

General

Platelet-Rich Plasma Therapy in Treating Tendon Injuries of the Hand: A Narrative Review

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Keywords: Platelet-rich plasma (PRP), tendon healing, hand injuries, flexor tendon repair, regenerative therapy

<https://doi.org/10.52965/001c.147173>

Orthopedic Reviews

Vol. 17, 2025

Platelet-rich plasma (PRP) therapy has emerged as a biologically based approach to enhance tendon healing and functional recovery in hand and other musculoskeletal injuries. PRP is an autologous concentrate of platelets and growth factors, including platelet-derived growth factor (PDGF), transforming growth factor-beta (TGF- β), insulin-like growth factor (IGF), and vascular endothelial growth factor (VEGF), which modulate inflammation, stimulate tenocyte proliferation, promote collagen synthesis, and support angiogenesis. Preclinical studies demonstrate that PRP improves extracellular matrix remodeling, collagen fiber alignment, and biomechanical strength in injured tendons, with effects influenced by PRP formulation, leukocyte content, activation method, and timing of application. Clinical evidence in hand tendon injuries—particularly flexor tendon repair, chronic tendinopathies, and stenosing tenosynovitis—suggests that PRP is generally safe and may enhance tendon morphology, range of motion, pain relief, and return to function. However, results are heterogeneous, with some randomized trials showing limited short-term functional improvements compared to conventional treatments such as corticosteroids, hyaluronic acid, or percutaneous needle tenotomy. The variability in outcomes reflects differences in PRP preparation, injection protocols, injury chronicity, and study design. Beyond the hand, PRP has been applied to rotator cuff, lateral epicondylitis, plantar fasciitis, ligament injuries, and spinal surgery, with mixed results and some evidence of tissue-specific limitations. Current challenges include standardizing PRP formulations, optimizing dosing and delivery, and identifying patient- and injury-specific factors influencing response. Future research should prioritize multicenter, well-powered randomized trials with uniform outcome measures, long-term follow-up, robust safety monitoring, and exploration of combination therapies to clarify the therapeutic role of PRP and support evidence-based integration into clinical practice.

1. INTRODUCTION

Tendon injuries of the hand, including lacerations, ruptures, and degenerative conditions, represent a significant clinical challenge due to the complex anatomy and high functional demands of the hand as one of the most exposed organs in the human body.¹ According to De Jong et al., concomitant tendon injuries occur in 54.8% of patients with small hand lacerations and in 92.5% of patients with deep injuries through small lacerations.² These injuries can lead to prolonged disability, impaired grip strength, and reduced quality of life, especially when the healing process is delayed or incomplete. Traditional management strategies, including surgical repair and physiotherapy, have been associated with variable outcomes and complications, such as adhesions, re-tears, or stiffness.³

In recent years, platelet-rich plasma (PRP) has grown as a promising biologic treatment aimed at increasing tendon

healing. The application of PRP has shown encouraging results acting like a biological scaffold in various musculoskeletal conditions, including lateral epicondylitis, rotator cuff injuries, Achilles tendinopathies and cartilage repair.⁴ Its applications have been expanding and its use in tendon injuries, particularly those in the hand, have been growing.

2. BACKGROUND

2.1. ANATOMY AND HEALING CHALLENGES OF HAND TENDON INJURIES

Tendon injuries are among the most prevalent hand injuries, constituting a significant portion of trauma cases. These injuries can lead to substantial functional impairment, affecting both personal and professional aspects of patients' lives.¹

The human hand relies on a complex interplay between flexor and extensor tendons to perform precise and powerful movements. These tendons, confined in fibrous sheaths and closely associated with neurovascular structures, are vulnerable to injury from trauma, overuse, or degenerative changes.⁵ Flexor tendon injuries, especially in zones I and II, commonly referred to as “no man’s land”, are notoriously difficult to treat, due to high risk of adhesions, limited vascularity, and need to preserve tendon gliding.⁶ Similarly, extensor tendon injuries, though more accessible surgically, often result in extension lag, stiffness, or rupture when healing is inadequate.⁷

Tendon healing is a complex, multi-phase process involving an orchestrated response from immune, vascular, and nervous systems. It begins with inflammation, where immune cells and platelets release cytokines and growth factors, followed by cell proliferation and angiogenesis, promoting fibroblast and tenocyte activity. Neural signals and growth factors like platelet-derived growth factor (PDGF), transforming growth factor-beta (TGF- β), insulin-like growth factor (IGF), and vascular endothelial growth factor (VEGF) play crucial roles in modulating inflammation, promoting collagen, and guiding regeneration.⁸ While intrinsic healing mechanisms attempt to restore tendon integrity, they are frequently insufficient, especially in tendons with poor vascular supply or in cases with extensive damage.⁹ Current management strategies for tendon injuries include surgical repair, early mobilization, and structured rehabilitation.¹⁰ Despite surgical repair, outcomes are often suboptimal, with common complications including re-rupture, adhesions, and tendon elongation, prompting interest in biologic therapies like PRP to potentially enhance healing.

