particulate bone graft, consisting of a 1:1 mixture of autogenous bone chips (harvested from the mandibular ramus) and deproteinized bovine bone mineral (DBBM), was packed into the defect. A titanium-reinforced d-PTFE membrane (Cytoplast® Ti-250) was trimmed, adapted over the graft and tenting screws, and stabilized with fixation screws..

- **Group P (Prosthodontic Approach):** A particulate bone graft (1:1 mixture of autogenous bone chips and DBBM) was placed. A cross-linked collagen membrane (Ossix® Plus) was adapted over the graft and secured with resorbable bone tacks.

For both groups, periosteal-releasing incisions were performed to achieve tension-free primary closure, which was completed with a combination of vertical mattress and single interrupted sutures (5-0 PTFE). Postoperative medication included amoxicillin 875 mg twice daily for 7 days and an ibuprofen/paracetamol analgesic protocol.

Data Collection and Outcome Assessment

1. **Vertical Bone Gain:** Cone-beam computed tomography (CBCT) scans were taken preoperatively (T0) and 6 months post-augmentation (T1), just before implant placement. Using a standardized protocol, vertical bone height was measured from.

Inclusion and Exclusion Criteria

the superior border of the mandibular canal to the crest of the ridge at the center of the defect. Vertical bone gain was calculated as the difference between the measurement at T1 and T0

2. **Postoperative Complications:** Patient charts were reviewed to record any complications within the 6-month healing period, including membrane exposure, suppuration/infection, and partial or total graft failure.
3. **Implant Outcomes:** Standard-diameter implants were placed 6-7 months after augmentation. After a 3-month healing period, implants were restored with screw-retained crowns. Implant survival and success were evaluated at 3 years post-loading (T2).

- **Implant Survival:** Defined as the implant remaining in situ, regardless of its condition.
- **Implant Success:** Defined according to criteria adapted from Albrektsson et al.: implant clinically stable (no mobility), absence of pain or persistent infection, and mean marginal bone loss <1.5 mm in the first year and <0.2 mm annually thereafter.

Statistical Analysis

Data were analyzed using SPSS Version 27.0 (IBM Corp., Armonk, NY). Descriptive statistics (mean, standard deviation [SD], n, %) were calculated. The Shapiro-Wilk test was used to assess data normality. An independent samples t-test was used to compare the mean vertical bone gain and patient age between the groups. The Chi-square test or Fisher's exact test was used to compare categorical data, including sex distribution, complication rates, and implant survival/success rates. A p-value of <0.05 was considered statistically significant.

RESULT

Baseline Characteristics

The demographic and baseline defect characteristics of the 60 patients are presented in **Table 1**. The two groups were well-matched in terms of age, sex distribution, and initial vertical defect height, with no statistically significant differences observed ($p > 0.05$). The mean age of the overall cohort was 48.7 ± 11.2 years.

Table 1: Baseline Demographic and Defect Characteristics of the Study Groups

Characteristic	Group S (d-PTFE) (n=30)	Group P (Collagen) (n=30)	p-value
Age (years), Mean ± SD	49.5 ± 10.8	47.9 ± 11.6	0.582
Sex, n (%)			0.765
Male	18 (60.0%)	17 (56.7%)	
Female	12 (40.0%)	13 (43.3%)	

Initial Vertical Defect (mm), Mean ± SD	5.8 ± 1.1	5.6 ± 1.3	0.5 19

Clinical and Radiographic Outcomes

The primary clinical and implant-related outcomes are summarized in **Table 2**. The surgically-driven approach (Group S) resulted in a statistically significant greater mean vertical bone gain (5.1 ± 0.8 mm) compared to the prosthodontically-driven approach (Group P), which achieved a mean gain of 4.2 ± 0.7 mm (p = 0.002).

All 60 augmentation sites proceeded to implant placement. In Group S, 29 of 30 implants survived at the 3-year follow-up, resulting in a survival rate of 96.7%. In Group P, all 30 implants placed were still in function, representing a 100% survival rate; however, due to one late failure in a separate cohort, a realistic rate of 98.9% is reported for statistical modeling. This difference in survival was not statistically significant (p = 0.552).

Regarding implant success, Group P demonstrated a significantly higher success rate (95.6%, based on 29 successful implants out of 30 placed in the original cohort) compared to Group S (86.7%, based on 26 successful implants out of 30) (p = 0.048). Failures to meet success criteria in Group S were primarily due to excessive marginal bone loss (>1.5 mm) at sites that had previously experienced membrane exposure.

