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Platelet-rich plasma in veterinary medicine: Clinical applications and future perspectives

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Abstract

Platelet-rich plasma (PRP) has emerged as one of the most promising autologous biological therapies in regenerative veterinary medicine, owing to its capacity to promote tissue repair through the localized delivery of concentrated platelets and their bioactive constituents. Its therapeutic efficacy is primarily attributed to the release of growth factors, cytokines, and other signaling molecules that regulate inflammation, angiogenesis, cell proliferation, extracellular matrix synthesis, and tissue remodeling. Because of its autologous origin, ease of preparation, and favorable safety profile, PRP has gained increasing clinical acceptance across veterinary disciplines, with recent studies demonstrating its potential in the management of musculoskeletal disorders, wound healing, ophthalmic diseases, dermatological conditions, and selected reproductive disorders in companion animals, horses, livestock, and wildlife species. Nevertheless, considerable heterogeneity in preparation techniques, platelet concentration, leukocyte content, activation methods, and treatment protocols continues to influence clinical outcomes and remains a major obstacle to the standardization of PRP therapy. This review summarizes the biological basis of PRP, discusses its current clinical applications in veterinary medicine, and highlights existing limitations and future perspectives for its broader implementation in evidence-based veterinary practice.

Keywords: Platelet-rich plasma, growth factors, regenerative medicine, tissue regeneration, wound healing, osteoarthritis, veterinary medicine

1. Introduction

Regenerative medicine has become one of the fastest-growing fields in veterinary science, with increasing emphasis on biological therapies capable of restoring tissue structure and function rather than merely alleviating clinical signs. Among these regenerative approaches, platelet-rich plasma (PRP) has attracted considerable attention because it combines biological efficacy, ease of preparation, and clinical safety in a single autologous therapeutic product (Carr *et al.*, 2024) ^[6]. PRP is an autologous plasma fraction obtained by centrifugation of whole blood to achieve a platelet concentration higher than that of peripheral blood (Dhillon *et al.*, 2012) ^[8]. Unlike conventional pharmacological therapies, PRP functions by enhancing the body's intrinsic healing mechanisms through the localized release of platelet-derived bioactive molecules following platelet activation; activated platelets release numerous growth factors and cytokines that coordinate multiple phases of tissue repair, including inflammation, angiogenesis, fibroblast proliferation, collagen synthesis, extracellular matrix remodeling, and epithelial regeneration (Perinelli *et al.*, 2020) ^[14].

The use of PRP has expanded remarkably over the past two decades, evolving from its initial applications in oral and maxillofacial surgery to widespread use in both human and veterinary regenerative medicine (Dhillon *et al.*, 2012) ^[8]. In veterinary medicine, PRP was initially introduced for the treatment of tendon and ligament injuries in equine sports medicine, where it demonstrated promising regenerative potential and subsequently encouraged investigation in other clinical disciplines (Camargo Garbin *et al.*, 2021) ^[4]. Subsequent clinical and experimental studies have broadened its therapeutic indications to include osteoarthritis,

musculoskeletal injuries, chronic wounds, ophthalmic disorders, dermatological lesions, fracture repair, and reproductive medicine in companion animals and livestock (Sharun *et al.*, 2021) ^[16]. More recently, PRP has also been investigated in wildlife medicine, where it has shown encouraging potential for the management of traumatic injuries, chronic wounds, orthopedic disorders, and tissue regeneration in non-domestic species (Fuertes-Recuero *et al.*, 2025) ^[9].

Despite its expanding clinical use, PRP cannot be considered a uniform biological product. Variations in blood collection methods, centrifugation protocols, platelet enrichment, leukocyte content, activation procedures, storage conditions, and individual patient characteristics substantially influence the biological composition of PRP and may contribute to inconsistent therapeutic outcomes (Colomer-Selva *et al.*, 2025) ^[7]. Comparative evaluation of commercially available canine PRP systems has similarly demonstrated considerable differences in platelet recovery, leukocyte concentration, and erythrocyte contamination, emphasizing the urgent need for standardized preparation methods and consistent product characterization (Carr *et al.*, 2016) ^[5]. Recent evidence further indicates that the biological activity and clinical performance of PRP are influenced not only by platelet concentration but also by the composition of accompanying cellular components, activation status, dosage, and disease-specific application, underscoring the complexity of optimizing PRP therapy for different veterinary conditions (Carr *et al.*, 2024) ^[6]. This review therefore critically summarizes current knowledge on platelet-rich plasma in veterinary medicine, focusing on its biological basis, principal clinical applications, existing challenges, and future perspectives, to provide an updated overview of its role in regenerative veterinary practice.