2.2. PRP: DEFINITION AND MECHANISM OF ACTION

PRP is an autologous platelet-rich plasma obtained by centrifuging the patient’s blood, and when activated, commonly with thrombin or calcium chloride, its platelets release growth factors like PDGF, TGF- β , IGF, EGF, and VEGF that promote tissue repair and regeneration.⁴ These bioactive molecules are instrumental in modulating inflammation, cell proliferation, and tissue regeneration.¹¹

In musculoskeletal applications, particularly tendon healing, TGF- β supports cell differentiation and matrix synthesis, while PDGF enhances cell proliferation and promotes extracellular matrix components production and remodeling.^{12,13} Preclinical studies have demonstrated that PRP can promote tenocyte proliferation and collagen type I expression, key components of tendon healing.^{14,15} PRP may also modulate inflammation by decreasing pro-inflammatory cytokines and increasing anti-inflammatory mediators, potentially reducing adhesions and enhancing functional recovery.¹⁶ This has driven the application of PRP in several musculoskeletal conditions, particularly tendon injuries.

2.3. PRP IN MUSCULOSKELETAL MEDICINE AND TENDINOPATHY

Over the past two decades, PRP has been widely studied and increasingly applied to musculoskeletal conditions, including chronic tendinopathies, ligament injuries, osteoarthritis, and post-surgical healing.^{17,18} Multiple studies and meta-analyses have reported variable results, with some showing significant clinical improvement while others fail to demonstrate superiority over placebo or corticosteroid injections.^{17,19,20} The variability in outcomes has been attributed to heterogeneity in PRP formulations, delivery protocols, and types of injuries.^{21,22}

Despite growing evidence in large tendon structures, PRP’s application in hand-specific tendon injuries remains relatively underexplored.²³ The intricate anatomy and function of hand tendons—characterized by complex sheath systems, proximity to pulleys, and the need for early motion to prevent adhesions—require careful consideration when selecting therapeutic interventions to balance healing and mobility.³ Whether PRP’s biologic benefits translate effectively to this anatomical context remains a subject of ongoing investigation.

2.4. RATIONALE FOR A FOCUSED REVIEW

PRP shows promise for tendon healing, but evidence specific to hand tendon injuries is limited, with small, methodologically diverse studies yielding mixed outcomes. The lack of standardized PRP protocols and hand-focused reviews further complicates interpretation and comparison of results.^{21,24} Given the functional importance of the hand and the potential of PRP to enhance tendon healing, a focused review of the current literature is warranted. This review aims to gather and interpret available evidence on the use of PRP for hand tendon injuries, highlight key findings and limitations, and identify gaps in knowledge that could drive future research.

3. SUMMARY OF EXISTING EVIDENCE

3.1. MECHANISMS AND RATIONALE FOR PRP IN TENDON HEALING

PRP has been widely studied for tendon healing because of its potential to modulate inflammation, enhance tissue regeneration, and support structural and functional recovery. As an autologous, biologically active preparation, it is rich in platelets and growth factors like PDGF, TGF- β , VEGF, and IGF, which are essential for tendon repair.^{24,25} PRP’s rationale in tendon injuries is based on its ability to affect key healing processes, including cell proliferation, matrix synthesis, angiogenesis, and modulation of inflammation.

3.1.1. CELLULAR PROLIFERATION AND TENOGENIC DIFFERENTIATION

In vitro studies show that PRP enhances tenocyte proliferation, migration, and extracellular matrix production, with PRP releasate promoting tendon stem cell differentiation

into active tenocytes and upregulating tenogenic markers like scleraxis, tenomodulin, and collagen type I.²⁶ Similarly, De Mos et al. found that platelet-rich clot releasate increased human tenocyte proliferation and collagen synthesis, while stimulating matrix remodeling enzymes and proangiogenic factors, such as VEGF and TGF- β 1.²⁷ Similar effects were observed in PRP-conditioned 3D scaffolds, where BM-MSCs and skin fibroblasts cultured with PRP showed enhanced tenogenesis and improved collagen I:III ratios, reflecting more organized tendon matrix formation.²⁸

