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Review Article

From bench to field: PRP's role in athletic trauma–current trend and applications

Mohamed Nazir Ashik[1]*, Gokula Krishnan Muthamizhselvan[2], Gowtham Krishnan Ramachandran[3], Vaibhav Jain[4], Sitaram Chopperla[5]

[1]Dept. of Orthopedics, Hiba Hospital, Chennai, India
[2]Dept. of Orthopedics, A.C.S Medical College, Chennai, India
[3]Dept. of Orthopedics, KMCH Medical College and Post Graduate Institute, Coimbatore, Tamil Nadu, India
[4]Dept. of Orthopedics, Gandhi Medical College, Bhopal, India
[5]Arthroplasty (National Board), Breach Candy Hospital, Mumbai

Abstract

Platelet-Rich Plasma (PRP) has emerged as a promising biologic therapy within regenerative medicine, owing to its reported reparative, immunoregulatory, and anti-inflammatory effects. Despite ongoing debate regarding its clinical efficacy, accumulating evidence suggests that PRP may support tissue repair in a wide range of injuries and disease processes, including conditions encountered in reproductive and inflammatory medicine. This review aims to critically outline the current understanding of PRP in the management of prevalent musculoskeletal disorders affecting athletic populations, who are particularly susceptible to such injuries due to repetitive and high-intensity physical demands. To date, the use of PRP in this setting remains underrepresented and inconsistently addressed in the literature. Following a concise discussion of precision medicine and regenerative medicine as complementary yet distinct disciplines, the biological properties of PRP and its therapeutic implications for athletic musculoskeletal injuries are explored. Finally, this review discusses existing clinical applications, prospective developments, and the inherent challenges and limitations associated with PRP-based interventions.

Keywords: PRP, sports medicine, athletes, sports injury, regenerative medicine

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1. Introduction

Conventional medical management is largely guided by symptom assessment, diagnosis, and standardized treatment pathways. In contrast, sports medicine involves athletes as a distinct patient population, requiring a more individualized approach in which symptom evaluation and diagnostic strategies are tailored to sport-specific demands, performance goals, and return-to-play considerations. In this context, Orthobiologics therapy, most commonly Platelet-Rich Plasma (PRP) have gained attention, as they aim not only to alleviate symptoms but also to enhance tissue healing and facilitate a timely and safe return to sport.[1] Platelet-Rich Plasma (PRP) represents a therapeutic strategy that bridges the principles of precision medicine and regenerative medicine. As an autologous biologic product, PRP can be tailored to the individual athlete through variations in platelet concentration, leukocyte content, and activation methods, aligning with the goals of precision medicine. PAW classification (platelets, activation, white cells) This classification is limited as it covers only the PRP family and is based on platelet quantity, mode of platelet activation, and the presence of white cells . Platelet concentration was the additional parameter that was included in the PAW classification. The PRP classified under this system is represented as a code, for example, 'P3 – x – Aα' that represent three parameters (one sub-parameter also); platelet concentration (platelets/μL); ≤ baseline (P1), >baseline – 750,000 (P2), >750,000–1,250,000 (P3), >1,250,000 (P4), activation (x – exogenous activation), presence of WBCs; above baseline (A) or below/equal to baseline (B), and presence of neutrophils (subparameter); above baseline (α) or below/equal to baseline (β) respectively. Simultaneously, PRP promotes tissue repair and regeneration by delivering a concentrated source of growth

*Corresponding author: Mohamed Nazir Ashik
Email: dr.ashik2k12@gmail.com

factors and bioactive molecules, thereby supporting healing processes rather than merely providing symptomatic relief.[2] In athletes, prolonged periods of rest are often impractical due to competitive demands and performance expectations. Consequently, there is a growing need for orthobiologic therapies that can accelerate tissue healing and bridge the gap between injury and safe return to play. The purpose of this review is to provide an overview of commonly utilized injectable PRP and to summarize the available evidence on it for the management of sports related injuries.

