BIOMATERIAL-BASED PLATELET-RICH FIBRIN IN DENTISTRY: BIOLOGICAL BASIS, PREPARATION PROTOCOLS, AND CLINICAL APPLICATIONS

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Abstract

Platelet-rich fibrin (PRF) has emerged as a biologically active autologous biomaterial with increasing relevance in contemporary dentistry. Owing to its fibrin architecture, cellular content, and sustained release of growth factors, PRF has been investigated as a therapeutic adjunct for soft- and hard-tissue healing in periodontal, surgical, and regenerative procedures. This review examined the biological basis of PRF, the influence of preparation protocols on its regenerative properties, and its principal clinical applications in dentistry. Particular attention was given to the role of centrifugation variables, including relative centrifugal force and low-speed protocols, in shaping cell distribution, growth factor release, and vascularization potential. The available evidence indicates that PRF is not a uniform product, but a protocol-dependent biomaterial whose clinical performance is closely related to its method of preparation. Current data support its beneficial role in periodontal intrabony defects, palatal wound healing, non-surgical periodontal therapy, and bone regenerative contexts. Nevertheless, heterogeneity in preparation methods and clinical study design remains a major limitation. PRF appears to be a promising adjunct in biomaterial-based dentistry, although greater methodological standardization is required to improve reproducibility, predictability, and translational relevance.

Keywords: platelet-rich fibrin, biomaterial, dentistry, tissue regeneration, centrifugation protocols, periodontal therapy

1. Introduction

The growing interest in biologically active adjuncts for oral tissue regeneration has intensified the search for biomaterials capable of enhancing wound healing while remaining clinically accessible, safe, and minimally invasive. Within this context, platelet-rich fibrin (PRF) has emerged as one of the most relevant autologous biomaterials in contemporary dentistry, owing to its simple preparation, favorable biologic profile, and broad applicability in periodontal and oral surgical procedures [1-3]. Unlike passive scaffold materials, PRF acts as a biologically dynamic matrix enriched with platelets, leukocytes, and fibrin architecture capable of modulating tissue repair through the sustained release of signaling molecules involved in angiogenesis, cell migration, and extracellular matrix remodeling [2]. This regenerative concept also aligns with the broader translational interest in platelet-derived products in tissue engineering and regenerative medicine, where blood-derived biomaterials are increasingly valued for their therapeutic versatility and biologic compatibility [3-5].

A major reason for the expanding use of PRF in dental medicine is that its clinical performance is closely linked to the way it is produced. Centrifugation variables are not merely technical details; they directly influence clot architecture, cellular

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distribution, and ultimately the biologic activity of the final biomaterial [4-6]. In this regard, increasing attention has been given to the role of relative centrifugal force and processing dynamics in shaping growth factor entrapment and release, especially in more recent PRF formulations [5]. Methodological refinements, including new approaches to cell quantification and the introduction of horizontal centrifugation concepts, have further contributed to a more nuanced understanding of PRF composition and standardization [6,7]. At the same time, the development of advanced platelet-rich fibrin (A-PRF) has strengthened the concept that PRF is not a static product category, but rather an evolving family of autologous biomaterials with potentially distinct biologic and clinical behaviors [7].

The relevance of PRF in dentistry is supported by growing evidence from both experimental and clinical studies. Its use has been associated with improved soft-tissue healing, including enhanced palatal wound repair after free gingival graft harvesting [10], and it has also shown promise as an adjunct in non-surgical periodontal therapy [9]. Such applications are particularly important in complex clinical settings where healing capacity may be compromised by local or systemic risk factors. Among these, tobacco smoking remains a major modifier of periodontal inflammation, tissue destruction, and treatment response, including outcomes related to implant therapy [10,11]. From a mechanistic perspective, comparative analyses have shown that PRF-derived preparations may differ substantially in growth factor release profiles, reinforcing the importance of formulation-specific evaluation [11-14]. Additional biologic interest derives from the antimicrobial potential observed in platelet-leukocyte preparations, suggesting a possible supportive role in contaminated surgical fields [12]. Clinically, PRF has already demonstrated usefulness in the management of periodontal intrabony defects, both as a stand-alone regenerative adjunct and in combination protocols [13,14]. Moreover, because smoking negatively affects periodontal tissues at multiple levels, it remains a relevant confounding factor when interpreting regenerative outcomes in PRF-based therapies [15].