3.1.2. COLLAGEN PRODUCTION AND MATRIX REMODELING

Tendon healing depends on restoring an organized collagen matrix, mainly composed of type I collagen, and PRP has been shown to enhance type I collagen expression and fiber alignment. Liu et al. demonstrated that leukocyte-rich PRP (LR-PRP) increased collagen synthesis in vitro and improved collagen organization and biomechanical properties in vivo, especially when applied during the early inflammatory phase.²⁹ In animal models, PRP-treated tendons displayed superior collagen fiber organization and increased hydroxyproline content, reflecting enhanced extracellular matrix remodeling.^{30,31}

These findings were corroborated by Kaux et al., who compared fresh and frozen-thawed PRP in rat tendons and observed that PRP, regardless of its preservation state, led to significant improvement in tendon strength and organization, especially at mid-term healing stages.³² Similarly, Bosch et al., using ultrasonographic tissue characterization in equine tendons, showed that PRP accelerated the maturation of collagen fibers with over 80% proper alignment compared to 60% in saline-treated controls.³³

3.1.3. ANGIOGENESIS AND GROWTH FACTOR MODULATION

PRP contains proangiogenic factors like VEGF that are essential for tendon revascularization. Anitua et al. showed that PRP-stimulated tendon cells increased VEGF and HGF production, regulated by TGF- β 1, promoting angiogenesis that supports nutrient delivery, fibroblast recruitment, and tissue remodeling during tendon regeneration.³⁴

Yu et al. further demonstrated that PRP releasate reduced inflammation and apoptosis while improving collagen alignment and repair strength in acutely injured tendons, highlighting its role in orchestrating early regenerative processes.³⁵ In transgenic mouse models, Zhang et al. identified platelet-derived HMGB1 as a critical mediator of PRP's healing effects, promoting stem cell recruitment and reducing macrophage-driven inflammation, ultimately enhancing wound closure and matrix remodeling.³¹

3.1.4. BIOMECHANICAL PROPERTIES AND STRUCTURAL INTEGRITY

Preclinical animal studies, including Kaux et al., have shown that PRP enhances the mechanical strength of healing tendons, with treated Achilles tendons exhibiting greater tensile strength at days 5, 15, and 30, alongside improved collagen alignment, fibroblast proliferation, and vascularization.³⁰ Geburek et al. found that PRP improved tendon structure on ultrasound in horses with flexor tendinopathies, but clinical lameness scores did not change, indicating structural improvements may not always translate to symptom relief.³⁶

3.1.5. PRP RELEASATE AND DELIVERY TIMING

Several studies emphasized the unique effects of PRP releasate — the growth factor-rich supernatant released after platelet activation — over whole PRP. Zhang and Wang and Yu et al. demonstrated that releasate alone was sufficient to drive tenogenic differentiation and early tendon repair.^{26, 35} Moreover, the timing of PRP application appears critical: Liu et al. and Chalidis et al. emphasized that PRP is most effective when administered in the early inflammatory phase, while its use in chronic or late-stage injuries may provoke undesired inflammatory responses or limited benefit.^{25,29}

3.2. PRP FORMULATIONS AND APPLICATION PROTOCOLS

Despite the promising evidence, findings across studies remain inconsistent. Chalidis et al. noted that while many in vitro and in vivo models support the anabolic and regenerative effects of PRP, several studies reported neutral or even negative outcomes, often related to study design, PRP formulation, or timing of intervention.²⁵ Kia et al., in a meta-analysis of 48 studies, reported that although PRP generally promotes tenocyte proliferation and matrix production, clinical efficacy was variable and injury-specific.³⁷ Significant heterogeneity in PRP formulations, including leukocyte concentration, activation method, and dosing protocols, continues to challenge interpretation and clinical translation.^{22,38} PRP's effectiveness in tendon healing depends on its preparation, leukocyte content, activation, and timing, as different formulations produce distinct growth factor profiles and cellular responses.^{32,39}

3.2.1. FRESH VERSUS FROZEN-THAWED PRP

Kaux et al. compared fresh PRP with PRP subjected to two freeze-thaw cycles in a rat tendon injury model. Both formulations demonstrated comparable biomechanical and histological healing outcomes at 7- and 40-days post-injury, with fresh PRP showing a transient mechanical advantage at 20 days. This finding suggests that frozen-thawed PRP maintains sufficient bioactivity to promote tendon repair, providing practical benefits in storage and repeated dosing scenarios without significant loss of efficacy.³²

3.2.2. SELECTIVE ACTIVATION OF PRP

PRP activation method influences its biological effects, as Zhang et al. showed that protease-activated receptor-4 PAR4 activation enhanced collagen organization and tendon healing, while PAR1 activation increased angiogenesis but impaired tissue quality, suggesting that tailoring activation to injury stage could optimize outcomes.³⁹

