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PLATELET-RICH PLASMA (PRP) IN MODERN DERMATOLOGY AND AESTHETIC MEDICINE: BIOLOGICAL MECHANISMS, CLINICAL APPLICATIONS, AND FUTURE DIRECTIONS

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ABSTRACT

Platelet-rich plasma (PRP) is an autologous blood-derived biologic increasingly used in dermatology and aesthetic medicine due to its regenerative and immunomodulatory effects. By providing a concentrated source of platelets and their mediators, PRP has the potential to enhance angiogenesis, promote collagen remodeling, and facilitate tissue repair. These properties support its application in various areas, including hair loss treatment, scar revision, chronic wound management, and minimally invasive rejuvenation procedures. This narrative review aims to summarize the current human clinical evidence regarding PRP, focusing on its biological mechanisms, preparation methods, clinical outcomes, safety profile, and future directions. A structured search was performed in PubMed, Scopus, and Web of Science for English-language studies involving human subjects published from 2010 to 2025. The search prioritized randomized controlled trials, comparative studies, and recent systematic reviews or meta-analyses. The existing evidence most strongly supports the effectiveness of PRP in treating androgenetic alopecia and as a complementary treatment for device-based acne scar therapies, such as microneedling or fractional lasers. However, significant variability in preparation techniques—such as single versus double centrifugation, platelet dosage, leukocyte content, activation methods, and treatment schedules—poses challenges for comparability and reproducibility of results. Overall, PRP is generally well tolerated, with adverse effects typically being mild and temporary. For future advancements, it will be essential to establish standardized frameworks for characterizing PRP, enhance the reporting of its composition, and conduct rigorous long-term studies that utilize technology for improved outcome assessment.

KEYWORDS

Platelet-Rich Plasma, Regenerative Dermatology, Androgenetic Alopecia, Acne Scars, Platelet-Rich Plasma Standardization, Aesthetic Medicine

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I. Introduction

Over the last twenty years, regenerative medicine has significantly influenced dermatology and aesthetic medicine, largely due to an increasing demand for minimally invasive and biologically compatible treatments. Among these innovative approaches, platelet-rich plasma (PRP) has emerged as one of the most commonly used biologic interventions in modern dermatologic care and cosmetic procedures (Pixley et al., 2023; Vladulescu & Patel, 2023; Rohanda, 2022).

PRP is derived from autologous blood as a plasma fraction that contains a higher concentration of platelets than usual, achieved through centrifugation (Dhurat & Sukesh, 2014). When activated, these platelets release a variety of growth factors, including PDGF, TGF-β, VEGF, EGF, and IGF-1, which play crucial roles in regulating processes such as angiogenesis, fibroblast proliferation, extracellular matrix remodeling, and inflammation. These biological mechanisms form the foundation for the use of PRP in treating skin and hair disorders (Dhurat & Sukesh, 2014; Vladulescu & Patel, 2023).

Clinically, PRP has been most thoroughly investigated for its effectiveness in treating androgenetic alopecia (AGA). Randomized trials and recent meta-analyses have shown that PRP can lead to significant improvements in hair density and thickness (Zhang et al., 2023; Li et al., 2024). Additionally, it has proven beneficial as an adjunctive treatment for managing acne scars, especially when used in conjunction with microneedling or fractional laser techniques (Kang & Lu, 2022; Cruciani et al., 2024). In the realm of aesthetic medicine, PRP is utilized for skin rejuvenation and is often combined with hyaluronic acid fillers (Asubiaro & Avajah, 2024).

Despite the promising results, research on PRP is marked by considerable methodological variability. Variations in centrifugation protocols, platelet dosages, leukocyte content, activation methods, and treatment

schedules complicate direct comparisons and reproducibility of results (Magalon et al., 2016; Pixley et al., 2023). Although classification systems like DEPA have been introduced, the reporting of PRP studies remains inconsistent (Magalon et al., 2016). New technologies, such as platelet-rich fibrin (PRF), may enhance regenerative strategies further (Sollitto et al., 2025).

