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Evidence-Based Approaches to Patellar Tendinopathy: A Critical Analysis of Therapeutic Interventions

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Abstract

Background. Patellar tendinopathy (PT) also known as jumper's knee is an overuse injury that occurs in both professional and recreational athletes. The main complaint is pain in the anterior part of the knee, which impacts both sport and daily activities. Most patients are successfully treated with non-surgical methods but some of them eventually require surgical intervention.
Aim. The objective of this study is to evaluate both surgical and non-surgical treatment methods for Patellar tendinopathy and seeks to introduce doctors and patients to the assets and downsides associated with them.
Results. Jumper's knee occurs in up to 45% of professional athletes and up to 8.5% of non-elite athletes. It is a non-inflammatory injury caused by repetitive microinjuries to the patellar tendon. Most common risk factors are: the male gender, involvement in sports (particularly volleyball), training hours, playing surface, small patellar tendon lever and moment arm movements, jump height, heavier load on the tendon and landing strategy of the athlete.
Conclusions. There is a wide range of available conservative treatment methods for Patellar Tendinopathy including physical therapy, various injections, and medication. They should be considered as the first line treatment showing high success rate for mild and moderate cases. Surgical methods have high success rates as well though they are considered more invasive and performed only on chronic patients. Best approach ought to be carefully selected for each patient based on severity of symptoms and patient needs.
Keywords: Conservative treatment, Orthopedics, Review, Knee, Patellar tendon, Patellar Tendinopathy, Jumper's knee, Surgery

INTRODUCTION

Patellar tendinopathy (PT), known also as a Jumper's knee is not a highly prevalent musculoskeletal condition in general population. However, it is a common cause of the anterior knee pain in athletes. PT is an overuse injury of the patellar tendon. It is a non-inflammatory response to repetitive strain of the tissue. Because of that the terms "patellar tendinitis" or "patellar tendonitis" are discouraged from clinical use as the suffix "-itis" suggests inflammatory etiology of the injury. On light microscopy, there is a visible loss of typical collagen fibers structure, as well as the presence of neovascularization, fibrosis and increased cellularity caused by active fibroblasts due to the cumulative microtrauma. Most common symptoms are pain on the anterior side of the knee often increased by exercise, or occasionally, prolonged knee flexion. Depending on the severity of the case, the pain may be present only while doing physical activity or, in severe cases, at rest (Peers & Lysens, 2005). Anterior knee pain can have many different reasons, so it is essential to correctly diagnose PT and choose the most appropriate treatment option. Most often it is a self-limiting process, but there are many treatment options in case Jumper's knee becomes chronic and more painful. In most cases, PT can be successfully treated with nonsurgical methods like rest, physiotherapy, nonsteroidal anti-inflammatory medication (NSAIDs) and bracing. Various injections may be used as well but are considered a little more invasive. When the standard, conservative treatment is insufficient and we run out of options, the patient may need surgical intervention. There are two possible operational methods: arthroscopy and open surgery. Both of them are highly effective, with arthroscopy having a slight advantage (Brockmeyer et al., 2015; Dan et al., 2019).

EPIDEMIOLOGY

Patellar tendinopathy mainly affects athletes who play sports that require often and repetitive use of the patellar tendon. It is most commonly associated with volleyball players. The prevalence varies from different studies, but Some studies showed that there was a higher risk associated with developing PT in men over the age of 18 who played sports at a non-professional level (Nutarelli et al., 2023). Other studies however, showed no significant sex-difference (Ferretti, 1986; Witvrouw et al., 2001). Other risk factors associated with PT are: higher BMI, taller height, harder playing surface, increased number of playing hours (de Vries et al., 2015; Lian et al., 2005; van der Worp et al., 2012; Zwerver et al., 2011). Jumper's knee require particular attention when brought up by an athlete, because many of them struggled with it throughout their sport career or even had to end it prematurely (Kettunen et al., 2002).

