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Biological basis and clinical applications of platelet-rich blood products: A narrative review

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Abstract

In recent years, autologous concentrated blood products have become increasingly widespread in dentistry and various medical disciplines as biologically active agents for wound healing and tissue regeneration. These autologous blood concentrates have emerged as effective biological adjuncts by accelerating wound healing and contributing to the reduction of postoperative pain and complications. Clinical studies indicate that platelet-rich fibrin (PRF) and its derivatives, in particular, provide favorable outcomes in both hard and soft tissue regeneration and are expected to be increasingly incorporated into minimally invasive treatment strategies. The aim of this review is to comparatively evaluate the biological basis, preparation methods, and clinical effects of autologous blood products in light of the current literature. In this review, experimental studies, systematic reviews, and randomized controlled trials involving human or animal models published between 2010 and 2025 were identified through searches of PubMed, Scopus, Web of Science, and Google Scholar using relevant keywords. Studies of low methodological quality, those with incomplete data, or publications available only in abstract form were excluded. This study was designed as a narrative review and did not follow PRISMA guidelines. A total of 120 articles were screened during the search process, of which 44 studies meeting the inclusion criteria were included in the final analysis. Current studies and systematic reviews indicate that autologous concentrated blood products function as effective biological agents in regenerative medicine and dentistry, contributing to improved clinical outcomes and enhanced patient satisfaction.

Keywords: Platelet-rich fibrin, platelet-rich plasma, tissue regeneration, autologous blood products

Introduction

In recent years, with a marked increase in their clinical use, concentrated blood products have attracted considerable attention from both researchers and clinicians as biological agents that support healing processes across various surgical disciplines [1].

Platelets, which constitute a central component in the preparation of concentrated blood products, play a critical role in the repair of vascular injuries and the regulation of hemostatic processes [2]. In adults, these cells have an approximate lifespan of 8–10 days and are present in the circulation in a population of nearly one trillion [3].

Evidence regarding the effects of platelet-derived growth factors on wound healing has enabled the clinical use of these products to support tissue repair and regeneration [4]. Among these growth factors, the most prominent include platelet-derived growth factor (PDGF), transforming growth factor-β1 (TGF-β1), vascular endothelial growth factor (VEGF), and epidermal growth factor (EGF) [5].

Through the formation of a robust fibrin matrix, concentrated blood products promote the migration and adhesion of platelets and fibroblasts, subsequently initiating tissue regeneration via cytokine release. Owing to the autologous nature of these fibrin networks, the structural integrity of growth factors is preserved, allowing for their sustained activation and prolonged biological activity [6].

In modern medicine, this therapeutic approach—referred to as orthobiologics—aims to provide a minimally invasive treatment option. By utilizing biologically derived materials, this strategy seeks to promote wound healing through the stimulation of various metabolic pathways within the organism [7].

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Material and Methods

Historical Background

The history of platelet concentrates dates back several decades to the development of fibrin sealants [8]. Platelets, first described in 1864, were initially recognized primarily for their roles in hemostasis and coagulation; however, subsequent animal studies conducted by Helena Matras demonstrated the use of fibrin sealants in the closure of local wounds, thereby revealing the regenerative potential of these cellular components in tissue healing [9,10].

In 1986, Knighton et al. developed an effective clinical application for the treatment of chronic non-healing cutaneous ulcers using a platelet-based preparation, which was later termed the platelet-derived wound healing formula (PDWHF) [11]. Subsequently, during the 1990s, platelet-rich plasma (PRP), a first-generation platelet concentrate characterized by a high concentration of growth factors, was introduced into oral surgery, representing a novel approach to regenerative therapies [12]. The demonstration by Marx that PRP combined with bone grafts yielded satisfactory clinical outcomes in the reconstruction of mandibular defects further facilitated the rapid adoption of this approach in clinical practice [13].

Over time, clinicians began to highlight several limitations associated with PRP application. In particular, the relatively time-consuming and complex preparation protocol, the mandatory use of citrate as an anticoagulant in blood collection tubes, and the requirement for additional agents such as calcium chloride ($CaCl_2$) to achieve platelet activation have been identified as major constraints that limit the practicality of this method in routine clinical practice [14].

In 2001, Choukroun et al. reported the direct application of a fully autologous preparation, produced without the use of any additives and containing growth factor levels exceeding physiological concentrations, to lesion sites in tissues with impaired vascularization, with highly satisfactory clinical outcomes. These favorable results laid the groundwork for the development of platelet-rich fibrin (PRF), which is classified as a second-generation platelet concentrate [15].