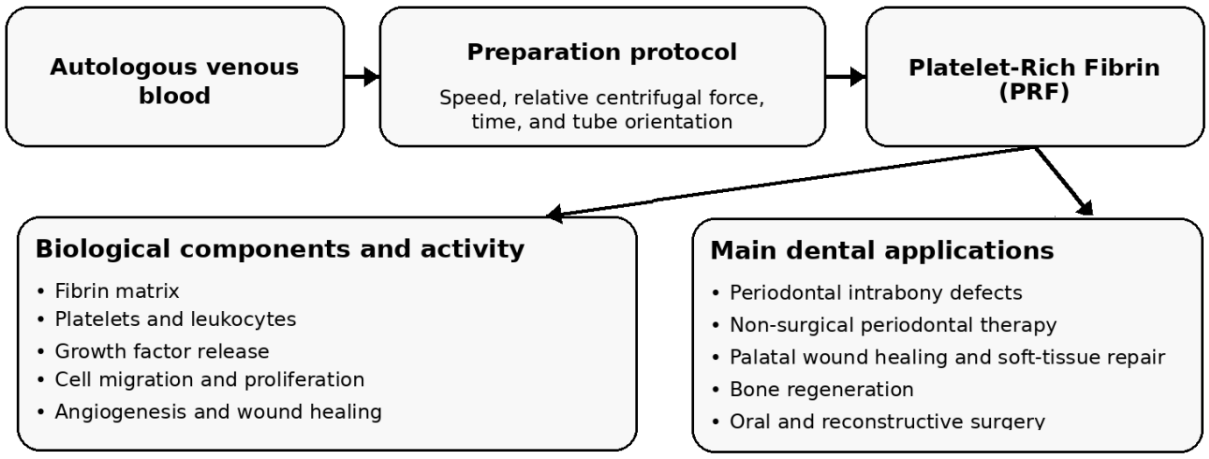

Figure 1. Conceptual overview of platelet-rich fibrin as a biomaterial in dentistry.

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Figure 1 summarizes the conceptual pathway from autologous venous blood collection and centrifugation-based preparation to platelet-rich fibrin formation, highlighting its principal biological components and its main clinical applications in dentistry. It also emphasizes that the clinical performance of PRF depends on both its biologic content and the preparation protocol.

2. Biological basis of platelet-rich fibrin

Platelet-rich fibrin (PRF) is currently regarded as one of the most biologically relevant autologous biomaterials in dentistry because it combines a structural fibrin scaffold with a reservoir of cellular and molecular mediators directly involved in tissue repair and regeneration [16-18]. Its biologic value lies not only in its autologous origin, which supports biocompatibility and clinical safety, but also in its capacity to function simultaneously as a matrix, a carrier of signaling molecules, and a microenvironment capable of supporting early healing events. In oral and maxillofacial regeneration, PRF has therefore been conceptualized not merely as a blood concentrate, but as a biologically active material whose therapeutic potential depends on the interaction between fibrin organization, entrapped cells, and released growth factors [16].

This interpretation is consistent with the broader evolution of platelet concentrates in regenerative medicine. Beyond conventional platelet-based preparations, newer generations of concentrates have been increasingly explored for their ability to enhance cell recruitment, tissue remodeling, and wound healing across different medical fields [17]. Within this spectrum, PRF occupies a distinctive position because it is produced without anticoagulants and forms a dense fibrin network through natural coagulation, thereby permitting progressive incorporation of platelets and leukocytes into the matrix. This gradual polymerization process is biologically important, as it creates a scaffold that may support sustained mediator release and cellular interaction rather than a rapid and short-lived burst effect [17,18].

