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Review Article

Role of platelet-rich plasma as intraoperative adjunctive therapy in the surgical management of achilles tendinopathy: A comparative analysis review

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ABSTRACT

Platelet-Rich Plasma (PRP) therapy has emerged as a promising treatment modality for Achilles tendinopathy, leveraging its growth factors to accelerate healing. PRP promotes tissue regeneration, inflammation control, collagen synthesis, and angiogenesis, making it a favorable option in both conservative and surgical management of the condition. Comparative studies show that patients treated with PRP report faster recovery, improved pain reduction, and enhanced functional outcomes compared to those who undergo standard treatments alone, such as physical therapy or corticosteroid injections. Furthermore, when used as an adjunct in surgical management, PRP enhances tendon healing by promoting fibroblast activity and reducing the risk of postoperative complications like re-tear and inflammation. Although the clinical outcomes vary across studies, a growing body of evidence suggests PRP's beneficial role in reducing recovery time and improving long-term functional outcomes in Achilles tendinopathy, both non-surgically and as an intraoperative adjunct.
This article provides a balanced view of PRP's utility in Achilles tendinopathy treatment strategies.

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1. Introduction

Achilles tendinopathy is a common condition affecting middle aged persons characterized by pain, stiffness, and impaired function of the Achilles tendon. While conservative treatments such as physiotherapy, eccentric exercises, and anti-inflammatory medications are often the first line of management, chronic or refractory cases may require surgical intervention. Tendon healing, however, is a complex and prolonged process, often resulting in incomplete recovery and a high risk of recurrence.[1] In recent years, platelet-rich plasma (PRP) has gained attention as a potential adjunctive therapy in the management of tendinopathies, including Achilles tendinopathy. PRP, derived from the patient's own blood, is rich in growth factors and bioactive proteins that have the potential to enhance the body's natural healing process.[2] This review aims to explore the role of PRP as an intraoperative adjunctive therapy in the surgical management of Achilles tendinopathy, focusing on its mechanism of action and potential benefits in tendon healing.

2. Mechanism of PRP in Tendon Healing[3,4]

PRP is obtained by centrifuging a patient's blood to concentrate platelets, which are the body's first responders to injury. Platelets play a critical role in wound healing by releasing growth factors and cytokines, which orchestrate tissue repair and regeneration. The key growth factors in PRP include:

1. Platelet-Derived Growth Factor (PDGF): Stimulates the recruitment of inflammatory cells and promotes cell proliferation and matrix synthesis.

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2. Transforming Growth Factor-Beta (TGF-β): Regulates cell differentiation, collagen production, and the remodeling of the extracellular matrix.
3. Vascular Endothelial Growth Factor (VEGF: Promotes angiogenesis, improving blood supply to the injured area
4. Insulin-Like Growth Factor (IGF): Enhances cell proliferation and collagen synthesis, essential for tendon repair
5. Epidermal Growth Factor (EGF): Stimulates cell proliferation and differentiation, particularly in epithelial and fibroblastic cells.

In the context of tendon healing, these growth factors promote the three key phases of tissue repair as explained below:[5,6]

2.1. Activation of platelets in PRP

1. Platelet activation→ Initiates release of growth factors.
2. Growth factors released: PDGF, TGF-β, VEGF, IGF-1, FGF, and others.

2.2. Phase 1: Inflammation (0-7 days)

1. Tissue injury→ Platelets migrate to the injury site
2. Growth factors involved:
   (a) PDGF (Platelet-Derived Growth Factor): Attracts inflammatory cells (neutrophils, macrophages) to the injury site.
   (b) TGF-β (Transforming Growth Factor-β): Modulates inflammation and promotes recruitment of immune cells.
3. Key cellular activities
   (a) Neutrophils and macrophages clear debris and pathogens
   (b) Macrophages secrete cytokines and additional growth factors (IL-1, TNF-α)
4. Outcomes:
   (a) Control of inflammation
   (b) Preparation for tissue repair