Results

Classification

With the increasing use of plasma and platelet concentrates in clinical practice, the number of studies conducted in this field has also risen substantially. In parallel, numerous new methods and preparations have been developed, with each novel protocol and classification giving rise to products with distinct biological and physicochemical characteristics. The first comprehensive effort to systematically define and classify these emerging biotechnological products was carried out by Dohan et al. in 2019 [16,17].

In this classification system, it was proposed that platelet concentrates should be evaluated based on three principal parameters:

1. The preparation kits and centrifugation devices used
2. The cellular composition of the concentrate, with particular emphasis on leukocyte content
3. The density of the fibrin network

Based on these three parameters, platelet concentrates were classified into four main categories; moreover, it was noted that each category could be further subdivided depending on the centrifugation protocols applied and the devices used. The classification was primarily established according to compositional characteristics and fibrin matrix density, resulting in the identification of four distinct subgroups [18]:

1. Pure PRP (P-PRP)
2. Leukocyte-rich PRP (L-PRP)
3. Pure PRF (P-PRF)
4. Leukocyte-rich PRF (L-PRF)

A schematic representation of the fibrin matrices corresponding to these four princial groups is presented below (see Figure 1).

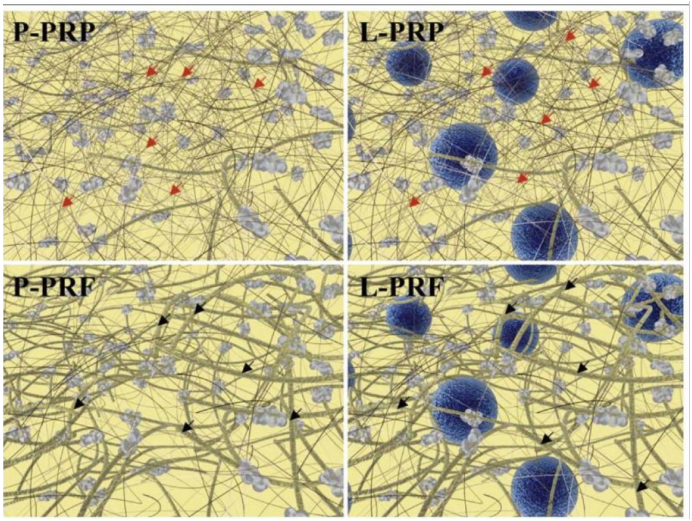

Figure 1. Schematic representation of the fibrin matrices corresponding to the four main classes of platelet concentrates. In the diagram, the yellow–brown network represents the fibrin matrix, blue circular structures indicate leukocytes, and light gray circles denote platelets [14]

DeLong and colleagues developed the "PAW" classification system based on key parameters such as platelet concentration, platelet activation status, and the presence of leukocytes. In this system, platelet concentration is quantitatively assessed as an absolute cell count per milliliter, with the aim of achieving a more standardized and comparable classification framework [17,19].

In their classification published in 2012, Mishra and colleagues restructured the system originally proposed by DeLong et

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al. in 2010 by incorporating different combinations of key parameters—namely platelet concentration, platelet activation status, and the presence of leukocytes—and accordingly defined four distinct types of PRP [20].

Type 1 – L-PRP (solution form):

A liquid form of PRP containing high concentrations of platelets and leukocytes, obtained without the use of any exogenous activator.

Type 2 – L-PRP (gel form):

A PRP preparation containing high concentrations of platelets and leukocytes, which is converted into a gel form through activation with an exogenous activator.

Type 3 – P-PRP (solution form):

A liquid PRP preparation containing a high concentration of platelets only, without leukocytes and without exogenous activation.

Type 4 – P-PRP (gel form):

A PRP preparation containing a high concentration of platelets only, which is transformed into a gel form through activation with an exogenous activator.

In 2015, Mautner et al. introduced the PLRA classification, emphasizing the need to account for red blood cell content, and accordingly developed the PLRA system based on platelet concentration, leukocyte presence, red blood cells, and activation status [17–19].

Magalon and colleagues developed the DEPA classification in 2016. Unlike previous systems, this classification places particular emphasis on two key factors: the proportion of platelets transferred from whole blood to PRP during the preparation process and the biological purity of the resulting PRP [17,21].