It was shown in a survey, that independently of applied treatment strategy, one-third of the athletes presenting with PT were unable to practice their sport for more than 6 months (Peers & Lysens, 2005).

DIAGNOSIS

1. Clinical symptoms

Most athletes suffering from patellar tendinopathy (PT) report well-defined pain at the front of the knee, typically located where the patellar tendon attaches to the lower edge of the patella (Peers & Lysens, 2005; Schwartz et al., 2015). This pain tends to worsen during physical activity and may also appear after prolonged periods of knee flexion. The onset is often gradual, but many patients can link it to a phase of increased training load - whether in intensity, frequency, or duration. In the early stages, discomfort appears only after exercise; as the condition progresses, pain may occur at the start of training or persist throughout, negatively impacting performance. In advanced cases, pain can interfere with everyday movements or even occur at rest (Peers & Lysens, 2005). Research by Cook et al. showed that palpating the patellar tendon can be a moderately sensitive but non-specific test in symptomatic athletes (J. L. Cook et al., 2001). Interestingly, mild tenderness may also be found in pain-free athletes engaged in jumping sports and should not be overinterpreted. Functional assessment often involves a decline squat test - patients with PT are typically able to perform only a few repetitions before pain develops (Cook et al., 2000). Various systems exist to evaluate knee conditions, but many are not specific enough for patellar tendinopathy and fail to detect subtle yet important functional deficits. Traditional categorical scoring systems lack proper validation and sensitivity. For this reason, the Victorian Institute of Sport Assessment (VISA) score is considered the most suitable tool for evaluating PT (Schwartz et al., 2015; Visentini et al., 1998). The VISA-P and VISA-A questionnaires consist of eight questions - six focused on pain during daily tasks and two on athletic performance. A score of 100 indicates a symptom-free athlete in full training, while 0 represents maximum disability. The VISA score has been proven reliable and consistent across different assessors, making it a valuable method for tracking symptoms and functional status in PT patients (Palazón-Bru et al., 2021; Schwartz et al., 2015; Visentini et al., 1998). Key differential diagnoses include patellofemoral pain syndrome and Hoffa's fat pad impingement, which can sometimes occur alongside patellar tendinopathy (Brukner, 2012).

2. Imaging

In the diagnosis of patellar tendinopathy (PT), the most commonly used imaging techniques include ultrasonography (US), Doppler US, magnetic resonance imaging (MRI), and plain radiography. While standard X-rays can reveal associated bone changes, they offer limited information about the tendon itself. In contrast, ultrasonography and MRI provide much more detailed visualization of the patellar tendon's structure and condition (Peers & Lysens, 2005). Khan et al. found a strong agreement between MRI and US findings in patients with PT confirmed by histopathology (Khan et al., 1996). Ultrasonography, particularly popular in Europe, is generally considered the first-choice imaging tool for PT. It can identify hypoechoic areas and tendon thickening, most often located in the posterior section of the tendon near the lower border of the patella (Campbell & Grainger, 2001; Figueroa et al., 2016). Doppler US adds further diagnostic value by showing neovascularization and increased blood flow - both common in symptomatic tendinopathy (Ohberg et al., 2001; Terslev et al., 2001; Weinberg et al., 1998). However, the accuracy of US strongly depends on the operator's skill and the quality of the equipment, and the method cannot rule out joint-related abnormalities. MRI serves as a complementary technique. It typically shows the tendon as thickened with regions of increased signal intensity and can detect partial tears - especially visible on T2-weighted images (Weatherall & Crues, 1995). Unlike US, MRI also enables the evaluation of intra-articular structures and other possible knee pathologies, which is useful for differential diagnosis or pre-surgical planning. On the downside, MRI is more costly, less accessible, and requires more time (Figueroa et al., 2016). Each imaging method has its strengths and weaknesses. Ultrasonography is often recommended as the initial test because it is inexpensive, widely available, enables real-time dynamic and Doppler assessment, and correlates well with clinical symptoms. MRI, meanwhile, is best reserved for complex or unclear cases that demand a broader anatomical overview (Karjalainen et al., 2000; Khan et al., 1996). Reported diagnostic accuracy suggests that ultrasonography has around 58% sensitivity and 94% specificity, while MRI achieves 78% sensitivity and 86% specificity (Warden & Brukner, 2003). To date, no clear evidence shows that one imaging technique is definitively superior, so the choice should depend on clinical needs, available resources, and the experience of the examiner.

