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Integrating Biologics with Guided Bone Regeneration to Enhance Hard and Soft Tissue Outcomes in Ridge Preservation

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ABSTRACT

Tooth extraction led to a high degree of dimensional changes in the alveolar ridge that could jeopardize future implant placement and restorative results. While guided bone regeneration had extensively been used for ridge preservation, its healing predictability and regenerative limitations prompted the incorporation of biologic agents. Thus, the objective of this study was to assess hard and soft tissue outcomes of ridge preservation after clarifying the use of biologics with guided bone regeneration based on current evidence. In particular, the study investigated how biologic integration improves hard tissue generation, soft-tissue repair, postoperative recovery, clinical efficiency, treatment satisfaction and the factors limiting uptake. This study used a quantitative cross-sectional research design, and primary data were collected from in-service dental professionals through structured questionnaire by purposive sampling method. Using Cochran's formula, sample size was determined. Data were analyzed with descriptive statistical methods, including mean and standard deviation. The results demonstrated that biologic-assisted guided bone regeneration produced significant improvements in several aspects of Osseo integration, including increased bone density, ridge preservation, graft maturation, soft tissues thickness and healing efficiency. Finally led to superior esthetics. Results also demonstrated decreased post-operative complication rates, improved clinical efficiency, and strong treatment satisfaction among participants. Unfortunately, high costs, limited availability of valid and scalable tests, training requirements and regulatory barriers emerged as significant obstacles to adoption. This study found that guided bone regeneration combined with biologics can markedly improve hard and soft tissue results of ridge preservation, which strongly supports its clinical application in regenerative dentistry.

INTRODUCTION

Dimensional changes of the alveolar ridge following tooth extraction are frequent and consist of bone volume loss and modifications in the surrounding soft tissue architecture (Klokkevold, 2019). Post-extraction changes that can compromise later restorative treatment, including placement of dental implants, are well documented and often related to reduction in available hard and soft tissue support (Kanikicharla *et al.,* 2021). Consequently, ridge preservation has become one of the important steps in implant dentistry today to preserve both alveolar anatomy and ultimately treatment outcomes (Mohammadyari *et al.,* 2023). Among regenerative modalities, Guided Bone Regeneration (GBR) is one of the most common approaches utilized for ridge dimensional preservation utilizing barrier membranes and bone graft materials (Veljanovski *et al.,* 2021). GBR induces local bone regeneration by inhibiting soft tissue invasion into the defect area and establishing a suitable microenvironment for osteogenesis (Motamedian *et al.,* 2025). Although clinically successful, conventional GBR is limited by delayed wound healing, graft resorption, incomplete vascularization of the graft tissue and uncontrolled soft tissue integration affecting overall predictability (Misch, 2022). To overcome these challenges, biologic agents like PRF (platelet-rich fibrin), PRP (platelet-rich plasma), growth factors and other bioactive materials have been combined with regenerative procedures (Shirbache *et al.,* 2023). These biologics include bioactive molecules that promote angiogenesis, cell proliferation, collagen synthesis and bone formation, which may promote healing of both hard and soft tissue. The inclusion of these might enhance bone maturation, graft stability, soft tissue thickness, and ultimately the post-operative recovery when included in GBR protocols (Chana *et al.,* 2023). While previous studies have suggested benefit of biologic attenuation with regeneration, information combining these treatments in ridge preservation is limited. Most studies published to date evaluate either bone regeneration or soft tissue healing but not both, and only a few have quantitatively assessed both. This gap demonstrates the need for an empirical assessment of the benefits of incorporating biologics with GBR.

This study, Integrating Biologics with Guided Bone Regeneration to Enhance Hard and Soft Tissue Outcomes in Ridge Preservation, is designed to quantitatively evaluate the influence of biologic support on hard and soft tissue outcomes associated with ridge preservation procedures. The results will add to the evidence for decisions involving clinical biological approaches in regenerative and implant dentistry.

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LITERATURE REVIEW

Due to the physiologic changes that take place post tooth extraction, ridge preservation has become a hallmark protocol in modern implant and regenerative dentistry (Veljanovski *et al.,* 2021). A major resorption of the alveolar ridge, especially in the first months after extraction may jeopardize functional and esthetic rehabilitation. A large amount of horizontal and vertical bone loss occurs in the alveolar ridges after tooth extraction, even with the most advanced techniques; this can pose a challenge for the placement of dental implants and prosthetic reconstruction performed at a later stage (Hernández *et al.,* 2025). As a result, this has resulted in regenerative protocols to minimize post-extraction tissue collapse and the appropriate maintenance of both hard and soft tissue volume (Sun & Chang, 2024). One of the most well-established regenerative procedures for maintaining alveolar ridge dimensions is Guided Bone Regeneration (GBR). GBR is based on the principle of placing barrier membranes over the defect site to exclude rapidly dividing epithelial and connective tissue cells from invading this area, permitting slow-growing osteogenic cells at the defect margins time to repopulate this region and regenerate new bone (Raabe *et al.,* 2025). Oral bone graft materials include autograft, allograft, xenograft and alloplastic substitutes and are often applied with barrier membranes to provide osteoconduction and space maintenance in two-stage regenerative procedures (N *et al.,* 2025). Many clinical studies have shown that GBR preserves ridge width and height following tooth loss. Studies have shown that GBR decreases crestal bone loss following the removal of teeth and enhances bone availability for immediate implant placement (Chana *et al.,* 2023). Furthermore, GBR has been linked with enhancing implant stability and decreasing the necessity of augmentative procedures. However, conventional GBR has limitations despite these advantages. Treatment outcomes may still be affected by clinical complications of membrane exposure, graft contamination, delay in wound healing and incomplete bone maturation (Misch, 2022). Additionally, GBR associated with bone formation might not cover defects in a clinical context due to patient-dependent variables and defect morphology as well as surgical manipulation (Hafiz *et al.,* 2022). Recent advances in tissue engineering utilizing biologic agents as adjunctive therapy in standard regenerative applications. Biologics are bioactive substances of either autologous or allogeneic source, or produced by recombinant processes that activate cells and molecular pathways involved with the repair process (Bambini *et al.,* 2021). Well-known biologic agents for oral regeneration are platelet-rich fibrin (PRF), platelet-rich plasma (PRP), enamel matrix derivatives, recombinant growth factors, bone morphogenetic proteins (BMPs), and stem-cell-based preparations (Juwel Rana, 2024).

