ORIGINAL ARTICLE

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COMPARATIVE EVALUATION OF TWO SURGICAL APPROACHES FOR THE REGENERATIVE TREATMENT OF INTRABONY PERIODONTAL BONE DEFECTS

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Abstract. *This study aimed to evaluate the influence of two minimally invasive surgical protocols – with different approaches to papilla management – on regenerative outcomes achieved using enamel matrix derivative in combination with bone grafts.* ***Materials and Methods:*** *Two treatment groups were analyzed, comprising a total of 19 patients diagnosed with advanced periodontitis. Group 1 included 11 patients contributing 14 vertical bone defects, treated with a combination of enamel matrix derivative (EMD) and xenograft. Group 2 consisted of 8 patients, also with 14 vertical defects, treated with EMD and allograft. The comparison between the two groups was based on three clinical parameters assessed at the 6-month follow-up: residual probing pocket depth, clinical attachment gain, and residual bone defect depth. The Shapiro–Wilk test was used to assess data distribution. Depending on normality and variance, intergroup comparisons were performed using either the Mann–Whitney U test or Welch's t-test.* ***Results:*** *Both treatment groups demonstrated similar clinical improvements at 6 months, with no statistically significant differences in residual probing pocket depth, clinical attachment gain, or residual bone defect depth.* ***Conclusion:*** *At the 6-month follow-up, both minimally invasive surgical approaches yielded comparable clinical and radiographic outcomes. Further long-term studies are warranted to assess the potential emergence of differences in soft tissue stability and clinical parameters over time.*

Key words: *minimally invasive periodontal surgery, periodontal regeneration, papilla elevation, vertical bone defects*

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INTRODUCTION

A central objective of periodontal therapy is to restore the tooth-supporting structures – alveolar bone, periodontal ligament, and cementum – that are compromised by periodontitis [1]. Contemporary approaches prioritize limited surgical trauma, enhanced wound stability, and secure primary closure to promote predictable healing and reduce postoperative morbidity [2, 3]. Minimally invasive surgical techniques have significantly reshaped the field of periodontal regenera-

tion by combining clinical efficacy with soft tissue preservation.

Secure stabilization of the blood clot is a fundamental requirement for successful healing in periodontal regenerative procedures [4]. Histological studies have demonstrated that, immediately after wound closure, a fibrin clot forms between the surgical flap and the root surface, serving as a biological scaffold for tissue regeneration [5]. However, inadequate flap stability may lead to dislodgement of the clot and apical migration of the epithelium, resulting in the formation of a long junctional epithelium rather than new connective tissue attachment. Consequently, primary wound closure and flap immobility are considered essential to support favorable healing dynamics and enhance the potential for periodontal regeneration [6].

Current minimally invasive surgical approaches emphasize minimal flap elevation and extension to reduce tissue trauma, while preserving the interdental papilla and adjacent supracrestal soft tissues. Among these techniques, the Minimally Invasive Surgical Technique (MIST) [7], its modified variants [8], and the Single Flap Approach (SFA) [9] have gained prominence for their ability to provide adequate access to intrabony defects while minimizing flap reflection and tissue manipulation. Such protocols promote effective clot stabilization and maintain regenerative space, both of which are critical to successful outcomes [8].

While much attention has been given to regenerative materials, increasing evidence suggests that the surgical technique itself – particularly how it manages interdental tissues – plays a crucial role in clinical success [10]. This study aimed to explore not only the regenerative outcomes of two different grafting materials used with enamel matrix derivative (EMD), but also the impact of distinct minimally invasive surgical protocols that differ in papilla management. Understanding how these surgical nuances influence short-term healing can provide valuable insights into optimizing regenerative periodontal therapy.

MATERIALS AND METHODS

Patient Selection

This study included two treatment groups comprising a total of 19 patients diagnosed with advanced periodontitis. Group 1 consisted of 11 patients contributing 14 vertical bone defects treated with a combination of enamel matrix derivative (EMD) and xenograft. Group 2 included 8 patients, also with 14 vertical bone defects, treated with EMD and allograft.

Patients in both groups were selected according to identical eligibility criteria. Inclusion criteria were: systemically healthy individuals aged 18 years or older, with no known allergies, and diagnosed with Stage III or IV periodontitis in accordance with the 2017 World Workshop classification [11]. All patients demonstrated satisfactory oral hygiene following initial periodontal therapy, as evidenced by a Full Mouth Plaque Score (FMPS) [12] and Full Mouth Bleeding Score (FMBS) [13] below 15%. Each participant presented with at least one interproximal angular bone defect characterized by a probing depth (PD) of ≥ 6 mm and bleeding on probing (BoP) at the time of re-evaluation.