2. Platelet-Rich Plasma: Production Methods and Role in Athletic Injuries

PRP is a volume of plasma, usually autologous, that has a platelet concentration above baseline, defined as at least 1 × 106/μL according to the original definitions. It can be obtained through a single or – more frequently – double centrifugation. Briefly, the double centrifugation process consists of the collection of a volume of anticoagulated blood, followed by a consecutive first separation of the majority of the red blood cells from the plasma – which contains platelets, white blood cells and clotting factors – and then a second spin separates the platelets and plasma from the other cells and from the so-called Platelet-Poor Plasma (PPP). Currently, there are no standard protocols for PRP production, due to the presence of many variables among the different techniques to obtain it – e.g., the number of centrifugations, the rotational velocity, centrifugation time chosen and the anticoagulant used – so its composition can vary according to the devices and protocols used in the process.[3,4] Owing to its autologous origin, Platelet-Rich Plasma (PRP) contains a high concentration of biologically active components, including platelet-derived growth factors, cytokines, and cellular elements such as leukocytes. The relative composition of these components varies according to the specific PRP formulation. Collectively, these elements are essential for the regenerative, anti-inflammatory, and immunomodulatory properties of PRP and play a key role in stimulating cell proliferation, angiogenesis, and tissue repair.[5]

The heterogeneous nature of PRP complicates the production of fully customized formulations, as its exact biological composition cannot be accurately anticipated prior to preparation. Additionally, the bioactive components of PRP demonstrate pleiotropic effects, and their influence on tissue healing in sports medicine should be considered collectively rather than evaluated in isolation.[6,7] Despite ongoing issues with standardization, PRP can be considered a beneficial modality in sports medicine because of its wide spectrum of applications, ease of preparation through commercially available devices, and low incidence of adverse events, largely attributable to its autologous origin. Overall, PRP demonstrates a favorable safety profile, with adverse events rarely reported and primarily limited to case reports.[8] PRP has emerged as a relevant therapeutic option in the management of athletic injuries, as it may enhance the biological healing response, potentially reducing the need for surgical intervention and shortening recovery times. We further discuss few important sports related injuries and their management with PRP. **(Table 1)**

Table 1: Contents of PRP

Growth factors	Effects
PDGF	1. Mitogenic for mesenchymal cells and osteoblasts. 2. Stimulation of chemotaxis and mitogenesis in fibroblasts, glial cells and smooth muscle cells. 3. Regulation of collagenase secretion and collagen synthesis. 4. Stimulation of macrophage and neutrophil chemotaxis.
VEGF	1. Increase in angiogenesis and vessel permeability. 2. Induction of mitogenesis in endothelial cells.
TGF (α-β)	1. Induction of undifferentiated mesenchymal cell proliferation. 2. Regulation of endothelial, fibroblastic and osteoblastic mitogenesis and collagen synthesis and secretion. 3. Stimulation of endothelial chemotaxis and angiogenesis. 4. Inhibition of macrophage and lymphocyte proliferation.
(a-b) FGF	1. Promotion of growth and differentiation of chondrocytes and osteoblasts. 2. Mitogenic for mesenchymal cells, chondrocytes and osteoblasts.
EGF	1. Stimulation of endothelial chemotaxis and angiogenesis. 2. Regulation of collagenase secretion. 3. Induction of epithelial and mesenchymal mitogenesis.
IGF-1	1. Stimulation of protein synthesis and chemotaxis for fibroblasts. 2. Enhancement of bone formation through proliferation and differentiation of osteoblasts.
CTGF	1. Promotion of angiogenesis, cartilage regeneration, fibrosis and platelet adhesion.
IL-8	1. Stimulation of epidermal cell mitosis and support of angiogenesis.

2.1. Pathologies of upperlimb

2.1.1. Rotator cuff injury

Rotator cuff injuries are a common and increasingly prevalent pathology. Although rotator cuff repair is associated with high patient satisfaction and functional improvement, failure rates remain considerable, averaging 26.6% at two years postoperatively depending on tear size, thereby supporting interest in biologic augmentation strategies such as PRP.[9] Accordingly, orthobiologic interventions have garnered considerable interest for their potential to augment tendon healing and reduce failure rates. On the basis of reported benefits in tendon healing and mechanical strength from general tendon models, several high-level randomized controlled trials have explored biologic augmentation approaches in tendon repair.[10] The efficacy of PRP injections compared with corticosteroid injections in 40 patients with symptomatic partial rotator cuff tears. In follow-up evaluations at 12 weeks after injection, those receiving PRP had significantly better Constant, ASES, and Simple Shoulder Test scores than those receiving corticosteroids, but at six months there was no significant difference in outcome. From these results, the authors concluded that PRP was a viable alternative therapy, particularly when considering the adverse effects of repeated steroid injections on cuff integrity.[11] Regarding tendinopathy, Rha et al examined the effect of PRP compared with dry needling in a randomized controlled trial of 39 patients with either tendinosis or a partial rotator cuff tear.[12] They identified sustained outcome improvement at six months after injection with no adverse effects.

