

Platelets Reimagined: A Periodontal Perspective

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Abstract

Platelet concentrates (PCs) have revolutionized regenerative dentistry, particularly in periodontics and implantology, by leveraging autologous growth factors and cytokines to enhance tissue healing and regeneration. Over the last two decades, platelet-rich plasma (PRP), platelet-rich fibrin (PRF), and concentrated growth factors (CGF) have been increasingly adopted as adjuncts to conventional therapies, demonstrating significant improvements in soft and hard tissue repair. PCs act as reservoirs of bioactive molecules, facilitating angiogenesis, osteogenesis, and wound healing while minimizing patient morbidity.

This article presents a comprehensive overview of platelet concentrates, including preparation techniques, biological mechanisms, clinical applications, and recent advances, emphasizing their evolving role in periodontal regeneration and implant integration.

Keywords: Platelet concentrates, PRP, PRF, CGF, periodontal regeneration.

INTRODUCTION

Regenerative dentistry has seen a paradigm shift with the advent of autologous platelet concentrates, which provide a rich source of growth factors and cytokines critical for tissue repair. Periodontal diseases and alveolar bone deficiencies pose significant clinical challenges, often compromising oral function and aesthetics.

Conventional therapies focus on infection control and mechanical regeneration; however, complete restoration of periodontal structures remains limited.

Platelet concentrates, derived from autologous blood, provide a biological scaffold enriched with growth factors such as platelet-derived growth factor (PDGF), transforming growth factor-beta (TGF- β), vascular endothelial growth factor (VEGF), and insulin-like growth factor (IGF). These bioactive molecules modulate cellular processes including chemotaxis, proliferation, differentiation, and angiogenesis, which are essential for soft tissue and bone regeneration. The first generation of PCs, platelet-rich plasma (PRP), introduced the concept of autologous growth factor therapy, while the evolution to platelet-rich fibrin (PRF) and concentrated growth factors (CGF) has improved handling, sustained release of growth factors, and reduced preparation complexity.

Beyond the well-documented clinical benefits, recent advances in molecular biology and bioengineering have led to innovative modifications of PCs, including the incorporation of platelet-derived extracellular vesicles (PDEVs), hybrid scaffolds with biomaterials, and nanofibrillar networks to enhance regenerative outcomes.

Understanding the preparation methods, biological mechanisms, and clinical applications of PCs is critical for optimizing patient outcomes in periodontal and implant therapies.

WHAT IS A PLATELET?

Platelets, also known as **thrombocytes**, are small, irregularly shaped, colourless cell fragments that play a **crucial role in blood clotting (hemostasis) and wound healing**.

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They are one of the three main cellular components of blood, along with red blood cells (erythrocytes) and white blood cells (leukocytes). Despite their small size and lack of a nucleus, platelets perform highly specialized and vital biological functions that help maintain vascular integrity and prevent excessive blood loss following injury.

Platelet Concentration Preparation Protocol

Platelet concentrates are prepared from autologous venous blood collected under strict aseptic conditions. Depending on the type, blood is drawn into tubes with

or without anticoagulant and immediately subjected to centrifugation at specific speeds and durations to separate its components. This process yields a platelet-rich fraction containing platelets, leukocytes, and growth factors. The desired layer is carefully isolated, with activation performed when required (as in PRP), while fibrin-based concentrates such as PRF undergo natural coagulation without additives. The prepared platelet concentrate is used immediately to preserve cellular viability and biological activity.