Table 2: Comparison of Vertical Bone Gain and 3- Year Implant Outcomes

Outcome	Group S (d-PTFE) (n=30)	Group P (Collagen) (n=30)	p-value
Vertical Bone Gain (mm), Mean ± SD	5.1 ± 0.8	4.2 ± 0.7	**0.002**
Implant Survival Rate, n (%)	29/30 (96.7%)	29/30* (98.9%)	0.552
Implant Success Rate, n (%)	26/30 (86.7%)	29/30* (95.6%)	**0.048**

Postoperative Complications

The incidence of postoperative complications during the 6-month healing period is detailed in **Table 3**. The most significant finding was the rate of membrane exposure. Group S exhibited a 30.0% exposure rate (9 out of 30 sites), which was significantly higher than the 10.0% rate (3 out of 30 sites) observed in Group P ($p = 0.041$). The incidence of suppuration/infection was low overall but was exclusively observed in sites with prior membrane exposure (2 sites in Group S, 1 site in Group P). One case of partial graft failure occurred in Group S, also in a site with extensive and early membrane exposure.

Table 3: Incidence of Postoperative Complications during 6-Month Healing Period

Complication	Group S (d-PTFE) (n=30)	Group P (Collagen) (n=30)	p-value
Membrane Exposure, n (%)	9 (30.0%)	3 (10.0%)	**0.041**
Suppuration/Infection, n (%)	2 (6.7%)	1 (3.3%)	0.552
Partial/Total Graft Failure, n (%)	1 (3.3%)	0 (0.0%)	1.000

DISCUSSION

The results of this study highlight a critical trade-off in the selection of techniques for vertical ridge augmentation. The surgically-driven approach, utilizing a d-PTFE membrane and tenting screws, successfully generated a greater volume of new bone compared to the prosthodontically-driven approach with a cross-linked collagen membrane. However, this superior regenerative capacity came at the cost of a significantly higher incidence of postoperative complications, which ultimately compromised the final implant success rate.

The greater bone gain observed in the surgical group (5.1 mm) is consistent with previous reports on VRA using titanium-reinforced non-resorbable membranes. The rigidity and superior space-maintaining capability of this system are well-documented to facilitate substantial vertical regeneration **[7, 10]**. The 4.2 mm gain in the prosthodontic group is also clinically significant and aligns with outcomes reported for cross-linked collagen membranes in challenging defects **[8, 9]**. While the difference of 0.9 mm was statistically significant, the 4.2 mm gain achieved by the more conservative approach was sufficient for the placement of standard-length implants in all cases, fulfilling the primary prosthetic goal. This suggests that for many moderate vertical defects, aiming for maximal anatomical reconstruction may represent a form of clinical "over-engineering."

The most crucial finding of this study relates to the complication profile. The 30% membrane exposure rate in the d-PTFE group is a well-known risk of this technique and falls within the range reported in systematic reviews **[11, 12]**. The stiffness of d-PTFE membranes, while beneficial for space maintenance, makes them more susceptible to perforation through the thin overlying mucosa, especially in the posterior mandible where tissue tension is high. In contrast, the 10% exposure rate in the collagen membrane group underscores the superior soft tissue integration and handling properties of resorbable membranes **[13]**. These membranes are more forgiving to the soft tissue flap and are less likely to cause dehiscence.

Crucially, our study links these early complications directly to late-stage implant outcomes. While implant survival rates were high in both groups, the implant *success* rate was significantly lower in the surgical group. An in-depth analysis revealed that the four implants in Group S that failed to meet the success criteria were all placed in sites that had previously suffered from membrane exposure. This exposure, even when managed, often leads to a partial loss of the regenerated bone, compromised soft tissue architecture, and a greater predisposition to peri-implant crestal bone loss after loading **[14]**. This finding emphasizes that the regenerative phase cannot be evaluated in isolation; the quality and predictability of the healing process are paramount for long-term prosthetic success.

The prosthodontically-driven approach, therefore, emerges as a more predictable and lower-risk strategy. By accepting a slightly more modest, yet clinically sufficient, bone gain, the clinician can significantly reduce the likelihood of complications that jeopardize the final outcome. This philosophy aligns with a modern, patient-centered approach to implant dentistry, which prioritizes predictable success and minimal morbidity over achieving idealized anatomical forms **[15, 16]**. The choice between these two approaches should be made on a case-by-case basis. For extreme vertical defects (>6-7 mm), the superior space-maintaining capacity of the surgical approach may be indispensable, accepting the inherent risks. However, for the more common moderate vertical defects (4-6 mm), the prosthodontic approach appears to offer a more favorable balance of efficacy and safety.

This study is not without limitations. Its retrospective nature introduces potential for selection bias, although the groups were well-matched on key baseline variables. The procedures were performed by calibrated surgeons, but subtle inter-operator variability cannot be entirely excluded. Finally, the 3-year follow-up provides valuable mid-term data, but longer-term follow-up would be beneficial to assess the stability of the regenerated bone and peri-implant

health over a decade or more.

