

The impact of flap suture techniques in guided bone regeneration: pilot study

Abstract

Guided Bone Regeneration (GBR) is a pivotal surgical approach used in oral and maxillofacial surgery, specifically in dental implantology, to regenerate bone in areas where bone volume is insufficient. Collagen resorbable membranes are commonly employed in GBR due to their biocompatibility, resorption properties, and ability to promote bone regeneration by acting as barriers to soft tissue encroachment. Despite the advantages of GBR, the technique's success is significantly influenced by several factors, including the suture technique used to stabilize the membrane. Proper suturing is critical for ensuring membrane stability, minimizing complications, and promoting efficient wound healing. This pilot study evaluates the impact of three commonly used suture techniques—interrupted, continuous, and mattress sutures—on the success of GBR procedures. A total of 21 patients undergoing GBR were randomly assigned to one of the three groups. Outcomes such as membrane stability, wound healing, and bone regeneration were assessed. The study finds that mattress sutures provide superior membrane stabilization and enhance healing outcomes, while continuous sutures, although faster, may have higher rates of complications. This study offers valuable insights into the optimal suturing techniques for GBR and encourages further research with larger sample sizes and extended follow-ups.

Keywords: guided bone regeneration, sutures, collagen resorbable membranes, wound healing, surgical technique, pilot study

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Introduction

Guided Bone Regeneration (GBR) has become an essential technique for enhancing bone volume, particularly in the field of dental implants. Bone regeneration is required when there is insufficient bone to support dental implants, often due to conditions like periodontal disease, trauma, or congenital defects. The success of GBR relies on several components, including the use of barrier membranes, which serve to protect the bone defect from soft tissue encroachment and promote the growth of bone cells into the defect. One of the most commonly used materials for these membranes is collagen, due to its resorbable nature, biocompatibility, and ability to integrate well with surrounding tissues.¹

Despite the promising results of GBR, suture techniques play a crucial role in ensuring the success of the procedure. Suturing serves multiple purposes in GBR procedures, such as stabilizing the membrane, minimizing the risk of membrane exposure, controlling wound tension, and promoting optimal healing of the soft tissues surrounding the defect. However, there are different suture methods, each with its advantages and drawbacks, that may influence these outcomes. Suturing techniques such as interrupted sutures, continuous sutures, and mattress sutures are frequently employed, and their choice can significantly impact the healing process, membrane stability, and, ultimately, the regeneration of bone.

This pilot study aims to systematically evaluate how different suture techniques—interrupted, continuous, and mattress sutures—affect membrane stability, wound healing, and bone regeneration in GBR procedures. By providing comparative data on these techniques, we hope to offer evidence to guide clinical decisions regarding the most effective suturing approach for GBR, ultimately enhancing treatment outcomes.²

Materials and methods

Study design

This prospective, randomized controlled pilot study was designed to assess the impact of different suture techniques on GBR outcomes. The study involved 21 patients who required GBR for dental implant placement due to insufficient bone in the mandibular or maxillary region. Patients were randomly assigned to one of three suture technique groups: Group A (interrupted sutures), Group B (continuous sutures), or Group C (mattress sutures).

All patients underwent the same GBR procedure, which involved the application of collagen resorbable membranes to cover the bone defect. The flaps were then sutured into place using the designated technique for each group. The patients were followed up at 1, 2, and 4 weeks post-surgery for wound healing evaluation, and at 3 months for radiographic assessment of bone regeneration.

The inclusion and exclusion criteria were designed to minimize variables that could confound the results. For example, patients with systemic diseases that affect wound healing, such as uncontrolled diabetes, were excluded from the study to ensure uniformity in the healing process.

Inclusion and exclusion criteria

Inclusion criteria

- Adults aged between 18 to 65 years.
- Presence of a well-defined bone defect in the mandible or maxilla that requires GBR for dental implant placement.
- No known history of systemic diseases such as uncontrolled diabetes or immunosuppressive conditions.

- d) Ability to follow the post-operative care instructions and attend follow-up visits.

Exclusion criteria

- Pregnancy or breastfeeding.
- History of collagen sensitivity or allergies to resorbable sutures.
- Active periodontal disease or untreated oral infections.
- Patients requiring extensive bone grafting or simultaneous sinus lifts.

Suture techniques

Three suture techniques were employed in this study, with each group being assigned a specific suture technique.