2.1.2. Elbow injury

The UCL stabilizes the medial elbow under valgus stress, and repetitive throwing motions place overhead athletes, particularly baseball pitchers, at increased risk of injury. As such, safe and effective augmentations to standard treatment options are sought to improve healing and long-term function. In 2015, Hoffman et al.[13] explored the possibility of using a dermal allograft, combined with PRP and mesenchymal stem cells, for the reconstruction of an Ulnar Collateral Ligament (UCL) in a professional basketball player to improve healing and accelerate return to sports activities. This case report demonstrated significant improvements in pain and limb function, with magnetic resonance imaging (MRI) confirmation of ligament integrity at 3 months and 17 months post-surgery. Dines et al.[14,15] reported the outcomes of 44 high-level throwing athletes with partial UCL tears treated with PRP. Sixteen patients received a single injection, six received two injections, and 22 received three injections. Of the cohort, 15 patients (34%) achieved excellent outcomes, 17 had good outcomes, 2 had average outcomes, and 10 had poor outcomes. The mean time from injection to return to general sports activity was five weeks, while the mean time to return to competitive play was 12 weeks. The authors concluded that PRP may provide superior results compared with conservative management for this type of injury. Podesta et al.[15,16] evaluated 34 athletes with symptomatic partial-thickness UCL tears who were treated with a single PRP injection combined with a graded rehabilitation program. Among these patients, 88% returned to competition at a mean of 12 weeks. The study also demonstrated significant improvements in ultrasonographic medial joint space measurements and in patient-reported outcomes at follow-up.[17] The studies reviewed in the literature do not typically report complications following the use of PRP.

2.2. Lateral epicondylitis

Lateral epicondylitis, commonly referred to as tennis elbow, is a frequent cause of elbow pain and functional impairment, affecting approximately 1%–3% of the population and often managed initially with conservative therapy.[18] The role of biologics in tennis elbow treatment has been extensively researched in several case series and meta-analyses.[19,20] Peerbooms et al.[21] conducted a randomized controlled trial in 100 patients comparing corticosteroid versus PRP injection. At one-year follow-up, the PRP group demonstrated significantly better outcomes on VAS and DASH scores. Although corticosteroid injections produced more favorable short-term results, these improvements declined over time, whereas outcomes in the PRP group progressively improved at each assessment. Mishra et al.[22] conducted a multicenter randomized controlled trial evaluating PRP treatment in 230 patients with chronic lateral epicondylitis. Patients were assessed at 12 and 24 weeks post-injection and compared with an active control group that did not receive biologic therapy. At 12 weeks, no significant differences were observed between the groups; however, by 24 weeks, patients treated with leukocyte-rich PRP demonstrated significantly greater reductions in VAS pain scores compared with controls.

Some small case series have suggested that PRP may improve the morphological characteristics of tendons as assessed by ultrasound.[23] However, larger studies have not demonstrated significant structural changes following PRP treatment.

2.3. Distal biceps tendonitis

Investigations into the use of PRP for distal biceps tendinopathy remain limited. In a small case series of six patients, Barker et al.[24] evaluated the efficacy of PRP injections using VAS and Mayo Elbow Performance scores. At a mean follow-up of 16.3 months, all patients reported complete resolution of pain and demonstrated improvements in Mayo Elbow Performance scores, with a mean increase from 68.3 pre-injection to 95 at final follow-up. Additionally, all patients reported subjective improvement, and no complications were observed. Sanli et al.[25] investigated PRP injections in 20 patients with MRI-confirmed distal biceps tendinopathy. At a median follow-up of 47 months, all patients demonstrated significant improvements in pain and functional outcomes and reported satisfaction with their clinical and functional results.