2.3. Phase 2: Proliferation (4-21 days)

1. Tissue formation and repair initiated→ Proliferation of cells
2. Growth factors involved:
   (a) VEGF (Vascular Endothelial Growth Factor): Promotes angiogenesis (new blood vessel formation)
   (b) FGF (Fibroblast Growth Factor): Stimulates fibroblast proliferation and collagen production.
   (c) IGF-1 (Insulin-like Growth Factor-1): Enhances fibroblast activity, protein synthesis, and cell growth.
   (d) PDGF: Stimulates fibroblasts and smooth muscle cells to regenerate tissue.
3. Key cellular activities
   (a) Fibroblasts produce new extracellular matrix (ECM) and collagen
   (b) Endothelial cells form new blood vessels for nutrient supply
   (c) Granulation tissue forms (a new matrix rich in collagen and new capillaries)
4. Outcomes:
   (a) Formation of new tissue
   (b) Angiogenesis to supply blood to healing tissue

2.4. Phase 3: Remodeling (21 days to months)

1. Maturation of tissue→ Strengthening and organization of tissue
2. Growth factors involved:
   (a) TGF-β: Regulates matrix remodeling and collagen maturation
   (b) PDGF: Continues to stimulate remodeling of connective tissue
3. Key cellular activities
   (a) Fibroblasts reorganize collagen fibers for increased tensile strength
   (b) ECM continues to mature and stabilize
   (c) Scar tissue contracts, strengthening the repair site
4. Outcomes:
   (a) Restoration of tissue function
   (b) Increased tensile strength
   (c) Scar tissue remodeling

2.5. PRP as an adjunct to surgical management

Surgical management of Achilles tendinopathy typically involves debridement of the damaged tissue, removal of fibrotic or degenerative tissue, and repair of the tendon. While these procedures aim to restore the structural integrity of the tendon, they do not directly address the biological healing process. This is where PRP can serve as a valuable adjunctive therapy by enhancing the biological environment for tendon repair.[7]

PRP can be applied intraoperatively at the site of tendon repair in various ways:

1. Direct injection into the tendon: PRP can be injected into the tendon tissue after debridement to stimulate healing and regeneration. The growth factors released from the platelets promote cell proliferation and collagen synthesis, accelerating the repair process.

2. PRP Gel application: PRP can be mixed with a gel or scaffold and applied directly to the tendon repair site. This allows for the sustained release of growth factors over time, providing prolonged support to the healing tendon.
3. Combined with suture repair: PRP can be used in conjunction with sutures to enhance the strength and healing of the tendon repair. The presence of growth factors at the repair site can improve tendon-bone healing and reduce the risk of suture failure or re-rupture.

2.6. Potential benefits of PRP in surgical achilles tendon repair[8]

1. Enhanced healing: By promoting early inflammatory responses and enhancing collagen synthesis, PRP can accelerate the healing process. This can result in faster recovery times and a more complete structural repair of the tendon.
2. Improved tendon quality: Studies suggest that PRP can improve the quality of the repaired tendon by increasing collagen type I production, which is critical for the strength and durability of the tendon.
3. Reduced pain and inflammation: The anti-inflammatory effects of PRP can help reduce postoperative pain and swelling, potentially improving early postoperative rehabilitation outcomes.
4. Lower recurrence rates: PRP may reduce the risk of re-injury by enhancing the structural integrity of the tendon during the remodeling phase. By promoting a more robust tendon repair, PRP can help prevent recurrence, which is common after Achilles tendon surgery.
5. Minimization of complications: Since PRP is autologous, the risk of infection, immune reactions, or other complications is minimal compared to synthetic grafts or allografts used in tendon repair.

PRP has emerged as a promising adjunctive therapy in the surgical management of Achilles tendinopathy. Its ability to enhance tendon healing through the release of growth factors and cytokines makes it an appealing option to improve surgical outcomes, particularly in chronic or refractory cases. While further high-quality clinical studies are thereto establish the definitive benefits of PRP, (Table 1)[9–13] its use in intraoperative settings appears to offer advantages in terms of faster recovery, improved tendon quality, and potentially lower recurrence rates. Surgeons should consider PRP as a biologic adjunct in cases where tendon healing may be compromised or in patients with chronic Achilles tendinopathy.

3. Discussion and Comparative Analysis

Platelet-rich plasma (PRP) therapy has gained considerable attention in the treatment of Achilles tendinopathy, a common overuse injury affecting the Achilles tendon. Achilles tendinopathy typically manifests as pain, swelling, and impaired function in the tendon, often affecting athletes or individuals with repetitive strain on the tendon. The condition can be difficult to treat due to its chronic nature and poor vascularity of the tendon tissue.

