DOI: 10.21088/joe.2454a.7956.11125.1

Journal of Orthopedic Education
Volume 11 Number 1, January-April 2025

ORIGINAL ARTICLE

The Role of Biologics in the Treatment of Tendon Injuries: Efficacy and Safety Concerns

Jeff Walter Rajadurai OR

How to cite this article:

Jeff Walter Rajadurai OR. The Role of Biologics in the Treatment of Tendon Injuries: Efficacy and Safety Concerns. Jr. Orth. Edu. 2025; 11(1): 07–10.

ABSTRACT

Tendon injuries characterized by chronic pain and functional limitation pose a big challenge in sports medicine and orthopaedic practice. The treatment protocols based on rest, physical therapy, and surgery do not seem to cure the root process involved in tendon degeneration, that is, it leads to long-term recovery periods and recurrence. Biologic treatments, including platelet-rich plasma, autologous tenocyte implantation, and stem cell-based therapy, are increasing their acceptance as promising alternatives that encourage tissue regeneration rather than symptom relief. This paper presents various criticisms regarding the use of biologics in the treatment of tendon injuries. It is discussed as to whether biologics are considerably effective, especially in safety terms. PRP has been dominant because it can easily be prepared and used to have acceleration of healing; however, its mixed outcomes arise because of differences in preparation technique. Stem cell therapy has potential indications for severe degeneration but is undependable concerning the stability of cells and the possibility of tumourigenesis. On the other hand, autologous tenocyte implantation is looking at restoring the tendon architecture but is not something that can be attempted with consistency and standardization. Preliminary promising results notwithstanding, biologics remain almost in the province of promises rather than acceptance since outcome data is often inconsistent and long-term safety seems a cause for concern. This article presents on the current state of efficacy as well as safety of biologics in tendon repair, enabling an understanding of the role for these in modern sports medicine.

KEYWORDS

• Tendon Injury • Biologic Therapy • Platelet-Rich Plasma • Stem Cell Treatment • Regenerative Medicine

AUTHOR'S AFFILIATION:

Associate Professor, Department of Orthopedics, Madha Medical College & Research Institute, Chennai, Tamil Nadu 600122, India.

CORRESPONDING AUTHOR:

Jeff Walter Rajadurai OR, Associate Professor, Department of Orthopedics, Madha Medical College & Research Institute, Chennai, Tamil Nadu 600122, India.
E-mail: jeffy.walter@gmail.com

➢ **Received:** 29-11-2025 ➢ **Accepted:** 28-12-2025

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INTRODUCTION

More common is the complaint of tendon injuries, experienced both by the athlete and the labourer and in the general population. Most range from mild strains to more severe ruptures that lead to chronic pain, functional impairment, and reduced quality of life. Traditional therapies applied to these patients, including physiotherapy, pharmacotherapy, and surgery, essentially focus on treating symptoms, not the root cause, of tendon degeneration. With this in mind, interest in biologic therapies that can not only repair injured tendons but also potentially restore structural and functional integrity has been increasing.

In recent years, the field of biologics, including platelet-rich plasma (PRP), stem cells, and autologous tenocyte implantation, continues to progress as part of evolving regenerative medicine that tries to take advantage of natural healing processes within the body. Hope is in accelerating recovery, minimizing complications, and lowering recurrence rates. However, efficacy and safety questions remain, especially as there is no standardization among the preparations and procedure. In the review to follow, we shall critically address the role of biologics in the treatment of tendons, outlining strengths and limitations and touching on concerns about the safety profile.

Platelet-Rich Plasma (PRP): Popularity and Challenges

Recently, platelet-rich plasma (PRP) has gained popularity as a biologic agent for the treatment of tendon injuries. It is extracted from the autologous blood of the patient, concentrated to have an elevated level of platelets that release the growth factors needed for healing and regeneration of tissues. Regarding a tendon injury, it is said that PRP heals by stimulating synthesis of collagen and reducing inflammation along with promoting blood flow to the damaged tissue[1].

Although this form of PRP may appear to be a rather simple application and has a minimal risk of causing an immune rejection, the evidence in relation to its efficacy is conflicting. One of the contributing factors to the inconsistencies noted in this modality of PRP was the variability among studies in preparation procedures, such as platelet concentration, activation protocols, and injection techniques. Some reported positive effects of using PRP for treating tendinopathy cases, which include tendonitis of the Achilles and patellar tendinitis-anecdotal reports of pain reduction and functional improvement. Despite the promising research, other trials have shown that PRP offers little to no significant advantage over placebo or standard care[3]. Thus, while promising, standardized protocols are needed to confirm the effectiveness and reliability of PRP in repairing tendons.

Stem Cell Therapy: Potential for Regeneration with Risks

Tendon injuries will be just one of the applications of this revolutionary approach in regenerative medicine-stem cell therapy. As mesenchymal stem cells from bone marrow, adipose tissue, or synovial fluid can differentiate into tenocytes which constitute the core structure of tendons; thus MSCs are used in tendon repair. Healing might be facilitated by these cells through attenuation of inflammation and enhancement of collagen synthesis followed by recovery of tissue integrity[4].

