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COMPARATIVE EVALUATION OF BIOACTIVE GLASS AND PLATELET-RICH BIOMATERIALS ON SOFT-TISSUE HEALING IN MINOR ORAL SURGERY: A CLINICAL AND HISTO-BIOLOGICAL STUDY

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ABSTRACT

Background: Accelerating soft-tissue healing following minor oral surgical procedures is essential to minimize postoperative discomfort and reduce healing-related complications. Bioactive glass and platelet-rich biomaterials, such as platelet-rich fibrin (PRF), have shown promising regenerative capabilities due to their bioactivity, growth-factor release, and influence on cellular proliferation.

Objective: To compare the clinical and histo-biological effects of bioactive glass and platelet-rich biomaterials on soft-tissue healing in patients undergoing minor oral surgery.

Methods: A randomized, split-mouth clinical trial was conducted on xx patients requiring symmetrical minor oral surgical procedures. Surgical sites were allocated into Group A (bioactive glass application) and Group B (PRF application). Clinical healing was evaluated at Days 3, 7, and 14 using the Landry, Turnbull, and Howley Wound Healing Index. Tissue samples from a subset of patients were collected at Day 7 for histo-biological assessment, including inflammatory cell count, fibroblast density, angiogenesis scoring, and epithelial thickness.

Results: Group B (PRF) showed significantly lower postoperative pain scores and superior early soft-tissue healing at Day 3 ($p < 0.05$). By Day 14, both groups demonstrated comparable clinical healing outcomes. Histologically, PRF demonstrated higher fibroblast activity and angiogenesis, while bioactive glass exhibited enhanced mineralized tissue deposition and improved epithelial maturation.

Conclusion: Both bioactive glass and PRF effectively enhance soft-tissue healing in minor oral surgery. PRF offers faster early healing due to its autologous growth-factor release, whereas bioactive glass demonstrates more pronounced tissue remodelling. A combination approach may yield synergistic healing benefits.

Keywords: Bioactive glass, platelet-rich fibrin, soft-tissue healing, minor oral surgery, wound healing.

INTRODUCTION

The repair of soft tissue is crucial for the overall effectiveness of oral surgical treatments. After minor oral surgeries, such as impacted tooth extraction, periapical curettage, frenectomies, biopsies, and alveoloplasty the healing process is affected by the quality of the wound environment, local blood supply, host immunological response, and the biomaterials utilized during the procedure.[1] Regenerative biomaterials have recently garnered attention for their capacity to promote healing by modifying biological processes, reducing inflammation, increasing tissue development, and enhancing patient comfort.[2]

Bioactive glass (BAG), initially introduced by Hench in the late 1960s, has evolved from a bone-regenerative substance into a multifunctional bioactive agent extensively utilized in dentistry. When BAG is exposed to wound fluids, it undergoes rapid ion exchange, releasing calcium, phosphate, sodium, and silica ions that trigger cellular reactions.[3] Protein adsorption and fibroblast movement are facilitated by the development of a hydroxycarbonate apatite (HCA) layer, and its ionic dissolution products have antibacterial and angiogenic properties. These ions can promote the creation of reparative tissue, lessen excessive inflammation, and alter macrophage polarization in soft-tissue healing.[4] Because of this, BAG is a dual-action substance that has anti-inflammatory and regenerating properties. It is particularly helpful for oral wounds that are vulnerable to bacterial colonization.[1]

Autologous platelet concentrates, such as Platelet-Rich Fibrin (PRF), have gained popularity as regenerative treatments due to their simplicity, biocompatibility, and high concentration of cytokines and growth factors. PRF is made from the patient's own blood without using anticoagulants, resulting in a fibrin mesh that traps leukocytes and platelets.[5] For up to 10 to 14 days, this structure slowly produces physiologically active chemicals such as TGF-β, PDGF, VEGF, IGF, and EGF. These chemicals are very important for angiogenesis, extracellular matrix deposition, collagen production, and epithelial proliferation.[6] The presence of leukocytes aids in immunomodulation and diminishes the risk of postoperative infection. PRF has therefore been progressively employed in extraction socket healing, mucosal regeneration, periodontal flap operations, and sinus lift treatments.[3]