While the strongest evidence supports the use of PRP for AGA and combination therapies for scars (Zhang et al., 2023; Kang & Lu, 2022), other indications are backed by smaller studies with limited follow-up (Wang et al., 2023). Therefore, this narrative review aims to synthesize contemporary literature published between 2010 and 2025 on the biological mechanisms, preparation variables, clinical efficacy, safety, challenges related to standardization, and the broader technological and societal implications of PRP implementation in dermatology and aesthetic medicine.

II. Methodology

This study was conducted as a narrative review aimed at gathering contemporary clinical evidence on platelet-rich plasma (PRP) therapy in dermatology and aesthetic medicine. The objective was to provide a structured overview of biological mechanisms, preparation variables, clinical applications, safety considerations, and technological advancements, rather than to perform a formal systematic review or meta-analysis.

A literature search was conducted in PubMed/MEDLINE, Scopus, and Web of Science, covering publications from January 2010 to January 2025, with particular emphasis on studies published between 2022 and 2025. Search terms included “platelet-rich plasma,” “PRP,” “regenerative dermatology,” “aesthetic medicine,” “androgenetic alopecia,” “acne scars,” “chronic wounds,” “microneedling,” “fractional laser,” “skin rejuvenation,” “PRP standardization,” and “platelet-rich fibrin,” combined using Boolean operators (AND/OR).

Eligible publications included randomized controlled trials, controlled clinical trials, cohort studies, comparative studies, and systematic reviews or meta-analyses evaluating PRP in dermatologic and aesthetic indications. Particular attention was given to studies reporting preparation parameters—such as centrifugation method, platelet concentration, leukocyte content, and activation strategy—due to their influence on biological activity and clinical outcomes (Magalon et al., 2016; Pixley et al., 2023). When addressing overlapping research questions, priority was given to higher levels of evidence (Zhang et al., 2023; Kang & Lu, 2022).

Animal studies, in vitro investigations without clinical correlation, case reports, small case series (<5 participants), conference abstracts, and non-dermatologic applications were excluded. Due to the heterogeneity in PRP preparation protocols and outcome measures, findings were synthesized qualitatively rather than through quantitative pooling.

As this review is based exclusively on previously published data, ethical approval was not required.

III. Results

1. Biological Mechanisms of Platelet-Rich Plasma

Platelet-rich plasma (PRP) is an autologous concentrate of platelets that is obtained through the process of centrifugation (Dhurat & Sukesh, 2014). Its therapeutic benefits in dermatology and aesthetic medicine stem from the regenerative capabilities of the growth factors released by platelets upon activation. Following activation—whether through exogenous means (such as calcium chloride or thrombin) or endogenous processes after tissue injection—platelets release several key growth factors, including platelet-derived growth factor (PDGF), transforming growth factor-beta (TGF-β), vascular endothelial growth factor (VEGF), epidermal growth factor (EGF), and insulin-like growth factor-1 (IGF-1). These factors collectively stimulate fibroblast proliferation, collagen synthesis, and angiogenesis (Vladulescu & Patel, 2023; Pixley et al., 2023), which are essential for dermal remodeling and tissue regeneration.

The activation of fibroblasts and the subsequent increase in collagen deposition are crucial to the skin rejuvenation and scar remodeling effects mediated by PRP (Kang & Lu, 2022; Cruciani et al., 2024). Angiogenesis driven by VEGF improves tissue perfusion and plays a significant role in hair restoration, where PRP has been shown to enhance hair density and thickness (Zhang et al., 2023; Li et al., 2024).

Additionally, PRP demonstrates immunomodulatory effects that can vary based on the leukocyte content. Formulations rich in leukocytes may provoke stronger inflammatory responses, which can be advantageous for wound healing but may not be ideal for aesthetic applications (Magalon et al., 2016; Pixley et al., 2023). Research indicates that the biological activity of PRP is dose-dependent, underscoring the importance of optimizing platelet concentration and adhering to standardized preparation protocols (Pixley et al., 2023).