Lana and colleagues developed and published the MARSPILL classification in 2017, deriving its name from the initials of the included parameters. In this system, the incorporation of four additional parameters beyond those used in previous classification frameworks was proposed [22].

1. The characteristics of the PRP preparation method, specifically whether it is automated or manual
2. The number of centrifugation steps
3. The use of visual guidance to determine the appropriate application site
4. The application of light-based activation to PRP

When all classification systems are considered collectively, it can be stated that the four-group classification developed by Dohan and colleagues in 2009 remains the most widely used framework in current clinical practice, whereas other systems are predominantly of academic or research-oriented relevance.

Platelet-Rich Plasma

Leukocyte-Poor Platelet-Rich Plasma (P-PRP)

The earliest applications of pure platelet concentrates for local use were performed in maxillofacial surgery using conventional platelet transfusion systems. The first technology employed for the preparation of topical PRP consisted of plasmapheresis-based automated cell separators. As these devices operate with an intermittent flow system, patients are required to remain connected to the device until approximately 300–450 mL of blood is collected, from which an average of 40 mL of PRP can be obtained. These separators typically operate at centrifugation forces of around 3000 g; optical sensors identify the buffy coat layer and direct PRP into a separate chamber, while leukocytes and erythrocytes are diverted into another chamber for reinfusion. Despite their advanced technological design, these systems consistently result in residual leukocyte and erythrocyte contamination in the final PRP product. Moreover, due to prolonged processing times and the occasional need for collaboration with a hematologist, these systems are not considered practical for routine clinical use [14,23].

The Vivostat PRF Centrifugation System (Vivolution, Denmark) was initially developed for the preparation of Vivostat fibrin sealant and, owing to its advanced cell separation capabilities, can also be utilized to obtain pure platelet concentrates. However, the literature regarding the clinical application of this protocol remains limited. Furthermore, the relatively slow processing time and high cost of the system restrict its feasibility and routine use in clinical practice [14].

Leukocyte- and Platelet-Rich Plasma (L-PRP)

Four different systems have been described for the manual preparation of L-PRP, including Curasan (Kleinostheim, Germany), Friadent-Schütze (Vienna, Austria), Regen, and Platelex. Both the Curasan and Friadent-Schütze systems employ a similar two-step centrifugation protocol. Following the first centrifugation, the acellular plasma and buffy coat layers are separated without erythrocyte contamination and subjected to a second centrifugation. After the second centrifugation, the acellular portion of the plasma is carefully separated from the buffy coat using visual separation techniques. Subsequently, bovine thrombin and calcium chloride are added to render the preparation usable. PRP prepared using this method contains high levels of platelets, leukocytes, and fibrinogen, along with a small amount of residual erythrocytes [14,24].

The Platelex system (Bratislava, Slovakia) differs from other manual protocols by utilizing specific gelling agents capable of maintaining PRP in a gel form for approximately 10 minutes, instead of bovine thrombin. These agents consist of calcium gluconate combined with lyophilized and purified batroxobin,

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which are added to the plasma concentrate following centrifugation to induce fibrin polymerization [14,25]. In the Regen protocol (Regen Lab, Switzerland), a separator gel added to the centrifugation tubes is used with the aim of obtaining a concentrate with higher platelet and leukocyte content at the end of the procedure [14].

Leukocyte-Poor Platelet-Rich Fibrin (P-PRF)

The only protocol described in the literature for obtaining P-PRF is the Fibrinet PRFM kit developed by Cascade Medical (USA). This method employs two separate tubes: one 9-mL collection tube containing tri-sodium citrate and a separator gel for whole blood collection, and a second tube specifically designed for the formation of the PRFM clot. In the initial step, the blood sample is centrifuged at high speed for 6 minutes to separate it into acellular plasma, buffy coat, and erythrocyte layers. The plasma and buffy coat fractions are then transferred to the second tube containing calcium chloride, where a second centrifugation step of 15 minutes is performed to obtain a stable PRFM clot. Although the manufacturer describes this method as a "completely natural, bovine thrombin–free PRF," the use of separator gel and anticoagulant renders this claim biologically debatable [14].

In the Fibrinet PRFM protocol, similar to Anitua's PRGF method, fibrin polymerization is activated solely by calcium chloride, a process that enables P-PRF to form a denser and structurally more stable fibrin matrix compared with PRP. Nevertheless, the limited volume capacity of the kits restricts the production of large quantities of P-PRF, while the relatively slow and costly nature of the method limits its routine clinical applicability. Moreover, the scarcity of studies evaluating the clinical effectiveness of the Fibrinet technique indicates that further comprehensive investigations are required to determine the true clinical value of this protocol [14].