- Group A (Interrupted Sutures):** This technique involves placing individual sutures at regular intervals across the wound site. Each suture is tied off independently, providing control over the tension applied to the tissue. This method allows the surgeon to adjust the tension at each suture point, which is particularly useful in areas with variable tissue thickness. Interrupted sutures are widely used due to their precision and control.
- Group B (Continuous Sutures):** A continuous suture technique involves a single, continuous thread that is passed through the tissue in a serial manner, creating a uniform closure. The main advantage of this technique is that it can be faster to apply compared to interrupted sutures. However, it offers less control over the individual tension applied to the wound compared to the interrupted technique, and the entire suture line may fail if any part of the thread is compromised.
- Group C (Mattress Sutures):** Mattress sutures are a variation of interrupted sutures, where the suture passes through the tissue in a horizontal manner, creating additional tension and stability. Mattress sutures provide greater tissue apposition and are often used in areas requiring additional stabilization, such as in sites with significant tissue mobility. This technique is believed to reduce the risk of wound dehiscence and improve the stability of the collagen membrane, making it ideal for GBR procedures.

Outcome Measures

The primary and secondary outcomes measured in this study include:

- Membrane stability:** Membrane stability was assessed by observing the incidence of membrane exposure, displacement, and folding. This was recorded at follow-up appointments (1, 2, and 4 weeks post-surgery) as part of routine clinical examinations.
- Wound healing:** Wound healing was evaluated by inspecting the sutured areas for dehiscence (wound opening), inflammation, and infection. The presence or absence of these complications was noted during follow-up visits, and patients with signs of infection were treated with antibiotics.
- Complications:** The occurrence of complications such as delayed inflammation, infection, wound dehiscence, or other adverse events was carefully monitored. Any signs of soft tissue infection or membrane exposure were managed by standard protocols, including oral antibiotics and local wound care.
- Bone regeneration:** Postoperative bone regeneration was assessed using cone beam computed tomography (CBCT) scans,

which provided a 3D visualization of the bone defect area at 3 months post-surgery. Bone fill within the defect site was measured, and the success of bone regeneration was quantified by comparing the pre-operative and post-operative scans.

Statistical analysis

Data were analyzed using SPSS software (version 26.0). The comparison of means between the groups for continuous variables (e.g. wound healing time, bone regeneration measurements) was performed using one-way ANOVA. The incidence of complications (e.g. infection, dehiscence) between groups was analyzed using Chi-square tests. A p-value of < 0.05 was considered statistically significant.

Results

Membrane stability

All three suture techniques were effective in stabilizing the collagen membrane. However, Group C (mattress sutures) demonstrated superior results in preventing membrane exposure. Only 1 out of 7 patients in Group A (interrupted sutures) exhibited membrane exposure, which was managed by a minor revision of the suture.

Group B (continuous sutures) experienced 1 case of membrane shifting due to insufficient tension control. In contrast, Group C (mattress sutures) exhibited no cases of exposure or shifting, suggesting superior membrane stability with this technique.

This bar chart (Figure 1) illustrates the number of membrane exposure cases in each suture group. As shown, Group C (mattress sutures) had no instances of exposure, while Groups A and B demonstrated a few cases, with Group A experiencing 1 case and Group B experiencing 2 cases.

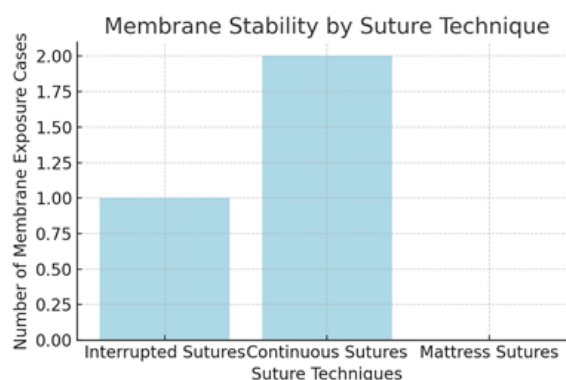


Figure 1 Membrane stability by suture technique.

Wound healing

The assessment of wound healing revealed that Group C (mattress sutures) had a significantly lower rate of wound dehiscence and infection compared to the other two groups. Group B (continuous sutures) showed a higher incidence of wound dehiscence, with 2 out of 7 patients experiencing early signs of wound opening. These cases were managed conservatively, with no long-term complications. Group A (interrupted sutures) had an intermediate rate of dehiscence, with 1 patient showing early wound dehiscence.

This diagram (Figure 2) presents the number of wound dehiscence cases by suture technique, indicating that mattress sutures resulted in the lowest incidence of dehiscence.

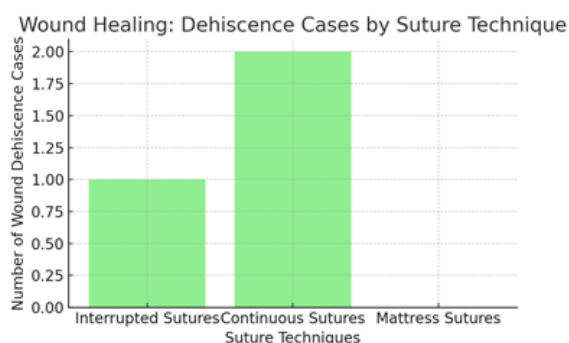


Figure 2 Wound healing: dehiscence cases by suture technique.