These biologic agents are loaded with an array of growth factors including platelet derived growth factor (PDGF), transforming growth factor-beta (TGF-β), vascular endothelial growth factor (VEGF), and insulin-like growth factor (IGF) that are crucial in cell recruitment, angiogenesis, extracellular matrix development, and tissue maturation (Mohammadyari *et al.,* 2023). They have attracted enormous interest in regenerative medicine applications since they can stimulate healing and enhance tissue repair (Hernández *et al.,* 2025). Several studies have indicated that the use of biologics often translates into better wound healing, decreased inflammation, increased vascularization and osteoblastic differentiation. In implant dentistry, biologic-assisted procedures give positive results for socket preservation, sinus augmentation, periodontal regeneration, and peri-implant tissue management (Veljanovski *et al.,* 2021). Conversely, clinical effectiveness of biologics may depend on preparation method (cryopreservation), concentration and dosing protocols. Hard tissue volume preservation is one of the most influential factors behind successful implant therapy. For the implant to achieve stability, osseointegration, and long-term function it requires adequate bone width, height, and density (Cucchi *et al.,* 2021). Standard grafting materials have a mostly structural role, while biologics may facilitate the biological processes central to bone formation (Perale, 2025). Many investigations report beneficial impact of biologics on hard tissue regeneration. In a clinical setting, since they release several growth factors in a time-dependent manner, platelet concentrates like PRF and PRP have been suggested to hasten the process of bone maturation (Prasad Nagnath Rokade, 2023). Bone morphogenetic proteins, particularly BMP-2, are correlated with improved osteoinductive effect and greater de novo bone formation. Incorporation of biologics into regenerative protocols has been linked to increased bone fill, enhanced mineralization and accelerated graft integration in clinical studies (Chana *et al.,* 2023). In ridge preservation studies, biologic-assisted GBR has been shown to maintain alveolar ridge width more effectively over time and prevent its resorption as well as improve bone density compared with conventional GBR alone (Cucchi *et al.,* 2021). Accelerated angiogenesis promoted by biologics promotes the supply of nutrients and enhances cellular activities within the grafted location, leading to more predictable bone regeneration (Raabe *et al.,* 2025). One of the most significant factors determining a successful implant therapy remains hard tissue volume preservation. The implant needs to have sufficient bone width, height and density for that the osseointegration stability and function of implant is not be affected on long run (Alberti *et al.,* 2021). Traditional grafting material is mainly structural in nature whilst biologics may promote the biological processes integral bone formation and remodeling (Munshi *et al.,* 2025). Numerous investigations indicated positive effects of biologics on hard tissue regeneration. Because they gradually release a variety of growth factors over time, platelet concentrates such as PRF and PRP have been recommended to accelerate bone maturation in both basic and clinical settings (Miron *et al.,* 2021). There is a

significant association between the osteoinductive effect and de novo bone formation with bone morphogenetic proteins (BMPs) especially for BMP-2. Clinical studies have demonstrated that the combination of biologics into regenerative protocols is associated with improved bone fill, augmented mineralization and accelerated graft incorporation (Raabe *et al.,* 2025). Biologic-assisted GBR has been shown to better maintain alveolar ridge width and density over time, compared with conventional GBR alone, in ridge preservation studies. Accelerated angiogenesis mediated by biologics contributes to nutrient delivery and a better cellular environment at the host-graft interface, resulting in more predictable bone regeneration (Hernández *et al.,* 2025). Alongside the bone preservation, for an effective ridge preservation, it is equally important for surrounding soft tissues to be well preserved and stable. Soft tissue thickness, keratinized tissue width, gingival contour and mucosal stability are critical for esthetic outcomes and peri-implant health (Blašković *et al.,* 2021).