Leukocyte- and Platelet-Rich Fibrin (L-PRF)

Platelet-rich fibrin (PRF), developed by Choukroun and colleagues in 2001, is defined as a second-generation platelet concentrate and represents a completely natural method that does not involve the use of anticoagulants or gelling agents. Venous blood collected in glass tubes undergoes a single-step, low-speed centrifugation, during which fibrin polymerization is initiated immediately, resulting in the separation of the sample into three layers: acellular plasma at the top, erythrocytes at the bottom, and the PRF clot in the middle. The three-dimensional, stable fibrin matrix within this clot enables the gradual and sustained release of growth factors from the entrapped platelets and leukocytes [14,26].

Using standard centrifugation devices with a capacity of up to eight tubes, or larger-volume models, sufficient amounts of L-PRF can be produced rapidly and at relatively low cost. Owing to this practicality and economic advantage, Choukroun's PRF protocol has emerged as one of the most suitable methods for routine clinical application. Nevertheless, despite its rapidly increasing use, further well-designed studies are required to more clearly delineate the effectiveness of this platelet concentrate across different clinical indications [14].

Platelet-Rich Fibrin (PRF)

In an effort to simplify the preparation process of platelet concentrates, researchers developed the first fully autologous blood concentrate. This anticoagulant-free system markedly reduces the risk of cross-contamination while preserving the physiological activity of cellular components. The primary objective of this technique is to streamline the preparation protocol by reducing procedural steps and shortening application time [27].

Low-Speed Centrifugation Concept (LSCC)

The low-speed centrifugation concept (LSCC) was developed based on the premise that centrifugation speed and the resulting g-force play a decisive role in determining the regenerative capacity of PRF. Histological studies have demonstrated that PRF prepared under lower g-forces exhibits a more porous structure, with a more homogeneous distribution of cells within the fibrin matrix, and that non-platelet cells also contribute to growth factor release [28].

These structural characteristics support a more organized fibrin matrix, which in turn facilitates a more sustained release of growth factors. However, the literature indicates that modifications in g-force alone may be insufficient to enhance the release of certain growth factors. Consequently, in newer systems, protocol adjustments have focused more on centrifugation time rather than speed, resulting in the production of biologically more favorable fibrin concentrates [28].

Advanced Platelet-Rich Fibrin (A-PRF)

Protocol modifications performed in accordance with the Low-Speed Centrifugation Concept (LSCC) have enabled the development of new fibrin concentrates with properties distinct from those of conventional L-PRF. Specifically, the standard L-PRF centrifugation protocol of 2700 rpm (approximately 708 g) for 12 minutes was reconfigured to 1500 rpm (approximately 230 g) for 14 minutes, resulting in the development of A-PRF [29,30] (Figure 2).

As centrifugation speed increases, the g-force applied to the tubes and the associated vibration also increase; these vibrations may reduce the viability of cells within the fibrin clot. Because A-PRF is prepared at a lower centrifugation speed, it better preserves the viability of inflammatory cells, particularly neutrophils and macrophages, thereby enhancing growth factor release. In a histological study conducted in a murine model, A-PRF prepared under low-speed conditions exhibited a more porous fibrin matrix, which facilitated increased cellular penetration

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into the fibrin network and resulted in significantly greater vascularization compared with L-PRF at 10 days following subcutaneous implantation [28,29].

Figure 2. Representative macroscopic appearance of the A-PRF clot obtained after centrifugation

In a comparative in vivo study reported by Kubesch et al., A-PRF prepared using a centrifugation force of 208 g in a murine model exhibited a more porous fibrin architecture compared with conventional PRF prepared at 708 g. This structural characteristic was associated with a significantly increased degree of cellular penetration into the fibrin scaffold and resulted in a markedly enhanced vascularization pattern 10 days after subcutaneous implantation when compared with PRF [31].

Advanced Platelet-Rich Fibrin Plus (A-PRF+)

As a result of various modifications to the A-PRF protocol, A-PRF+ was developed, exhibiting enhanced biological properties. It is well established that reductions in centrifugation speed have a direct impact on the density and mechanical stability of the PRF matrix. In an effort to achieve a more porous yet stable structure with increased growth factor release, researchers directed protocol modifications primarily toward centrifugation time. Shortening the centrifugation duration was intended to minimize cellular damage caused by excessive centrifugal forces [28,30].