2.4. TFCC injuries

The Triangular Fibrocartilage Complex (TFCC) is situated on the ulnar aspect of the wrist between the lunate, triquetrum, and ulnar head. It acts as a weight-bearing structure that stabilizes the distal radioulnar joint and serves as a shock absorber for the ulnocarpal joint. TFCC injuries can be classified based on etiology as acute or degenerative.[26] Recent studies have suggested that PRP injections may serve as an adjunct to TFCC repair due to their capacity to enhance tissue healing via growth factors. This approach aims to support the repair process and potentially improve patient outcomes. Although preliminary results are promising, clinical evidence remains limited, and larger studies are needed to determine the efficacy of PRP in improving structural healing, functional outcomes, and long-term wrist stability.[27]

2.5. Pathologies of lower limb

2.5.1. Hamstring injuries

Hamstring injuries are among the most frequent soft tissue injuries in athletes, particularly in sports that involve sprinting, jumping, or rapid changes in direction. The severity of these injuries can range from minor strains to complete tears, resulting in recovery periods that may extend from a few weeks to several months. Despite improvements in rehabilitation strategies, hamstring injuries are characterized by high recurrence rates, often exceeding 30%.[28] In hamstring strains, 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-1 (IGF-1) play a central role in tissue repair and regeneration. Autologous PRP may therefore be valuable in promoting angiogenesis, stimulating collagen synthesis, and recruiting key reparative cells, including fibroblasts and myoblasts, to facilitate the healing process.[29] Borrione et al. reported that athletes with grade 3 hamstring strains who received PRP demonstrated earlier functional improvement and more complete recovery compared with those managed nonoperatively.[30] Hamilton et al. reported the case of an athlete with a grade 2 semimembranosus muscle injury who was treated with a single 3 mL ultrasound-guided injection of platelet-rich plasma. The athlete was pain-free and able to resume training at pre-injury intensity 21 days after the procedure.[31] Sanchez et al.[32] observed that 20 professional athletes with hamstring and adductor muscle injuries achieved full functional recovery approximately twice as quickly when treated with plasma rich in growth factors (PRP). The study noted that smaller muscle tears responded well to a single PRP application, whereas medium- to large-sized tears typically required two to three applications at one-week intervals. Rettig et al.[33] conducted a retrospective case-control study to evaluate the effect of autologous PRP on return-to-play timelines following acute hamstring injuries in professional National Football League (NFL) athletes. Ten players with acute hamstring injuries were retrospectively assigned to either a PRP group (n = 5) or a control group (n = 5). The PRP group received a single 6 mL ultrasound-guided injection, while both groups followed the same standardized rehabilitation protocol. Return-to-play readiness was assessed using a functional progression evaluation conducted by the same athletic trainer for all participants. In a study by Hamid et al.[34] Twenty-eight patients were randomly allocated to autologous PRP, and half of the patients in the PRP group made a full recovery, they conducted weekly evaluations of their athletes and reported a mean return-to-sport of 42 days in the control group compared with 26 days in the PRP-treated group. In a study by Hamilton B et al.[35] specific to Hamstring injuries, indicate that there is no benefit of a single Platelet-Rich Plasma (PRP) injection over intensive rehabilitation in professional athletes who have sustained acute, MRI positive hamstring injuries. A single PRP injection combined with intensive rehabilitation was associated with a shorter return-to-sport duration compared with a single platelet-poor plasma injection combined with the same rehabilitation protocol.

2.5.2. Anterior cruciate ligament injuries

ACL rupture is considered as a common complication due to exercise and one of the most common reasons for the need for knee treatment in young people.[36] Studies have shown that PRP treatment can be an alternative to surgery and improve patient performance and disability.[37,38,39] Figueroa et al.[39] conducted a systematic review of 516 patients who underwent Anterior Cruciate Ligament (ACL) reconstruction with surgical repair, comparing outcomes between those who received adjunctive PRP injections and those who did not. The authors reported that the addition of PRP showed promising evidence of accelerating graft maturation compared with grafts that were not treated with PRP. Everhart et al.[40] conducted a similar study involving 550 patients and reported that the PRP preparations used in their analysis had a significant protective effect, reducing the risk of isolated meniscal repair failure over a three-year follow-up period. Thus, based on various literatures, surgical reconstructions are associated with better results and are highly recommended, while injection of PRP could also improve patient's pain and knee functions. Therefore, according to previous studies and protocols, younger patients with higher physical activities are better candidates for surgical ACL repair, while older patients with ACL rupture could benefit more from PRP injections.

