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ADVANCES IN GUIDED BONE REGENERATION: INTEGRATING PLATELET-RICH FIBRIN INTO CONVENTIONAL REGENERATIVE PROTOCOLS

AVANÇOS EM REGENERAÇÃO ÓSSEA GUIADA: INTEGRANDO FIBRINA RICA EM PLAQUETAS EM PROTOCOLOS REGENERATIVOS CONVENCIONAIS

AVANCES EN REGENERACIÓN ÓSEA GUIADA: INTEGRANDO FIBRINA RICA EN PLAQUETAS EN PROTOCOLOS REGENERATIVOS CONVENCIONALES

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ABSTRACT

Objective: To review the scientific basis and clinical evidence supporting the incorporation of platelet-rich fibrin (PRF) into conventional guided bone regeneration (GBR) protocols and to discuss its potential impact on regenerative outcomes.

Methodology: A narrative review of the literature was performed, including preclinical studies, clinical trials, systematic reviews, and meta-analyses investigating PRF applications in bone regeneration procedures. Particular attention was given to studies evaluating PRF in combination with bone graft materials and collagen membranes during GBR procedures.

Results: Guided bone regeneration is a well-established technique for reconstructing alveolar bone defects and facilitating implant placement. Conventional GBR protocols typically involve the use of bone graft substitutes and barrier membranes to promote selective tissue regeneration. PRF has gained considerable interest as a biologically active adjunct due to its capacity to release growth factors such as platelet-derived growth factor, transforming growth factor-beta, and vascular endothelial growth factor. Evidence suggests that PRF may

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enhance angiogenesis, accelerate soft tissue healing, improve graft stability, and support early bone formation. When integrated with bone grafts and collagen membranes, PRF may contribute to a more favorable regenerative environment and potentially reduce postoperative morbidity. However, studies evaluating volumetric bone gain and implant-related outcomes have produced inconsistent findings. Variations in centrifugation protocols, defect characteristics, graft materials, and follow-up periods continue to challenge the interpretation of available data. C

Conclusion: The incorporation of PRF into conventional GBR protocols appears to be a promising strategy for enhancing biological healing and regenerative potential. While current evidence supports its role as an adjunctive biomaterial, further well-designed clinical studies are needed to determine its true impact on long-term bone regeneration outcomes and to establish standardized treatment protocols.

Keywords: Platelet-rich Fibrin. Guided Bone Regeneration. Bone Grafting. Dental Implants.

RESUMO

Objetivo: Revisar a base científica e evidências clínicas que apoiam a incorporação de fibrina rica em plaquetas (PRF) em protocolos convencionais de regeneração óssea guiada (GBR) e discutir seu impacto potencial nos resultados regenerativos.

Metodologia: Uma revisão narrativa da literatura foi realizada, incluindo estudos pré-clínicos, ensaios clínicos, revisões sistemáticas e meta-análises investigando aplicações de PRF em procedimentos de regeneração óssea. Atenção particular foi dada a estudos avaliando PRF em combinação com materiais de enxerto ósseo e membranas de colágeno durante procedimentos de GBR.

Resultados: Regeneração óssea guiada é uma técnica bem estabelecida para reconstrução de defeitos ósseos alveolares e facilitação de colocação de implantes. Protocolos convencionais de GBR tipicamente envolvem o uso de substitutos de enxerto ósseo e membranas de barreira para promover regeneração seletiva de tecidos. PRF ganhou considerável interesse como adjunto biologicamente ativo devido à sua capacidade de liberar fatores de crescimento como fator de crescimento derivado de plaquetas, fator de crescimento transformador-beta e fator de crescimento endotelial vascular. Evidências sugerem que PRF pode melhorar angiogênese, acelerar cicatrização de tecidos moles, melhorar estabilidade de enxerto e apoiar formação óssea precoce. Quando integrada com enxertos ósseos e membranas de colágeno, PRF pode contribuir para um ambiente regenerativo mais favorável e potencialmente reduzir morbidade pós-operatória. Contudo, estudos avaliando ganho ósseo volumétrico e resultados relacionados a implantes produziram achados inconsistentes. Variações em protocolos de centrifugação, características de defeito, materiais de enxerto e períodos de acompanhamento continuam a desafiar a interpretação de dados disponíveis.