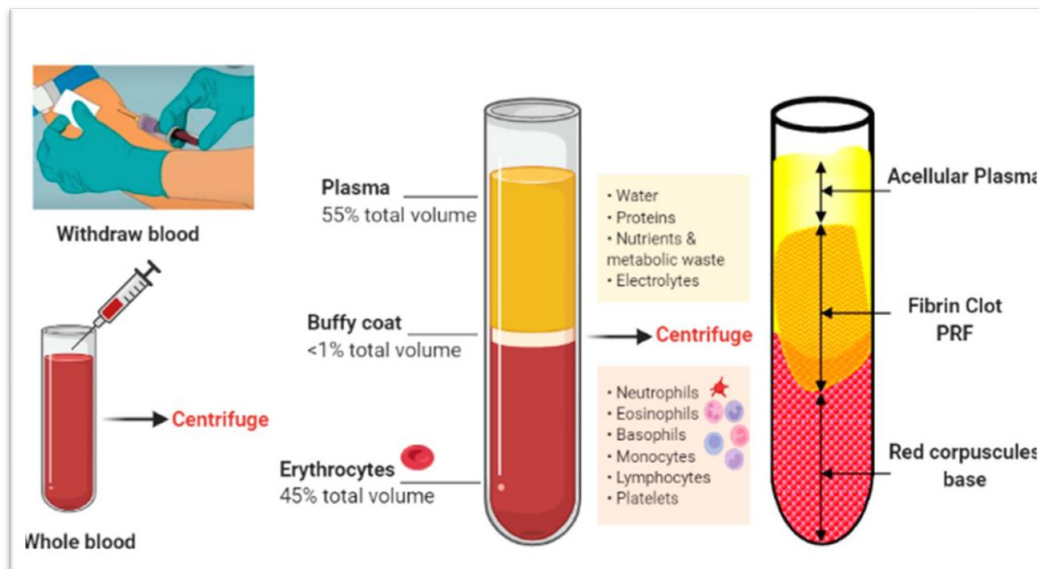


Figure 1. Platelet concentration preparation protocol.

TYPES OF PLATELET CONCENTRATES

Platelet-Rich Plasma (PRP)

PRP represents the first generation of platelet concentrates. It is a liquid formulation obtained by centrifugation of autologous blood, often combined with anticoagulants to prevent clotting. Activation is achieved via calcium chloride or thrombin, forming a gel-like matrix that delivers growth factors to the wound site. PRP has been used extensively in periodontal regeneration, alveolar ridge augmentation, and implantology, enhancing fibroblast proliferation, osteoblast differentiation, and neovascularization.

Platelet-Rich Fibrin (PRF)

PRF, a second-generation platelet concentrate, eliminates the need for anticoagulants and offers a fibrin matrix that enables slow and sustained release of growth factors. Different protocols, such as L- PRF (Leukocyte-rich PRF) and A-PRF (Advanced PRF), have been developed to modulate cellular content and enhance regenerative

potential. PRF has shown superior handling, adaptability, and clinical outcomes compared to PRP, particularly in soft tissue healing and bone regeneration.

Concentrated Growth Factors (CGF)

CGF is prepared using specialized centrifugation techniques that yield a highly dense fibrin matrix enriched with growth factors. CGF demonstrates improved mechanical strength, higher growth factor concentration, and extended release kinetics, making it ideal for guided bone regeneration and implant site preparation.

Emerging Platelet Derivatives

Recent innovations include lyophilized platelet concentrates,

injectable PRF, and platelet-derived extracellular vesicles (PDEVs), which provide targeted delivery of growth factors at the molecular level, potentially enhancing osteogenic and angiogenic responses.

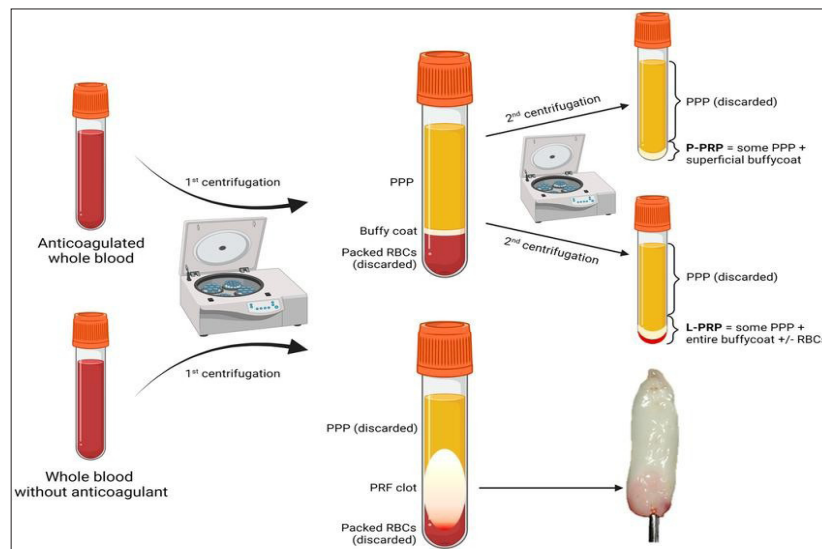


Figure 2. Platelet concentration processing techniques.