2.5.3. Meniscal injuries

The menisci play a crucial role in distributing load within the knee joint. They also provide stability and lubrication to the knee joint.[41] Meniscal repair involves various approaches, including open and arthroscopic procedures, inside-out sutures, outside-in sutures, and all-inside sutures.[42] Multiple clinical trials have confirmed that PRP injection yields favorable functional ratings and radiographic enhancement in patients with symptomatic meniscal lesions. Li et al.[43] demonstrated significant improvements in VAS scores and failure rates following PRP treatment, whereas IKDC and Lysholm scores—patient-reported outcome measures of knee function—did not show similar improvement. Ultrasound-guided intra-articular perimeniscal PRP injections provided

effective pain relief in meniscal injury patients, with MRI at 6–7 months demonstrating significant healing progression.[44,45] The existing literature highlights the beneficial roles of fibroblast growth factor, transforming growth factor-β1, bone morphogenetic proteins, and platelet-derived growth factor in meniscal regeneration.[46,47] As an autologous reservoir of these growth factors, PRP represents a promising therapeutic option for meniscal injuries. The standardization of PRP parameters is limited by intrinsic variability in individual blood products.

2.5.4. Muscle injuries

Muscle injuries are among the most frequent injuries in sports and physical activities, contributing significantly to time lost from both training and competition. Muscle healing progresses through inflammation, regeneration, and remodeling phases that may be prolonged, increasing the risk of incomplete recovery or re-injury.[48] Pogliacomi et al.[49] presented a case report on PRP treatment of a rectus femoris myotendinous lesion in a non-professional athlete, using three injections at 10, 20, and 30 days after injury, with progressive healing and return to sport at 90 days. In 2024, de Aysa et al.[50] presented a case of an 18-year-old professional football player with an acute-on-chronic lateral distal rectus femoris tear. Following seroma aspiration, the patient received a 1-ml liquid LR-PRP injection under intermittent ultrasound guidance at 34 days post-injury. The athlete returned to competition 52 days after the injury, and at one-year follow-up remained asymptomatic, competitive, and free of re-injury. While PRP therapy has been associated with faster recovery, pain reduction, and lower re-injury rates, its effectiveness appears to be influenced by factors such as injury type.

2.5.5. PRP in patellar tendinopathy

Patellar tendinopathy is an affliction causing anterior knee pain. It has been found to be associated with sports involving jumping, such as basketball and athletics. Literature suggests that chronic repetitive motion is the most significant risk factor, and interplay with intrinsic risk factors is implicated in its causation. The pathological hallmark entails progressive degeneration of the tendon, paucity of tissue repair and an absence of inflammatory cells.[51,52] Although physical therapy mainly eccentric exercises has shown to be beneficial, the improvement is often slow and incomplete and may result in less than satisfactory outcomes. Chronic recalcitrant patellar tendinopathy often requires surgery, which carries its own risks and a delayed return to sports activities.

PRP versus No-injection treatment modalities PRP versus extracorporeal shock wave therapy Vetrano et al., RCT was included in this review that compared the efficacy of PRP injection with Extracorporeal Shock Wave Therapy (ESWT). The authors of this study divided 46 persons with patellar tendinopathy equally into two groups, with one group (n = 23) treated with two PRP injections (1-week interval) and the second group (n = 23) treated with three sessions of ESWT (each session comprising 2,400 impulses at 0.17–0.25 mJ/mm^2) at intervals of 48 to 72 h. Study participants were followed up at 2, 6, and 12 months. All subjects followed a structured exercise program comprising stretching (knee-flexors, extensors, hip flexors, and tendoachillis [TA]) and strengthening (isometric and isotonic exercises) exercises for 2 weeks. T hose persons who received PRP injections showed more significant improvements ($P < 0.05$) in terms of VAS pain scores at both visits (medium term and long term Similarly, in terms of functional activities (VISA P scores), persons in the PRP group achieved much bet ter scores ($P < 0.05$) in the medium term.

Post PRP injection MRI evaluation of Maffulli N et al. [51] in their study concluded that complete return of structural integrity of patellar tendon were 57% of cases while the remaining had partial healing ended in treatment failures.

2.5.6. Achilles tendinopathy

Achilles tendinopathy is a frequent overuse injury in young and competitive athletes participating in sports that involve repetitive sprinting and jumping, in which the underlying pathology represents a failed tendon healing response secondary to mechanical overload rather than a purely inflammatory process.[53,54] While conventional management with eccentric loading exercises, physiotherapy, NSAIDs, and shockwave therapy is effective in many cases, a subset of athletes develops persistent symptoms that delay return to sport and increase the risk of chronic degeneration or rupture.