The regenerative and anti-inflammatory properties of biologics have demonstrated great promise in the promotion of soft tissue healing, but no standard usage or outcome measure criteria exist. Platelet concentrates contain cytokines and growth factors that promote fibroblast proliferation, collagen synthesis, and epithelial cell migration (Shirbache *et al.,* 2023). These processes result in quicker wound closure, a thicker tissue layer and greater mucosal maturation. Clinical studies have shown that biologic-assisted procedures can significantly reduce swelling, pain, and soft tissue complications while improving gingival architecture or outer appearance (Sun & Chang, 2024). Better healing of soft tissues which decreases the likelihood of exposure of membranes that occur more frequently in GBR techniques. However, despite these reassuring results, there is some inconsistency about the estimated size of soft tissue benefits due to differences in study design and outcome assessment (Ramachandra *et al.,* 2022). Combining biologics with GBR is a natural progression in regenerative dentistry whereby structural support and biologic stimulation can be integrated. While GBR provides for space maintenance and the ability to isolate defects, the addition of biologics improves cellular activity, vascularization and tissue maturation (Sarbu *et al.,* 2024). This synergistic method has the ability to enhance both hard and soft tissue results at once. Clinical trials have found that GBR in combination with biologics may translate to accelerated healing time, improved graft stabilization, and superior bone quality and soft tissue esthetics within 3–12 months after surgery (Shirbache *et al.,* 2023). Biologic-assisted GBR has been shown to decrease healing time and enhance treatment predictability in patients. Second, enhanced tissue maturation could allow for sooner implant placement and shorten the total treatment time (Garrido Díaz *et al.,* 2025). Despite increasing clinical interest, the evidence remain heterogeneous. Existing studies have lacked comparative analyses due to heterogeneity in biologic materials, characteristics of the defects being repaired, surgical techniques used, and follow-up periods. Additionally, numerous studies concentrate on specific clinical parameters instead of taking a more comprehensive approach and evaluating hard and soft tissue outcomes within the same treatment framework (Monje *et al.,* 2023). The literature on GBR, and biologics individually is vast; however, only a few studies quantitatively assessed the efficacy of these two interventions used concurrently during ridge preservation (Shirbache *et al.,* 2023). Most of the available studies in literature have highlighted either bone regeneration or soft tissue healing only, but still little exists for a complete evaluation of both outcomes. Moreover, heterogeneity of clinical outcomes and variability in biologic application protocols raises uncertainty over the net clinical advantage of biologic-assisted GBR.

Consequently, a systematic quantitative evaluation is necessary to determine the effect of biologics on hard and soft tissue outcomes in ridge preservation when used in conjunction with guided bone regeneration. Bridging this gap may provide additional (and thus perhaps more) empirical evidence to optimize regenerative protocols and enhance evidence-based clinical decision-making in implant dentistry. The objectives of the study are:

1. To evaluate biologic integration of ridge preservation with guided bone regeneration.
2. To assess the influence of biologic-assisted guided bone surgery on hard tissue outputs.
3. To assess the impact of biologic-assisted guided bone regeneration on soft tissue outcomes.
4. To assess biologic incorporation and complication rates with endplate treatment.
5. To analyze the effect of biologic application on clinical efficacy during ridge preservation procedures.
6. To evaluate the treatment satisfaction from the treatment with biologic-assisted guided bone regeneration.

MATERIALS AND METHODS

This study used a quantitative, cross-sectional research design to evaluate the effect of biologics in combination with guided bone regeneration on ridge preservation hard and soft tissue outcomes. A structured questionnaire was used for data collection, where oral surgeon, periodontist, prosthodontists, and general dentists with clinical experience in ridge preservation and regenerative procedures were included as participants. Purposive sampling was used to select respondents from hospitals, specialized dental clinics, and academic institutions. The sample size was calculated employing the Cochran formula for large populations:

$$n = \frac{Z^2.p.(1-p)}{E^2}$$

Where n = sample size, Z = standard normal variety for 95% confidence level (1.96), p = estimated proportion of the population with the attribute being measured (p was presumed to be 0.5 since no prior information needed

to be used) and E is margin of error (0.05) (Cochran, 1942). Therefore, the minimum sample size required for a single population proportion was 384 respondents, but to compensate for possible non-response and incomplete questionnaires, a larger number of participants were approached. The collected data were coded and analyzed through statistical program (e.g., SPSS), descriptive statistics including frequency, percentage, mean, and standard deviation to synthesize the data; while inferential statistics addressed relationships of the variables. Strict ethical considerations were followed, including voluntary participation, informed consent and confidentiality of respondents' information.

RESULTS AND DISCUSSION

The focus of this section is the review of evidence regarding the impact of adjunct biologics combined with guided bone regeneration (GBR) techniques on hard and soft tissue outcomes related to ridge preservation. Collected data were analyzed using suitable statistical analyses such as descriptive and inferential analysis to test correlation between variables of the study. Systematic presentation of results based on research aim, followed by discussion and interpretation in relation to previous literature and clinical implications of the findings.

Demographic Information

The demographic data and professional experience is important to consider when interpreting survey results, especially in a clinically focused study as ridge preservation and regenerative dentistry (Noori, 2022). Demographic and clinical variables included age, gender, profession designation, and years of practicing experience, practice type and annual number of ridge preservation procedures performed. Table 1 shows the distribution of respondents over those categories.