EVOLVING GENERATIONS OF PLATELET CONCENTRATES

First-generation (PRP) employs two-step centrifugation, releasing most growth factors early but dissolving within ~3 days. Useful when combined with grafts (e.g., β -TCP + PRP led to ~2.8 mm probing depth reduction vs ~2.2 mm for graft alone).

Second-generation (PRF, L-PRF, A-PRF, i-PRF) uses single-step centrifugation without additives, forming a fibrin scaffold that releases GF over ~10 days and integrates leukocytes for healing modulation.

Third-generation (CGF) offers even denser fibrin networks with sustained GF release up to 28 days, outperforming PRP in growth factor content.

Fourth Generation – Concentrated Growth Factor (CGF)

Concentrated Growth Factor (CGF), developed by Sacco in 2006, is considered the fourth generation of platelet concentrates. It represents the most advanced evolution, characterized by a denser fibrin matrix, higher concentration of platelets, and enhanced mechanical strength.

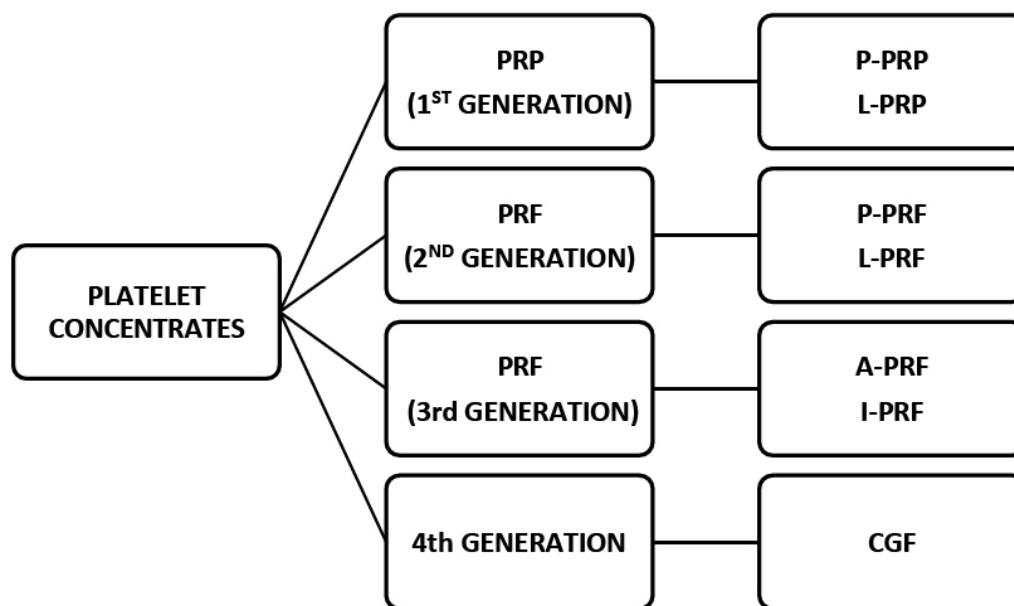


Figure 3. Schematic Representative Diagram showing the Classification of platelet concentrates. Platelet-Rich Plasma (PRP), Platelet-Rich Fibrin (PRF), Pure Platelet-Rich Plasma (P-PRP), Leukocyte- and Platelet-Rich Plasma (L-PRP), Pure Platelet-Rich Fibrin (P-PRF), Leukocyte- and Platelet-Rich Fibrin (L-PRF), Advanced Platelet-Rich Fibrin (A-PRF), Injectable platelet-rich fibrin (I-PRF), Concentrated Growth Factor (CGF).

MECHANISM OF ACTION

Platelet concentrates exert regenerative effects through multiple mechanisms:

- Growth factor delivery: PDGF, TGF- β , VEGF, and IGF stimulate cell proliferation, migration, and differentiation.
- Cytokine modulation: Anti-inflammatory and immunomodulatory cytokines reduce tissue destruction and promote healing.
- Angiogenesis: VEGF and other factors enhance new blood vessel formation.
- Osteogenesis and matrix remodelling: Activation of osteoblasts and fibroblasts facilitates bone deposition and collagen synthesis.
- Scaffold function: Fibrin matrices act as a 3D structure supporting cell adhesion and tissue organization.