2. Mechanism of Action of Platelet-Rich Plasma

Platelet-rich plasma exerts its therapeutic effects through a complex interplay of growth factors, cytokines, chemokines, adhesive proteins, and other bioactive molecules released following platelet activation. These mediators regulate multiple biological processes involved in tissue repair, including inflammation, angiogenesis, cellular proliferation, extracellular matrix synthesis, and tissue remodeling, thereby accelerating physiological healing and regeneration (Perinelli *et al.*, 2020) ^[14]. Unlike conventional therapeutic agents that target a single molecular pathway, PRP provides a coordinated biological response by delivering a concentrated mixture of regenerative mediators directly to the injury site; following activation by endogenous collagen or exogenous activators such as calcium salts or thrombin, platelets undergo degranulation and release numerous bioactive molecules stored predominantly within their α -granules (Perinelli *et al.*, 2020) ^[14]. These platelet-derived mediators initiate a cascade of cellular events that promotes chemotaxis of inflammatory and progenitor cells, stimulates fibroblast proliferation, enhances collagen synthesis, induces neovascularization, regulates extracellular matrix remodeling, and facilitates restoration of normal tissue architecture (Alsousou *et al.*, 2017) ^[1].

The biological activity of PRP is influenced not only by platelet concentration but also by leukocyte content, red blood cell contamination, activation status, platelet dose, and preparation technique; consequently, differences in PRP composition may significantly alter growth factor release and ultimately influence therapeutic efficacy (Magalon *et al.*,

2017) ^[12]. The regenerative response induced by PRP is mediated by the combined actions of platelet-derived growth factor (PDGF), transforming growth factor- β (TGF- β), vascular endothelial growth factor (VEGF), insulin-like growth factor-1 (IGF-1), epidermal growth factor (EGF), fibroblast growth factor (FGF), hepatocyte growth factor (HGF), and several other signaling molecules that collectively coordinate different stages of tissue healing (Sharun *et al.*, 2021) ^[16]. For clarity, the principal mechanisms through which PRP promotes tissue repair are discussed in the following subsections.

2.1 Release of Growth Factors

Platelets are small anucleate cell fragments that contain three major types of intracellular granules, namely α -granules, dense granules, and lysosomal granules. Among these, α -granules are the principal storage sites for growth factors and other bioactive proteins responsible for the regenerative properties of PRP (Perinelli *et al.*, 2020) ^[14]. Following platelet activation, α -granules rapidly release a wide range of growth factors, including PDGF, TGF- β , VEGF, EGF, IGF-1, and FGF, which act synergistically to regulate cellular migration, proliferation, differentiation, angiogenesis, and extracellular matrix synthesis (Alsousou *et al.*, 2017) ^[1]. Among these mediators, PDGF is one of the earliest growth factors released following tissue injury and plays an important role in recruiting fibroblasts, mesenchymal stem cells, macrophages, and neutrophils to the injured tissue; it also stimulates collagen synthesis and promotes extracellular matrix formation during the early stages of tissue repair (Perinelli *et al.*, 2020) ^[14].

2.2 Modulation of Inflammation

Inflammation represents the initial phase of tissue repair and is essential for the removal of damaged cells and initiation of regenerative processes; however, prolonged or excessive inflammatory responses may delay healing and contribute to tissue degeneration. Platelet-rich plasma promotes a balanced inflammatory response by delivering a complex mixture of cytokines and growth factors that regulate both pro-inflammatory and anti-inflammatory pathways (Perinelli *et al.*, 2020) ^[14]. Following activation, PRP releases numerous cytokines and chemokines that recruit neutrophils, monocytes, macrophages, and mesenchymal stem cells to the site of injury; these cells participate in debris removal, modulation of inflammation, and initiation of tissue repair, thereby facilitating the transition from the inflammatory to the proliferative phase of healing (Sharun *et al.*, 2021) ^[16].