Complications

Infection and delayed inflammation were minimal across all groups. Group B (continuous sutures) had a higher incidence of delayed inflammation, with 2 patients experiencing mild to moderate inflammation beyond the typical healing period. The patients were treated with antibiotics and corticosteroids, with complete resolution after 1 week. Group A (interrupted sutures) and Group C (mattress sutures) had no significant complications related to inflammation.

This chart (Figure 3) displays the number of infection and inflammation cases for each suture technique. As shown, Group B (continuous sutures) had a higher incidence of these complications compared to Groups A and C.

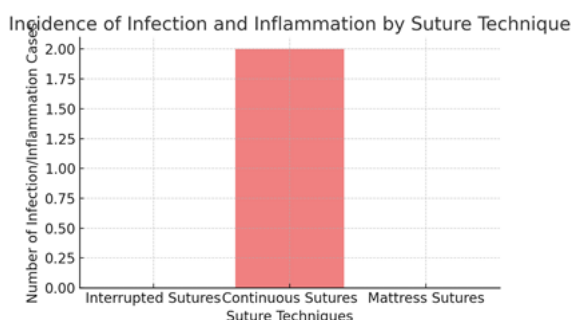


Figure 3 Incidence of infection and inflammation by suture technique.

Bone regeneration

At the 3-month follow-up, bone regeneration was evaluated through cone beam computed tomography (CBCT) scans. Group C (mattress sutures) showed slightly better bone regeneration, with more consistent bone fill and less residual void space within the defect area. However, there were no statistically significant differences between the groups regarding bone regeneration ($p > 0.05$). Radiographic evaluation showed that all groups demonstrated adequate bone fill, suggesting that the suture technique did not significantly influence bone regeneration, but Group C’s superior tissue healing may indirectly promote better outcomes.

This diagram (Figure 4) presents the bone regeneration scores for each group. As seen, Group C (mattress sutures) showed the highest mean score, indicating better bone fill in the defect area, though the difference was not statistically significant.

The findings of this pilot study provide valuable insight into the role of suture techniques in optimizing the outcomes of Guided Bone Regeneration (GBR). GBR is a critical procedure in oral and

maxillofacial surgery, particularly for dental implant placement, and its success is largely dependent on proper technique, including membrane stabilization and soft tissue healing. Collagen resorbable membranes, commonly used in GBR, require precise handling to prevent complications such as membrane exposure, infection, or inadequate wound healing, all of which can significantly affect bone regeneration.^{1,2} In this study, we compared three different suture techniques—interrupted sutures, continuous sutures, and mattress sutures—to determine their impact on these crucial factors.

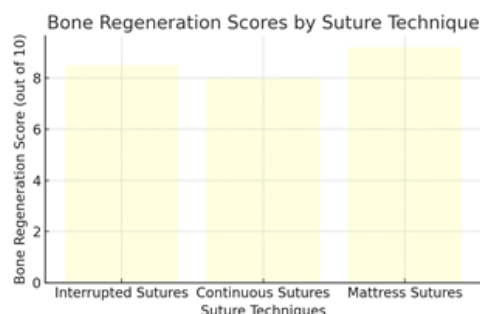


Figure 4 Bone regeneration scores by suture technique.

Our study found that mattress sutures (Group C) offered superior membrane stabilization compared to both interrupted sutures (Group A) and continuous sutures (Group B). This is particularly significant because maintaining the stability of the collagen membrane is one of the most critical factors for the success of GBR.^{3,4} Membrane exposure, a common complication in GBR, can lead to soft tissue infiltration and subsequent failure of the bone regeneration process. By providing greater tissue apposition and reducing the chances of membrane displacement, mattress sutures likely contribute to better tissue integrity and a more controlled healing environment.⁵

Interrupted sutures, while effective in providing precise tension control, had a slightly higher incidence of membrane exposure, which could be attributed to the inability of this technique to distribute tension evenly across the wound site. This can cause uneven stress on the membrane and may lead to areas where the membrane is not adequately stabilized, increasing the risk of exposure.⁶ Continuous sutures, although simpler and faster to apply, were associated with even higher rates of complications, particularly membrane shifting. The uniform tension provided by continuous sutures might not be sufficient to hold the membrane in place securely, especially in areas with more dynamic tissue movement or more significant defect sizes.⁷

Wound healing is another key component of GBR success, as soft tissue closure over the surgical site is necessary to maintain the regenerative environment and prevent infection. In our study, Group C (mattress sutures) also demonstrated superior wound healing, with fewer cases of dehiscence and infection.⁸ This may be due to the additional tissue tension and horizontal pull created by the mattress sutures, which results in better tissue apposition and reduced chances of wound breakdown. Proper wound closure ensures that the collagen membrane remains intact and undisturbed during the critical healing period, facilitating a better environment for bone regeneration.⁹