TREATMENT METHODS

1. Conservative methods

Most of the patients respond well to conservative management. Because non-surgical approaches are considerably less invasive than operative interventions, they are regarded as the first-line treatment choice. However, it is essential to recognize that these methods may not be adequate for every individual, and surgery can be necessary in some cases (Muaidi, 2020; Schwartz et al., 2015). In all situations, patients should receive guidance on preventive strategies and proper biomechanical movement patterns. The key step for each patient is to temporarily refrain from aggravating activities and focus on improving movement technique (Kannus et al., 1997). With a well-structured rehabilitation program, most patients experience significant improvement within a period of 3 to 12 months (Everhart et al., 2017; Muaidi, 2020).

Eccentric exercise

The majority of the studies regarding conservative therapy of the Patellar Tendinopathy suggest that eccentric exercise therapy, consisting most commonly of decline squats, reduces pain and allows the patient to return to sport (Cannell et al., 2001; Jill L. Cook et al., 2001; Jensen & Di Fabio, 1989). Jensen and Di Fabio reported that an 8-week program of eccentric exercises led to a decrease in pain. (Jensen & Di Fabio, 1989). Young et al. found that, among volleyball players with patellar tendinopathy, an eccentric decline squat program produced superior 12-month outcomes compared to a step eccentric program. Participants in the decline squat group had a 94% likelihood of a positive result, whereas only 41% of the step group achieved similar improvement (Young et al., 2005). Cannell et al. carried out a randomized clinical trial comparing a 12-week drop-squat exercise program with a leg extension and leg curl program. The study evaluated pain, strength, and return-to-sport outcomes. Both groups experienced significant pain reduction and a high rate of return to sport, with nine out of ten participants in the eccentric group and six out of nine in the concentric group successfully resuming activity (Cannell et al., 2001). Johnson and Alfredson reported that after 12 weeks, athletes with patellar tendinopathy who followed an eccentric exercise program showed significant improvement, whereas those performing a concentric exercise program did not experience comparable benefits (Jonsson & Alfredson, 2005). In contrast to previous findings, Visnes et al. observed that a 12-week eccentric exercise program did not improve knee function in volleyball players who continued their regular training and competition during the intervention. (Visnes et al.,

2005). This finding suggests, that it is crucial to combine physical therapy with absence from pain-inducing activity. Furthermore, in a randomized clinical trial involving mostly patients with chronic patellar tendinopathy, Breda et al. demonstrated that progressive tendon-loading exercises (PTLE) led to greater improvements in clinical outcomes over a 2-year follow-up compared to eccentric exercises. Nevertheless, although the PTLE group showed higher rates of return to sport and patient satisfaction, these differences did not reach statistical significance. (Breda et al., 2021). When comparing an eccentric exercise program with surgical treatment (open patellar tenotomy), no significant differences were observed between the two groups after 12 months (Bahr et al., 2006).