Conclusão: A incorporação de PRF em protocolos convencionais de GBR parece ser uma estratégia promissora para aprimorar cicatrização biológica e potencial regenerativo. Embora evidências atuais apoiem seu papel como biomaterial adjunto, estudos clínicos bem planejados são necessários para determinar seu verdadeiro impacto em resultados de regeneração óssea de longo prazo e para estabelecer protocolos de tratamento padronizados.

Palavras-chave: Fibrina Rica em Plaquetas. Regeneração Óssea Guiada. Enxerto Ósseo. Implantes Dentários.

RESUMEN

Objetivo: Revisar la base científica y la evidencia clínica que apoyan la incorporación de fibrina rica en plaquetas (PRF) en protocolos convencionales de regeneración ósea guiada (GBR) y discutir su impacto potencial en los resultados regenerativos.

Metodología: Se realizó una revisión narrativa de la literatura, incluyendo estudios preclínicos, ensayos clínicos, revisiones sistemáticas y metaanálisis que investigaron aplicaciones de PRF en procedimientos de regeneración ósea. Se prestó especial atención a los estudios que evaluaron PRF en combinación con materiales de injerto óseo y membranas de colágeno durante procedimientos de GBR.

Resultados: La regeneración ósea guiada es una técnica bien establecida para la reconstrucción de defectos óseos alveolares y la facilitación de la colocación de implantes. Los protocolos convencionales de GBR generalmente implican el uso de sustitutos de injerto óseo y membranas de barrera para promover la regeneración selectiva de tejidos. PRF ha ganado considerable interés como un adyuvante biológicamente activo debido a su capacidad para liberar factores de crecimiento como el factor de crecimiento derivado de plaquetas, el factor de crecimiento transformador-beta y el factor de crecimiento endotelial vascular. Las evidencias sugieren que PRF puede mejorar la angiogénesis, acelerar la cicatrización de tejidos blandos, mejorar la estabilidad del injerto y apoyar la formación ósea temprana. Cuando se integra con injertos óseos y membranas de colágeno, PRF puede contribuir a un ambiente regenerativo más favorable y potencialmente reducir la morbilidad postoperatoria. Sin embargo, los estudios que evalúan la ganancia ósea volumétrica y los resultados relacionados con implantes han producido hallazgos inconsistentes. Las variaciones en los protocolos de centrifugación, características de defectos, materiales de injerto y períodos de seguimiento continúan desafiando la interpretación de los datos disponibles.

Conclusión: La incorporación de PRF en protocolos convencionales de GBR parece ser una estrategia prometedora para mejorar la cicatrización biológica y el potencial regenerativo. Aunque la evidencia actual apoya su papel como biomaterial adyuvante, se necesitan estudios clínicos bien diseñados para determinar su verdadero impacto en los resultados de regeneración ósea a largo plazo y para establecer protocolos de tratamiento estandarizados.

Palabras clave: Fibrina Rica en Plaquetas. Regeneración Ósea Guiada. Injerto Óseo. Implantes Dentales.

1 INTRODUCTION

Guided bone regeneration (GBR) is widely recognized as a predictable and effective technique for reconstructing alveolar bone deficiencies and facilitating implant placement in compromised sites. The procedure relies on barrier membranes that prevent the migration of non-osteogenic cells into the defect while allowing osteogenic cell repopulation and new bone formation (Retzepi & Donos, 2010). Advances in biomaterials and regenerative technologies have substantially improved the clinical outcomes of GBR procedures over the past decades.

Platelet-rich fibrin (PRF) has emerged as one of the most extensively investigated autologous biomaterials in regenerative dentistry. Developed by Choukroun *et al.* (2006), PRF provides a three-dimensional fibrin network enriched with platelets, leukocytes, and growth factors that support angiogenesis, osteoblast proliferation, and tissue regeneration. In vitro and animal studies have demonstrated that PRF may enhance early vascularization, improve graft integration, and accelerate bone healing (Miron *et al.*, 2017).