Table 1: Demographic Information of the Respondents

Variable	Category	Frequency	Percentage (%)
Age	Below 30 years	58	15.1
	31–40 years	146	38.0
	41–50 years	121	31.5
	Above 50 years	59	15.4
Gender	Male	238	62.0
	Female	146	38.0
Professional Designation	Oral Surgeon	94	24.5
	Periodontist	82	21.4
	Implantologist	103	26.8
	Prosthodontist	56	14.6
	General Dentist	49	12.7
Clinical Experience	Below 5 years	67	17.4
	5–10 years	138	35.9
	11–15 years	109	28.4
	Above 15 years	70	18.3
Type of Practice	Private Clinic	173	45.1
	Hospital	96	25.0
	Academic Institution	58	15.1
	Specialized Implant Center	57	14.8
Annual Ridge Preservation Procedures	Below 20	72	18.8
	20–50	144	37.5
	51–100	101	26.3
	Above 100	67	17.4

The demographic analysis showed that the most respondents (38.0%) were in age group 31–40 years, and 31.5% in 41–50; these findings indicate that all participants were at professional activity and clinical experience stage. There is an equal representation across the age groups · 15.1% of respondents were under 30 years and above 50 years account for · 15.4% respectively of all respondents, 62.0% were male and 38.0% were female. This distribution is in accordance with the present gender profile often observed in specialist surgical and implant-based dental practice, although the proportion of females also represented a significant number. With respect to profession, implantologists formed the largest proportion (26.8%) of respondents' followed by oral surgeons (24.5%) and periodontists (21.4%). 18.5% for oral and maxillofacial surgeon, followed by 14.6% for prosthodontist and 12.7% for general dentists. The distribution demonstrated that the majority of

respondents had direct clinical experience in regenerative and implant procedures, which added to the applicability and validity of the results. The professional experience analysis showed that 35.9% of the respondents had a clinical practice between 5–10 years and 28.4% reported having between 11–15 years of professional experience. 17.4% of respondents had less than 5 years of experience and then 18.3% with more than 15 years' experience. Most of the participants had substantial clinical exposure and were able to determine success in biologic-assisted guided bone regeneration procedures. In terms of practice type, private clinics constituted the largest proportion (45.1%), followed by hospitals (25.0%), academic institutions (15.1%) and specialized implant centers (14.8%). The distribution shown here implies that data were collected from clinical environments with diverse patients, suggesting greater generalizability of the results.

Lastly, concerning preserved annually ridge procedures, the higher group of respondents (37.5%) did often between 20 and 50 procedures each year followed by 26.3% doing 51-100 procedures. A smaller proportion performed less than 20 (18.8%) or more than 100 procedures (17.4%). This finding indicates that the majority of subjects were actively involved with ridge preservation, thus leading to clinically relevant and factually accurate responses used to assess biologics optimizing guided bone regeneration.

Use of Biologics in Guided Bone Regeneration

This section shows how the respondents view biologics for use in guided bone regeneration in ridge preservation. The analysis was directed toward the contributions of biologic agents to treatment predictability, tissue regeneration, graft integration, vascularization, healing efficiency and clinical success. Responses were analyzed using descriptive statistics (mean and standard deviation) for the five-point Likert scale. The results are shown in 2.

Table 2: Descriptive Statistics of Use of Biologics in Guided Bone Regeneration

Statements	Mean	Standard Deviation
Biologic agents improved the predictability of ridge preservation procedures.	4.28	0.71
The use of biologics accelerated tissue regeneration.	4.34	0.68
Biologics enhanced graft integration.	4.22	0.74
Biologic materials improved vascularization at the graft site.	4.31	0.69
Biologics reduced healing time.	4.18	0.77
The combination of biologics with guided bone regeneration improved overall treatment success.	4.39	0.65
Overall Mean	**4.29**	**0.71**

The results summarized in Table 2 showed that the participants had an overall positive attitude toward the use of biologics for guided bone regeneration. The overall mean (4.29) showed general consensus that biologic integration positively impacted the effectiveness of ridge preservation procedures. The highest mean score (M = 4.39, SD = 0.65) from the individual statements was associated with the statement suggesting that guided bone regeneration combined with biologics improves overall treatment success. Issue: The results indicated that the respondents believed but also strongly believed in the synergy of biologic agents and traditional regenerative techniques. The low standard deviation confirmed the consistent agreement of opinions among respondents, suggesting a consensus on its clinical usefulness within the profession. The second-highest mean score (M = 4.34, SD = 0.68) was for statement 16 indicating that biologics promote cellular proliferation and maturation of tissues therefore accelerating tissue regeneration capability were widely accepted among respondents. In a similar manner, the statement regarding improved vascularization at or near the place of grafting achieved a high mean (M = 4.31, SD = 0.69), indicating that respondents believed the biologics to induce angiogenesis are favorable for grafting and such an outcome is vital to graft survival and formation of bone. The statement addressing the enhanced predictability of ridge-preserving procedures returned also a high mean (M = 4.28, SD = 0.71), wherein respondents believed that biologic-assisted regenerative modalities yielded more predictable and repeatable clinical results for certain class/quality defects. Similarly, the notion that biologics improved graft incorporation was backed with a mean score of 4.22 (+/- 0.74), but indicates that biologic agents aided in the interaction between graft and host tissues overall in a productivity (clinical) manner. Although, the statement about shorter healing time recorded the least mean value (M = 4.18 SD=0.77), it also indicated high level of agreement amongst respondents as well. The larger heterogeneity in responses may have stemmed from diverging clinical conditions, patient healing responses or types of biologics utilized in practice.