In 2017, Fujioka-Kobayashi and colleagues developed the A-PRF+ protocol by reducing the centrifugation speed to 1300 rpm (approximately 200 g) and the duration to 8 minutes. Histological studies have demonstrated that A-PRF+ provides significantly higher growth factor release compared with both A-PRF and L-PRF. Offering a more practical clinical application, A-PRF+ can be readily separated from the erythrocyte layer and applied directly without the need for additional processing steps. Moreover, platelets are homogeneously distributed throughout the A-PRF+ matrix, and its cellular content—particularly leukocytes—is markedly higher than that observed in L-PRF [28,30,32].

Injectable Platelet-Rich Fibrin (i-PRF)

The fact that PRF can traditionally be obtained only in gel form has been considered a significant limitation compared with PRP, particularly in applications requiring injection. Consequently, researchers have focused on developing a liquid form of PRF that can be directly injected or combined with other biomaterials. Protocol modifications have again centered on centrifugation speed and duration; reducing the speed to 700 rpm (approximately 60 g) and the duration to 2–3 minutes led to the development of the injectable PRF (i-PRF) protocol. To eliminate the need for anticoagulants, specialized plastic blood collection tubes are used. In contrast to the glass-coated tubes employed for gel PRF preparation, the hydrophobic plastic surface does not initiate the coagulation cascade during centrifugation, thereby allowing the acquisition of a liquid form [28,30,32].

Following centrifugation, the blood sample separates into two layers: a yellow–orange liquid i-PRF layer in the upper portion and an erythrocyte layer at the bottom. The liquid i-PRF can be easily aspirated using a syringe and retains its injectable, liquid state for approximately 10–15 minutes after preparation [28,30].

Cell-based studies have demonstrated that i-PRF contains the highest concentrations of platelets and leukocytes among all PRF variants. Comparative analyses with other liquid concentrates, such as PRP and PRGF, have further shown that i-PRF exhibits a markedly higher cellular density. In studies evaluating growth factor release, PRP was found to release a greater amount of growth factors within the first 15 minutes; however, over longer observation periods, i-PRF demonstrated a higher total growth factor secretion [28,30,33].

Titanium-Prepared Platelet-Rich Fibrin (T-PRF)

The growing popularity of PRF has accelerated research in this field, leading to the introduction of a novel protocol known as titanium-prepared platelet-rich fibrin (T-PRF), developed by Tunalı and colleagues in 2014. In this method, medical-grade titanium tubes are used instead of glass-coated plastic tubes employed in conventional L-PRF protocols. The authors reported that T-PRF, prepared by centrifugation at 2800 rpm for 12 minutes, exhibits a clinically thicker structure, which was attributed to a fibrin matrix network occupying a larger surface area. Animal studies have further demonstrated that T-PRF persists within tissues for a longer duration compared with L-PRF [30,32].

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Platelet-Rich Fibrin Obtained by Horizontal Centrifugation (H-PRF)

Horizontal platelet-rich fibrin (H-PRF), prepared using horizontal (swing-bucket) centrifugation systems, represents a protocol in which the horizontal rotation of the tubes allows for a more homogeneous distribution of cells without adhesion to the tube walls. At the beginning of the protocol, venous blood is collected from the patient into anticoagulant-free tubes, typically with a volume of 10 mL, and is placed into the horizontal centrifugation device immediately after collection (within less than one minute). Based on the available literature, centrifugation parameters are generally set at approximately 700 g (≈1,200–1,400 rpm) for a duration of 8–12 minutes.

Compared with fixed-angle rotors (typically 33–45°), the use of a horizontal rotor (90°) not only ensures a more uniform cell distribution but also significantly increases platelet and leukocyte counts, thereby enhancing the biological potential of the resulting concentrate. Following centrifugation, the tube separates into three layers: platelet-poor plasma in the upper layer, the fibrin clot (H-PRF) in the middle layer, and red blood cells in the lower layer. The fibrin clot in the middle layer can be carefully retrieved using sterile forceps and, if necessary, gently compressed to obtain a membrane form. Alternatively, while the clot remains in a liquid state (i.e., before complete polymerization of H-PRF, typically within 15 minutes), it may be collected using a sterile syringe for injectable applications.