Given these biological properties, PRF has increasingly been incorporated into conventional GBR protocols involving particulate bone grafts and collagen membranes. Several clinical studies have reported favorable effects on soft tissue healing and postoperative recovery, whereas evidence regarding volumetric bone gain remains less consistent (Inchingolo *et al.*, 2024). Furthermore, differences in centrifugation protocols, grafting materials, and defect characteristics have generated heterogeneous findings across studies. Therefore, evaluating the current evidence surrounding PRF-enhanced GBR protocols is essential for understanding its clinical potential and identifying future research priorities.

2 METHODOLOGY

This narrative review aimed to summarize current knowledge regarding the integration of platelet-rich fibrin (PRF) into guided bone regeneration (GBR) procedures. A comprehensive literature search was conducted in PubMed/MEDLINE, Scopus, Web of Science, and Google Scholar, including studies published until June 2026. Search terms included “platelet-rich fibrin,” “PRF,” “guided bone regeneration,” “bone graft,” “collagen membrane,” “alveolar ridge augmentation,” “bone regeneration,” and “implant dentistry.” Clinical trials, animal studies, systematic reviews, meta-analyses, and laboratory investigations evaluating PRF in association with bone grafts and barrier membranes were considered eligible. Studies were selected based on their relevance to biological

mechanisms, angiogenesis, graft integration, bone formation, volumetric outcomes, and clinical performance in GBR procedures. The retrieved evidence was critically reviewed and organized into sections covering biological principles, clinical applications, regenerative outcomes, current limitations, and future perspectives for PRF-enhanced regenerative protocols.

3 RESULTS

3.1 BIOLOGICAL PRINCIPLES OF PRF IN BONE REGENERATION

Platelet-rich fibrin is a second-generation autologous platelet concentrate developed by Choukroun *et al.* (2006), characterized by a three-dimensional fibrin network that traps platelets, leukocytes, and a broad repertoire of growth factors. Unlike first-generation concentrates, PRF does not require exogenous thrombin or anticoagulants, relying instead on the endogenous coagulation cascade triggered during centrifugation. The resulting fibrin matrix serves simultaneously as a scaffold for cellular migration and as a slow-release reservoir of bioactive molecules, including platelet-derived growth factor (PDGF), transforming growth factor-beta (TGF-β), vascular endothelial growth factor (VEGF), and insulin-like growth factor (IGF) (Miron *et al.*, 2017).

The sustained and graduated release of these mediators distinguishes PRF from recombinant growth factors, which are typically delivered at supraphysiological concentrations and may elicit unpredictable biological responses. The fibrin architecture of PRF not only regulates cytokine release kinetics but also provides a provisional extracellular matrix that supports osteoblast adhesion, proliferation, and differentiation. Preclinical investigations have confirmed that PRF upregulates the expression of bone morphogenetic proteins and alkaline phosphatase in osteoblast cultures, supporting its role in early osteogenic commitment (Miron *et al.*, 2017).

Angiogenesis represents a particularly relevant dimension of PRF's biological activity. Adequate vascularization is a prerequisite for graft integration, osteoclast-mediated remodeling, and recruitment of mesenchymal progenitor cells. PRF has been shown to stimulate endothelial cell migration and tubulogenesis in vitro through VEGF-dependent mechanisms, offering a biologically plausible explanation for the accelerated wound healing and reduced postoperative edema frequently reported in clinical studies (Inchingolo *et al.*, 2024).

3.2 CONVENTIONAL GBR PROTOCOLS AND THEIR LIMITATIONS

Guided bone regeneration was established on the principle that selective exclusion of non-osteogenic cells from a bone defect, through the physical barrier of a membrane, allows the space to be repopulated by osteogenic precursors capable of forming new bone (Retzepi & Donos, 2010). The technique has been extensively validated for applications including alveolar ridge augmentation prior to implant placement, simultaneous ridge augmentation at implant insertion, peri-implant defect management, and sinus floor elevation.