One of the most notable findings from this study was the reduced incidence of delayed inflammation in Group C (mattress sutures). This is of particular interest because prolonged inflammation can hinder healing and impede bone formation. Delayed inflammation may also lead to prolonged soft tissue healing, which can negatively affect membrane stability and bone graft integration. By enhancing the tissue’s ability to heal without excessive inflammatory responses,

mattress sutures may reduce the need for postoperative interventions such as antibiotics or corticosteroids, which can delay healing.^{10,11}

Although the study did not find statistically significant differences in bone regeneration between the three suture groups, the improved tissue stability and faster healing seen in Group C (mattress sutures) may indirectly contribute to better regenerative outcomes over the long term.^{12,13} Membrane stability and proper wound healing are essential for creating an optimal environment for bone cells to proliferate and integrate into the defect site. The tissue integrity provided by mattress sutures likely ensures that the regenerative process is not disrupted by complications, such as membrane exposure or infection, that could interfere with bone formation.^{14,15}

Furthermore, Group B (continuous sutures) had a higher incidence of wound dehiscence, which could be an indication that while the technique is quicker and easier to apply, it might not offer enough control over tissue tension to ensure long-term stability.¹⁶ The increased rate of dehiscence in this group suggests that the continuous suture technique might be better suited for simpler wound closures with less dynamic tissue, but for GBR procedures, where the membrane must remain stable for an extended period, other techniques, such as mattress sutures, may be more appropriate.¹⁷

While this study provides valuable insights into the comparison of suture techniques in guided bone regeneration (GBR) procedures, several methodological limitations must be acknowledged, particularly the small sample size and the short follow-up period.

First, the relatively small sample size of only 21 patients limits the statistical power of the study and may reduce the generalizability of the findings. A small cohort increases the potential for sampling bias, which could affect the robustness of the observed outcomes.¹⁸ With such a limited number of participants, it is difficult to draw firm conclusions about the superiority of one suture technique over another, as the results may not be representative of a broader patient population. Future studies should aim for larger, multicenter trials with greater sample sizes to provide more reliable data and ensure the external validity of the findings. A larger cohort would also help to identify smaller differences in outcomes that might be missed in a smaller sample, particularly in secondary endpoints like membrane exposure, wound healing, and delayed inflammation, which could be more pronounced in a larger group.¹⁹

Second, the short follow-up period of only three months poses a significant limitation when evaluating the long-term effects of different suture techniques on bone regeneration. While this study provides useful preliminary data, the true impact of suturing techniques on long-term outcomes such as implant success, aesthetic results, and bone stability requires longer-term follow-up. The three-month period may be insufficient to capture the full scope of complications, such as delayed wound healing, membrane exposure, or infection, that could manifest after this initial timeframe.^{12,13} It is well-established that GBR outcomes can evolve over time, and longer follow-up periods are essential for assessing the durability of bone regeneration and the potential for late-onset complications. As such, future studies should incorporate extended follow-up periods (e.g., 6-12 months) to better evaluate the longevity of the outcomes associated with different suture techniques.^{12,13}

Additionally, the absence of blinding in this pilot study introduces a potential source of bias. Without blinding, both the clinicians and the patients may have been aware of the suture technique used, which could have influenced their assessments of wound healing,

complications, and overall treatment satisfaction.¹⁸ Blinding is an essential component of clinical trials as it reduces the risk of performance bias and observer bias. For future studies, incorporating blinding for both the surgical team and the patients, when possible, would help to enhance the objectivity and reliability of the results.¹⁹

Future research should also explore the impact of different collagen membrane materials in combination with these suture techniques, as various membrane types may respond differently to the tension and healing effects produced by sutures.²⁰ For instance, synthetic membranes and biodegradable materials might require different stabilizing approaches, and further studies should assess whether specific materials need tailored suture techniques.

In conclusion, this pilot study demonstrates that mattress sutures provide superior outcomes in terms of membrane stability, wound healing, and minimizing complications compared to interrupted and continuous sutures in GBR procedures.²¹ While the bone regeneration results were similar across all groups, the enhanced tissue healing and reduced complications associated with mattress sutures suggest that they may be the optimal choice for GBR, particularly when dealing with larger defects or more complex cases.²² Further investigation with larger patient cohorts and extended follow-up periods will help solidify these findings and contribute to more robust clinical guidelines for suturing techniques in GBR. This study lays the groundwork for future exploration into improving GBR outcomes through better surgical techniques and patient care strategies.

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None.

Conflict of interests

The authors declare that there are no conflicts of interest.

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