Comparative analyses reported in the literature indicate that H-PRF produced via horizontal centrifugation demonstrates superiority over fixed-angle centrifugation protocols in terms of growth factor release, fibrin matrix density, and antibacterial and anti-inflammatory effects [34,35].

Concentrated Growth Factor (CGF)

Concentrated growth factor (CGF) is a fibrin structure rich in leukocytes and platelets that was introduced by Sacco in 2006. Similar to PRF, CGF is obtained using a single-step centrifugation method and contains osteoinductive growth factors within an osteoinductive fibrin matrix. However, the preparation of CGF requires a specific centrifugation program. To obtain CGF, anticoagulant-free plastic tubes coated with silica particles (red-capped tubes) are used, and the procedure does not require the addition of any exogenous agents. The blood collected in these tubes is centrifuged at alternating and controlled speeds using a dedicated centrifugation device (Medifuge, Silfradent, Italy). The different preparation protocols for CGF are presented in Table 1 [36].

Following centrifugation, three distinct layers are observed within the tube: the lower layer consists of red blood cells, the middle layer comprises a fibrin gel containing concentrated growth factors and platelet aggregates (Figure 3), and the upper layer consists of platelet-poor plasma. The upper and lower layers are discarded, while the middle layer yields a dense fibrin matrix rich in growth factors.

The use of CGF in bone augmentation procedures is limited, as it lacks the ability to stabilize bone particles. To overcome this limitation, the combination of CGF with autologous fibrin adhesives has been proposed to obtain so-called “sticky bone,” thereby enhancing graft stability [32,37].

Table 1. CGF preparation protocol (Sacco, 2006; Medifuge centrifugation system) [37].

Stage	Centrifugation speed / duration	Purpose	Resulting fraction	Notes
Stage 1: Rapid acceleration	Automatic speed increase	Preparation for phase separation of blood	—	Unlike conventional PRF, the speed is not constant; a variable speed profile is applied.
Stage 2: 2400–2700 rpm (≈ 2 min)	Moderate speed	Initiation of separation of leukocytes and platelets from upper phases	Initial buffy coat	This stage marks the beginning of the formation of a denser CGF fibrin structure.
Stage 3: 2700–3000 rpm (≈ 4 min)	Highest speed	Complete sedimentation of erythrocytes	Lower phase: red blood cells (RBCs)	A more homogeneous and dense fibrin matrix forms in the upper phase.
Stage 4: Deceleration to 2400 rpm (≈ 4 min)	Deceleration phase	Optimization of fibrin polymerization	Middle phase: CGF gel / matrix	The characteristic dense fibrin structure of CGF is formed during this stage.
Stage 5: Slow stopping	Automatic	Stabilization of the fibrin structure	Upper phase: platelet-poor plasma (PPP)	In clinical practice, the CGF fraction is the most frequently utilized component.

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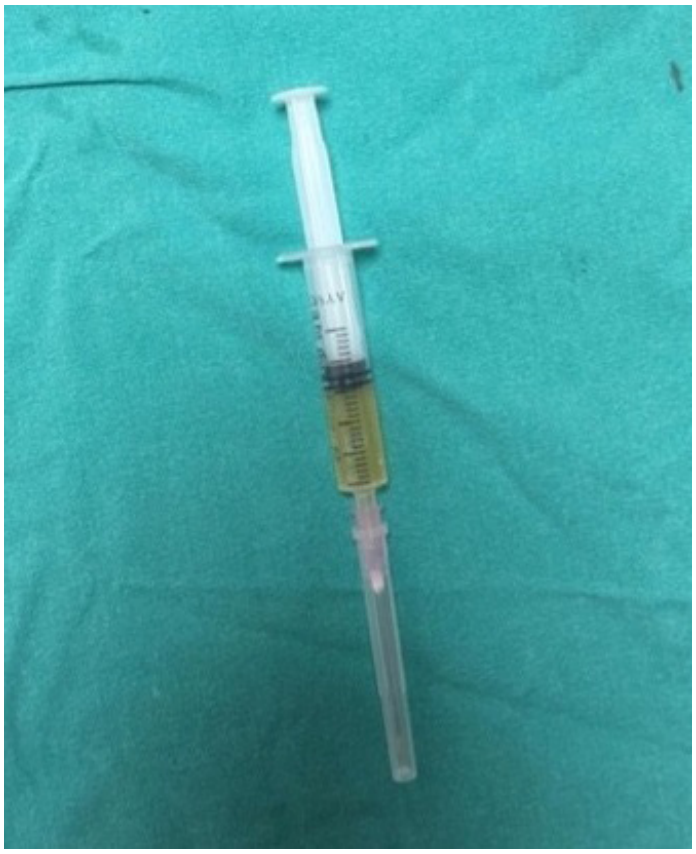