The original conceptualization of PRF introduced it as a therapeutic opportunity in paro-implantology, with the central premise that a second-generation platelet concentrate could overcome some limitations associated with earlier platelet-derived preparations [18]. The key biologic principle was that a stable fibrin matrix enriched with autologous cellular elements could improve the local healing milieu in surgical and regenerative procedures. Since then, PRF has been progressively understood as a living biomaterial whose regenerative effects are mediated by both its architecture and its bioactive content. In practical terms, this means that PRF does not act only as a filler or membrane, but as a functional biologic interface between damaged tissue and the host reparative response [18-20].

A critical component of this biologic rationale is the role of PRF in wound healing. The fibrin scaffold provides mechanical support for cell migration, while platelets release mediators involved in angiogenesis, proliferation, and matrix synthesis; leukocytes may additionally contribute to immune regulation and defense [19]. This combination helps

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explain why PRF has attracted attention in procedures requiring accelerated epithelialization, connective tissue maturation, and stabilization of the healing clot. The biologic actions of PRF are therefore multidimensional, integrating scaffold function, cytokine release, and modulation of the local inflammatory response [19].

Importantly, the biologic performance of PRF is highly dependent on its preparation conditions. Experimental work supporting the low-speed centrifugation concept demonstrated that reducing relative centrifugal force can increase growth factor release within solid PRF-based matrices, indicating that the final regenerative potential of PRF is not fixed but protocol-sensitive [20]. This was further reinforced by studies on optimized PRF formulations, which showed improved growth factor release, favorable biocompatibility, and enhanced cellular responses when low-speed protocols were applied [21,22]. In vivo evidence also indicated that lower-speed centrifugation promotes greater cell accumulation and vascularization, both of which are central to tissue regeneration [22]. Consequently, the biologic basis of PRF cannot be separated from the technical determinants of its preparation. The significance of this concept was already foreshadowed when PRF was introduced into reconstructive surgery as a clinically adaptable regenerative material [23].

Table 1. The main biological principles underlying the regenerative potential of platelet-rich fibrin.

Biological concept	**Synthesis**	**Ref.**
PRF as an autologous biomaterial	PRF is a biologically active autologous biomaterial that combines a fibrin scaffold with cellular and molecular mediators involved in tissue repair and regeneration.	[16-18]
Biologically active matrix	Beyond its structural role, PRF functions as a carrier of signaling molecules and as a microenvironment that supports early healing events.	[16,17]
Natural fibrin polymerization	Because PRF is obtained without anticoagulants, natural coagulation enables progressive incorporation of platelets and leukocytes into the fibrin network.	[17,18]
Regenerative rationale	PRF was introduced as a second-generation platelet concentrate designed to improve the local healing milieu in periodontal and surgical regenerative procedures.	[18]
Role in wound healing	Its fibrin scaffold supports cell migration, while platelets and leukocytes contribute to angiogenesis, proliferation, matrix synthesis, and immune regulation.	[19]
Multidimensional biologic activity	PRF acts through scaffold support, cytokine release, and modulation of the inflammatory response during tissue repair.	[19,20]
Protocol-dependent biologic performance	The biologic properties of PRF are strongly influenced by preparation conditions, particularly centrifugation-related variables.	[20-22]
Low-speed centrifugation and optimization	Lower centrifugal force has been associated with greater growth factor release, improved cellular response, enhanced vascularization, and potentially superior regenerative performance.	[20-23]

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Table 1 summarizes the core biological features of PRF as an autologous biomaterial in dentistry, with emphasis on its fibrin architecture, cellular and molecular composition, wound-healing properties, and the influence of preparation protocols on its regenerative behavior.