Exclusion criteria included the presence of systemic conditions that could impair periodontal healing or outcomes, the need for antibiotic prophylaxis related to transient bacteremia, current pregnancy or breast-feeding, smoking, acute viral infections [14], parafunctions [15, 16] or insufficient plaque control.

At the tooth level, inclusion required the presence of a proximal angular defect with a radiographically detectable intrabony component of at least 3 mm, a PD of ≥ 6 mm, and the absence of periapical pathology. Teeth were excluded if they showed signs of inadequate endodontic treatment, periapical lesions, furcation involvement, Grade III mobility, or were third molars.

Ethical approval was obtained from the Research Ethics Committee at the Medical University of Sofia – KENIMUS. All participants received comprehensive information regarding the aims and methods of the study and provided written informed consent.

Surgical Procedure

Two minimally invasive regenerative protocols were employed in this study, with the primary distinction being the management of the interdental papilla. In Group 1, papilla elevation was performed to access the defect, while in Group 2, the interdental papilla was preserved *in situ*.

In Group 1, a minimally invasive surgical technique was used, incorporating papilla preservation principles. The choice of papilla preservation flap design was based on the width of the interdental space: the simplified papilla preservation flap was used in narrow spaces, while the modified papilla preservation technique was employed in wider interdental areas [2]. After elevation of the papilla, buccal and lingual incisions were extended minimally in the mesiodistal direction. Full-thickness flaps were elevated to expose only the coronal portion of the residual bony walls, minimizing tissue trauma and maintaining soft tissue integrity. This conservative flap design aimed to ensure optimal wound stability and favorable postoperative healing.

Defect debridement and root surface instrumentation were performed using a combination of ultrasonic and manual instruments. The root surfaces were then conditioned with 24% EDTA gel (PrefGel®, Straumann) for two minutes and rinsed with sterile saline. Enamel matrix derivative (Emdogain®, Straumann) was applied from the base of the defect over the exposed root surface. The xenogeneic bone graft (Bio-Oss Collagen®, Geistlich), pre-mixed with Emdogain, was placed into the intrabony defect. The flap was repositioned and secured to achieve primary closure.

In Group 2, the surgical approach followed the Single Flap Approach (SFA) proposed by Trombelli et al. [9], further refined in accordance with the Modified Minimally Invasive Surgical Technique (MIST) described by Cortellini and Tonetti [8]. A horizontal incision was made at the base of the papilla associated with the defect, followed by sulcular incisions on the adjacent teeth. The flap was initially raised as a partial-thickness flap up to the bone crest, then extended as a conservative full-thickness flap approximately 2 mm beyond the alveolar crest, without reaching the mucogingival junction. Unlike Group 1, the interdental papilla was not elevated. Instead, a horizontal incision was performed at the base of the suprabony component to detach the supracrestal soft tissues from the intrabony portion of the defect, allowing improved visualization and debridement. Thorough instrumentation of the defect and root surface was performed using ultrasonic scalers and manual curettes, ensuring complete removal of granulation tissue and bacterial deposits. As in Group 1, the root surface was conditioned with EDTA gel for two minutes, rinsed with saline, and treated with Emdogain. The allogeneic graft material (Puros Allograft, Zimmer Biomet) was mixed with Emdogain and inserted into the defect. The flap was repositioned and sutured to achieve stable closure and support healing.

All patients received systemic antibiotic therapy with amoxicillin/clavulanic acid (Augmentin® 1,000 mg) every 12 hours for 7 days, initiated one day before surgery. Patients were instructed to rinse with 0.2% chlorhexidine gluconate three times daily for one week prior to and for two weeks following the procedure, then twice daily for an additional two weeks. Sutures were removed at the two-week follow-up. Patients were provided with comprehensive oral hygiene instructions to support healing and minimize postoperative plaque accumulation.

Clinical and Radiographic Measurements

At baseline, the following clinical parameters were recorded to assess oral hygiene and periodontal status: Full Mouth Plaque Score (FMPS), Full Mouth Bleeding Score (FMBS), probing depth (PD), clinical attachment level (CAL), bleeding on probing (BoP), and gingival recession (R). Measurements were performed using a manual UNC-15 periodontal probe (Hu-Friedy) and documented at six sites per tooth in a periodontal chart. Clinical data were collected at three time points: initial diagnosis (baseline), post-non-surgical re-evaluation, and at the 6-month post-operative follow-up.

Radiographic assessment of the bone defects was performed using standardized intraoral periapical radiographs taken at two time points – initial diagnosis and 6 months post-surgery. Radiographic parameters included the depth of the intrabony component, measured from the base of the defect to the level of the interproximal bone crest of the adjacent, unaffected tooth. The defect angle was also measured, defined as the angle between the root surface and the adjacent osseous wall.