Direct comparable studies are few, however bioactive glass and PRF have independently improved soft-tissue regeneration. Clinically, PRF is thought to heal wounds faster because to its biological nature, whereas BAG's mineral-inducing properties rebuild them longer.[7] However, the clinical and histological variations in healing dynamics in soft tissue rather than bone are still poorly understood. Comprehending the comparative efficacy of these materials holds important clinical significance. Enhanced soft-tissue healing results in decreased postoperative pain, fewer complications, increased patient satisfaction, and a quicker return to normal function. Furthermore, comparing an autologous biological product (PRF) with a commercially produced synthetic bioactive glass can assist clinicians in making well-informed decisions regarding cost-effectiveness, accessibility, handling properties, and expected therapeutic results.[8]

This study aimed to compare the clinical and histobiological effects of bioactive glass and platelet-rich fibrin in minor oral surgical wounds. This study utilizes standardized clinical evaluations and microscopic analysis of healing tissues to provide evidence-based insights regarding the efficacy of various biomaterials in soft-tissue regeneration and the specific clinical contexts in which each material may be most advantageous.

METHODOLOGY

This randomized split-mouth clinical and histo-biological study was conducted at the Department of Oral and Maxillofacial Surgery, following approval from the Institutional Ethics Committee vide No. ERC/0-2349-1. A total of 66 systemically healthy patients aged 18–45 years who required bilateral symmetrical minor oral surgical procedures were recruited after obtaining informed consent.

The split-mouth design allowed each patient to act as their own control. One surgical site was randomly assigned to receive bioactive glass (Group A), while the contralateral site was treated with platelet-rich fibrin (Group B). PRF was prepared immediately prior to surgery by centrifuging 10 mL of venous blood at 2700 rpm for a duration of 12 minutes. Bioactive glass granules of 45S5 composition were utilized in accordance with the manufacturer's protocol.

All surgeries were performed by the same surgeon under aseptic conditions. After local anesthesia, mucoperiosteal flaps were elevated and the necessary surgical procedure completed. Before closure, the allocated biomaterial was placed at each site, and the flaps were sutured with 3-0 silk sutures. Patients received standard postoperative instructions and analgesics but no antibiotics unless clinically indicated.

Clinical healing was evaluated on Days 3, 7, and 14 using the Landry, Turnbull, and Howley Wound Healing Index. Pain was assessed using a 10-point Visual Analog Scale (VAS). A subset of patients consented to soft-tissue biopsy at Day 7, which was processed for histological analysis to quantify inflammatory infiltrate, fibroblast density, angiogenesis, epithelial thickness, and collagen organization using hematoxylin-eosin and Masson trichrome staining.

Data were analyzed using SPSS version 28. Paired t-tests and ANOVA were applied for inter-group and intra-group comparisons, with $p < 0.05$ considered statistically significant.

RESULTS

PRF demonstrated significantly better early healing (Days 3 and 7), which is crucial for reducing postoperative complications, improving patient comfort, and minimizing infection risk (Table 1). PRF significantly reduced postoperative pain in the early period, which is clinically important because faster pain relief improves patient satisfaction and reduces the need for analgesics (Table 2).

Table 1: Mean Wound Healing Index Scores

Day	Bioactive Glass (Mean ± SD)	PRF (Mean ± SD)	p-value
Day 3	3.1 ± 0.6	4.2 ± 0.5	0.001
Day 7	4.0 ± 0.5	4.6 ± 0.4	0.010
Day 14	4.8 ± 0.3	4.9 ± 0.2	0.380

Table 2: Mean VAS Pain Scores

Day	Bioactive Glass (Mean ± SD)	PRF (Mean ± SD)	p-value
Day 1	6.5 ± 1.2	4.9 ± 1.1	0.002
Day 3	4.1 ± 1.0	2.6 ± 0.9	0.001
Day 7	1.8 ± 0.7	1.4 ± 0.6	0.090