3. Preparation protocols and technical determinants

The clinical and biologic performance of platelet-rich fibrin (PRF) is closely dependent on the protocol used for its preparation, since centrifugation parameters directly affect clot architecture, cellular composition, and the distribution of bioactive mediators within the final biomaterial [1]. This protocol sensitivity is particularly relevant in dentistry, where PRF is used not as a uniform commercial product, but as an autologous material obtained chairside, with significant variability introduced by centrifuge characteristics, tube orientation, rotational speed, relative centrifugal force (RCF), and processing time [2,6,23]. As a result, the regenerative potential of PRF cannot be interpreted independently of the technical conditions under which it is produced. In this context, PRF should be regarded not simply as a blood-derived adjunct, but as a protocol-dependent biomaterial whose final structure and biologic behavior are directly shaped by procedural variables during preparation [5,6,20].

An additional reason why preparation protocols are so important is that PRF is produced without anticoagulants, which means that blood collection and centrifugation must occur within a narrow time window to ensure consistent fibrin formation and cellular entrapment [18,23]. Unlike standardized industrial biomaterials, PRF is generated at chairside and is therefore especially vulnerable to operator-dependent variation. Even when the same patient and general method are used, differences in handling time, spin parameters, or centrifuge configuration may produce clots with distinct structural and regenerative characteristics [6,20,23]. This helps explain why PRF cannot be evaluated as a single homogeneous material category and why detailed protocol reporting is essential when interpreting both experimental and clinical studies [5,6].

One of the most important distinctions within the PRF family is represented by the evolution from standard leukocyte- and platelet-rich fibrin (L-PRF) to advanced platelet-rich fibrin (A-PRF), A-PRF+, and concentrated growth factors (CGF), each of which reflects a different centrifugation strategy and therefore a distinct biologic profile [7,18]. This differentiation is not merely terminological. Rather, it reflects progressive attempts to optimize the cellular distribution and growth factor content of the final fibrin matrix by modifying centrifugation intensity and processing conditions [7,20,21]. Advanced formulations were introduced on the basis of the concept that lower centrifugation speeds and forces may promote higher retention of platelets and leukocytes within the fibrin scaffold, thereby potentially improving the regenerative potential of PRF [7,20]. In this respect, protocol refinement has become a central theme in the biologic evolution of platelet concentrates used in regenerative dentistry [17,20].

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Experimental evidence has shown that centrifugation speed influences platelet behavior and separation dynamics, supporting the broader concept that alterations in mechanical processing can substantially modify the characteristics of platelet-derived products [4]. In PRF specifically, the applied RCF has been demonstrated to affect the intramembranous distribution of transforming growth factor-β, indicating that growth factor entrapment within the fibrin scaffold is highly protocol-dependent [5]. This observation is biologically important because the regenerative activity of PRF depends not only on the presence of bioactive mediators, but also on their localization within the matrix and their capacity for gradual release at the healing site [5,11]. Comparative studies have further shown that PRP, PRF, and A-PRF differ in their growth factor release profiles, reinforcing the concept that platelet concentrates generated through different protocols should not be considered biologically equivalent [11].

A major methodological advance in this field has been the introduction of the low-speed centrifugation concept, according to which reduced relative centrifugal force may improve the biologic composition of PRF-based matrices [20]. Experimental studies demonstrated that lower centrifugal forces increase growth factor release within solid PRF constructs and may enhance the retention of cells involved in tissue regeneration [20]. These findings were supported by subsequent work showing improved biocompatibility and cellular response in optimized PRF formulations obtained with low-speed approaches [21]. In vivo evidence also indicated that reduced centrifugation intensity can promote greater cell accumulation and vascularization, both of which are essential for regenerative performance in clinical settings [22]. Collectively, these observations suggest that the biologic quality of PRF is not fixed, but modifiable through protocol design [20-22].

Another relevant technical aspect concerns the distinction between revolutions per minute and relative centrifugal force. Although RPM is often reported in clinical protocols, RCF is the more meaningful parameter because it reflects the actual force applied to blood components during centrifugation [5,20]. Since centrifuges with different rotor dimensions may generate different g-forces at the same rotational speed, the use of RPM alone may create inconsistencies across studies and limit reproducibility [5,6]. This issue is particularly important in the PRF literature, where apparently similar preparation protocols may in fact produce biologically different materials due to unrecognized technical differences in centrifuge design or operation [6,20]. For this reason, accurate reporting of centrifugation conditions is essential for both methodological rigor and clinical translation.