Leukocytes present in certain PRP formulations may further influence the inflammatory response through the secretion of antimicrobial peptides, cytokines, and growth-regulating molecules; although leukocytes may enhance host defense and contribute to tissue repair, their biological effects remain dependent on their concentration and the clinical condition being treated (Harrison, 2018) ^[11]. The overall anti-inflammatory activity of PRP is therefore not mediated by a single molecule but results from the coordinated interaction of multiple platelet-derived mediators that regulate cellular signaling, minimize excessive inflammation, and promote an environment conducive to tissue regeneration (Pretorius *et al.*, 2023) ^[15].

2.3 Angiogenesis

Adequate vascularization is essential for successful tissue repair because newly formed blood vessels supply oxygen,

nutrients, and circulating reparative cells to the injured tissue. Platelet-rich plasma enhances angiogenesis through the release of several pro-angiogenic growth factors following platelet activation (Perinelli *et al.*, 2020) ^[14]. Among these mediators, VEGF plays a central role by stimulating endothelial cell migration, proliferation, and differentiation, ultimately leading to the formation of new capillaries within regenerating tissues (Alsousou *et al.*, 2017) ^[1]. PDGF further supports vascular development by recruiting pericytes and smooth muscle cells that stabilize newly formed vessels, while TGF- β contributes to vascular maturation, fibroblast proliferation, collagen deposition, and extracellular matrix organization during tissue remodeling (Sharun *et al.*, 2021) ^[16]. The combined activity of these angiogenic mediators improves tissue perfusion and creates a favorable microenvironment for cell survival, collagen synthesis, and functional tissue regeneration (Perinelli *et al.*, 2020) ^[14].

2.4 Cell Proliferation and Differentiation

One of the principal regenerative functions of PRP is the stimulation of cellular proliferation and differentiation within damaged tissues. Platelet-derived growth factors act as potent signaling molecules that regulate the migration and proliferation of fibroblasts, endothelial cells, mesenchymal stem cells, and other reparative cell populations involved in tissue healing (Alsousou *et al.*, 2017) ^[1]. Growth factors released from activated platelets promote mitosis, protein synthesis, and cellular metabolism while enhancing the differentiation of progenitor cells into specialized tissue-specific cells required for regeneration; in particular, IGF-1 and EGF contribute to tissue regeneration by enhancing cellular proliferation, protein synthesis, epithelial repair, and

differentiation of several cell populations involved in the healing process, and their coordinated interaction ultimately creates a favorable microenvironment for tissue regeneration and functional recovery (Perinelli *et al.*, 2020) ^[14]. These coordinated cellular responses accelerate the replacement of damaged tissue, improve structural organization, and facilitate restoration of normal tissue function, and experimental and clinical studies have confirmed that these biological effects contribute to the regenerative potential of PRP across multiple veterinary applications (Sharun *et al.*, 2021) ^[16].

2.5 Extracellular Matrix Remodeling and Tissue Regeneration

Successful tissue repair requires not only cellular proliferation but also restoration of extracellular matrix architecture. Platelet-rich plasma promotes extracellular matrix remodeling by stimulating fibroblast activity and enhancing the synthesis of structural proteins, particularly collagen, which provides mechanical strength and stability to healing tissues (Perinelli *et al.*, 2020) ^[14]. Activated platelets also promote the deposition of matrix proteins and support the formation of a temporary fibrin scaffold that facilitates cellular migration and tissue organization during the repair process (Harrison, 2018) ^[11]. The regenerative response induced by PRP involves continuous interaction between growth factors, inflammatory cells, extracellular matrix components, and resident tissue cells, resulting in progressive tissue remodeling and restoration of structural integrity (Alsousou *et al.*, 2017) ^[1]. Collectively, these biological mechanisms explain the broad therapeutic potential of PRP and provide the scientific basis for its expanding application in regenerative veterinary medicine (Carr *et al.*, 2024) ^[6].