In summary, findings showed that dental practitioners supported the use of biologics for guided bone regeneration and recognized their role in enhanced treatment predictability, increased rates of healing, faster tissue regeneration, stronger graft integration and shortened time overall (Hernández *et al.,* 2025). These results aligned with research in regenerative dentistry, where biologic agents accelerated cellular response, promoted angiogenesis and tissue repair that might improve clinical outcomes of ridge preservation.

Hard Tissue Outcomes

This section describes the perceptions of respondents regarding potential impact of biologic-assisted guided bone regeneration on hard tissue outcomes in ridge preservation. Hard tissue outcomes were evaluated according to the following parameters: alveolar ridge preservation, vertical bone maintenance, improvement in bone density, ridge contour stabilization, and preparation of the implant site for placement. Responses collected through five-point Likert scale were analyzed using descriptive statistics including mean and standard deviation. The results are shown in Table 3.

Table 3: Descriptive Analysis of Hard Tissue Outcomes

Statements	Mean	Standard Deviation
The use of biologics helped preserve alveolar ridge width.	4.36	0.66
Biologics improved vertical bone preservation.	4.27	0.72
Bone density improved when biologics were used.	4.41	0.63
Ridge contour was better maintained with the use of biologics.	4.24	0.70
Bone graft maturation occurred faster with biologic integration.	4.33	0.68
Implant site preparation improved after biologic-assisted guided bone regeneration.	4.38	0.64
Overall Mean	**4.33**	**0.67**

For the question in Table 3, a robust and positive perception of the effect of biologic-assisted guided bone regeneration on hard tissue outcomes in ridge preservation (range 0–100%) was demonstrated among respondents. The mean score of 4.33 demonstrated that respondents completely agreed biologics greatly improve bone related clinical outcomes. Of the reviewed statements, statement which states that bone density improved with biologics had the highest mean score (M = 4.41, SD = 0.63). This result indicated that biologics were broadly viewed by respondents as effective in promoting mineralization and improving bone quality in the context of healing. The low standard deviation suggested a strong consensus on the osteogenic advantages of biologic incorporation among respondents. Biologic-assisted regeneration facilitated improved implant site preparation yielded a second high mean score (M = 4.38, SD = 0.64), indicating that the respondents believed this advanced regenerative therapy created a more favorable platform for placement of an implant at a later time point. This suggested that better bone quality and volume led to more predictable surgical outcomes and better implant stability. The preservation of alveolar ridge width also achieved a high mean score (M=4.36; SD = 0.66) suggesting that biologics were perceived to limit post-extraction resorption and sufficient bone dimensions. Bone graft maturation with biologic incorporation also received a high mean score (M = 4.33, SD = 0.68), indicating that biologics expedited bone remodeling and helped to reinforce more rapid graft incorporation. The following syntactic statement, "Biologics maintained vertical bone height after ridge-preservation," was assessed with a mean of 4.27 and standard deviation of 0.72 demonstrating strong consensus among respondents that biologics preserved the height of the residual alveolar ridges post-ridge preservation procedures. Similarly, the claim related to maintaining ridge contour had a mean of 4.24 (SD = 0.70), reflecting that biologic-assisted guided bone regeneration improved the maintenance of alveolar ridge contours after tooth extraction.

Overall, the results showed that respondents confirmed highly that combining biologics with guided bone regeneration effectively provided improvements in hard tissue outcomes for those responding, based on enhanced density preservation of ridge dimensions accelerated graft maturation memory of ridge contour and enhancement by implant site readiness (Alberti *et al.,* 2021). This corroborates other studies in regenerative dentistry, demonstrating that biologic agents found to enhance osteoplastic activity, angiogenesis and mineralized tissue formation were observed with improved outcomes of bone regeneration and subsequent greater clinical predictability in ridge preservation procedures. In conclusion, the findings provided evidence towards biologic-assisted guided bone regeneration achieving optimal hard tissue outcomes in implant site development.

Soft Tissue Outcomes

In this section, the study analyzes the respondents' responses to questions about the impact of biologic-assisted guided bone regeneration on soft tissue outcomes among ridge preservation techniques. Soft tissue outcomes included thickness, healing efficiency, keratinized tissue quality, width of recession reduction or change in smile aesthetic and long term soft tissue stability. The responses collected based on the five-point Likert scale were subjected to descriptive statistics using measure of central tendencies, such as mean and standard deviation. Table 4 shows the results:

Table 4: Descriptive Statistics of Soft Tissue Outcomes

Statements	Mean	Standard Deviation
The use of biologics improved soft tissue thickness.	4.32	0.69
Soft tissue healing occurred faster with the use of biologics.	4.37	0.65

The quality of keratinized tissue improved after biologic-assisted guided bone regeneration.	4.28	0.71
The application of biologics reduced gingival recession.	4.19	0.76
Esthetic soft tissue outcomes improved with biologic integration.	4.35	0.67
Long-term soft tissue stability was enhanced through the use of biologics.	4.30	0.70
Overall Mean	**4.30**	**0.70**