Statistical Analysis

All statistical analyses were performed using data compiled in Microsoft Excel. The normality of data distribution was assessed using the Shapiro–Wilk test. Depending on the distribution characteristics, intergroup comparisons were conducted using either the Mann–Whitney U test (for non-normally distributed variables) or Welch's t-test (for normally distributed variables with unequal variances). All statistical tests were performed using GraphPad Prism (GraphPad Software, San Diego, CA, USA), and a p-value of less than 0.05 was considered statistically significant.

RESULTS

The study cohort consisted of 19 systemically healthy patients diagnosed with Stage III or IV periodontitis, who collectively contributed 28 vertical bone defects for treatment. Group 1 comprised 11 patients (5 men and 6 women), and Group 2 included 8 patients (2 men and 6 women), with 14 defects treated in each group. The overall mean age of participants was 41 ± 7 years.

All individuals included in the study received comprehensive non-surgical periodontal therapy prior to surgical intervention. This phase involved detailed oral hygiene instructions, thorough supra- and subgingival debridement, and the removal of any local plaque-retentive factors. The marked improvement in oral hygiene parameters observed at re-evaluation confirmed the effectiveness of this initial phase and established the clinical stability necessary to proceed with the surgical regenerative procedures.

Table 1 presents the baseline data on the characteristics of the treated defects in both groups.

Table 1. Baseline characteristics of the defects

Parameter	Group 1		Group 2	
	Mean ± SD	95% CI	Mean ± SD	95% CI
PPD (mm)	7.43 ± 1.40	6.62-8.24	6.79 ± 1.67	5.82- 7.75
CAL (mm)	7.36 ± 2.13	6.12-8.59	7.43 ± 2.74	5.83-9.03
Intraoperative depth (mm)	4.36 ± 1.22	3.66-5.06	4.36 ± 1.22	3.66-5.06
Radiographic depth (mm)	4.71 ± 1.54	3.82-5.60	3.57 ± 0.85	3.08-4.06

To ensure an objective comparison of treatment outcomes between the two groups, the vertical bone defects selected for intervention were matched based on intraoperative defect depth. As shown in Table 1, the mean intraoperative measurements were closely aligned between groups, reflecting the intentional selection of defects with comparable baseline morphology. This methodological approach aimed to minimize bias and enhance the validity of the intergroup comparison.

To compare the clinical outcomes between the two treatment groups, the following parameters were analyzed at the 6-month postoperative follow-up: residual probing pocket depth (PPD), clinical attachment level (CAL) gain, and residual radiographic depth of the bone defect. Prior to conducting between-group comparisons, the distribution of each variable was assessed for normality using the Shapiro–Wilk test (Table 2).

Table 2. Results of the Shapiro–Wilk Test for Normality of Distribution of Clinical Parameters at 6-Month Follow-Up

Parameter	Group 1	Group 2	Normality Group 1	Normality Group 2
Residual pocket depth (mm)	0.033	0.065	Non-normal	Normal
Clinical attachment gain (mm)	0.399	0.364	Normal	Normal
Residual bone Defect (mm)	< 0.001	< 0.001	Non-normal	Non-normal

As indicated by the Shapiro–Wilk test results in Table 2, residual pocket depth and residual bone defect depth did not follow a normal distribution in at least one of the study groups. Accordingly, between-group comparisons for these parameters were conducted using the non-parametric Mann–Whitney U test. In contrast, clinical attachment gain demonstrated normal distribution in both groups and therefore satisfied the assumptions for parametric testing; thus, Welch's t-test was applied for its comparative analysis (Table 3).

Table 3. Comparison of Postoperative Clinical Outcomes Between Groups

Parameter	Group 1	Group 2	p-value
Residual pocket depth (mm)	2.0 [2.0-3.0]	2.5 (2.0-3.0)	0.960
Clinical attachment gain (mm)	4.0 [4.0-5.75]	4.5 (3.25-5.0)	0.888
Residual bone defect	0.0 [0.0-0.0]	0.0 (0.0-0.75)	0.290

At the 6-month follow-up, no statistically significant differences were observed between the two treatment groups across the evaluated clinical parameters. The median residual probing depth was 2.0 mm (IQR: 2.0–3.0) in the xenograft group and 2.5 mm(IQR: 2.0–3.0) in the allograft group (p = 0.960). Clinical attachment gain was comparable between groups, with median values of 4.0 mm (IQR: 4.0–5.75) for the xenograft group and 4.5 mm (IQR: 3.25–5.00 for the allograft group (p = 0.888). Residual radiographic bone defect depth was minimal in both groups, with a median of 0.0 mm in both cases, though the interquartile range was slightly wider in the allograft group (0.0–0.75) compared to the xenograft group (0.0–0.00 (p = 0.290). These findings indicate that both treatment modalities yielded comparable clinical and radiographic outcomes.

