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Platelet Concentrates (PRF, PRP)-Nature's Gift to Surgeons

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Abstract: Platelet-rich plasma (PRP) and platelet-rich fibrin (PRF) are widely used autologous platelet concentrates that enhance healing in oral and maxillofacial surgery. PRP, prepared through centrifugation with anticoagulants, delivers a rapid burst of growth factors that supports early inflammatory and reparative phases, though its long-term effects on bone regeneration remain variable. In contrast, PRF, produced without additives, forms a fibrin matrix that enables sustained release of growth factors and cytokines, promoting predictable osteogenesis, angiogenesis, and soft tissue healing. Literature consistently demonstrates PRF's superior clinical performance in bone grafting, sinus lift procedures, socket preservation, and general oral surgery due to its biocompatibility, prolonged activity, and immune-modulatory properties. While PRP remains valuable for early healing and compromised tissue conditions, PRF offers more reliable regenerative outcomes. Overall, both concentrates serve as effective adjuncts, with PRF demonstrating greater consistency across applications.
Keywords: Platelet-rich plasma, Platelet-rich fibrin, Bone regeneration, Growth factors, Oral surgery.

I. INTRODUCTION

Platelet-rich plasma (PRP) is a therapeutic modality derived from a patient's own blood, which is processed through centrifugation to concentrate platelets and growth factors. This concentration is pivotal for its application in maxillofacial surgery, where PRP is utilized to accelerate bone healing.[1] The centrifugation process must be performed with precision and under sterile conditions to ensure the effective separation of platelets from red blood cells, maintaining their integrity and avoiding any damage that could impair their functionality. PRP was first introduced to the oral surgery field by Whitman et al., and has since gained prominence for its role in enhancing bone regeneration.[2] The therapeutic efficacy of PRP is largely attributed to its rich content of growth factors, including Platelet-Derived Growth Factor (PDGF), Transforming Growth Factor-Beta (TGF-β), Vascular Endothelial Growth Factor (VEGF), and Epidermal Growth Factor (EGF). These factors are essential for promoting cellular proliferation, collagen synthesis, and angiogenesis—key processes in bone repair and regeneration. PRP, particularly when used as Platelet-Rich Growth Factor (PRGF), has demonstrated remarkable clinical success in oral and maxillofacial surgeries by improving outcomes such as bone integration in grafts, enhancing the healing of fractures, and increasing the success rates of dental implants.[3] The utilization of PRP in these contexts is based on the premise that higher concentrations of platelets and their growth factors significantly contribute to more efficient and effective bone healing by stimulating the body's natural regenerative processes.[4] Platelets are crucial for hemostasis and wound healing, playing a key role in the repair process across various types of wounds. The growth factors contained in platelet α-granules are vital for the differentiation and proliferation of cells at the wound site, such as fibroblasts, endothelial cells, and osteoblasts, which are essential for effective healing. Given their significant role, extensive research is being conducted on the impact of platelets in different fields, including maxillofacial surgery, oral implantology.[5] Platelet-Rich Plasma (PRP) is a cost-effective and easily prepared treatment that can be used in outpatient settings due to advancements in machinery. However, the blood collection required for PRP preparation is invasive, which may limit its routine use for all patients. Additionally, while PRP offers numerous benefits, it is important to consider potential inhibitory effects, such as those from the TSP-1 factor, which can negatively impact the healing process.[6]

II. APPLICATIONS AND CLINICAL BENEFITS OF PRP AND PRF IN ORAL AND MAXILLOFACIAL SURGERY

Platelet-rich plasma (PRP) and platelet-rich fibrin (PRF) have emerged as valuable autologous biomaterials in oral and maxillofacial surgery, with applications extending from bone regeneration to enhanced soft tissue healing. Initially popularized by Marx et al.[7] for maxillofacial reconstructive surgery using large bone grafts, PRP has since been evaluated in diverse clinical situations including alveolar cleft repair, bone defects following tumor resection, and fibrous dysplasia though outcomes across studies remain mixed and its overall impact on bone healing continues to be debated. PRP appears particularly beneficial in compromised tissue environments, such as in patients on bisphosphonates where it may reduce the risk of delayed healing and osteonecrosis, as well as in anticoagulated patients where its intrinsic coagulation factors support hemostasis and early repair; it may also aid healing in irradiated tissues post-tumoral surgery.[8] However, its advantages in healthy tissues are less definitive. By contrast, leukocyte- and platelet-rich fibrin (L-PRF), a newer second-generation platelet concentrate, has shown more consistent and favorable outcomes due to its solid fibrin matrix, enabling effective cavity filling and improved regenerative support especially in conditions like bisphosphonate-induced osteonecrosis and healing in anticoagulated patients.[9] PRF has also demonstrated wide-ranging clinical utility, including reducing pain, edema, and trismus after third molar extractions; preserving alveolar ridge volume; supporting sinus lift and perforation repair; enhancing bone regeneration and vascularization in ridge augmentation; aiding closure of oroantral communications; improving outcomes in guided bone regeneration and periodontal surgeries; promoting healing after cyst and tumor removal; and serving as an adjunct in managing medication-related osteonecrosis of the jaw.[10] Its regenerative benefits stem from its ability to stimulate osteoblasts, fibroblasts, and periodontal ligament cells, enhance angiogenesis and osteogenesis, reduce inflammation and postoperative discomfort, and provide a natural, cost-effective, biocompatible option with minimal immunologic risk.[11]