Emerging derivatives, such as platelet-rich fibrin (PRF), may provide different kinetics for growth factor release; however, there is still limited comparative randomized evidence available (Sollitto et al., 2025).

In summary, PRP exerts its regenerative effects through a combination of mechanisms that include angiogenesis, fibroblast activation, remodeling of the extracellular matrix, and modulation of inflammation. The clinical efficacy of PRP is influenced by preparation methods and the selection of appropriate patients.

2. Preparation Protocols and Standardization Challenges

Despite its widespread clinical application, the absence of standardized preparation protocols poses a significant challenge in PRP research (Magalon et al., 2016; Pixley et al., 2023). Variability in factors such as centrifugation techniques, platelet concentrations, leukocyte content, activation strategies, and injection methods contributes to substantial heterogeneity across studies.

PRP is generally prepared using either single- or double-spin centrifugation methods (Dhurat & Sukesh, 2014). While double-spin systems can achieve higher platelet concentrations, this increased enrichment does not always translate to better clinical outcomes. Research indicates that the biological effects of PRP are dose-dependent, with excessively high platelet levels potentially diminishing regenerative responses (Pixley et al., 2023).

The composition of leukocytes also plays a crucial role in determining the biological activity of PRP. Formulations that are rich in leukocytes may enhance inflammatory responses, which can be beneficial for wound healing (Meznerics et al., 2022). In contrast, leukocyte-poor PRP is often preferred for aesthetic applications to reduce post-procedural inflammation (Magalon et al., 2016).

Commercial PRP systems differ in their centrifugation parameters and the composition of the final product, leading to variations in platelet yield and growth factor concentrations (Magalon et al., 2016; Pixley et al., 2023). Although classification frameworks like DEPA have been introduced to promote better reporting standards, adherence to these frameworks remains inconsistent (Magalon et al., 2016).

Moreover, differences in treatment schedules and combination protocols—such as those involving microneedling or fractional lasers—further complicate the interpretation of clinical outcomes (Kang & Lu, 2022; Cruciani et al., 2024).

Overall, the lack of methodological standardization continues to be a major barrier to reproducibility and the establishment of evidence-based guidelines in PRP research.

3. Clinical Applications in Dermatology

3.1 Androgenetic Alopecia

Androgenetic alopecia (AGA) is the most extensively studied dermatologic indication for PRP and demonstrates the strongest clinical evidence. The condition is characterized by progressive follicular miniaturization mediated by dihydrotestosterone, leading to shortening of the anagen phase and gradual hair thinning. Randomized trials and recent meta-analyses consistently report significant improvements in hair density and thickness compared to placebo, particularly in early-stage disease (Zhang et al., 2023; Li et al., 2024). Pooled analyses indicate moderate-to-high effect sizes (Li et al., 2023).

PRP may also provide additive benefits when combined with topical minoxidil (Li et al., 2024). Proposed mechanisms include stimulation of dermal papilla cells, enhanced perifollicular vascularization, and activation of anti-apoptotic pathways (Vladulescu & Patel, 2023).

Typical protocols involve three to four monthly sessions followed by maintenance therapy. However, variability in platelet concentration, leukocyte content, and outcome assessment limits standardization (Magalon et al., 2016; Pixley et al., 2023). Adverse effects are generally mild and transient (Zhang et al., 2023). Nonetheless, long-term durability beyond 12–18 months remains insufficiently documented (Li et al., 2024).

3.2 Acne Scars

Atrophic acne scars occur due to the loss of dermal collagen and structural disruption following inflammatory acne. Platelet-rich plasma (PRP) has gained attention as an adjunctive treatment aimed at improving collagen remodeling and promoting tissue repair.