Horizontal centrifugation and newer approaches to quantifying cell populations within PRF matrices have further expanded understanding of how technical parameters influence final composition [6]. These developments showed that the physical configuration of centrifugation may affect the distribution of platelets and leukocytes within the clot and therefore influence the biologic profile of the material [6]. Such findings are particularly relevant for

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regenerative dentistry because they help explain why some PRF preparations may demonstrate superior angiogenic or wound-healing behavior under certain protocol conditions [6,21,22]. Therefore, the technical determinants of PRF preparation should not be viewed as secondary laboratory details, but as core factors that define the structure, composition, and clinical potential of the biomaterial [20-23].

Overall, preparation protocols are central to the identity and therapeutic value of PRF in dentistry. Variations in blood handling, centrifuge configuration, tube orientation, spin duration, and applied centrifugal force may all alter the final characteristics of the fibrin matrix and partly explain the heterogeneity of published findings [5,6,20-23]. Consequently, PRF should be interpreted as a family of protocol-sensitive autologous biomaterials rather than as a single standardized product [7,18,20]. In biomaterial-based dentistry, improved methodological standardization and transparent reporting of preparation parameters remain essential for ensuring reproducibility, improving comparability across studies, and translating biologic potential into predictable clinical outcomes [20-23].

4. Clinical applications of PRF in dentistry

Platelet-rich fibrin (PRF) has gained broad clinical relevance in dentistry because its biologic properties translate into practical benefits across periodontal, oral surgical, and regenerative procedures [1,4]. As an autologous biomaterial characterized by a fibrin matrix enriched with platelets, leukocytes, and growth factors, PRF has been increasingly incorporated into clinical protocols aimed at improving soft- and hard-tissue healing [16,17]. Its appeal in daily practice derives not only from its regenerative rationale, but also from its relatively simple chairside preparation, favorable safety profile, and versatility across different therapeutic indications [18,23]. For this reason, PRF has progressively moved from an experimental adjunct to a clinically relevant component of biomaterial-based treatment strategies in dentistry [16,17].

One of the most documented indications is the treatment of periodontal intrabony defects, where PRF has been used as an adjunct to guided tissue regeneration and has demonstrated favorable effects on clinical healing and regenerative outcomes [1]. Randomized clinical evidence further supports its utility in the regeneration of intrabony periodontal defects, confirming that PRF may improve defect resolution and soft-tissue healing when incorporated into periodontal surgical protocols [1,13]. Its adjunctive use with enamel matrix derivative has also shown clinical benefit, suggesting that PRF can enhance established regenerative strategies rather than functioning only as a stand-alone material [14]. These findings are clinically important because intrabony defects represent challenging lesions in which successful treatment depends on coordinated clot stability, cell recruitment, angiogenesis, and maturation of the periodontal attachment apparatus [1,13,14]. In this context, PRF may contribute to a more favorable local healing environment by acting simultaneously as a scaffold and as a source of bioactive mediators involved in tissue repair [16,19].

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Beyond surgical periodontal regeneration, PRF has also shown promise in non-surgical periodontal therapy. Split-mouth randomized clinical data suggest that its local application may improve treatment response, which is clinically relevant in cases where minimally invasive enhancement of healing is desired [9]. This potential indication is of particular interest because it extends the role of PRF beyond conventional regenerative surgery and suggests a broader adjunctive value in periodontal care [9]. Although the magnitude of benefit may vary according to case selection and protocol design, the available evidence supports the concept that PRF can positively influence early healing and local tissue response even when used in less invasive therapeutic settings [9,19]. This broadens the clinical relevance of PRF and reinforces its position as a multifunctional autologous biomaterial rather than a niche regenerative material limited only to surgical defects [16,17].