3.2.3. LEUKOCYTE-RICH VERSUS LEUKOCYTE-POOR PRP

The leukocyte content within PRP is a critical determinant of its inflammatory and regenerative potential. It can vary, leading to classifications, such as LR-PRP and leukocyte-poor PRP (LP-PRP). A study by Chen et al. examined the effects of LR-PRP and LP-PRP on myoblast proliferation, revealing that both formulations similarly enhance cell proliferation.⁴⁰ Although this research centers on muscle cells, the comparable regenerative processes in tendon tissues suggest that varying leukocyte concentrations in PRP may not significantly alter its efficacy in promoting tendon healing.⁴¹

McCarrel et al. found that in equine tendon explants, leukocyte-rich PRP minimized inflammatory cytokine expression while promoting anabolic markers, whereas higher leukocyte concentrations increased pro-inflammatory cytokines and catabolic enzymes, and maintaining platelet-to-WBC ratios did not reduce this inflammation.⁴²

Zhou et al. demonstrated that LR-PRP enhanced tendon stem cell proliferation but also induced catabolic and inflammatory gene expression, which may be detrimental in chronic tendon injuries. In contrast, P-PRP stimulated anabolic pathways, increasing collagen synthesis without the adverse inflammatory effects, suggesting it may be a safer choice for regenerative tendon therapy.⁴³ Similarly, Rubio-Azpeitia et al. showed that in human tendon cells, leukocyte-rich PRP triggered a strong pro-inflammatory response, while leukocyte-poor PRP enhanced cell proliferation and collagen production with minimal inflammation, highlighting the importance of selecting PRP formulations to balance inflammation and regeneration.⁴⁴

3.2.4. INFLAMMATION MODULATION AND IMMUNE CELL INTERACTION

PRP's effect on inflammation is context- and time-dependent, transiently promoting acute inflammation necessary for healing while reducing chronic inflammation, as Liu et al. found that LR-PRP increased pro-inflammatory genes in vitro but improved tendon histology and decreased chronic inflammation in vivo when applied early post-injury.²⁹ Yu et al. similarly reported a reduction in ED1⁺ macrophage-mediated inflammation following PRP treatment, facilitating faster transition from inflammation to regeneration.³⁵

PRP's inflammatory effects depend on leukocyte content, which can provide early antimicrobial and catabolic benefits but may cause excessive matrix degradation if prolonged, highlighting the importance of tailoring PRP composition to the injury phase and tissue environment.^{29,38}

3.2.5. EXPERT CONSENSUS ON STANDARDIZATION AND APPLICATION

Tischer et al. reported expert consensus on PRP's potential for acute and chronic tendinopathies, emphasizing the need for standardized preparation, activation, and dosing, with multiple injections preferred for chronic cases but optimal intervals remaining unclear.⁴⁵

3.2.6. SUMMARY

PRP's formulation and activation methods significantly impact its healing effects, with leukocyte-poor or reduced preparations generally favored for chronic tendinopathies due to lower inflammation. Standardized protocols are needed, and future research should refine preparation, activation, and dosing to optimize outcomes for specific tendon injury types and stages.

3.3. PRP IN HAND TENDON INJURIES: CLINICAL EVIDENCE

PRP therapy shows promise for improving healing and function in various hand tendon injuries, but current evidence from randomized controlled trials (RCTs), prospective studies, case reports, and animal models remains limited and highlights the need for further research.

3.3.1. PRP IN ACUTE FLEXOR TENDON INJURIES

Several RCTs have evaluated the efficacy of PRP in acute flexor tendon injuries. Darwish et al. conducted a study on 20 patients with acute flexor tendon injuries repaired via modified Kessler sutures, administering 0.5 ml PRP injections at the repair site. Functional assessment at 12 weeks using Total Active Motion (TAM) scores showed a higher incidence of excellent outcomes in the PRP group without an increase in complications, suggesting that PRP may accelerate tendon healing post-repair.⁴⁶ Similarly, Majeed et al. reported improved times to resume activities in a cohort of 40 patients, with PRP-treated individuals returning to activity at a median of 4 weeks compared to 6 weeks in controls.⁴⁷ This study also used objective ultrasound criteria to evaluate tendon healing, indicating enhanced tendon matrix remodeling with PRP. Elfeshawy et al. reinforced these findings, demonstrating via ultrasound that intraoperative PRP injection significantly improved tendon morphology, reduced pain in the early postoperative period, and shortened return-to-activity times.⁴⁸