III. REVIEW OF LITERATURE

Experimental animal work by Niimi et al. demonstrated that PRP accelerates early healing in extraction sockets, with treated sites showing richer granulation tissue and more pronounced angiogenesis compared to controls, indicating enhanced early inflammatory and reparative responses.[12] Similarly, Zhang's review noted that PRP promotes osteoblast activity and improves bone healing kinetics in animal models, and while clinical studies suggest it can shorten healing duration in fractures, the overall rate of fracture healing and long-term functional outcomes remain inconclusive.[13] Mohanty et al. further observed that PRP significantly improves soft tissue healing, reduces probing depths, and enhances bone density and height over time, with fewer postoperative complications such as pain and trismus.[14] Complementing this, a study by Niedzielska showed that PRF leads to superior soft tissue outcomes and improved bone quality reflected in higher grayscale values on CBCT thereby reducing alveolar ridge atrophy.[15] Additional clinical evidence from Hanif demonstrated that PRP effectively reduces postoperative pain and trismus following mandibular third-molar surgery, while Gawai reported improved early bone healing and consistently better soft tissue healing in PRP-treated sockets, despite limited long-term radiographic differences.[16,17] Zaid's findings further support PRP's role in promoting soft tissue repair and influencing bone regeneration, including root development and dentin wall thickening.[18] Collectively, these studies reinforce that PRP and PRF are biologically active autologous concentrates rich in growth factors such as PDGF, TGF-β, and VEGF, which facilitate angiogenesis, cellular proliferation, and matrix formation. Their applications span oral surgery, implant dentistry, and regenerative procedures, although variations in leukocyte content may modulate inflammatory responses, underscoring the importance of selecting the appropriate formulation for optimal clinical outcomes.

IV. ROLE OF GROWTH FACTORS AND CYTOKINES IN PRF AND PRP FOR ENHANCED BONE REGENERATION

Growth factors and cytokines released from platelet concentrates such as Platelet-Rich Fibrin (PRF) and Platelet-Rich Plasma (PRP) play an essential and synergistic role in bone healing by promoting osteogenesis, angiogenesis, and regulated inflammation, all of which contribute to effective bone regeneration. PRF contains key growth factors—including TGF-β, PDGF, VEGF, and IGF-1 that stimulate osteoblast proliferation, differentiation, collagen synthesis, and new bone matrix formation, while its cytokines (IL-1ra, IL-6, TNF-α, MCP-1, RANTES) help modulate inflammation and immune responses by recruiting macrophages and mesenchymal stem cells to support osteogenesis.[19] PRF's fibrin matrix acts as a natural scaffold that protects and gradually releases these bioactive molecules, ensuring sustained signaling for prolonged tissue repair. Similarly, PRP enhances bone healing through its rich content of inflammatory cytokines (IL-1, IL-6, TNF-α), growth factors (PDGF, TGF-β, IGF-1), and angiogenic mediators (VEGF, angiogenin), which together regulate the early inflammatory phase, promote extracellular matrix formation, stimulate osteoprogenitor cells, and drive neovascularization necessary for nutrient delivery and bone formation.

PRP also contains biologically active substances such as serotonin, histamine, dopamine, calcium, and adenosine that influence clot stability, immune activation, and wound healing dynamics.[20] Despite its therapeutic promise, variability in PRP preparation methods including single-spin versus double-spin centrifugation and differences across commercial kits results in inconsistent platelet and leukocyte concentrations, making the ideal formulation for optimal bone regeneration still a subject of debate.[21] Overall, both PRF and PRP enhance osteogenesis, angiogenesis, and controlled inflammation, with PRF offering the advantage of a slow-release fibrin matrix, thereby supporting predictable and accelerated bone regeneration in oral and maxillofacial surgical applications.[22]