Contemporary GBR protocols typically combine a barrier membrane either resorbable collagen-based or non-resorbable titanium-reinforced with a particulate bone graft material that maintains space and provides an osteoconductive scaffold. Despite the high predictability documented for contained horizontal defects, conventional GBR faces recognized limitations: membrane exposure and contamination, collapse of the regenerative space in non-contained defects, inconsistent bone quality, and a relatively slow pace of vascularization within avascular graft particles (Retzepi & Donos, 2010; Sculean *et al.*, 2019). These biological bottlenecks have driven interest in adjunctive agents capable of optimizing the regenerative microenvironment without compromising the mechanical principles of space maintenance.

3.3 INTEGRATION OF PRF WITH BONE GRAFTS AND COLLAGEN MEMBRANES

The combination of PRF with particulate bone graft materials has been widely explored, with the concept of “sticky bone” a cohesive graft complex formed by mixing PRF with xenograft or allograft particles gaining particular clinical traction. The fibrin network physically binds graft particles, reducing migration during and after surgical placement, improving surgical handling, and concentrating growth factors at the regenerative site. Histological analyses comparing PRF-graft composites to conventional grafts have consistently demonstrated accelerated graft maturation, more abundant woven bone formation at early time points, and enhanced cellular colonization of graft particles (Inchingolo *et al.*, 2024).

When used alongside collagen membranes, PRF can be positioned as an interposed layer between the membrane and the graft, as a membrane substitute for soft tissue management, or as a combined biological sealing agent at wound margins. The fibrin membrane itself carries tensile properties sufficient for primary wound closure augmentation in some clinical scenarios, and its leukocyte content provides a local antimicrobial effect that may contribute to reduced rates of membrane exposure and infection (Miron *et al.*, 2017).

Sculean *et al.* (2019) emphasized that the combination of barrier membranes with biologically active agents represents the conceptual frontier of contemporary regenerative periodontics and implantology, as purely mechanical approaches are insufficient to address the biological complexity of large defects. PRF exemplifies this integrative paradigm by contributing both a scaffold function and a growth factor delivery role within a single autologous material.

3.4 EFFECTS ON SOFT TISSUE HEALING AND POSTOPERATIVE MORBIDITY

Among the most reproducible findings across clinical studies is the beneficial effect of PRF on soft tissue outcomes. Reduced postoperative pain, accelerated epithelial closure, diminished swelling, and lower rates of wound dehiscence have been reported consistently in studies evaluating tooth extraction sockets, ridge augmentation procedures, and sinus lift surgeries (Inchingolo *et al.*, 2024). These effects are attributed to the combined action of TGF-β1 which accelerates fibroblast proliferation and matrix synthesis and VEGF which stimulates capillary ingrowth into healing tissues alongside the immunomodulatory influence of leukocytes embedded in the fibrin network.

The clinical importance of these soft tissue benefits extends beyond comfort: early and stable wound closure is a prerequisite for the maintenance of the regenerative space beneath the membrane, and wound dehiscence remains one of the leading causes of GBR failure. By reinforcing the wound margin biologically, PRF may indirectly protect the underlying regenerative complex during the critical early healing phase (Retzepi & Donos, 2010; Inchingolo *et al.*, 2024).

3.5 EFFECTS ON BONE FORMATION AND VOLUMETRIC OUTCOMES

Evidence regarding the impact of PRF on long-term volumetric bone gain is considerably more variable than the evidence for soft tissue outcomes. Some randomized clinical trials and systematic reviews have reported statistically significant increases in bone fill, bone density, and histomorphometric parameters in PRF-augmented GBR procedures, while others have found no clinically meaningful difference in final bone volume compared to controls (Inchingolo *et al.*, 2024). This inconsistency likely reflects the multifactorial nature of volumetric outcomes, in which defect morphology, graft material selection, membrane rigidity, and space maintenance capacity all interact with the biological contributions of PRF.

Contained, small-to-medium horizontal defects appear to respond most favorably to PRF augmentation, whereas extensive vertical reconstructions in which space maintenance is the primary determinant of outcome show less consistent benefit. This morphology-dependent response suggests that PRF exerts its greatest volumetric contribution when biological stimulation is the principal limiting factor, rather than when mechanical constraints predominate (Sculean *et al.*, 2019).