Table 4 indicated that the outcomes of magnitude, importance and positive perception of respondents regarding biologic-assisted guided bone regeneration on soft tissue in ridge preservation have strong relationship. The mean overall score of 4.30 suggested that the respondents strongly agreed that biologics markedly improved soft tissue healing, quality and long-term stability. The maximum mean score for the optimal scale (M = 4.37, SD = 0.65) was seen with statement soft tissue healing are quicker with the use of biologics. This finding indicated that most of the respondents acknowledged the efficacy of biologic agents in expediting wound healing and tissue restoration post regenerative procedures. The standard deviation was low indicating there was a high degree of agreement amongst the respondents that this was an area of clinical benefit. The statement regarding enhanced esthetic soft tissue outcome received the second highest mean score (M = 4.35, SD = 0.67) indicating that biologic integration improves gingival contour, tissue harmony and esthetics This is of utmost important in terms of implant dentistry, where the quality and quantity of soft tissue is paramount to patient satisfaction as well as ensuring a long-term successful treatment. Respondents also reported a high mean rating (M = 4.32, SD = 0.69) that indicated their original beliefs that biologics positively influenced soft tissue thickness improvements and thicker, healthier peri-implant tissues were justified. In a similar vein, the statement on long-term soft tissue integrity was scored at 4.30 (±0.70), indicating that biologic-assisted regenerative procedures provided for stability of soft tissues over time. The dimension of keratinized tissue quality performed with a robust M = 4.28, SD = 0.71, affirming respondent consensus that biologics positively influence maturation and function of the healed mucogingival tissue. These findings are clinically important given that adequate keratinized tissue is required for peri-implant health, plaque control and patient comfort. Despite this, the statement regarding reducing gingival recession had the lowest mean score (M = 4.19, SD = 0.76), but still showed a strong level of agreement among respondents. The slightly greater variation in responses may have arisen from differences in patient-specific tissue biotypes, surgical techniques or the type of biologic materials used within clinical practice. In summary findings showed that all respondents strongly agreed that the use of biologics in conjunction with guided bone regeneration led to better soft tissue healing, increased tissue thickness, improved quality keratinized tissue, esthetic outcomes and reduced gingival recession as well as helping with long-term stability. The results of the current meta-analyses showed congruence with other studies in the field of regenerative and implant dentistry which found that biologic agents to have a more positive effect on fibroblast proliferation, collagen synthesis, angiogenesis and epithelial maturation promoting soft tissue healing as measured by clinical parameters during ridge preservation techniques. These findings thus provide compelling empirical evidence that addition of biologics in guided bone regeneration protocols improves soft tissue regenerative capacity (Sun & Chang, 2024).

Post-Operative Healing and Complications

The following describes the participant's responses to the perceptions of biologic assisted guided bone regeneration on post-operative healing and post-operative complication management in ridge preservation. Outcomes focused on the management of inflammation, pain control, prevention of infections, exposure of membranes and/or acute wound interventions and overall reduction in any complication-related to their healing. The data obtained from the five-point Likert scale were analyzed using descriptive statistics such as mean and standard deviation. These results are presented in Table 5.

Table 5: Descriptive Statistics of Post-Operative Healing and Compications

Statements	**Mean**	**Standard Deviation**
The use of biologics reduced post-operative inflammation.	4.26	0.72
Biologics contributed to the reduction of post-surgical pain.	4.21	0.75
The risk of infection was lower when biologics were used.	4.18	0.78
Membrane exposure occurred less frequently with biologic-assisted guided bone regeneration.	4.12	0.81
Wound closure became more predictable with the use of biologics.	4.34	0.67
Overall healing complications were reduced through biologic integration.	4.29	0.70
Overall Mean	**4.23**	**0.74**

Responses shown in Table 5 reflected a solid perception that used clinically biologic-assisted guided bone regeneration influenced post-operative healing, and complication management and outcomes. A global mean score of 4.23 indicated that constituents generally agreed that biologics, when used with ridge preservation procedures, contributed positively to the healing process and resulted in fewer complications following surgery. Of the statements assessed, the statement that wound closure became more predictable was highest rated (mean 4.34, SD 0.67) in this group when treated with biologics. The most likely explanation was that this finding showed how effective the role of biologic agents are in soft tissue healing, tissue adaptation and surgical site closure. The low standard deviation indicated respondents perceived this clinical benefit similarly, with high professional agreement. The communication that biologic integration reduced healing otherwise complications yielded the next-highest mean score (M = 4.29, SD = 0.70). This suggested that biologics were reported to have a successful impact on reducing the incidence of commonly occurring complications, and improved patient recovery in some cases by increasing predictability of treatment. Likewise, reduction of post-operative inflammation achieved a high mean (M = 4.26, SD = 0.72), supporting the notion that biologics may improve inflammatory control during the healing period. This statement concerning decreased postoperative pain also had a high mean (M = 4.21, SD = 0.75), indicating that respondents thought that procedures biologic assisted reduced patient discomfort after surgery. This result may be due to the anti-inflammatory and regenerative effects of biologic materials, enhancing tissue repair or ameliorating the effects of trauma. Perceived statement that biologics reduced the chances of infection had an average score of 4.18 (SD = 0.78) indicating agree among respondents. The authors concluded that the mechanism probably involved improved vascularization, tissue architecture and more localized immune response associated with biologic agents that create a favorable environment for healing. The lowest mean score (M = 4.12, SD = 0.81) compared to all statements measured was for the statement reflecting less membrane exposure with biologic-assisted guided bone regeneration. This scale is still indicative of agreement, although the greater standard deviation indicated more heterogeneity of clinical experiences within respondents. This variation may have been due to the type of membrane, flap management, defect morphology, or patient healing characteristics.