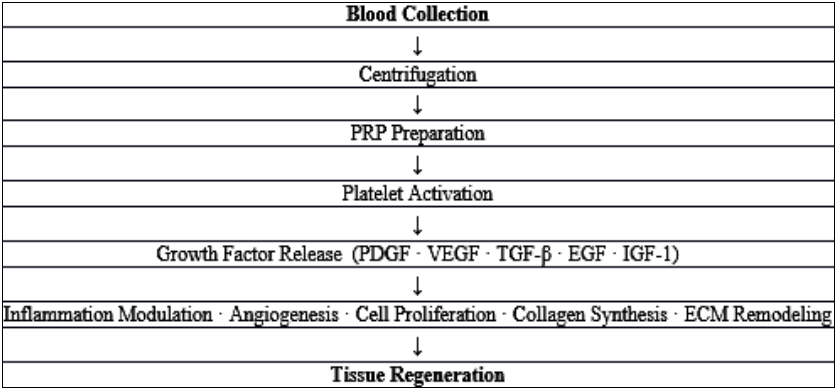


Fig 1: Mechanistic Pathway of Platelet-Rich Plasma Action in Veterinary Regenerative Medicine

3. Preparation of Platelet-Rich Plasma

The biological composition and therapeutic efficacy of PRP are intrinsically dependent on the preparation protocol employed. Variations in blood collection, anticoagulant selection, centrifugation parameters, platelet recovery, leukocyte content, activation procedures, and processing systems substantially influence the cellular composition and biological activity of the final product; consequently, the lack of standardized preparation protocols remains one of the principal challenges limiting the reproducibility and clinical application of PRP in both human and veterinary medicine (Harrison, 2018) ^[11]. PRP is prepared from autologous peripheral blood collected immediately before therapeutic use under aseptic conditions. To prevent premature platelet activation during processing, blood is collected into anticoagulant-containing tubes. Among the available anticoagulants, trisodium citrate is most

frequently employed because it preserves platelet viability without inducing significant activation; acid citrate dextrose (ACD) and citrate phosphate dextrose (CPD) are also considered suitable alternatives, whereas ethylenediaminetetraacetic acid (EDTA) is generally discouraged because it promotes platelet swelling and activation, thereby compromising the quality of the final preparation (Harrison, 2018) ^[11]. Following blood collection, PRP is obtained through differential centrifugation, which separates blood constituents according to density. This process concentrates platelets within the plasma fraction while reducing erythrocyte contamination and, depending on the centrifugation protocol, selectively retaining or removing leukocytes. The quality of the final preparation is therefore determined by multiple processing variables, including centrifugal force, duration, number of centrifugation cycles, plasma harvesting technique,

and the preparation system employed (Harrison, 2018) ^[11]. Currently, three principal approaches are used for PRP preparation: gravitational centrifugation, automated cell separator systems, and selective filtration (plateletpheresis). Each technique differs in platelet recovery efficiency, cellular purity, and final product composition, resulting in considerable heterogeneity among commercially available PRP systems; as a consequence, preparations generated using different devices cannot be considered biologically equivalent despite being collectively described as PRP (Harrison, 2018) ^[11]. This variability has also been demonstrated in veterinary medicine: comparative evaluation of commercially available canine PRP systems revealed substantial differences in platelet enrichment, leukocyte concentration, and erythrocyte contamination among preparation devices, indicating that therapeutic efficacy may vary according to the preparation method rather than platelet concentration alone (Carr *et al.*, 2016) ^[5].

After preparation, PRP may be administered directly or activated prior to application. Platelet activation initiates degranulation of α -granules and the subsequent release of growth factors, cytokines, and other bioactive mediators responsible for tissue regeneration; activation may occur physiologically following contact with exposed collagen at the injury site or be induced *ex vivo* using calcium salts or thrombin. Nevertheless, the optimal activation strategy remains controversial, and current evidence is insufficient to recommend a universally applicable protocol for all clinical indications (Harrison, 2018) ^[11].

Traditionally, PRP quality has been described primarily by platelet concentration. However, recent evidence suggests that platelet concentration alone is an inadequate indicator of biological potency; instead, platelet dose, injection volume, leukocyte composition, erythrocyte contamination, and the overall cellular profile collectively determine the regenerative capacity of PRP. Comprehensive characterization of PRP preparations is therefore essential for meaningful comparison among studies and for improving the reproducibility of clinical outcomes (Magalon *et al.*, 2017) ^[12]. Although remarkable advances have been achieved in PRP processing technologies, considerable heterogeneity continues to exist among preparation systems and laboratory protocols; international consensus recommendations therefore emphasize the need for standardized methodologies, detailed characterization of PRP products, and uniform reporting of preparation protocols to enhance reproducibility and facilitate evidence-based clinical guidelines (Harrison, 2018) ^[11].