3.3.2. MIXED FUNCTIONAL OUTCOMES IN CLINICAL TRIALS

However, some studies report less definitive functional improvements. Gamal et al. studied 40 patients with Zone II flexor tendon repairs and found no statistically significant difference between PRP and control groups regarding the Buck-Gramcko II clinical outcome scores or proximal interphalangeal joint range of motion at 6 and 12 weeks postoperatively, indicating that PRP may not universally enhance

short-term functional recovery.⁴⁹ Additionally, Kollitz et al., using an animal model, found no significant difference in ultimate tensile strength or range of motion between PRP-treated and control groups, though cell counts were reduced in the PRP group at 4 weeks, hinting at a complex biological response that may not translate immediately to biomechanical advantages.⁵⁰

3.3.3. IMPROVING TENDON GLIDING AND REDUCING ADHESIONS

The potential for PRP to improve tendon gliding and reduce adhesions post-repair has been specifically investigated in Zone II flexor tendon injuries, known for their challenging healing environment. Mohamed and Setta conducted prospective RCTs where patients receiving activated PRP injections intraoperatively showed significantly improved total active range of motion, grip strength, and pinch strength at 8 weeks, 6 months, and 12 months compared to controls. Their studies concluded that activated PRP enhances tendon gliding and functional outcomes by potentially reducing adhesion formation and promoting anabolic repair pathways.⁵¹

3.3.4. PRP IN CHRONIC TENDON PATHOLOGIES AND INFLAMMATORY CONDITIONS

Beyond tendon rupture repair, PRP has demonstrated promise in managing chronic tendon pathologies and inflammatory conditions of the hand. For instance, Medina-Porqueres described a case of trigger finger treated with ultrasound-guided PRP injection into the flexor tendon sheath. The patient reported relief of symptoms, decreased triggering, and reduced thickness of sheath on ultrasound, highlighting PRP's potential in modulating inflammation and facilitating tendon healing.⁵² In a larger prospective randomized trial on carpal tunnel syndrome (CTS), Ertilav and Ertilav compared ultrasound-guided PRP injections to corticosteroids. Although clinical improvements were comparable, electrophysiological parameters showed more sustained improvement in the PRP group, suggesting a regenerative effect on nerve and tendon tissues involved in CTS.⁵³ Similarly, Trull-Ahuir et al. found PRP to be an effective adjuvant to surgical carpal ligament release, with faster return of hand grip strength and symptomatic relief compared to platelet-poor plasma controls.⁵⁴

3.3.5. ANIMAL AND EXPERIMENTAL MODELS

Animal and experimental models further support PRP's biological effects on tendon healing relevant to hand injuries. Bosch et al. demonstrated that PRP induces significant neovascularization in equine superficial digital flexor tendons post-injury, a key factor in enhancing nutrient supply and repair capacity.⁵⁵ Schnabel et al. confirmed that PRP enhances anabolic gene expression in flexor tendons, increasing collagen I, collagen III, and matrix protein synthesis without upregulating catabolic enzymes, underpinning the molecular basis for PRP's reparative effects.⁵⁶ Novel approaches combining PRP with biomaterials, such as

hyaluronic acid/PRP nanofiber membranes, have shown promise in reducing postoperative adhesions while promoting tendon healing and gliding function in rabbit models, suggesting potential future applications in human tendon repair to minimize complications.⁵⁷

3.3.6. PRP IN COMPLEX HAND INJURIES

Clinical applications of PRP extend to complex hand injuries with soft tissue defects. Du et al. compared PRP treatment to skin flap transplantation in patients with open hand injuries involving skin defects, finding PRP effective in reducing surgical time, postoperative pain, and cost, with comparable or better functional outcomes despite longer healing times.⁵⁸ In a severe trauma case, Saha demonstrated that PRP combined with tissue scaffolds facilitated extensive upper extremity reconstruction, enabling significant wound size reduction and restoration of hand function with minimized surgical risk.⁵⁹

Lastly, case reports such as Dixon et al. illustrate successful remodeling of tendinopathic lesions in the first dorsal compartment of the wrist using ultrasound-guided PRP injections, leading to marked pain reduction, improved tendon architecture on MRI, and restored function, thus extending PRP's potential indications in hand tendon disorders.⁶⁰

In summary, clinical evidence supports the safety and efficacy of PRP in promoting healing and functional recovery in various hand tendon injuries, especially flexor tendon repair and chronic tendinopathies. While some studies show inconsistent functional improvements, the majority indicate benefits in tendon morphology, neovascularization, pain reduction, and range of motion.