Current evidence suggests that this therapy is most effective when used in conjunction with microneedling or fractional laser therapy, rather than as a standalone treatment (Kang & Lu, 2022; Cruciani et al., 2024). Meta-analyses indicate that combining PRP with these techniques leads to greater improvements in scar severity scores and faster recovery times compared to device-based treatments alone (Kang & Lu, 2022).

The underlying regenerative mechanism is thought to involve the stimulation of fibroblast proliferation and collagen synthesis (Vladulescu & Patel, 2023). However, many studies in this area involve small cohort sizes and short follow-up periods, and the variability in preparation methods complicates direct comparisons (Cruciani et al., 2024; Magalon et al., 2016). Overall, PRP appears to function primarily as a biological enhancer of controlled dermal injury.

3.3 Vitiligo and Other Inflammatory Dermatoses

Vitiligo is a chronic depigmenting disorder characterized by the autoimmune-mediated loss of melanocytes. Although standard therapies include topical agents and phototherapy, clinical response remains variable. PRP has been explored as an adjunctive treatment due to its regenerative and immunomodulatory properties (Pixley et al., 2023; Vladulescu & Patel, 2023). Preliminary evidence indicates that combining PRP with phototherapy or laser-based procedures may improve repigmentation outcomes (Wang et al., 2023). However, the existing data are limited by small sample sizes and short follow-up durations.

Similarly, the evidence supporting the use of PRP in other inflammatory dermatoses is still in the early stages and is insufficient to justify routine clinical application. Larger, well-designed trials are required to clarify the clinical role of PRP in these conditions.

A concise overview of the main dermatologic applications of PRP and the nature of the available clinical evidence is presented in Table 1.

Table 1. Dermatologic applications of platelet-rich plasma (PRP) and characteristics of available clinical evidence.

Indication	Nature of Available Evidence	Main Reported Clinical Findings	References
Androgenetic alopecia	Randomized controlled trials and recent meta-analyses	Consistent improvement in hair density and thickness; greater benefit in early-stage disease; potential additive effect with minoxidil	Zhang et al., 2023; Li et al., 2024
Acne scars	Randomized trials and systematic reviews	Enhanced scar severity scores and faster recovery when used in combination with microneedling or fractional laser procedures	Kang & Lu, 2022; Cruciani et al., 2024
Vitiligo	Small randomized and comparative studies	Potential improvement in repigmentation when combined with phototherapy or laser-based interventions	Wang et al., 2023
Chronic wounds	Randomized trials and meta-analyses	Accelerated wound healing and improved tissue repair outcomes	Meznerics et al., 2022
Skin rejuvenation	Small prospective clinical studies	Modest improvement in dermal thickness, elasticity, and overall skin quality	Asubiaro & Avajah, 2024; Koshkinbayeva et al., 2024

4. PRP in Aesthetic Medicine

4.1 Skin Rejuvenation

Platelet-rich plasma (PRP) is increasingly recognized as a minimally invasive regenerative therapy aimed at stimulating dermal remodeling rather than providing immediate volumetric correction. By activating fibroblasts, promoting collagen synthesis, and enhancing angiogenesis, PRP has the potential to improve dermal thickness and elasticity (Vladulescu & Patel, 2023).

Clinical studies have reported modest improvements in skin texture and the appearance of fine wrinkles following intradermal injections of PRP (Asubiaro & Avajah, 2024; Koshkinbayeva et al., 2024). Objective assessments demonstrate measurable, albeit moderate, changes; however, many studies continue to rely on subjective grading scales (Pixley et al., 2023). Typical treatment protocols involve three to four sessions. While the results from PRP treatments are generally subtler compared to those achieved with energy-based devices or dermal fillers, it remains an appealing option due to its autologous nature and favorable short-term safety profile (Asubiaro & Avajah, 2024).