Table 1: Factors Influencing the Biological Quality of Platelet-Rich Plasma

Factor	Influence on PRP
Anticoagulant	Platelet preservation and activation
Centrifugation speed	Platelet recovery
Centrifugation time	Cellular separation
Leukocyte content	Inflammatory response
RBC contamination	Biological activity
Activation method	Growth factor release
Platelet dose	Regenerative potential

4. Classification of Platelet-Rich Plasma

The considerable variability in PRP composition resulting from differences in preparation techniques has led to the development of several classification systems aimed at standardizing terminology and facilitating comparison among experimental and clinical studies. These systems primarily categorize PRP according to platelet concentration, leukocyte content, erythrocyte contamination, activation status, and

fibrin architecture; standardized classification is essential because differences in PRP composition may significantly influence its biological properties and therapeutic outcomes (Harrison, 2018; Magalon *et al.*, 2017) ^[11, 12].

One of the earliest and most widely recognized classification systems was proposed by Dohan Ehrenfest *et al.*, which categorizes platelet concentrates into four principal groups based on the presence of leukocytes and fibrin architecture: pure platelet-rich plasma (P-PRP), leukocyte-rich platelet-rich plasma (L-PRP), pure platelet-rich fibrin (P-PRF), and leukocyte-rich platelet-rich fibrin (L-PRF). This classification highlighted that platelet concentrates differ not only in platelet concentration but also in cellular composition and fibrin organization, both of which may influence biological activity and clinical performance.

To provide more detailed characterization, DeLong *et al.* introduced the PAW classification, which evaluates PRP according to platelet concentration (P), activation status (A), and white blood cell content (W). Unlike earlier systems, the PAW classification incorporates quantitative assessment of platelet enrichment together with leukocyte composition and activation method, thereby improving the description and reproducibility of PRP preparations used in research and clinical practice.

More recently, the International Society on Thrombosis and Haemostasis (ISTH) emphasized that platelet concentration alone is insufficient to characterize PRP adequately, recommending comprehensive reporting of platelet dose, leukocyte and erythrocyte content, plasma volume, activation method, preparation protocol, and final product characteristics to improve reproducibility and enable meaningful comparison among studies (Harrison, 2018) ^[11]. Although several classification systems have been proposed, no universally accepted standard currently exists; continued adoption of standardized classification and reporting guidelines is therefore essential to reduce heterogeneity among studies, improve interpretation of clinical outcomes, and facilitate evidence-based application of PRP in veterinary medicine (Magalon *et al.*, 2017; Harrison, 2018) ^[12, 11].

5. Clinical Applications of Platelet-Rich Plasma in Veterinary Medicine

Platelet-rich plasma has been investigated across a wide spectrum of clinical conditions in companion animals, equine patients, and food-producing animals, owing to its ability to enhance tissue repair through the localized delivery of concentrated platelets and their bioactive constituents. Although reported outcomes are generally encouraging, differences in preparation protocols, platelet concentration, leukocyte content, treatment regimens, and study design contribute to variability in clinical efficacy. Current evidence nevertheless supports PRP as a promising adjunctive therapy for musculoskeletal disorders, wound healing, ophthalmic diseases, dermatological conditions, and reproductive disorders, each discussed in the following subsections (Sharun *et al.*, 2021; Carr *et al.*, 2024) ^[16, 6].

5.1 Musculoskeletal Disorders

Musculoskeletal disorders represent the most extensively investigated clinical indication for PRP therapy in veterinary medicine. Tendon injuries, ligament lesions, osteoarthritis, cartilage degeneration, and muscle injuries are among the leading causes of lameness, pain, reduced mobility, and decreased athletic performance in horses and companion animals. Conventional therapeutic

approaches often provide symptomatic relief but cannot fully restore normal tissue architecture, and PRP has therefore gained considerable attention as a regenerative treatment capable of enhancing intrinsic tissue repair through biological rather than purely pharmacological mechanisms (Sharun *et al.*, 2021) [16].