3.4. COMPARISON WITH CONVENTIONAL TREATMENTS

The clinical utility of PRP compared to conventional treatments such as corticosteroid injections, hyaluronic acid (HA), and ultrasound-guided percutaneous needle tenotomy (PNT) has been extensively investigated, revealing efficacy depending on the condition, timing, and characteristics of patients.

3.4.1. SYSTEMATIC REVIEW AND META-ANALYSIS EVIDENCE

A systematic review and meta-analysis of 27 RCTs involving 1779 patients compared PRP to corticosteroids across tendinopathies including rotator cuff tears, lateral epicondylitis, plantar fasciitis, and tenosynovitis. PRP generally provided greater pain reduction at one month for rotator cuff and lateral epicondylitis and superior pain relief at six months for plantar fasciitis and tenosynovitis, though many differences diminished by three to six months. These findings suggest that while corticosteroids may offer rapid short-term relief, PRP may provide more durable symptomatic improvement, particularly in chronic conditions, highlighting its potential role in longer-term management.⁶¹

3.4.2. PRP VS CORTICOSTEROIDS AND HYALURONIC ACID IN FLEXOR STENOSING TENOSYNOVITIS

An RCT of 197 patients with flexor stenosing tenosynovitis compared PRP, corticosteroids, and hyaluronic acid over 12 weeks, finding that all improved pain and hand movement, but corticosteroids were most effective in severe trigger finger (grade IV), while PRP and HA offered no clear short-term advantage and were ineffective in grade V, indicating corticosteroids remain first-line for acute relief and PRP's role, particularly in severe or chronic cases, remains unclear.⁶²

3.4.3. ULTRASOUND-GUIDED PERCUTANEOUS NEEDLE TENOTOMY WITH AND WITHOUT PRP

In a double-blinded RCT, Kirschner et al. compared PNT alone versus PNT with LR-PRP for chronic tendinosis of the rotator cuff, wrist, patellar, and Achilles, finding lower pain at six weeks with PNT alone, but no differences in pain, function, or quality of life at 52 and 104 weeks, and similar low adverse events, suggesting PRP does not enhance early recovery but both approaches achieve comparable long-term outcomes, highlighting the efficacy of mechanical tenotomy.⁶³

3.4.4. RETROSPECTIVE EVIDENCE FOR PRP IN TENDINOPATHY

A retrospective cohort of 214 patients receiving peritendinous PRP injections showed significant pain and function improvements at 6 weeks and 6 months, with 83% reporting moderate to complete symptom relief and 85% high satisfaction, especially in lateral epicondyle and patellar tendinopathies; better outcomes were linked to female sex, older age, and upper extremity tendon involvement, supporting PRP as a well-tolerated option for sustained symptom relief consistent with controlled trial data in upper limb tendons.⁶⁴

- Inflammatory profile and PRP formulation matters: Rubio-Azpeitia et al. and McCarrel et al. highlight that leukocyte-poor PRP minimizes inflammation while enhancing anabolic tendon healing, which may partly account for variability in clinical outcomes across different PRP preparations and conventional treatments.^{28,42}
- PRP may enhance tendon matrix remodeling: Studies by Geburek et al. and Schnabel et al. showed that PRP promotes collagen synthesis and improved tendon matrix organization, which underpins potential long-term benefits over corticosteroids, which primarily reduce inflammation and may weaken tendon structure if overused.^{36,56}
- Variable effects based on injury chronicity and PRP activation: Zhang et al. highlight that selective activation of PRP can modulate angiogenesis and collagen organization, potentially tailoring PRP use to acute versus chronic tendinopathies, which may influence comparative efficacy with steroids or mechanical treatments like tenotomy.³⁹

In summary, PRP is a promising adjunct or alternative to corticosteroids, hyaluronic acid, and needle tenotomy for tendinopathies, particularly when long-term tendon healing is prioritized over short-term symptom relief. While corticosteroids remain effective for rapid pain control in acute or severe cases like trigger finger, PRP may provide superior structural and functional improvements in conditions such as rotator cuff tendinopathy and lateral epicondylitis over six months or longer.

3.5. PRP USE IN TENDONS BEYOND THE HAND

PRP therapy is used across diverse musculoskeletal conditions beyond hand tendons, with its efficacy and safety evaluated through numerous systematic reviews, meta-analyses, clinical trials, and animal studies.