More promisingly, MSCs have shown better recovery in the treatment of severe tendon degeneration or chronic tendinopathies. Preliminary findings for stem cell injections for rotator cuff injuries and lateral epicondylitis indicate improved structural integrity with concomitant pain management[5]. Safety, of course, remains a concern. Apart from immune response and infection, the concern is even more paramount regarding tumourigenic potential and long-term safety for these stem cell therapies[6]. Improving outcomes in tendon repair through stem cell application require continuation of research and clinical trials to mitigate risks better and standardize treatment protocols towards improving efficacy.

Autologous Tenocyte Implantation: Enhancing Tendon Architecture

Autologous tenocyte implantation is a form of biologic therapy intended for the restoration of tendon architecture through the introduction of the patient's own tenocytes to the site of injury. Tenocytes are obtained from a healthy tendon and expanded in culture, subsequently injected into the injured site to rebuild tendon structure, enhance biomechanical properties, and prevent recurrence[7].

ATI has proven promising, especially for chronic tendinopathies. Various studies have shown improvement in both pain and function. In addition, MRI evidence reveals increased tendon thickness and better collagen fiber alignment after the treatment. However, ATI is complex and time-consuming, with difficulties associated with the reliability of results and cell viability during the expansion phase[8]. Another drawback to the use of ATI is that it's expense and logistical demands make it unattractive to serve many patients, which casts doubts over its practicality as a widespread tendon repair solution.

Growth Factors: Supporting Healing at the Cellular Level

Transformation factor-beta (TGF-β), vascular endothelial growth factor (VEGF) and fibroblast growth factor (FGF) are some of the most important growth factors that contribute to processes involved in tendon repair. These molecules have an essential role in the processes involved in collagen synthesis, vascularisation, and mediation of inflammation necessary for healing in tendons[9].

While growth factors are being used in various therapies, PRP to name just one, injection of isolated growth factors is being explored as a treatment for tendinous injuries. Early work has been encouraging, particularly in those early stages of tendinopathies, where growth factors have the potential to stimulate healing without highly invasive interventions; however, their short half-life and susceptibility to causing excessive inflammation or fibrosis make the use of such isolated factors questionable and merits further study.[10]

Safety Concerns: Navigating the Risks of Biologics in Tendon Repair

Use of biologics in tendon injury is not risk-free. While the use of PRP injections appears safe compared to other injections, there could be risks including infection, localised pain, and inflammation. Conversely, stem cell therapies have a far more complex risk profile; complications may include immune reactions, infection, and improper growth of the cells, which in some cases can lead to inappropriate development, resulting in possible tumours. The preparation and administration of biologics vary partly because the process has mostly not been under the regulation, thereby making variations in techniques in treatment outcomes and generally affecting patient safety[11].

Add to these problems the lack of standardization in biologic therapies. Without universally accepted protocols, outcomes from studies cannot easily be compared, safety profiles cannot be adequately assessed, and guidelines for widespread clinical use cannot easily be established. Until such time that standardized methods and long-term data can be provided, the safety of biologics in tendon repair remains a concern both practitioners and patients must address with great care.

Future Directions: Towards Standardisation and Personalised Medicine

Standardization and offering personalized treatment protocols will be the steps in the advancement of biologic therapy to tendon injuries. The efficacy of the particular biologic preparation will be ensured when uniform protocols are followed in the preparation of such biologics, such as the concentration of PRP and stem cell isolation techniques. Personalized medicine will always dictate having the best benefit from the biologic treatment while minimizing risks, as each patient may have his genetic and lifestyle attributes.

More importantly, progress in combination therapies for example, PRP together with stem cells or growth factors, and so on might allow for better outcomes to be realized by their action at more than one stage in the healing process. Moreover, as data continues to continue to accumulate from these clinical trials as they have so far, a safe and effective biologic could emerge from its development environment and into mainstream practice, assuming that these treatments are safe and effective in a variety of clinical situations.

CONCLUSION

Biologic therapies appear to be an exciting new approach in the treatment of tendons, promising to offer regenerative properties that cannot be matched by more traditional approaches. However, aspects of efficacy and safety continue to be concerns with regard to their adoption. While each of these has merit with platelet-rich plasma, stem cell therapy, autologous tenocyte implantation, and growth factors, variability in both preparation and application techniques has meant that clinical results have been quite variable. At a basic

level, there remains the safety issue that is related to the long-term effects of stem cells and, therefore, requires a very regulatory framework and standardized protocols. The future of biologics in tendon repair standardization and personalized approaches could ultimately change to that which truly regenerates rather than merely being controlled through symptoms. For now, the practitioner and patient both must weigh possible benefits against inherent risks in an ever-changing field of biologic-based tendon repair.

Source(s) of Support and Funding: Nil

Conflict of Interest: Nil

Ethical Approval and/or Institutional Review Board (IRB): Not applicable

Declaration of Generative AI and AI Assisted Technologies in the Writing Process: The author has'nt used any generative AI/AI assisted technologies in the writing process.

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