At the soft-tissue level, PRF has been associated with improved palatal wound healing after free gingival graft harvesting, highlighting its potential to reduce donor-site morbidity and promote more favorable postoperative tissue repair [8]. This application is particularly meaningful in periodontal plastic surgery, where patient discomfort and the speed of epithelialization at the donor site directly influence postoperative quality of life and clinical acceptance of the procedure [8]. These observations are consistent with in vitro evidence showing that L-PRF and A-PRF+ stimulate periodontal fibroblast behavior in wound-healing models, thereby providing a mechanistic basis for the clinical findings [2]. The convergence between in vitro and clinical data strengthens the rationale for PRF use in soft-tissue management and supports the view that its beneficial effects are not merely empirical, but biologically plausible and tissue-specific [2,8].

In oral and maxillofacial regeneration, PRF has also been considered a useful biomaterial for bone repair and grafting-related applications [16]. Its fibrin scaffold, growth factor content, and cellular composition support its use in reconstructive settings where biologic stimulation of angiogenesis and tissue maturation is desirable [16,17,23]. In these contexts, PRF is often valued not only for its intrinsic biologic activity, but also for its capacity to complement other regenerative materials or techniques by improving local healing dynamics [16,23]. This integrative role is relevant in clinical situations where optimization of the early healing phase may influence the predictability of subsequent bone formation and soft-tissue stability [16,17].

Table 2 summarizes the main clinical applications of platelet-rich fibrin (PRF) in dentistry and highlights the principal benefits reported in the literature. It provides a concise overview of the therapeutic settings in which PRF has shown the most relevant adjunctive value.

Table 2. Main clinical applications of PRF in dentistry

Clinical application	**The main reported benefit**	**Ref.**
Periodontal intrabony defects	Improved healing and regenerative outcomes	[1,10,13]

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Non-surgical periodontal therapy	Adjunctive improvement in treatment response	[9]
Palatal wound healing after free gingival graft harvesting	Better soft-tissue healing and reduced donor-site morbidity	[8]
Bone repair and grafting-related applications	Support for angiogenesis and tissue maturation	[16,17,23]

Comparative studies indicate that distinct PRF formulations differ in growth factor release [11], while low-speed preparation concepts appear to improve the regenerative quality of the material by enhancing mediator release, biocompatibility, and vascularization [20-22]. These observations are clinically relevant because they suggest that the therapeutic effect of PRF may vary not only according to indication, but also according to the specific formulation and preparation protocol employed [11,20-22]. Accordingly, the interpretation of clinical outcomes requires attention to the technical characteristics of the PRF product used, since protocol-dependent differences may partly explain variability in reported efficacy across studies [5,6,20]. This reinforces the need to evaluate PRF applications in dentistry not as a single uniform intervention, but as a family of biologically distinct autologous products with potentially different clinical performances [7,11,20].

Nevertheless, clinical outcomes may still be influenced by patient-related factors, including smoking, which adversely affects periodontal tissues and healing capacity [10,15]. This point is essential when interpreting the apparent success or limitations of PRF-based procedures, because even a biologically active regenerative adjunct cannot fully compensate for unfavorable host conditions [10,15]. Smoking may impair vascularization, inflammatory regulation, and connective tissue repair, thereby reducing the predictability of regenerative outcomes and acting as an important confounder in both periodontal and implant-related settings [10,15]. Therefore, while the current evidence supports a meaningful role for PRF in multiple areas of dentistry, its clinical value should be interpreted within the broader context of defect characteristics, protocol selection, and host-related healing potential [9,10,15,20].

Overall, the available literature supports PRF as a versatile adjunct with applications in periodontal regeneration, soft-tissue healing, and bone-related procedures [1,8,13,16]. However, the strength of evidence is not entirely uniform across indications, and the magnitude of benefit may depend on both biologic and technical variables [9,11,20-23]. Consequently, PRF appears most convincingly supported as an adjunctive biomaterial rather than as a universally standardized regenerative solution, and its clinical integration should continue to be guided by indication-specific evidence and protocol transparency [16,20,23].