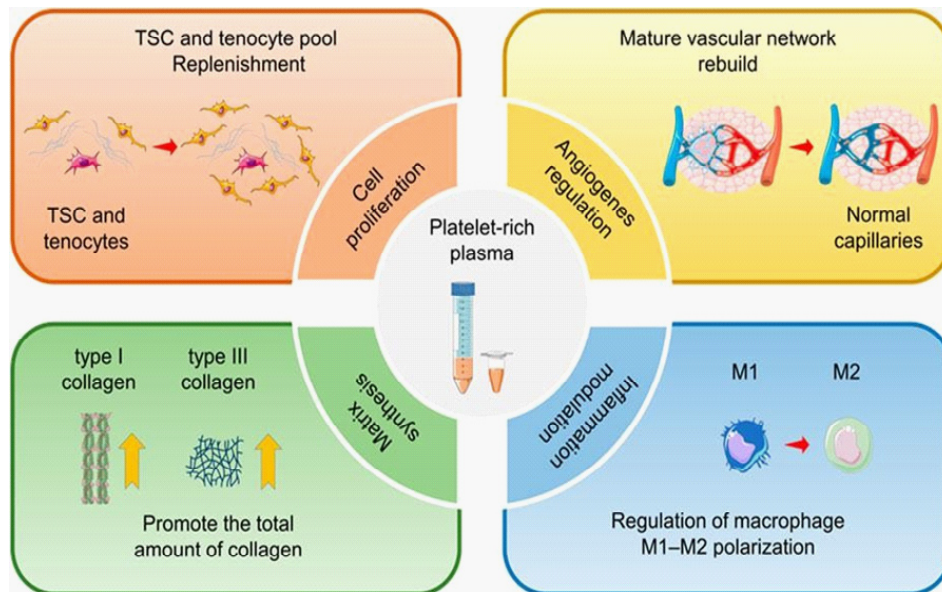


Figure 4. Therapeutic effects of platelet-rich plasma (PRP).

CLINICAL APPLICATIONS IN PERIODONTICS AND IMPLANTOLOGY

Periodontal Regeneration

PRF and CGF have been employed in treating intrabony defects, furcation involvement, and gingival recession. Studies demonstrate significant clinical attachment level gain, probing depth reduction, and radiographic bone fill when PCs are used adjunctively with bone grafts or membranes.

Alveolar Ridge Augmentation

In implantology, PCs enhance bone volume and quality, reducing the need for extensive autogenous grafting. PRF membranes and CGF blocks improve graft stabilization, angiogenesis, and early wound healing.

Soft Tissue Management

PRF and CGF promote gingival thickness, keratinized tissue width, and flap healing. These properties are particularly beneficial in peri-implant soft tissue management and root coverage procedures.

Sinus Lift and Implant Integration

The use of PRF/CGF in maxillary sinus floor elevation has demonstrated improved bone formation and reduced postoperative complications. PC incorporation accelerates osseointegration and stabilizes implant sites.

RECENT ADVANCES AND EMERGING TRENDS

Platelet-Derived Extracellular Vesicles (PDEVs)

PDEVs are nano-sized vesicles released by platelets, carrying bioactive molecules that can influence target cell behavior. They enhance angiogenesis, osteogenesis, and immunomodulation, representing a promising cell-free regenerative therapy.

Hybrid Scaffolds

Combining PCs with biomaterials such as hydroxyapatite, tricalcium phosphate, or collagen scaffolds improves mechanical stability and controlled release of growth factors, enhancing bone regeneration outcomes.

Injectable PRF (i-PRF)

i-PRF is a low-speed centrifugation product that remains injectable, allowing minimally invasive delivery into bone defects, extraction sockets, and peri-implant sites.

Nanotechnology and Bioprinting

Incorporation of PCs into nanofibrillar scaffolds and 3D bioprinted matrices has shown enhanced cellular

proliferation, differentiation, and tissue organization in preclinical models.

Combination Therapies

Synergistic use of PCs with stem cells, growth factor-loaded biomaterials, and pharmacological agents is emerging as a strategy to overcome limitations in regenerative capacity.