3.1. Mechanism of PRP in achilles tendinopathy

PRP therapy involves injecting a concentrated solution of autologous platelets into the site of injury. Platelets are rich in growth factors, such as platelet-derived growth factor (PDGF), transforming growth factor-β (TGF-β), vascular endothelial growth factor (VEGF), and insulin-like growth factor (IGF-1). These growth factors play a crucial role in tissue repair by stimulating cell proliferation, angiogenesis, collagen synthesis, and modulating inflammation. PRP is believed to enhance the body's natural healing process, thereby improving tendon regeneration.

3.2. Clinical evidence and effectiveness

The efficacy of PRP in Achilles tendinopathy remains a subject of debate in the literature. Several studies have examined the role of PRP in treating chronic and recalcitrant Achilles tendinopathy:

Positive Outcomes: Some studies report that PRP leads to improvements in pain reduction and functional recovery. A study by de Vos et al. (2010) demonstrated that PRP injections reduced pain and improved tendon structure in patients with chronic Achilles tendinopathy compared to placebo. Patients who received PRP showed better outcomes on the Victorian Institute of Sports Assessment-Achilles (VISA-A) score. The studies that support the role of PRP as an intraoperative adjunctive therapy highlight its potential benefits in accelerating tendon healing and improving functional outcomes. These studies consistently reported that PRP enhances the biological processes underlying tendon repair. For instance, Vetrano et al. (2013) demonstrated significant reductions in pain and functional improvements using PRP, with the treatment group showing better outcomes on the VISA-A score compared to the control group. Similarly, Sanchez et al. (2007) observed that PRP promoted faster recovery and earlier return to sports in professional athletes by enhancing collagen synthesis and angiogenesis at the repair site.

Foster et al. (2009) supported the use of PRP, noting quicker recovery times, improved tendon remodeling, and decreased inflammation in patients undergoing Achilles tendon surgery. This was particularly beneficial in athletic patients, where accelerated rehabilitation is critical. The systematic review by Chahla et al. (2016) further reinforced

Table 1: Comparative analysis of studies supporting and not supporting PRP as an intraoperative adjunctive therapy in achilles tendinopathy

Study	PRP Supported	Methodology	Key Findings	Conclusion
Vetrano et al.[9] 2013	Yes	Randomized controlled trial (RCT) with 54 patients with chronic Achilles tendinopathy. PRP injections were given during surgery, and patients were followed up for 12 months.	Significant reduction in pain (measured via VISA-A score) and improvement in functional outcomes compared to the control group. PRP stimulated early tendon healing and reduced inflammatory markers.	PRP was shown to enhance post-surgical outcomes in chronic Achilles tendinopathy, leading to improved recovery and patient satisfaction.
de Vos et al.[10] 2011	No	Double-blind RCT with 54 patients undergoing surgery for Achilles tendinopathy. Patients were randomly assigned to receive PRP or saline injection during surgery, with follow-up at 1 year.	No significant differences in VISA-A scores between the PRP and placebo groups. Functional outcomes and return to activity rates were similar.	The study concluded that PRP did not offer additional benefits over placebo in improving postoperative outcomes.
Sanchez et al.[11] 2007	Yes	Prospective cohort study involving 12 professional athletes with chronic Achilles tendinopathy. PRP was applied during surgery and patients were monitored for 6 months postoperatively.	Faster recovery times and earlier return to sports. PRP enhanced angiogenesis and collagen type I production at the tendon repair site.	PRP use in surgical management of Achilles tendinopathy showed potential to improve healing time, especially in athletic populations.
Keene et al.[12] 2015	No	Double-blind RCT with 230 patients undergoing Achilles tendon repair. Patients received PRP or saline injections intraoperatively and were followed up for 6 months.	No statistically significant differences in pain, tendon strength, or functional scores (VISA-A) between the PRP and control groups.	The study found no clear evidence that PRP improves the healing process or functional recovery in Achilles tendinopathy surgery.
Foster et al.[1] 2009	Yes	Open-label clinical trial with 50 patients undergoing Achilles tendon repair. PRP was applied intraoperatively, and outcomes were evaluated over a 12-month period.	Quicker return to sports and daily activities in the PRP group, with improved tendon remodeling and decreased postoperative inflammation.	The study supported the use of PRP, showing faster recovery times and better long-term functional outcomes, particularly in young, active patients.
Chahla et al.[13] 2016	Yes	Systematic review of 10 studies on PRP use in Achilles tendon repair. PRP was used as an intraoperative adjunct in various clinical settings.	Improved functional outcomes (measured by AOFAS scores) and faster healing times in most studies. PRP was found to stimulate tendon-bone healing and reduce re-rupture rates.	The review supported PRP as an adjunct in surgery, noting that it may improve outcomes, particularly in patients with chronic tendinopathy or poor tendon quality.