3.5.1. SYSTEMATIC REVIEWS AND META-ANALYSES ON TENDON AND LIGAMENT HEALING

Chen et al.'s meta-analysis of 37 studies found that PRP may reduce short-term pain in lateral epicondylitis and rotator cuff disease, but inconsistent preparations and outcome measures limit conclusions on its long-term effectiveness.⁶⁵ Similarly, Ye et al.'s meta-analysis of 27 RCTs found PRP provided greater short-term pain relief than corticosteroids in rotator cuff and lateral epicondylitis and superior pain reduction at six months in plantar fasciitis and tenosynovitis, supporting its potential for longer-term benefit in select tendinopathies.⁶¹ Fitzpatrick et al.'s meta-analysis of RCTs showed PRP significantly improves pain and function, particularly beyond six months, outperforming corticosteroids while remaining safe, though variability in formulations and protocols limits standardized clinical guidance.¹⁸

3.5.2. PRP IN LIGAMENT HEALING AND SPINAL SURGERY

Unlike tendon applications, PRP shows limited benefit for ligament healing, as LaPrade et al. found high-dose PRP impaired MCL strength and tissue quality in rabbits, indicating a dose-dependent negative effect and the need for careful dosing optimization.⁶⁵ In spinal fusion, Wang et al.'s meta-analysis found that while high-concentration PRP may accelerate early bone formation, it does not improve final fusion rates, pain, or function, and variability in formulations limits its generalizability, offering no support for routine clinical use.⁶⁶

3.5.3. COMBINATIONAL AND EMERGING MODALITIES

Emerging studies indicate that combining PRP with biologics like hyaluronic acid, stem cells, scaffolds, or physical therapy may enhance tissue repair, reduce inflammation, and improve clinical outcomes, though standardized protocols and larger trials are needed to confirm these benefits.⁶⁷

3.5.4. SUMMARY

PRP's anabolic and regenerative effects, evidenced in vitro and in vivo, support its use beyond hand tendons, with enhanced collagen synthesis and matrix remodeling correlating with improved pain and function in larger tendons like the rotator cuff and plantar fascia.^{36,56}

PRP outcomes are strongly affected by preparation methods, patient factors, and tissue type, with high doses potentially harmful in ligament healing. The therapy shows promising long-term efficacy for tendinopathies such as lateral epicondylitis, rotator cuff injuries, and plantar fasciitis. However, its benefits in ligament repair and spinal fusion remain uncertain and require further investigation.

4. LIMITATIONS AND CONTROVERSIES

Despite the increasing application of PRP in tendon and ligament injuries, several limitations and controversies persist, complicating the interpretation of clinical outcomes and the establishment of standardized treatment protocols.

4.1. HETEROGENEITY OF PRP PREPARATIONS

A major challenge in PRP research is the wide variability in formulations, including platelet concentration, leukocyte content, activation, preparation methods, and injection volume, which hinders study comparisons. For instance, LaPrade et al. showed high platelet concentrations can harm ligament healing, highlighting the need for clinically defined dose optimization.⁶⁵

Interpreting PRP literature is challenging due to heterogeneity in preparation and administration, including differences in platelet concentration, leukocyte content, activation methods, and application volume or frequency. This variability, along with inconsistent reporting and differing commercial PRP systems, limits study comparability and complicates the establishment of standardized treatment guidelines.

4.2. VARIABILITY IN CLINICAL PROTOCOLS AND OUTCOMES

Beyond PRP preparation, clinical protocols differ in injection timing, frequency, rehabilitation approaches, and injury chronicity, while outcome measures vary from pain scores and functional questionnaires to imaging and biomechanical assessments. This wide variability in metrics, including VAS, DASH, grip strength, and tendon healing markers, complicates evidence synthesis and limits the reliability of meta-analyses.

Follow-up periods in PRP studies are often short (3–6 months), limiting assessment of long-term tendon healing, durability of benefits, and potential delayed complications like adhesions or re-rupture. This contributes to heterogeneous evidence and conflicting results, as seen in zone II flexor tendon repair studies regarding function and complication rates.^{46,50}

4.3. INCONSISTENT CLINICAL EFFICACY AND COMPARISON WITH CONVENTIONAL TREATMENTS

While many studies report favorable outcomes with PRP, especially in long-term pain reduction and function, others find no significant benefit over corticosteroids or placebo in the short term.^{18,49,61,62} Some RCTs show PRP provides similar improvements to conventional treatments like corticosteroids for trigger finger and tendinopathies, without clear superiority despite higher cost and complexity. Its clinical significance remains debated, and cost-effectiveness data are limited.