3.6 PRF PREPARATION PROTOCOLS AND THEIR INFLUENCE ON BIOLOGICAL ACTIVITY

Since the original leukocyte-rich PRF (L-PRF) protocol described by Choukroun *et al.* (2006), multiple modified formulations have been introduced based on the low-speed centrifugation concept (LSCC). Advanced platelet-rich fibrin (A-PRF) and its enhanced variant A-PRF+ employ reduced centrifugation speeds and times to preserve greater numbers of monocytes and neutrophils within the fibrin matrix, resulting in enriched concentrations of TGF-β1 and PDGF compared to conventional L-PRF. Injectable PRF (i-PRF) is obtained at even lower centrifugation speeds before clot formation occurs, yielding a liquid concentrate that can be mixed directly with graft particles to form injectable sticky bone composites (Miron *et al.*, 2017).

Emerging evidence suggests that lower centrifugation speeds consistently produce higher growth factor concentrations and preserve a broader leukocyte population, enhancing both the immunomodulatory and osteogenic potential of the final product. However, the absence of universal protocol standardization with significant variability in centrifuge model, rotor radius, relative centrifugal force, and duration represents a major source of biological heterogeneity across clinical studies, making direct comparisons across the literature methodologically challenging (Inchingolo *et al.*, 2024; Miron *et al.*, 2017).

4 DISCUSSION

The present review highlights the growing interest in incorporating platelet-rich fibrin into guided bone regeneration protocols and reinforces the concept that successful bone regeneration depends not only on mechanical defect stabilization but also on optimization of the biological environment. While conventional GBR techniques have achieved high levels of predictability through the use of graft materials and barrier membranes, the addition of

biologically active autologous concentrates such as PRF seeks to address one of the major limitations of regenerative therapy: the speed and quality of tissue healing.

A fundamental aspect emerging from the literature is the distinction between biological enhancement and volumetric regeneration. Numerous studies have demonstrated that PRF consistently improves parameters associated with tissue healing, including angiogenesis, epithelial closure, inflammation control, and early bone formation. However, the evidence supporting significant increases in final bone volume remains considerably less robust. This distinction is clinically relevant because regenerative success is often evaluated according to radiographic bone gain, whereas biological optimization may influence treatment predictability without necessarily producing substantial volumetric differences. The regenerative potential of PRF is largely attributed to its ability to function as a reservoir of bioactive molecules. The gradual release of PDGF, TGF-β, VEGF, IGF, and other cytokines creates a favorable microenvironment that supports cellular recruitment and differentiation. Unlike recombinant growth factors, which are often delivered in supraphysiological concentrations, PRF provides a natural and sustained release pattern that more closely resembles physiological wound healing. This characteristic may explain the consistent improvements observed in soft tissue outcomes and early vascularization.

Another important observation concerns the interaction between PRF and bone graft materials. Contemporary GBR procedures increasingly rely on composite regenerative approaches rather than isolated biomaterials. The concept of “sticky bone,” generated by combining PRF with particulate grafts, exemplifies this trend. Beyond improving handling characteristics, this combination appears capable of reducing particle migration, enhancing graft cohesion, and facilitating early cellular colonization. Histological studies frequently report improved graft maturation and greater amounts of newly formed bone when PRF is incorporated into grafting complexes.

Nevertheless, the effectiveness of PRF appears to be highly dependent on defect morphology. Smaller contained defects typically exhibit more favorable outcomes than extensive vertical or non-contained defects. This observation suggests that PRF may exert its greatest influence when biological stimulation is the limiting factor, whereas large reconstructive procedures remain primarily dependent on mechanical stability, space maintenance, and graft volume preservation. Consequently, the benefits of PRF should not be generalized across all regenerative scenarios.

The evolution of PRF preparation protocols represents another critical consideration. Since the introduction of the original leukocyte-rich PRF protocol, numerous modifications have been proposed based on the low-speed centrifugation concept. Advanced formulations such as A-PRF, A-PRF+, and injectable PRF have demonstrated higher concentrations of regenerative cells and growth factors. Emerging evidence suggests that reduced centrifugation speeds may improve biological activity by preserving leukocyte populations and enhancing cytokine release. However, the absence of protocol standardization remains one of the major barriers preventing meaningful comparisons among studies.