4.2 Combination With Microneedling and Fractional Laser

Combination therapy represents one of the most well-supported aesthetic applications of platelet-rich plasma (PRP). Procedures such as microneedling and fractional laser treatment create controlled dermal injury and promote collagen remodeling. When PRP is applied concurrently, it may enhance regenerative signaling, leading to improved outcomes (Kang & Lu, 2022). Meta-analyses have shown that this combination results in better scar severity scores and reduced post-procedural erythema compared to monotherapy with devices alone (Kang & Lu, 2022; Cruciani et al., 2024). However, the variability in preparation methods and laser parameters complicates direct comparisons across studies (Magalon et al., 2016).

4.3 Periorbital Rejuvenation and Combination With Fillers

The periorbital region poses unique therapeutic challenges due to its thin dermal structure and susceptibility to pigmentation changes. PRP has been investigated for its potential in periorbital rejuvenation, particularly in combination with hyaluronic acid fillers (Sollitto et al., 2025; Asubiaro & Avajah, 2024). Preliminary studies indicate modest improvements in dermal thickness and increased patient satisfaction; however, the evidence is still limited by small sample sizes and short follow-up durations.

The main aesthetic indications of PRP and the characteristics of available clinical evidence are summarized in Table 2.

Table 2. Aesthetic applications of platelet-rich plasma (PRP) in clinical practice

Indication	Nature of Available Evidence	Main Reported Clinical Findings	References
Skin rejuvenation	Small prospective studies and systematic reviews	Modest improvement in dermal thickness, elasticity, and fine wrinkles; measurable but moderate objective changes	Asubiaro & Avajah, 2024; Koshkinbayeva et al., 2024
PRP combined with microneedling	Randomized trials and meta-analyses	Greater scar improvement, enhanced collagen remodeling, and faster recovery compared to microneedling alone	Kang & Lu, 2022; Cruciani et al., 2024
PRP combined with fractional laser	Randomized and comparative studies	Reduced post-procedural erythema and improved scar severity scores compared to laser monotherapy	Kang & Lu, 2022; Cruciani et al., 2024
Periorbital rejuvenation	Small prospective and comparative studies	Modest improvement in dermal thickness and skin texture	Sollitto et al., 2025
PRP combined with hyaluronic acid fillers	Preliminary comparative studies	Increased patient satisfaction and improved skin quality; potential synergistic regenerative effect	Asubiaro & Avajah, 2024

Overall, PRP shows promise in aesthetic medicine, especially as part of combination treatment protocols. Nonetheless, additional standardized trials with objective outcome measures are necessary to establish definitive clinical guidelines.

5. Safety Profile

Platelet-rich plasma (PRP) is associated with a favorable safety profile, primarily due to its autologous nature (Pixley et al., 2023). Reported adverse events are generally mild and transient. Common side effects include localized erythema, edema, and discomfort at the injection site, while serious complications are rare (Zhang et al., 2023; Asubiaro & Avajah, 2024).

Contraindications for PRP treatment include active infections, severe thrombocytopenia, platelet dysfunction disorders, and uncontrolled systemic diseases (Dhurat & Sukesh, 2014). Careful patient selection and strict adherence to sterile protocols remain essential.

While the short-term safety of PRP is well-documented, long-term observational data are still limited (Li et al., 2024). Additionally, variability in preparation methods and differences in reporting standards complicate the assessment of safety (Magalon et al., 2016).

Overall, current evidence supports the short-term safety of PRP treatments but emphasizes the need for standardized reporting and longer follow-up studies to better understand its long-term safety profile.

IV. Discussion

Current evidence highlights platelet-rich plasma (PRP) as a promising regenerative therapy in dermatology and aesthetic medicine, particularly demonstrating strong clinical data in the treatment of androgenetic alopecia and as an adjunctive therapy for acne scars. Recent studies consistently report significant improvements in clinical outcomes for these indications.