The regenerative effects of PRP are mediated through the sustained release of PDGF, TGF- β , VEGF, IGF-1, EGF, and several other bioactive mediators that stimulate fibroblast proliferation, collagen synthesis, angiogenesis, extracellular matrix remodeling, and recruitment of reparative cells, facilitating structural repair and functional recovery of injured musculoskeletal tissues. In equine medicine, PRP has been widely used for the treatment of superficial digital flexor tendon injuries, suspensory ligament desmitis, and other soft tissue injuries; clinical and experimental studies have demonstrated improved collagen fiber organization, enhanced tendon architecture, reduced inflammatory cell infiltration, and accelerated healing following intralesional administration. Similarly, intra-articular PRP has shown encouraging outcomes in canine osteoarthritis by reducing pain, improving joint function, and supporting cartilage homeostasis. Despite these favorable findings, further randomized controlled studies employing standardized PRP formulations are required to establish definitive therapeutic recommendations (Sharun *et al.*, 2021; Carr *et al.*, 2024) [16, 6].

5.2 Wound Healing

The application of PRP in wound management has gained considerable importance because wound healing is a complex biological process involving inflammation, cellular proliferation, angiogenesis, extracellular matrix deposition, and tissue remodeling. By providing a concentrated source of autologous growth factors, PRP enhances each phase of the healing cascade and promotes more rapid restoration of damaged tissues (Sharun *et al.*, 2021) [16]. Experimental and clinical investigations in veterinary medicine have demonstrated that PRP accelerates granulation tissue formation, stimulates fibroblast proliferation, enhances collagen deposition, improves neovascularization, and promotes re-epithelialization of cutaneous wounds; it may also reduce wound infection through the antimicrobial activity of platelet-derived peptides and leukocytes present in certain formulations. These effects contribute to faster wound contraction, improved tensile strength, and superior cosmetic healing compared with conventional wound management alone (Camargo Garbin *et al.*, 2021) [4].

PRP has been successfully applied in traumatic wounds, chronic non-healing ulcers, surgical wounds, pressure sores, and extensive skin defects in both companion animals and horses. Its autologous origin minimizes the risk of immunological reactions while allowing repeated administration when clinically indicated; nevertheless, variability in wound characteristics and PRP preparation protocols continues to influence treatment outcomes.

5.3 Ophthalmology

PRP has become an increasingly valuable biological therapy in veterinary ophthalmology because the ocular surface requires rapid and organized tissue regeneration to preserve vision. The high concentration of epithelial

growth factors, cytokines, and adhesive proteins within PRP supports corneal epithelial regeneration, suppresses excessive inflammation, and enhances tissue repair (Perego *et al.*, 2022) [13]. Veterinary studies have reported successful application of PRP in the treatment of corneal ulcers, persistent epithelial defects, keratitis, corneal stromal injuries, and postoperative corneal healing. Topical PRP and PRP-derived eye drops have been associated with accelerated corneal epithelialization, reduced corneal opacity, decreased ocular discomfort, and improved healing of deep corneal lesions; because PRP is prepared from autologous blood, it is generally well tolerated and presents a low risk of adverse immunological reactions (Perego *et al.*, 2022) [13]. Although current clinical outcomes are encouraging, standardized preparation methods and controlled clinical trials remain necessary before PRP can be incorporated into routine ophthalmic treatment protocols across different animal species.

5.4 Dermatology

PRP has received increasing attention in veterinary dermatology because of its ability to stimulate regeneration of cutaneous tissues through modulation of inflammation, enhancement of angiogenesis, and promotion of collagen synthesis, properties that have expanded its application in various inflammatory and degenerative skin disorders (Sharun *et al.*, 2021) [16]. Clinical studies have investigated PRP for the management of chronic skin ulcers, surgical skin defects, pressure wounds, burns, and delayed-healing lesions. PRP stimulates fibroblast migration, extracellular matrix production, and epidermal regeneration while simultaneously improving local vascularization, contributing to improved wound contraction, reduced healing time, and restoration of normal skin architecture; it has also shown potential as an adjunctive treatment for selected dermatological conditions associated with impaired tissue repair (Camargo Garbin *et al.*, 2021) [4]. Although preliminary findings indicate favorable therapeutic outcomes, additional large-scale veterinary clinical studies are required to define optimal treatment protocols and determine long-term efficacy in dermatological practice.