The variability observed across the literature is further compounded by differences in graft materials, membrane types, defect characteristics, implant timing, imaging methodologies, and follow-up durations. Some investigations evaluate extraction socket preservation, whereas others focus on horizontal ridge augmentation, vertical augmentation, peri-implant defects, or sinus floor elevation. Such heterogeneity significantly limits the ability to establish universal clinical recommendations and contributes to conflicting findings regarding bone gain.

From a clinical perspective, one of the most consistent advantages of PRF involves postoperative recovery. Reduced pain, swelling, and wound complications have been reported in numerous studies. These benefits may improve patient satisfaction and decrease morbidity, which is particularly relevant in extensive regenerative procedures. Even when differences in bone volume are modest, enhanced patient-centered outcomes may justify the incorporation of PRF into routine clinical practice. Another noteworthy consideration is the economic aspect of regenerative therapy. Compared with recombinant growth factors and advanced biologic agents, PRF is relatively inexpensive, autologous, and easy to obtain. This favorable cost-benefit profile has contributed significantly to its widespread adoption in implant dentistry and regenerative surgery. However, despite these practical advantages, clinicians should avoid overestimating its regenerative capacity. Current evidence does not support the notion that PRF can replace established GBR principles or compensate for inadequate defect management.

Future research should focus on high-quality randomized clinical trials employing standardized PRF protocols, uniform outcome measures, and long-term follow-up periods. Histomorphometric analyses, three-dimensional volumetric assessments, and implant survival outcomes should be prioritized to clarify the true contribution of PRF to regenerative success. Furthermore, direct comparisons among A-PRF, A-PRF+, i-PRF, and conventional

L-PRF are necessary to identify the most effective preparation methods for specific clinical applications.

5 CONCLUSION

Platelet-rich fibrin represents a valuable biological adjunct in guided bone regeneration procedures due to its ability to enhance angiogenesis, support early osteogenesis, improve graft stability, and accelerate soft tissue healing. The available evidence consistently demonstrates beneficial effects on biological healing dynamics and postoperative recovery.

When combined with bone graft materials and collagen membranes, PRF contributes to the creation of a more favorable regenerative microenvironment and may increase the predictability of healing outcomes. However, evidence supporting significant improvements in long-term volumetric bone gain remains inconsistent, largely due to methodological heterogeneity and the lack of standardized preparation protocols. Current data support the use of PRF as an adjunctive biomaterial rather than a replacement for conventional GBR components. Its greatest clinical value appears to reside in enhancing biological performance during the early stages of regeneration while complementing the mechanical principles provided by graft materials and barrier membranes.

Further well-designed randomized clinical trials with standardized methodologies, histological validation, and long-term follow-up are required to establish definitive clinical protocols and determine the true magnitude of PRF's contribution to guided bone regeneration outcomes.

REFERENCES

Choukroun, J., Adda, F., Schoeffler, C., & Vervelle, A. (2006). Une opportunité en paro-implantologie: Le PRF. Implantodontie, 42, 55–62.

Inchingolo, F., Dipalma, G., Isacco, C. G., Ballini, A., De Vito, D., Malcangi, G., & Inchingolo, A. M. (2024). Guided bone regeneration: Concentrated growth factors and platelet-rich fibrin combined with different scaffolds. Journal of Functional Biomaterials, 15(12), 408.

Miron, R. J., Fujioka-Kobayashi, M., Hernandez, M., Kandalam, U., Zhang, Y., Ghanaati, S., & Choukroun, J. (2017). Injectable platelet-rich fibrin and regenerative medicine: Biological principles and clinical applications. Clinical Oral Investigations, 21(8), 2619–2627.

Retzepi, M., & Donos, N. (2010). Guided bone regeneration: Biological principle and therapeutic applications. Clinical Oral Implants Research, 21(6), 567–576.

Sculean, A., Stavropoulos, A., Bosshardt, D. D., & Schwarz, F. (2019). Regeneration of periodontal tissues: Combinations of barrier membranes and biologically active agents. Periodontology 2000, 79(1), 122–147.