Platelet-Rich Plasma (PRP), has gained attention as a biological adjunct that enhances tenocyte proliferation, collagen synthesis, angiogenesis, and extracellular matrix remodeling Ultrasound-guided injection of leukocyte-poor PRP (2–5 mL), combined with a structured eccentric rehabilitation program, has been shown to improve pain (VAS), functional outcomes (VISA-A), and tendon morphology, particularly in young, high-demand athletes with non-insertional disease and early degenerative changes.[55,56,57] Although clinical outcomes vary due to heterogeneity in PRP preparation and protocols, PRP remains a safe and biologically rational option that may facilitate an earlier and safer return to sport in appropriately selected athletes.

2.5.7. PRP in atfl injury

Among all ankle injuries, ankle sprains are the most common accounting for approximately 80% of which 77% are lateral ankle sprains. 73% of lateral ankle sprains are due to rupture or tear of the anterior talofibular ligament (ATFL) and ATFL is the weakest ligament in the lateral collateral complex of the ankle. Its main function is to resist inversion and plantarflexion. Mechanically, ATFL is injured due to forced supination in plantarflexion movement.

RCT partial tear of ATFL patients were divided into two groups One group receiving PRP with rehabilitation and the other group with rehabilitation alone assessment with VAS and FADI (foot and ankle Disability index score)

There was significant difference in the mean changes from baseline to 2nd, 6th and 12th weeks follow-ups in between the two groups with more improvement was seen in the PRP plus rehabilitation group.[58] A case of LAS with complete tear of ATFL which showed complete healing of ligament and early ankle stabilization after PRP. The healing is supported by dynamic ultrasound images and magnetic resonance imaging.[59]

One of the study concluded that in acute ankle sprain cases a single dose of PRP with walking cast showed improvements in VAS,FADI scores. Another study concluded that PRP addition to conservative treatment has achieved a good result in ATFL tear management.[58]

2.5.8. PRP in plantar fascitis

Plantar fasciitis management involves- stretching exercises, activity modification, and use of several analgesics resolve symptoms in over 80% of patients, while biomechanical factors can be corrected by insoles or various kinds of orthotics or night splints. Patients with intractable PF, other available strategies are extracorporeal shock wave therapy and corticosteroid injections. In recent years, biological treatments have been getting popularity in many orthopedic conditions.

The use of PRP injections under ultrasonography guidance to physiotherapy. They prospectively recruited patients suffering from chronic PF and divided them into two treatment groups (PRP group vs physiotherapy group). All patients were evaluated using the American Orthopaedic Foot and Ankle Society (AOFAS) score before and after treatment. The AOFAS score improved significantly in the PRP group. Ultrasonography was performed before and 4 weeks after treatment, fascial echogenicity was significantly changed in most of the patients after PRP injection, and fascial thickness was statistically decreased in the PRP group compared to the physiotherapy group.[60]

In the controlled, randomized, blinded clinical study by Acosta-Olivo et al.,[60] patients were randomized into two groups. Administration of dexamethasone 8 mg plus 2 mL of lidocaine was adopted in the steroid treatment group, while 3 mL of PRP activated with 0.45 mL of 10% calcium gluconate was used in the PRP treatment group. The VAS, Foot and Ankle Disability Index (FADI), and AOFAS scale were proposed to all patients at the beginning of the study, and at 2, 4, 8, 12, and 16 weeks post treatment.

Platelet-rich plasma was a valid strategy when patients with PF failed to respond to nonoperative treatment. The PRP efficiency was comparable to that of steroids injections, without complications associated with steroid use.

3. Conclusion

PRP has been a drug of debate under the anti-doping regulations. The World Anti-Doping Agency (WADA) has carefully examined this issue and concluded the following: To date, no studies have shown that PRP consistently or acutely improves athletic performance. PRP has no systemic effects as they are targeted locally. Accordingly, PRP is not prohibited by anti-doping regulations and is therefore permissible for use by athletes in any sport. PRP and other injection-based therapies offer a minimally invasive approach to musculoskeletal rehabilitation in athletes. By potentially accelerating recovery and shortening downtime from training and competition, these therapies support the goals of conservative management while maintaining athletic performance.

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