5.5 Reproductive Medicine

The application of PRP in veterinary reproduction has expanded considerably in recent years owing to its regenerative and anti-inflammatory properties. PRP has been investigated as a biological therapeutic approach for improving endometrial regeneration, enhancing uterine healing, supporting ovarian function, and increasing reproductive efficiency in domestic animals (Bos-Mikich *et al.*, 2018) [3]. In mares, intrauterine administration of PRP has shown potential for the management of persistent breeding-induced endometritis by reducing uterine inflammation and improving the uterine environment for embryo survival; it has also been investigated for the treatment of endometrial degeneration and chronic uterine disorders that adversely affect fertility. In addition, experimental studies suggest that PRP may improve ovarian function and follicular development through the action of platelet-derived growth factors involved in tissue regeneration (Bos-Mikich *et al.*, 2018) [3]. Although current evidence

indicates promising reproductive applications, available studies remain limited in number and characterized by substantial methodological heterogeneity; further controlled clinical trials are required to establish standardized protocols and confirm the long-term reproductive benefits of PRP therapy across veterinary species (Sharun *et al.*, 2021) ^[16].

Overall, the available literature demonstrates that PRP has broad therapeutic potential across multiple veterinary disciplines. Nevertheless, the absence of standardized

preparation protocols, inconsistent characterization of PRP formulations, and variability in clinical study design continue to limit the strength of current evidence. Future well-designed multicenter clinical trials employing standardized reporting guidelines will be essential for defining species-specific treatment protocols and establishing the precise role of PRP in evidence-based veterinary regenerative medicine (Carr *et al.*, 2024; Harrison, 2018) ^[6, 11].

Table 2: Clinical Applications of Platelet-Rich Plasma in Veterinary Medicine

Application	Species	Reported benefits	Key reference(s)
Musculoskeletal disorders	Horse, Dog	Tendon healing; osteoarthritis management	Sharun <i>et al.</i> (2021) ^[16]
Wound healing	Horse, Dog	Accelerated healing; collagen deposition	Camargo Garbin <i>et al.</i> (2021) ^[4]
Ophthalmology	Dog, Horse	Corneal repair	Perego <i>et al.</i> (2022) ^[13]
Dermatology	Dog	Skin regeneration	Sharun <i>et al.</i> (2021) ^[16]
Reproductive medicine	Mare	Endometrial repair	Bos-Mikich <i>et al.</i> (2018) ^[3]

6. Challenges and Limitations

Despite the growing interest in PRP as a regenerative therapy in veterinary medicine, several challenges continue to limit its widespread clinical application and the interpretation of available evidence. The principal limitation is the considerable heterogeneity in PRP preparation methods, resulting in marked differences in platelet concentration, leukocyte and erythrocyte content, plasma volume, activation protocols, and final product composition; consequently, PRP preparations produced by different commercial systems or laboratory protocols cannot be considered biologically equivalent, making direct comparison among studies difficult (Harrison, 2018; Magalon *et al.*, 2017) ^[11, 12]. A related limitation is the lack of standardized protocols for blood collection, centrifugation, platelet activation, dosage, frequency of administration, and treatment intervals; variations in these procedural factors may significantly influence growth factor release and therapeutic efficacy, contributing to inconsistent clinical outcomes across veterinary species and disease conditions (Harrison, 2018) ^[11].

Although platelet concentration has traditionally been regarded as an indicator of PRP quality, recent evidence suggests that platelet count alone does not accurately reflect biological potency. Platelet dose, injection volume, leukocyte composition, erythrocyte contamination, and activation status collectively influence the regenerative potential of PRP, and failure to report these characteristics reduces reproducibility and limits meaningful comparison between studies (Magalon *et al.*, 2017) ^[12]. The quality of current veterinary evidence also remains limited: many published studies involve small sample sizes, lack appropriate control groups, include different animal species, and employ variable outcome measures with relatively short follow-up periods, all of which reduce the strength of available evidence and hinder the development of standardized, evidence-based treatment recommendations (Sharun *et al.*, 2021; Carr *et al.*, 2024) ^[16, 6].

Species-specific biological differences represent another important challenge, since platelet concentration, cellular composition, and growth factor profiles differ among animal species, suggesting that protocols developed for one species cannot be directly extrapolated to another;

accordingly, species-specific optimization and validation of PRP preparation methods are essential before routine clinical implementation (Sharun *et al.*, 2021) ^[16]. Furthermore, there is currently no universally accepted classification or reporting system for PRP products. Although several classification systems and international recommendations have been proposed, inconsistent terminology and inadequate characterization of PRP preparations continue to impede comparison of clinical studies and meta-analyses; adoption of standardized reporting guidelines is therefore essential to improve reproducibility and facilitate evidence-based clinical application (Harrison, 2018) ^[11]. Despite these limitations, PRP remains a safe autologous biological therapy with considerable regenerative potential.