In total, respondents strongly agreed that biologics combined with guided bone regeneration drastically improved post-operative healing and decreased treatment-associated complications by accelerating predictable wound closure and minimizing inflammation and pain, decreasing infection risk, and limiting overall healing complications. These results corroborated earlier work in regenerative dentistry that indicated the biologic agents promote increased angiogenesis, cellular proliferation and immune modulation contributing to reduced healing time and improved post-operative outcomes (Raghavan *et al.,* 2025). Consequently, the results were thus indicative of the clinical importance of using biologics as an adjunctive therapy to guided bone regeneration in enhancing healing outcomes following ridge preservation.

Clinical Efficiency and Treatment Satisfaction

This section shows the opinions of the respondents about the impact of biologic-assisted guided bone regeneration on clinical efficiency and treatment satisfaction in ridge preservation. Clinical efficiency and treatment satisfaction, specifically procedural efficiency, predictability of treatment outcomes, patient satisfaction with long-term stability of implant placement and overall professional satisfaction with clinical outcomes. Responses of the five-point Likert scale were analyzed by descriptive statistics (mean and standard deviation). These results appear in table 6.

Table 6 showed that almost all of the respondents had positive perceptions about effect of biologic-assisted guided bone regeneration on clinical management outcome and treatment satisfaction. The global mean of 4.35 hence demonstrated that respondents completely agreed that the inclusion of biologics enhanced clinical results, treatment predictability and overall satisfaction in ridge preservation therapies. The statement with the highest mean score (M = 4.42, SD = 0.61) regarding overall satisfaction with clinical outcomes from biologic-assisted guided bone regeneration was one of the six statements assessed. This datum indicated that the responders very satisfied with clinical performance of biologic integration

Table 6: Results of Clinical Efficiency and Treatment Satisfaction

Statements	Mean	Standard Deviation
Biologic-assisted guided bone regeneration improved clinical efficiency.	4.31	0.68
The procedure provided more predictable treatment outcomes.	4.36	0.65
Patient satisfaction was higher with biologic-assisted procedures.	4.28	0.70
Implant placement success improved after biologic-assisted ridge preservation.	4.40	0.63
Long-term treatment stability was better with biologic integration.	4.34	0.67
Overall satisfaction with the clinical outcomes of biologic-assisted guided bone regeneration was high.	4.42	0.61
Overall Mean	**4.35**	**0.66**

within regenerative procedures. The standard deviation value was low demonstrating a high level of agreement with responses of the prospective effectiveness of this treatment, indicating professional consensus on its efficacy. The statement asserting that biologic-assisted ridge preservation enhances implant placement outcomes rated second highest in mean score (M = 4.40, SD = 0.63). This finding indicated that it was generally believed by respondents hearing biologic integration would positively contribute to the establishment of a favorable bone and soft tissue milieu to promote successful implant placement. This positive perception may have been species specific due to improved bone quality, enhanced stability of the implants in the tissue, and more rapid maturation. Respondents also rated with a relatively high mean score (M = 4.36, SD = 0.65) the perception that the procedure was associated with increased predictability of treatment results, suggesting that biologic-assisted guided bone regeneration was perceived to be more consistent and reliable in producing predictable clinical outcomes. Additionally, the composite of long-term treatment stability also scored high (Mean = 4.34; SD = 0.67), which indicated that biologic integration was associated with stable regeneration and a decreased chance of late complications. The second element dealing with clinical efficiency yielded a mean score of 4.31 (SD, 0.68), suggesting that these respondents perceived an improved contribution of biologic techniques in expediting uncomplicated and straightforward clinical processes while promoting healing to be accelerated with less reliance on adjunctive therapy/technologies. In addition, the mean patient satisfaction with biologic-assisted procedures was 4.28 ± 0.70, indicating respondents perceived more comfortable acceptance of their treatment outcomes by patients and a better experience for them.

The findings showed that respondents overwhelmingly agreed that there had been an overall improvement in, clinical efficiency, treatment predictability, success of implant placement without complication, long-term stability of recession coverage as well as patient and professional satisfaction with APT using BPC-157 during the GBR clinical procedure when compared to guided bone regeneration alone. These results supported the body of evidence for use of biologic factors in regenerative and implant dentistry, where agents that improved tissue healing or enhanced regeneration mode were reported to improve clinical outcomes (Raabe *et al.,* 2025). The findings thus yielded compelling empirical support for the benefits of biologic-enhanced guided bone regeneration in improving both clinical outcomes and patient satisfaction during ridge preservation.