V. COMPARISON OF PRP AND PRF: PREPARATION TECHNIQUES, BIOLOGICAL BEHAVIOR, AND CLINICAL EFFECTIVENESS

Platelet-rich plasma (PRP) and platelet-rich fibrin (PRF) differ significantly in their preparation methods and biological performance, resulting in distinct clinical outcomes in oral and maxillofacial surgery. PRP is produced by drawing blood with anticoagulant and processing it through a two-step centrifugation technique to isolate a platelet-rich layer, which is then activated using agents such as calcium chloride or thrombin; this yields a liquid concentrate that delivers a rapid, short-lived burst of growth factors conducive to early-stage healing but limited by its brief biologic activity.[23] In contrast, PRF is prepared without anticoagulants using a single low-speed, short-duration centrifugation process that forms a fibrin clot enriched with platelets, leukocytes, and growth factors within a natural scaffold, enabling gradual release of bioactive molecules over 7–14 days and providing superior support for wound healing, angiogenesis, and bone regeneration.[24] Recent research has further emphasized the complexity of optimizing PRP formulations, with widely varying platelet concentration thresholds proposed—from Marx's recommendation of 1,000,000 platelets/μL to the FDA's minimum of 250,000 platelets/mL while studies report inconsistent findings regarding the ideal platelet dose, with both insufficient and excessively high concentrations potentially reducing osteogenic benefits.[25] The role of leukocytes remains controversial: leukocyte-rich PRP (LR-PRP) may enhance growth factor diversity but is associated with increased inflammation and postoperative pain, whereas leukocyte-poor PRP (LP-PRP) appears better suited for intra-articular applications. Variability in preparation systems plasma-based versus buffy coat-based methods, as well as single-spin versus double-spin centrifugation adds further complexity, as these approaches produce differing platelet and leukocyte yields, resulting in inconsistent clinical outcomes.[26]

A. PRP And PRF in Bone Regeneration

Platelet concentrates such as PRP and PRF have been widely investigated for their potential to enhance bone healing. PRP has shown mixed outcomes across studies: some report increased osteoblast activity and improved bone formation, while others find no measurable benefit. Its effectiveness appears to depend heavily on the type of graft biomaterial used and the specific PRP formulation.[27] In contrast, PRF demonstrates more predictable results due to its dense fibrin matrix and the slow, sustained release of growth factors such as PDGF, VEGF, and TGF-β. This natural scaffold supports cell migration, angiogenesis, and extracellular matrix deposition, making PRF particularly effective in ridge preservation, ridge augmentation, and bone grafting procedures. Overall, while PRP mainly provides an early stimulatory environment that may support natural healing, PRF offers prolonged biological activity that promotes more consistent and long-term bone regeneration.[28]

B. PRP And PRF In Sinus-Lift Procedures

Sinus-lift surgery serves as a reliable clinical model for studying bone formation due to the creation of a protected subantral healing chamber beneath the Schneiderian membrane. Although a variety of grafting materials can achieve successful outcomes, platelet concentrates have been used to improve vascularization and accelerate regeneration. PRP and L-PRF may enhance angiogenesis and early bone formation, particularly when simultaneous implant placement relies on the stability of the blood clot.[29] However, PRP's benefits remain inconsistent, with some studies reporting improved healing and others finding no significant advantage. PRF, on the other hand, consistently demonstrates superior outcomes by supporting membrane elevation, forming a biologically active fibrin scaffold, and enhancing new bone formation and implant stability. Evidence generally favors PRF as a more reliable adjunct to sinus augmentation compared to PRP.[30]

C. PRP and PRF IN Alveolar Socket Healing

Both PRP and PRF have been utilized to improve healing after tooth extractions, though their effects differ in predictability and duration. PRP has been shown to reduce postoperative pain, control bleeding, enhance early soft tissue repair, and promote early radiographic bone density within the first 1–2 weeks.[31]

Despite these early benefits, long-term healing outcomes often show no significant difference compared with untreated sites. PRF provides more stable and consistent results due to its fibrin matrix, which stabilizes the clot, enhances angiogenesis, and supports rapid soft tissue closure. It also significantly reduces the incidence of dry socket and facilitates early bone formation, making it a more effective material for socket preservation and improving patient comfort.[32]

D. PRP And PRF In General Oral Surgery

In broader oral surgical applications, both PRP and PRF contribute to enhanced tissue regeneration, though PRF consistently offers superior outcomes. PRP has been associated with improved healing in mandibular fractures, increased bone formation when combined with bone marrow, and potentially better osseointegration when applied to implant surfaces. However, these effects remain technique- and material-dependent.[33] PRF demonstrates more reliable acceleration of soft and hard tissue healing, reduced inflammation, minimized postoperative pain and swelling, and a lower risk of infection. Its leukocyte-rich composition provides immune-modulatory benefits that support a favorable healing environment across procedures such as third molar extraction, cyst enucleation, and closure of oroantral communications. Overall, PRF's simplicity, autologous nature, and sustained biological activity make it a highly effective adjunct in various oral and maxillofacial surgeries.[34]