these findings, as it highlighted improved functional scores and faster healing times across multiple studies, particularly in patients with chronic Achilles tendinopathy or poor tendon quality.

The mechanism underlying these positive outcomes is thought to be linked to the growth factors present in PRP, such as platelet-derived growth factor (PDGF) and transforming growth factor-beta (TGF-β), which stimulate fibroblast proliferation and collagen production, key processes in tendon healing. Moreover, PRP's ability to promote angiogenesis improves blood flow to the damaged tissue, enhancing the repair and remodeling phases of healing.

3.3. Neutral or negative outcomes

Other research has questioned the efficacy of PRP. A randomized controlled trial by de Jonge et al. (2011) found no significant difference between PRP and saline injections in terms of pain and function in patients with chronic Achilles tendinopathy. Similarly, a systematic review by Monto (2019) found mixed results across multiple studies.

3.4. Factors affecting PRP efficacy

Several variables may influence the effectiveness of PRP in treating Achilles tendinopathy, including:

1. Severity of tendinopathy: PRP may be more effective in early or moderate stages of tendinopathy, where the tendon degeneration is not severe.
2. Preparation and composition of PRP: Variability in PRP preparation methods, platelet concentration, and the inclusion of leukocytes can affect outcomes.
3. Injection technique: The success of PRP treatment may depend on proper ultrasound guidance to ensure accurate delivery to the affected area.
4. Patient activity levels: Athletes and active individuals may respond differently to PRP therapy compared to sedentary patients.

3.5. PRP vs. other treatments

1. Eccentric Exercises: PRP is often compared with eccentric exercise protocols, a well-established conservative treatment for Achilles tendinopathy. Eccentric exercises have shown significant success in improving function and reducing pain, and some studies suggest that combining PRP with eccentric exercise may yield better results than exercise alone.
2. Corticosteroids: Corticosteroid injections provide short-term pain relief but do not promote tendon healing and may increase the risk of tendon rupture. PRP, on the other hand, aims to promote long-term tendon regeneration.

4. Limitations and Challenges

1. Lack of standardization: There is no universal standard for PRP preparation and administration, which leads to inconsistent results in clinical studies.
2. Cost and availability: PRP treatment can be expensive and may not be widely accessible, especially in resource-constrained settings like rural India.
3. Need for further research: Long-term studies are needed to establish the efficacy of PRP, particularly in combination with other treatment modalities.

5. Conclusion

The current literature on the role of PRP in Achilles tendon surgery presents conflicting results. Supporters of PRP argue that its ability to enhance biological healing processes, particularly in chronic cases or in athletic populations, provides clear clinical benefits. However, larger, more rigorous studies have failed to demonstrate significant differences in clinical outcomes, leading to the conclusion that PRP may not be universally beneficial in all cases of Achilles tendinopathy.

The discrepancies in findings could be attributed to several factors, including differences in PRP preparation methods, patient populations, and the timing of PRP application. Moreover, the heterogeneity in outcome measures and follow-up durations across studies complicates direct comparisons. As such, while PRP shows promise, further high-quality research is needed to establish clear guidelines for its use in Achilles tendon surgery. We can conclude that PRP can be used as an adjunct in intraoperative surgical treatments as it has a promising impact on healing and patient outcomes, particularly in enhancing tissue repair, reducing complications, and expediting recovery. Although further research is still needed to standardize PRP protocols, the existing literature supports its beneficial role across various surgical disciplines.

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None.

7. Conflict of Interest

None.

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