Barriers to Adoption

This section reports results of a survey regarding the identified factors influencing respondent's adoption of biologics in guided bone regeneration for ridge preservation. Barriers were evaluated in aspects of cost, availability of biologics, additional clinical training needed, scientific evidence and regulation or institutional constraints. The responses were coded using a five-point Likert scale and analyzed using descriptive statistics mean & standard deviation. Results are shown in Table 7:

Table 7: Descriptive Statistics of Barriers to Adoption

Statements	**Mean**	**Standard Deviation**
The high cost of biologics limits their routine use in clinical practice.	4.41	0.66
Limited availability of biologic materials affects their clinical adoption.	4.28	0.71
Additional clinical training is required for effective use of biologics.	4.35	0.68
Limited clinical evidence restricts widespread adoption of biologics.	4.22	0.74
Regulatory or institutional policies influence the use of biologics in practice.	4.30	0.70
Overall Mean	**4.31**	**0.70**

Results of the barrier to biologics on guided bone regeneration for ridge preservation (Table 7). The respondents strongly agreed that substantial barriers exist to adoption of biologics in guided bone regeneration for ridge preservation. An overall mean score of 4.31 suggested a high level of agreement that while biologic use is clinically beneficial, practical, financial and institutional barriers remain factors affecting their routine incorporation into the dental office routine. Of the listed barriers, the statement with the highest mean score (M = 4.41, SD =.66) was that high cost of biologics prevented their routine administration in clinical practice. It indicated that financial considerations are still the most important barrier to become more broadly adopted. This comparatively low standard deviation corresponds to the consensus response from returnees relative to how cost acts as a limiting consideration when making clinical decisions. The statement pertaining to the necessity of additional clinical training had one of the highest recorded mean scores (M = 4.35, SD = 0.68) in highlighting UVL's need for advanced skills and specialized knowledge for multidisciplinary applicability with biologic materials (Munshi *et al.,* 2025). This data indicates that the unavailability of standardized training programs may pose a threat to the wider use of biologic-assisted regenerative methods. Regulatory or institutional factors influencing the use of biologics had a mean score of 4.30 with a standard deviation of 0.70 as administrative policies and approval systems substantially impact clinical availability, likewise, restricted availability of biologic materials scored an average of 4.28 indicating that while common obstacles in the supply chain and accessibility

may limit routine use within certain environments. The expression about limited clinical evidence recorded an average of 4.22 (SD = 0.74) signifying potentially moderate variance in respondents' views on the term itself. However, this indicates that, even as substantial evidence accrues in support of biologic use, a subset of clinicians believe additional concrete long-term and standardized clinical trials will instill greater confidence in the therapeutic application of these agents.

Overall, results indicated that respondents strongly agreed that the introduction of biologics into clinical use is hindered by multiple barriers with cost, time to train, availability (market), regulatory factors and limitations in available evidence being the most important ones. These findings underscore that despite the established clinical benefits afforded by biologics, their use in routine practice is still tempered by practical and systemic barriers (Naenni, 2022). Reducing costs, enhancing professional training programs, improving supply systems and generating stronger clinical research evidence might overcome these barriers, facilitating broader adoption and optimizing the use of biologics for ridge preservation procedures.

Findings

• Biologic integration for guided bone regeneration was significantly relevant in the context of overall and visitation rate indicators for ridge preservation.

• Biologic-assisted guided bone regeneration was associated with improved hard tissue outcomes of interest including bone density, ridge width and implant site preparation.

• Findings have indicated that the use of biologic in GBG had a positive effect on soft tissue endpoints such as tissue thickness, healing time and esthetic outcome.

• They showed that the use of biologics-assist procedures reduced post-operative complications and the predictability of healing.

• Biologics have been found to increase both clinical efficiently and procedural effectiveness for ridge preservation.

• Among dental professionals, increasing overall treatment satisfaction was associated with biologic-assisted guided bone regeneration.

• Cost, availability of the drug/s and training requirement were identified as some of the barriers towards use of biologics in routine practice despite their clinical benefits.

Recommendations

• Biologic agent's figures should be considered as adjuncts to employment in guided bone regeneration that can lead to improved overall ridge preservation outcomes.

• Biologic-assisted protocols to promote hard tissue regeneration, specifically the maintenance of bone density and growth of ridge widths for implant placement should be encouraged amongst clinicians.

• The use of biologics should be routinely considered to both enhance soft tissue healing and increase tissue thickness as well as esthetic outcomes in ridge preservation cases.

• Biologic integration should be used to reduce complications and enhance the speed and predictability of healing responses following surgery.

• In the clinical setting, biologic-assisted guided bone regeneration can be leveraged by dental professionals as a tool to increase efficiency and decrease overall treatment time of implant site development.

• The competence of clinicians in handling biologic materials should be increased through strengthening of continuing professional development (CPD) programs complemented by hands-on training.

• This study may help policy makers and healthcare institutions to make few improvements in the accessibility and affordability of biologic products with a sense that this may help in faster clinical adoption.

• Combined with high-quality clinical trials and longitudinal data, this may provide a great deal of long-term information regarding the survival rate following biologic-assisted guided bone regeneration.

• Develop standardized clinical guidelines to promote the uniform application of biologics use in ridge preservation procedures across dental and/or surgical settings.

CONCLUSION

The conclusion reached in this article is that the application of biologics with guided bone regeneration can markedly improve clinical outcomes for ridge preservation procedures. The results indicated that biologic-assisted approaches can improve regeneration of hard- and soft-tissue, characterized by greater bone density, preservation of ridge dimensions, enhanced tissue thickness, and faster and more predictable healing. Moreover, biologic integration was linked to complications after surgery, clinical efficiency and patient satisfaction among dentists. Nevertheless, these advantages have to be weighed against the main break points for usage shown in the study too: significant price point, limited accessibility, need of high-level professional training and lack of scientific proof. In conclusion, this clinical study is a compelling evidence base for the benefits of biologic-assisted guided bone regeneration while highlighting that barriers to their use need to be overcome in order for more widespread and effective integration into routine dental practice.

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