4.4. LIMITATIONS IN STUDY DESIGN AND EVIDENCE LEVELS

Many studies are limited by small sample sizes, short follow-up, and inconsistent blinding, weakening the evidence. Retrospective cohorts and case reports provide lower-level evidence, and PRP's biological rationale, largely based on in vitro and animal studies, may not fully translate to humans.^{55,56}

4.5. TISSUE-SPECIFIC AND CONDITION-SPECIFIC RESPONSES

PRP's effects vary by tissue type and injury. While it appears beneficial in many tendon pathologies, its role in ligament healing is controversial, with evidence of potential harm at higher doses.⁶⁵ Similarly, PRP's utility in spinal fusion surgeries is uncertain, with some meta-analyses showing no improvement in clinical outcomes despite accelerated early bone healing.¹²

4.6. NEED FOR STANDARDIZED PROTOCOLS AND FURTHER RESEARCH

There is a critical need for consensus on PRP preparation, dosage, timing, and delivery techniques tailored to specific injuries and tissues. Larger, well-designed, RCTs with standardized methodologies and longer follow-up periods are required to clarify PRP's therapeutic role. Additionally, investigating combination therapies (PRP with hyaluronic acid or stem cells) and understanding patient-specific factors influencing response could enhance clinical applicability.

5. CRITICAL APPRAISAL OF THE LITERATURE

The body of research evaluating PRP therapy for tendon injuries, particularly in the hand, is expanding but remains characterized by notable methodological and clinical limitations that restrict the interpretability and applicability of findings.

5.1. METHODOLOGICAL QUALITY AND STUDY DESIGNS

The quality of evidence for PRP in hand tendon injuries is variable, with few RCTs, small sample sizes, and inadequate blinding increasing bias and reducing statistical power.

Limited use of placebo or active comparators hinders assessment of true efficacy, while non-randomized and retrospective studies face selection bias and confounding, weakening conclusions from observational data.

5.2. SAFETY REPORTING AND ADVERSE EVENTS

PRP is generally considered safe due to its autologous nature; however, adverse event reporting is inconsistent and often lacks rigor. Many studies do not systematically monitor or define complications, leading to incomplete safety profiles, particularly relevant for repeated injections or in comorbid populations.

5.3. GENERALIZABILITY AND PATIENT POPULATION

Most research originates from specialized centers and relatively homogeneous patient groups, limiting generalizability to broader, more diverse populations. There is a paucity of data on elderly patients, those with systemic inflammatory or metabolic diseases, and patients undergoing complex reconstructive surgeries.

6. FUTURE DIRECTIONS

To overcome current limitations and clarify the role of PRP in tendon injury management, future research should prioritize:

- **Large, Multicenter RCTs:** Focused specifically on hand tendon injuries, adequately powered with rigorous randomization and blinding to minimize bias.
- **Standardization of PRP Protocols:** Detailed reporting of preparation methods, platelet and leukocyte concentrations, activation status, injection technique, and dosing schedules to enhance reproducibility and clinical applicability.
- **Uniform Outcome Measures:** Adoption of validated, standardized instruments such as DASH, QuickDASH, total active motion (TAM), and pain scales to facilitate cross-study comparisons.
- **Extended Follow-up:** Incorporation of long-term follow-up (≥ 12 months) to assess sustained functional outcomes, re-injury rates, and late complications.
- **Robust Safety Monitoring:** Systematic and standardized adverse event tracking, including patient subgroups with comorbidities, to better understand risks.
- **Combination Therapies:** Exploration of synergistic effects of PRP combined with other biologics (e.g., hyaluronic acid, stem cells), scaffolds, or physical therapies.
- **Personalized Medicine Approaches:** Research into biomarkers or imaging techniques to predict treatment response and tailor PRP therapy to individual patient profiles.
- **Cost-effectiveness and Patient-reported Outcomes:** Evaluations incorporating health economics and quality-of-life metrics to inform practical clinical decision-making.

7. CONCLUSION

PRP therapy represents a promising, biologically based intervention for tendon injuries in the hand and other musculoskeletal sites. While early evidence suggests potential benefits in pain relief and functional recovery, significant methodological inconsistencies, heterogeneity in PRP preparation and administration, and short-term follow-up limit definitive conclusions.

The current literature underscores the need for rigorous, standardized clinical trials with long-term outcome assessment and comprehensive safety reporting. Until such data are available, clinicians should approach PRP use cautiously, balancing its biological rationale and minimal invasiveness against the uncertainties in efficacy and optimal protocols.

Advances in standardized PRP techniques, better understanding of patient selection, and combination treatment strategies may eventually position PRP as an integral component of tendon injury management. Future research is essential to confirm its therapeutic value and guide evidence-based integration into routine clinical practice.

Submitted: August 24, 2025 EST. Accepted: September 21, 2025 EST. Published: November 23, 2025 EST.

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