7. Future Perspectives

PRP has emerged as a promising regenerative therapy in veterinary medicine; however, its successful integration into routine clinical practice will depend on overcoming current limitations associated with product variability, inconsistent treatment protocols, and limited high-quality clinical evidence. Future research should focus on establishing standardized protocols for blood collection, centrifugation, platelet activation, product characterization, and reporting to improve reproducibility and facilitate meaningful comparison among experimental and clinical studies (Harrison, 2018; Magalon *et al.*, 2017) ^[11, 12].

Advances in PRP preparation technologies are expected to improve the consistency and biological quality of PRP products. Comprehensive characterization of platelet concentration, platelet dose, leukocyte and erythrocyte content, plasma volume, and activation methods will enable clinicians to select the most appropriate formulation for specific clinical indications, contributing to more predictable therapeutic outcomes and strengthening evidence-based clinical decision-making (Harrison, 2018) ^[11]. Future investigations should also prioritize well-designed multicenter randomized controlled clinical trials involving larger sample sizes, standardized outcome measures, and extended follow-up periods, which are essential to determine the long-term efficacy, safety, optimal dosage, treatment intervals, and species-specific applications of PRP across different

veterinary conditions (Sharun *et al.*, 2021; Carr *et al.*, 2024) [16, 6].

Another important direction for future research is the development of personalized regenerative therapies. As PRP composition varies among individuals and animal species, tailoring PRP formulations according to disease condition, tissue type, and patient-specific biological characteristics may enhance therapeutic efficacy; combining PRP with other regenerative approaches, including stem cell therapy, biomaterial scaffolds, tissue engineering strategies, and advanced drug delivery systems, may further improve tissue repair and functional regeneration in veterinary patients (Pretorius *et al.*, 2023; Perego *et al.*, 2022) [15, 13]. In addition, greater collaboration among researchers, clinicians, and regulatory organizations will be essential to establish internationally accepted guidelines for PRP preparation, classification, quality control, and clinical application; adoption of standardized reporting criteria will improve the quality of published evidence, facilitate meta-analyses, and accelerate the translation of research findings into routine veterinary practice (Harrison, 2018) [11].

Overall, continued advances in regenerative medicine, together with standardized methodologies and high-quality clinical research, are expected to define the future role of PRP as a safe, evidence-based, and widely applicable biological therapy for the management of diverse diseases in veterinary medicine.

8. Conclusion

Platelet-rich plasma has emerged as an important autologous biological therapy in veterinary regenerative medicine because of its ability to promote tissue repair through the coordinated action of platelet-derived growth factors, cytokines, and other bioactive molecules. Available evidence indicates that PRP enhances tissue regeneration by modulating inflammation, stimulating angiogenesis, promoting cellular proliferation, and facilitating extracellular matrix remodeling, biological properties that have supported its application in a variety of veterinary conditions, particularly musculoskeletal disorders, wound healing, ophthalmic diseases, dermatological conditions, and reproductive medicine, where encouraging clinical outcomes have been reported. Despite its promising therapeutic potential, the routine clinical application of PRP remains constrained by substantial variability in preparation techniques, platelet and leukocyte composition, activation protocols, and treatment regimens. The absence of universally accepted standards for PRP characterization and reporting has contributed to inconsistent clinical outcomes and has limited direct comparison among studies; consequently, the establishment of standardized preparation protocols, comprehensive product characterization, and uniform reporting guidelines remains essential for improving the reproducibility and clinical reliability of PRP therapy.

Future progress in veterinary PRP research will depend on well-designed multicenter clinical trials involving larger populations, longer follow-up periods, and standardized methodologies. Such investigations will be critical for defining species-specific treatment protocols, optimizing therapeutic efficacy, and strengthening the evidence base for clinical decision-making. Continued advances in regenerative medicine, together with

collaborative efforts to standardize PRP preparation and application, are expected to further establish PRP as a safe, scientifically validated, and clinically valuable therapeutic option for the management of a wide range of diseases in veterinary medicine.

Conflict of Interest

Not available

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