5. Discussion

The current body of evidence supports platelet-rich fibrin (PRF) as a biologically active, autologous biomaterial with meaningful applications in dentistry, yet interpreting its effectiveness requires

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careful consideration of methodological and clinical heterogeneity [1-3]. Although many studies report favorable outcomes, PRF should not be viewed as a uniform therapeutic entity because differences in preparation protocols substantially influence its composition, biologic behavior, and regenerative potential [2,4]. This is one of the central issues in the literature: the term "PRF" is often used broadly, while the underlying products may differ considerably in fibrin architecture, leukocyte distribution, platelet entrapment, and mediator release [3].

A major source of variability derives from centrifugation-related factors. Experimental and translational evidence indicates that centrifugal force, processing dynamics, and tube orientation influence the structural and cellular characteristics of PRF matrices [4-6]. The development of advanced formulations such as A-PRF and A-PRF+ reflects the recognition that lower centrifugation intensity may promote more favorable cell retention and biologic activity [7]. This concept is clinically relevant because improved biologic content has been associated with enhanced fibroblast response, wound healing, and regenerative performance [2,8]. At the same time, comparative studies suggest that PRF-derived preparations differ from other platelet concentrates, including PRP, not only in composition but also in the kinetics of growth factor release, which may partly explain differences in clinical behavior [11].

The strongest clinical evidence appears to concern periodontal regeneration and soft-tissue healing. Randomized and controlled studies support the adjunctive value of PRF in intrabony periodontal defects and in procedures involving soft-tissue repair, including palatal wound healing after graft harvesting [1,8,13,14]. More recent controlled data also indicate potential benefits in non-surgical periodontal therapy, suggesting that PRF may extend beyond conventional surgical indications [9]. However, the magnitude of benefit is not always consistent across studies, and this inconsistency likely reflects variation in defect morphology, indication, protocol design, follow-up duration, and operator-dependent application methods [13,14]. Consequently, positive findings should be interpreted with clinical nuance rather than generalized indiscriminately.

Another important point is that biologic efficacy may be modified by patient-related factors. Smoking, for example, remains highly relevant when analyzing periodontal and implant-related outcomes because it negatively affects vascularization, inflammatory response, and tissue repair [10,15]. Therefore, PRF cannot be assumed to overcome all host-related limitations, even when its regenerative rationale is strong. In addition, some mechanistic claims regarding antimicrobial or immunomodulatory effects remain promising but not yet sufficiently standardized for broad clinical extrapolation [12].

Overall, the literature supports PRF as a versatile biomaterial with a credible biologic rationale and clinically relevant applications, but its benefits are clearly protocol-dependent and context-sensitive. The main challenge for future interpretation is not whether PRF has regenerative potential, but under which preparation conditions and clinical indications that

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potential can be reproduced most reliably [16-23].

Conclusions

Platelet-rich fibrin represents a promising autologous biomaterial in contemporary dentistry due to its favorable biologic profile, ease of preparation, and broad regenerative applicability. The available evidence indicates that PRF can support both soft- and hard-tissue healing through the combined action of its fibrin matrix, cellular content, and sustained release of growth factors. Its use appears particularly relevant in periodontal regeneration, oral wound healing, and bone-related applications. However, PRF should not be regarded as a uniform product, since its biologic and clinical performance is strongly influenced by the preparation protocol.

Overall, the literature supports the integration of PRF into biomaterial-based dental practice, but also highlights the need for cautious interpretation of reported outcomes. Differences in centrifugation speed, relative centrifugal force, formulation type, and clinical indication may significantly alter its regenerative potential and partly explain the heterogeneity of published results. Current data are most convincing for periodontal intrabony defects and soft-tissue healing, while broader reconstructive applications remain encouraging but less standardized. Future progress in this field depends on improved methodological consistency, clearer protocol reporting, and better alignment between biologic characterization and clinical endpoints, so that PRF-based therapies can be applied with greater predictability and scientific rigor.

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