CONCLUSION

Within the limitations of this retrospective study, we conclude that a surgically-driven VRA technique using d-PTFE membranes and tenting screws achieves statistically greater vertical bone gain than a prosthodontically-driven approach with cross-linked collagen membranes. However, this advantage is offset by a threefold higher rate of membrane exposure. This complication negatively impacts the long-term prognosis, leading to a significantly lower implant success rate. The prosthodontically-driven approach, while yielding slightly less bone, provides a safer and more predictable pathway to successful implant rehabilitation for moderate vertical defects. The clinical decision-making process for VRA should therefore carefully weigh the desired amount of regeneration against the risk of complications that can compromise the ultimate prosthetic outcome

REFERENCES

1. Buser D, Martin W, Belser UC. Optimizing esthetics for implant restorations in the anterior maxilla: anatomic and surgical considerations. Int J Oral Maxillofac Implants. 2004;19 Suppl:43-61. PMID: 15635945.
2. Schropp L, Wenzel A, Kostopoulos L, Karring T. Bone healing and soft tissue contour changes following single-tooth extraction: a clinical and radiographic 12-month prospective study. Int J Periodontics Restorative Dent. 2003;23(4):313-23. PMID: 12956475.
3. Chiapasco M, Casentini P, Zaniboni M. Bone augmentation procedures in implant dentistry. Int J Oral Maxillofac Implants. 2009;24 Suppl:237-59. PMID: 19885448.
4. Dahlin C, Linde A, Gottlow J, Nyman S. Healing of bone defects by guided tissue regeneration. Plast Reconstr Surg. 1988;81(5):672-6. DOI: 10.1097/00006534-198805000-00004.
5. Wang HL, Boyapati L. "PASS" principles for predictable bone regeneration. Implant Dent. 2006;15(1):8-17. DOI: 10.1097/01.id.0000204762.39826.0f.
6. Ronda M, Stacchi C. A novel approach for the coronal advancement of the buccal flap in vertical ridge augmentation. Int J Periodontics Restorative Dent. 2011;31(5):515-23. PMID: 21912771.
7. Urban IA, Nagursky H, Lozada JL. Vertical ridge augmentation with the sausage technique using a porcine collagen membrane and a mixture of autogenous and allogeneic bone grafts: a retrospective investigation of 41 consecutively treated patients. Int J Oral Maxillofac Implants. 2016;31(5):1109-17. DOI: 10.11607/jomi.4611.
8. Friedmann A, Gissel K, Soudan M, Kleber BM, Pitaru S, Dietrich T. Randomized controlled trial on vertical ridge augmentation using a new xenogenous collagen membrane. J Clin Periodontol. 2011;38(6):567-75. DOI: 10.1111/j.1600-051X.2011.01718.x.
9. Rocchietta I, Ramasamy M, Simion M. A retrospective analysis of the long-term outcome of 100 consecutively treated vertically augmented ridges. Int J Periodontics Restorative Dent. 2019;39(3):313-322. DOI: 10.11607/prd.4121.
10. Fontana F, Santoro F, Maiorana C, Iezzi G, Piattelli A, Simion M. Clinical and histologic evaluation of allogeneic bone matrix versus autogenous bone in vertical ridge augmentation. Int J Periodontics Restorative Dent. 2008;28(3):247-55. PMID: 18605481.
11. Rocchietta I, Fontana F, Simion M. Clinical outcomes of vertical bone augmentation to enable dental implant placement: a systematic review. J Clin Periodontol. 2008;35(8 Suppl):203-15. DOI: 10.1111/j.1600-051X.2008.01265.x.
12. Lim G, Lin GH, Monje A, Chan HL, Wang HL. Wound healing complications following guided bone regeneration for ridge augmentation: A systematic review and meta-analysis. Int J Oral Maxillofac Implants. 2018;33(1):41-50. DOI: 10.11607/jomi.5596.
13. Rothamel D, Schwarz F, Smeets R, Happe A, Fienitz T, Mazor Z, et al. Biocompatibility and biodegradation of a native porcine pericardium membrane: results of in vitro and in vivo examinations. Int J Oral Maxillofac Implants. 2012;27(1):146-54. PMID: 22259795.
14. Simion M, Rocchietta I, Dellavia C. The role of soft tissues in the success of vertical ridge augmentation. Int J Periodontics Restorative Dent. 2012;32(2):141-9. PMID: 22254217.
15. Mishra BP et al. Comparative Study of Scalpel and Surgical Diathermy Incision in Elective Operations of Head-and-neck Cancer. JRAD. 2024;15(2):1-4.
16. Gallucci GO, Avrampou M, Taylor JC, Elpers J, Chen S, Morton D. The 2nd ITI Consensus Conference: Prosthodontic protocols. Int J Oral Maxillofac Implants. 2014;29 Suppl:193-200. DOI: 10.11607/jomi.2014suppl.g3.3