Figure 3. Macroscopic appearance of CGF aspirated into a syringe following separation of the phases within the tube after centrifugation

Clinical Applications of PRF in Oral and Maxillofacial Surgery

Use of PRF in Tooth Extraction Sockets

Tooth extraction is inherently a bleeding and traumatic surgical procedure, and various postoperative complications such as bleeding, swelling, edema, and infection may occur during the healing period. Effective management of these complications is essential for achieving clinical success. In addition, the alveolar bone—whose morphology is largely dependent on the extracted tooth—undergoes physiological resorption following the loss of blood supply provided by the periodontal ligaments. Although the alveolar bone remodeling process is generally completed within approximately one year, the majority of volumetric bone loss occurs during the first three months after extraction. To enable treatment planning that meets esthetic and functional requirements, it is crucial to control bone loss during this period and to rehabilitate the extraction socket.

For this purpose, various biomaterials and techniques have been employed. Platelet-rich fibrin (PRF), which has been shown to support biological processes such as cellular migration, differentiation, and proliferation, as well as to promote tissue healing and regeneration, is among the most frequently used biological agents in alveolar preservation and regenerative treatment strategies [38–40].

Use of PRF in Sinus Floor Elevation

Alveolar bone resorption resulting from tooth loss represents a significant limitation for implant surgery, particularly in the posterior maxilla. Surgical procedures aimed at increasing the distance between the sinus floor and the alveolar crest to overcome vertical bone deficiency in this region are collectively referred to as sinus floor elevation. In sinus lifting procedures, various biomaterials are used to support bone regeneration and enhance graft stability.

In recent years, the combination of graft materials with platelet-rich fibrin (PRF) has gained increasing attention in both research and clinical practice, owing to the biological properties of PRF, including its sustained growth factor release and its modulatory effects on tissue healing [41].

Choukroun and colleagues (2006) reported that the use of PRF in combination with graft materials during lateral approach sinus floor elevation enhanced angiogenesis and promoted new bone formation. This finding laid the foundation for the use of PRF as an adjunctive biological agent in sinus augmentation procedures [41].

Platelet-rich fibrin (PRF) is also utilized as an important biological adjunct for the repair of Schneiderian membrane perforations during sinus floor elevation procedures. The literature reports that membrane perforations occur in approximately 20% of sinus lifting procedures, particularly when a lateral approach is employed. Owing to its biocompatible structure and wound-healing–promoting properties, PRF offers distinct advantages in the management of perforation sites.

It has been reported that perforations with a diameter of approximately 3 mm can be covered using three layers of PRF membranes, whereas larger defects may require the combined use of PRF with collagen membranes. To ensure effective coverage and adequate membrane stability, the application of at least two PRF membranes is recommended [42].

Use of PRF in Implantology

The success of implant surgery is directly dependent on the quantity and quality of both hard and soft tissues at the recipient site. To achieve adequate primary stability, the presence of approximately 2–4 mm of surrounding bone is required, along with at least 2–3 mm of horizontal and vertical soft tissue support to maintain this stability. In immediate implant placement, resorption of the buccal socket wall often necessitates positioning the implant in a more palatal/lingual and apical location, which subsequently results in a gap between the implant surface and the buccal socket wall.

Various approaches have been described in the literature to manage this gap, including the use of PRF alone or in combination with different graft materials. It is suggested that the growth factors and cytokines contained within PRF enhance osteoblastic activity, thereby supporting bone regeneration around dental implants [43].

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Use of PRF in Periodontology

Platelet-rich fibrin (PRF) is among the most frequently used biological materials in the treatment of periodontal intrabony defects. Eleven randomized clinical trials reported in the literature have demonstrated that PRF application yields superior outcomes compared with flap debridement alone, particularly in terms of enhanced bone regeneration and improvements in clinical attachment levels. In a study comparing PRF with demineralized freeze-dried bone allograft in the treatment of intrabony defects, no statistically significant difference was observed between the two treatment modalities [10].

Discussion

In this narrative review, the biological foundations, preparation protocols, and clinical applications of autologous concentrated blood products in oral surgery were evaluated. Based on the available evidence, current studies indicate that platelet-rich blood products function as biological agents that support tissue healing and regeneration.