VI. CONCLUSION

Overall, both PRP and PRF play valuable roles in enhancing bone and soft tissue healing, but their clinical effectiveness varies. PRP tends to provide early-phase benefits, particularly in soft tissue repair, yet its long-term influence on bone regeneration remains inconsistent. In contrast, PRF offers more predictable and sustained regenerative outcomes due to its fibrin matrix and gradual release of growth factors. Together, these platelet concentrates serve as useful adjuncts in oral and maxillofacial procedures, with PRF showing superior reliability across diverse clinical applications.

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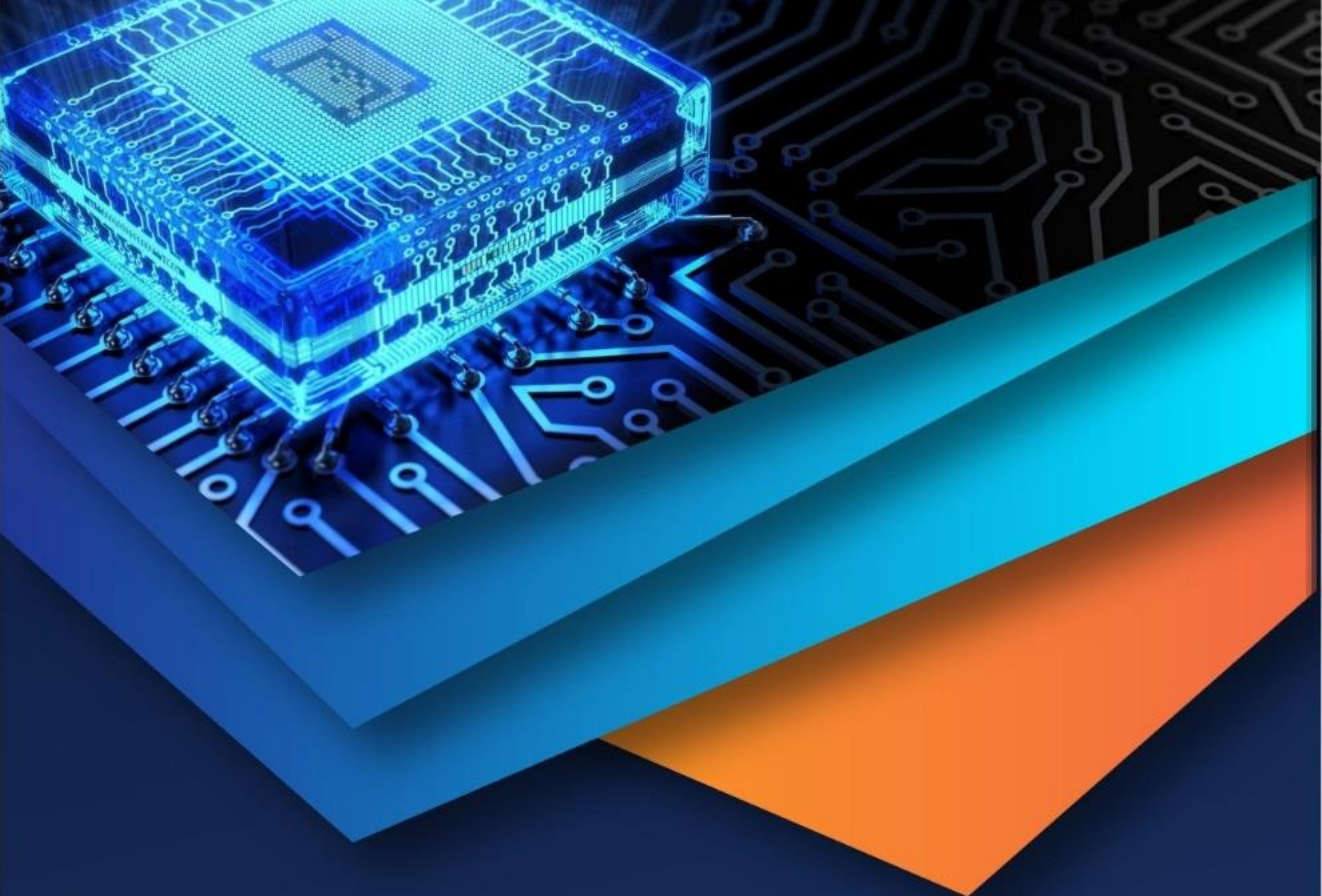

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