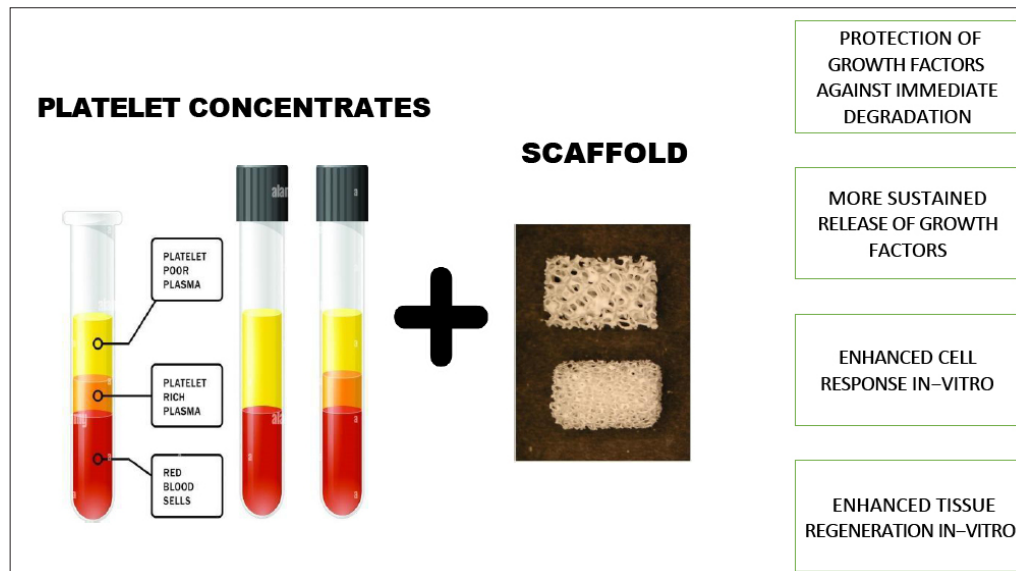


Figure 5. The use of platelet concentrates and a scaffold for biomedical applications, specifically in tissue regeneration. The process involves combining platelet-rich plasma (PRP) with a scaffold material to create a sustained release of growth factors, leading to enhanced healing.

CHALLENGES AND LIMITATIONS

Despite their advantages, PCs have inherent limitations:

- Variability in platelet concentration and growth factor content.
- Short-term release kinetics (especially in PRP).
- Technical sensitivity during preparation.
- Lack of standardized protocols across clinical settings.
- Limited long-term clinical data for emerging modalities like PDEVs.

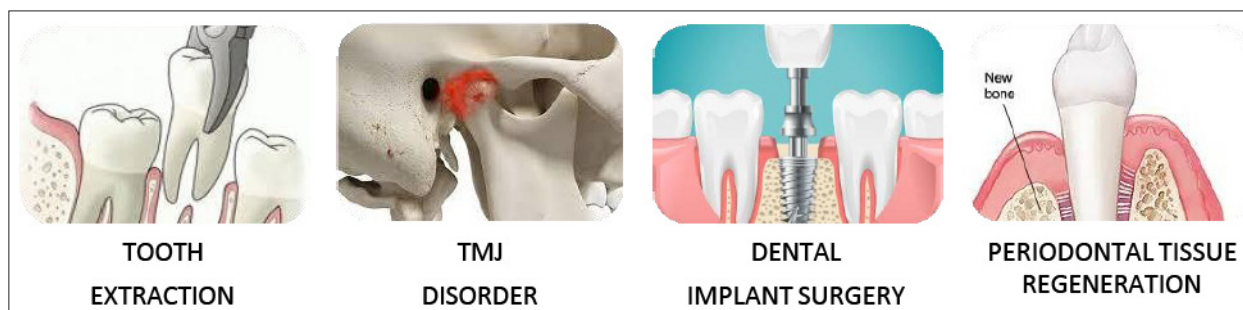


Figure 6. The use of biomedical appliances in dentistry, specifically focusing on tissue regeneration and various dental procedures.

FUTURE PERSPECTIVES

Future research should focus on:

- Standardization of preparation protocols.
- Optimization of growth factor delivery systems.
- Large-scale clinical trials evaluating long-term efficacy.

- Integration with tissue engineering, stem cell therapy, and nanotechnology.
- Exploration of personalized regenerative approaches based on patient-specific platelet profiles.

CONCLUSION

Platelet concentrates have transformed regenerative approaches in periodontics and implantology, providing autologous, biologically active scaffolds that enhance soft and hard tissue healing. The evolution from PRP to PRF, CGF, and PDEVs reflects an ongoing commitment to optimizing clinical outcomes. While challenges remain, emerging technologies and combination therapies hold significant promise for achieving predictable, long-lasting regenerative results. Incorporating PCs into routine dental practice can improve patient care, reduce morbidity, and expand the boundaries of oral regenerative therapy.

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25. Song & He (2024) – fresh review of PRF, good for latest trends.
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