Despite these positive findings, the substantial heterogeneity in preparation methods, platelet concentrations, leukocyte content, and treatment protocols poses challenges to comparability and hinders the establishment of standardized recommendations. Additionally, the variability in outcome assessment tools, especially in aesthetic applications, complicates the interpretation of results. For other indications, such as vitiligo and periorbital rejuvenation, the evidence remains preliminary and underscores the need for larger, well-designed controlled trials to validate the efficacy of PRP.

To enhance the reliability of clinical recommendations, it is crucial to achieve greater methodological consistency and conduct well-structured randomized trials. This will help clarify the role of PRP in various dermatological applications and support its integration into clinical practice.

Technological and Societal Implications of PRP Implementation

Platelet-rich plasma (PRP) therapy represents a significant shift in modern healthcare systems, particularly at the intersection of biotechnology, patient expectations, and minimally invasive therapeutic innovation. The rapid adoption of PRP in dermatologic and aesthetic practices illustrates how regenerative technologies are reshaping treatment paradigms to emphasize biological stimulation rather than structural replacement.

From a technological standpoint, PRP serves as a point-of-care biotechnological intervention that relies on standardized blood processing systems, centrifugation devices, and increasingly automated preparation platforms. The variability among commercial kits underscores the need for regulatory harmonization and transparent reporting standards. Differences in device calibration, platelet yield, and growth factor concentration can significantly impact clinical outcomes, raising important concerns regarding reproducibility and quality control. As regenerative technologies advance, integrating digital monitoring tools and standardized preparation frameworks will be crucial for ensuring consistency and safety.

The growing demand for PRP reflects a shift in patient preferences toward autologous and biologically derived treatments. Many individuals view regenerative procedures as more “natural” compared to synthetic fillers or pharmacologic therapies. This perception can influence treatment decisions but may not always align with evidence-based clinical guidance. Therefore, responsible communication and ethical marketing practices are vital to prevent overestimating therapeutic benefits.

Economic accessibility is another important consideration. Although PRP is less invasive than surgical interventions, it is often not covered by public health insurance systems, making it primarily available in private practice settings. This situation may lead to disparities in access to regenerative therapies. Currently, cost-effectiveness analyses are limited, particularly concerning long-term outcomes in conditions such as

androgenetic alopecia. Future research should include health-economic evaluations to better define the value proposition of PRP within broader healthcare frameworks.

Regulatory classification of PRP varies by country. In many regions, PRP is regarded as a minimally manipulated autologous product, facilitating rapid clinical adoption but resulting in heterogeneous oversight. Establishing clearer international guidelines regarding preparation standards, reporting transparency, and device validation could enhance patient safety and support evidence-based implementation.

Moreover, the integration of digital imaging, trichoscopy, and artificial intelligence-assisted outcome assessment tools marks a significant advancement in evaluating PRP efficacy. These technologies may reduce subjectivity in aesthetic outcome measurement and improve methodological rigor in future trials. As dermatology increasingly incorporates digital health solutions, PRP therapy may become part of a broader ecosystem of technology-supported regenerative medicine.

In this context, PRP not only functions as a therapeutic intervention but also exemplifies how biotechnology, clinical innovation, and social expectations converge in contemporary medical practice. Understanding these broader implications is essential for the responsible and sustainable integration of regenerative therapies into modern healthcare systems.

V. Conclusions

Platelet-rich plasma (PRP) is an evolving regenerative therapy in dermatology and aesthetic medicine. Its autologous nature, biological rationale, and favorable safety profile have contributed to its growing clinical adoption.

The evidence most strongly supports the use of PRP in treating androgenetic alopecia and as an adjunctive therapy for acne scars, particularly when combined with microneedling or fractional laser procedures. In other indications, available data remain limited and largely preliminary.

The ongoing heterogeneity in preparation methods and treatment protocols highlights the urgent need for standardized reporting and optimized preparation techniques. Further high-quality randomized trials are essential to better define the clinical role of PRP and support its evidence-based integration into practice.

Conflicts of interest: No conflicts of interest to declare.

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