Table 3: Comparison of Histological Parameters at Day 7

Parameter	Bioactive Glass	PRF	Interpretation
Inflammatory cells (cells/HPF)	42 ± 8	28 ± 7	PRF shows lower inflammation
Fibroblast density (cells/HPF)	56 ± 10	84 ± 12	PRF significantly higher
Microvessel density (vessels/mm²)	18 ± 4	29 ± 5	PRF shows higher angiogenesis
Epithelial thickness (μm)	185 ± 22	148 ± 20	BAG more mature epithelium
Collagen organization (score 1–4)	3.1 ± 0.4	2.7 ± 0.3	BAG shows better organization

The histological findings indicate that PRF accelerates biological processes associated with early healing, including angiogenesis, fibroblast proliferation, and inflammation reduction, whereas

bioactive glass promotes subsequent tissue remodelling and epithelial maturation. This distinction is crucial for selecting the suitable biomaterial based on clinical objectives.

DISCUSSION

This study reveals distinct differences in soft-tissue healing patterns associated with bioactive glass and platelet-rich fibrin in the early postoperative phase after minor oral surgery. PRF demonstrated enhanced early clinical healing and decreased pain, while bioactive glass played a more significant role in epithelial maturation and the structural organization of healing tissues. The findings align with the specific biological mechanisms associated with each biomaterial.

Prior research indicates that PRF promotes early soft-tissue healing through its supply of growth factors. Hazari et al. (2019)[9] demonstrated enhanced epithelialization and angiogenesis in extraction sockets treated with PRF. Rajendra et al. (2019)[10] reported comparable findings, highlighting the prolonged release of TGF-β1 and PDGF over multiple days, which facilitates fibroblast proliferation and collagen synthesis. The results corroborate these observations, indicating that PRF-treated sites demonstrated elevated fibroblast density and enhanced neovascularization.

Bioactive glass has been primarily investigated regarding its role in bone regeneration. Recent research has emphasized its significance in soft-tissue healing. Giannelli et al. (2025)[11] showed that BAG dissolution products enhance angiogenesis by activating VEGF pathways. Shaikh et al. (2023)[12] identified the anti-inflammatory properties of BAG, highlighting its capacity to modulate macrophage phenotype from M1 to M2, thereby facilitating tissue repair. Our study indicates that BAG-treated sites exhibited increased epithelial thickness and improved collagen organization, implying enhanced remodelling rather than merely early inflammatory resolution.[13]

Direct comparisons between PRF and BAG are still restricted. In a study of periodontal intrabony defects, Sun et al. (2024)[14] discovered that PRF enhanced early gingival healing whereas bioactive glass produced greater long-term structural regeneration. This aligns with our findings: PRF facilitated quick soft-tissue closure, whereas BAG contributed to strong tissue remodelling by Day 14. One possible explanation for PRF's improved early effects is its autologous origin, which eliminates immunological responses while delivering bioactive chemicals directly to the wound.[15] In contrast, BAG requires dissolving and ion exchange to activate biological reactions, which may delay its early therapeutic impact. Nonetheless, once triggered, BAG creates a regulated milieu ideal for long-term tissue integration.

The histological analysis in this study revealed distinct patterns: PRF facilitated significant angiogenesis and fibroblastic activity, while BAG promoted epithelial maturation, likely due to bioactive ions stimulating keratinocyte proliferation.[16] The identified advantages indicate a possible synergistic effect when employing both materials together PRF for expedited wound closure and BAG for sustained tissue reinforcement. The findings of this study are consistent with existing literature and provide new comparative evidence relevant to minor oral surgery. The findings indicate that PRF is more effective as an early-stage healing enhancer, whereas BAG may provide benefits during the later maturation phases. Long-term studies, molecular cytokine analyses, and clinical trials of combination therapies may enhance understanding of their synergistic potential.[17]

CONCLUSION

PRF demonstrates enhanced efficacy in early soft-tissue healing through mechanisms involving growth factor-mediated angiogenesis and fibroblast activation. Bioactive glass plays a crucial role in epithelial maturation and tissue remodelling. Both materials offer significant regenerative advantages, with clinical selection potentially influenced by procedural needs.

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