Growth factors such as platelet-derived growth factor (PDGF), transforming growth factor-β (TGF-β), vascular endothelial growth factor (VEGF), and epidermal growth factor (EGF), which form the biological basis of the regenerative effects of concentrated blood products, are released following platelet activation and play a critical role in regulating cellular migration, proliferation, and angiogenesis [4,5,44]. However, the clinical outcomes reported in the literature are characterized by a degree of heterogeneity that cannot be explained solely by the presence of growth factors. This variability suggests that biological parameters such as the micromorphological properties of the fibrin matrix, leukocyte content, and the kinetics of growth factor release are key determinants of clinical efficacy [14,26].

The principal difference between PRP and PRF lies in the nature of fibrin polymerization and the associated duration of growth factor release. In PRP, growth factors are released rapidly but over a relatively short period, whereas in PRF and its derivatives, the presence of a more stable fibrin network allows for a gradual and more sustained release of these factors [26,27]. This biological characteristic suggests that PRF may offer advantages over PRP in clinical situations where bone regeneration and soft tissue healing occur over extended timeframes. However, based on the current body of evidence, it cannot be concluded that this potential superiority is applicable across all clinical indications.

The influence of leukocyte content on clinical outcomes represents one of the most debated issues in the literature. Leukocyte-rich preparations such as L-PRF and A-PRF have been suggested to support angiogenesis and the early healing process by modulating the inflammatory response [28,29]. In contrast, some studies have indicated that excessive inflammatory cell content may adversely affect soft tissue healing, particularly during the early stages of wound repair [10]. These conflicting findings demonstrate that the simplified assumption that a higher cellular content invariably translates into superior clinical outcomes is not scientifically sustainable.

Experimental studies have demonstrated that LSCC-based protocols, including A-PRF, A-PRF+, and i-PRF, enhance fibrin matrix porosity, thereby improving cellular distribution and vascularization [28,31,32]. In particular, the higher growth factor release and increased cellular content reported for A-PRF+ and i-PRF are considered key features that may augment their regenerative potential. Nevertheless, the number of long-term randomized controlled trials that clearly establish the clinical superiority of these protocols remains limited.

When the use of PRF across different clinical fields—such as extraction sockets, sinus floor elevation, implantology, and periodontal therapy—is considered, numerous studies have reported shortened healing times and reduced complication rates [38,42]. Nevertheless, the generalizability of these findings is limited by several methodological factors, including small sample sizes, heterogeneity among control groups, and insufficient standardization of application protocols. In particular, with respect to sinus augmentation and peri-implant bone regeneration, it remains unclear whether PRF is more effective when used as a standalone treatment or as an adjunctive biological agent [41,43].

Alternative fibrin concentrates such as CGF and T-PRF appear theoretically advantageous due to their denser fibrin structures and greater mechanical stability [30,37]. However, the available evidence regarding their clinical efficacy is more limited when compared with L-PRF and A-PRF. Therefore, based on the current data, there is insufficient evidence to support the replacement of standard PRF protocols with these preparations in routine clinical practice.

Limitations

The considerable variability among studies in parameters used for the preparation of autologous blood products—such as centrifugation speed, g-force, duration, rotor type, and tube material—results in significant methodological heterogeneity within the literature. This heterogeneity hampers the direct comparison of biological and clinical outcomes across studies. Moreover, most available clinical studies investigating PRF variants are characterized by small sample sizes and limited methodological quality. Differences among commercial devices and kits, which may alter the composition of the final product, further compromise the generalizability of the reported findings. In addition, the paucity of studies evaluating the influence of patient-related biological variables on the structural characteristics of the obtained concentrates leaves the impact of individual variability on clinical outcomes insufficiently defined. For these reasons, there is a clear need for future studies employing standardized protocols, larger sample sizes, and long-term follow-up in order to generate more reliable and generalizable evidence.

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Conclusion

Autologous platelet-rich blood products are biological agents increasingly used in medicine and dentistry due to their ability to promote tissue healing through growth factors. In surgical applications, they offer a minimally invasive approach that accelerates healing and improves patient comfort. The current literature suggests that these products may have positive effects on clinical outcomes and patient satisfaction. Despite existing limitations, they are considered promising adjunctive therapies in regenerative medicine and dental practice.

Conflict of Interests
The authors declare that there is no conflict of interest in the study.

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