DISCUSSION

This clinical study aimed to evaluate and compare the short-term outcomes of two minimally invasive regenerative protocols for the treatment of intraosseous periodontal defects, with the primary distinction being the design of the surgical flap – either incorporating elevation of the interdental papilla or preserving it. Both approaches employed enamel matrix derivative (EMD) as a regenerative agent, while differing in the grafting material used: a xenogeneic graft in the papilla-elevation group and an allogeneic graft in the papilla-preservation group. At the six-month follow-up, both treatment modalities demonstrated comparable clinical efficacy, with no statistically significant differences observed in residual probing pocket depth, clinical attachment level gain, or residual radiographic bone defect depth. The absence of significant intergroup differences is consistent with previous reports highlighting the critical role of surgical technique, wound stability, and defect morphology in periodontal regeneration – often outweighing the choice of biomaterial alone. A systematic review

and meta-analysis of Nibali et al. [17] has shown that defect morphology plays a pivotal role in periodontal regeneration, with deeper intrabony defects characterized by narrow angles and multiple bony walls consistently achieving superior clinical attachment gains and radiographic bone fill – regardless of the grafting material applied. Similarly, evidence from another review indicates that minimally invasive surgical techniques – which enhance wound stability and reduce surgical trauma – can yield comparable clinical outcomes irrespective of the use of adjunctive biomaterials, highlighting the critical role of surgical methodology [18]. Furthermore, expert consensus reports emphasize that the variability observed in regenerative outcomes is more closely linked to defect-specific and patient-related factors, as well as surgical execution and flap design, rather than the type of biomaterial utilized [2].

Consensus reports and systematic reviews by the American Academy of Periodontology highlight that, although the use of biologics in combination with bone grafts may offer additional benefits, the primary determinants of clinical success in regenerative therapy are the surgical approach, the stability of the wound, and the specific characteristics of the defect [19, 20]. Accordingly, current evidence suggests that these factors play a more decisive role in treatment outcomes than the selection of biomaterials alone.

Taken together, these findings underscore that regenerative outcomes are primarily influenced by anatomical and technical factors rather than the specific biomaterial used. In the present study, the standardized baseline defect depth across both groups likely contributed to the homogeneity of clinical outcomes, facilitating an objective comparison. This further reinforces the critical importance of careful defect selection and surgical precision in achieving predictable regenerative success.

Considering the surgical technique itself, both the papilla preservation and the modified minimally invasive flap approaches have demonstrated comparable outcomes in the regeneration of periodontal vertical (intrabony) defects. When applied with proper attention to wound stability and defect morphology, both techniques result in significant clinical attachment level (CAL) gain, probing depth (PD) reduction, and minimal gingival recession. Evidence from randomized controlled trials and systematic reviews indicates no statistically significant differences in these primary clinical parameters when either technique is used in conjunction with enamel matrix derivative or other regenerative materials [6, 21–23].

Despite the promising results of the research, several limitations must be acknowledged. The relatively small sample size and short-term follow-up period limit the generalizability of the findings. A larger patient cohort and extended observation period would provide more robust data and may uncover subtle differences in healing dynamics or long-term stability between the grafting materials. Moreover, the study did not include a focused assessment of interdental soft tissue outcomes – particularly papilla height and recession – which are essential for both functional and esthetic success. This omission is especially relevant, given that the two surgical approaches used in this study differ in how they manage the interdental papilla, which could plausibly influence its postoperative morphology and stability. Future investigations should incorporate detailed analysis of papillary architecture to better understand the soft tissue implications of varying minimally invasive techniques [24].

Another limitation is the lack of histological validation, which remains the gold standard for assessing true periodontal regeneration. While clinical and radiographic parameters serve as valuable surrogate markers, they cannot confirm the formation of new cementum, periodontal ligament, and alveolar bone.

CONCLUSION

In conclusion, this study contributes to the growing body of evidence supporting the efficacy of regenerative periodontal therapy using minimally invasive surgical techniques combined with biologically active materials. The comparable clinical and radiographic outcomes observed between the xenograft and allograft groups suggest that both treatment modalities can effectively support tissue regeneration in deep intrabony defects. These findings reinforce the importance of individualized treatment planning and emphasize that careful defect selection and precise surgical execution remain critical determinants of success. Future studies with larger patient cohorts and long-term follow-up are warranted to confirm these results and refine clinical protocols for optimal regenerative outcomes.

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Ethical Statement: *This study has been performed in accordance with the ethical standards as laid down in the Declaration of Helsinki.*

Informed Consent from Participants: *Informed consent was obtained from all participants included in the study.*

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