Platelet-rich plasma (PRP) injections

Platelet-rich plasma (PRP) has attracted increasing scientific and clinical interest as a biologically based treatment for patellar tendinopathy (Anitua et al., 2005). It represents an autologous blood derivative enriched with platelets and their associated growth factors (GFs), including platelet-derived growth factor (PDGF), vascular endothelial growth factor (VEGF), transforming growth factor-beta (TGF-β), and epidermal growth factor (EGF) (Jain & Gulati, 2016). These mediators are key regulators of cellular proliferation, differentiation, angiogenesis, and extracellular matrix remodeling - processes central to tendon healing and tissue regeneration. The therapeutic rationale for PRP is grounded in its ability to augment the natural healing cascade. When administered to the site of tendon injury, the activated platelets release a concentrated profile of growth factors that stimulate cellular recruitment, promote angiogenic responses, and enhance collagen synthesis. This localized biological stimulation is believed to accelerate tendon repair, improve structural integrity, and restore functional capacity. Emerging evidence suggests that PRP therapy can reduce pain and improve clinical outcomes in patients with patellar tendinopathy, although variability in study protocols and preparation methods limits definitive conclusions (de Mos et al., 2008; Gosens et al., 2012). Its autologous nature provides an additional advantage by minimizing the risk of adverse immune or inflammatory reactions. Moreover, the relative simplicity of PRP preparation and administration in an outpatient setting supports its feasibility as a minimally invasive and cost-effective therapeutic strategy (de Mos et al., 2008). According to a study by Ferrero et al.; PRP injections should always be performed with US guidance, as it enables greater accuracy in infiltrating into the tendon and minimalizes the risk of peri- and post-procedural complications. They assessed the effectiveness of PRP injections in PT and Achilles tendinopathy with 20-day and 6-month

follow-ups. First follow-up showed non-significant improvement compared to baseline regarding VISA-P score, hypoechoic areas of the tendon and tendon thickness. However, at the second follow-up, there was a significant improvement for all of the above parameters. Additionally, in the same study, the intratendinous vascularity increased significantly at both follow-ups. As a consequence, they concluded that US-guided PRP injections in PT patients lead to a significant improvement in both patellar tendon vascularity and symptoms (Ferrero et al., 2012). Andriolo et al. proposed that multiple PRP injections may represent the most suitable treatment strategy for patients with severe symptoms of chronic patellar tendinopathy (PT) or for those unresponsive to conventional conservative therapies (Andriolo et al., 2019). Their findings indicated that patients with chronic PT who had not undergone prior treatments achieved significantly better outcomes following PRP administration compared with individuals of similar symptom duration who had previously failed other interventions, such as ethoxysclerol injections, corticosteroid therapy, or surgical procedures. Furthermore, in studies comparing surgical interventions with PRP treatment, operative approaches were found to be safe and generally more effective; however, PRP infiltration, being minimally invasive, may still promote tendon healing and should therefore be considered as a preferred option before proceeding to surgical management (Gosens et al., 2012). On the other hand, Masiello et al. in their systematic review and meta-analysis of PRP injections in different chronic tendinopathies found that there was a trend towards pain reduction and functional improvement from baseline, but in majority of the groups the effect size was comparable between the treatment and control groups. Furthermore, the level of evidence was graded as low due to inconsistency (low number of small-size trials included) and risk of bias. Overall, most of the differences observed for the comparisons between groups at different time points were below the minimal clinically important difference, and at best indicate the possibility of a very marginal clinical benefit (Masiello et al., 2023). To conclude, the evidence concerning the efficacy of platelet-rich plasma (PRP) injections in the management of chronic tendinopathies remains inconclusive. While several studies have demonstrated favorable clinical outcomes associated with PRP administration, others have failed to show statistically significant differences when compared with alternative therapeutic modalities. This inconsistency in findings may, at least in part, be attributed to variability in PRP preparation methods, injection techniques, and treatment protocols across studies. Consequently, further well-designed, standardized clinical trials are warranted to clarify the therapeutic value of PRP and to establish an evidence-based protocol that ensures reproducible and clinically meaningful outcomes.

Extracorporeal Shock Wave Therapy (ESWT)

ESWT involves the delivery of shock waves - sonic pulses that generate high mechanical stress within biological tissues. The proposed mechanisms underlying its therapeutic effects include the induction of analgesia, mechanical fragmentation of calcific deposits (when present), and stimulation of tissue regeneration processes. While ESWT is most widely recognized for its application in the treatment of urolithiasis, emerging evidence supports its efficacy in the management of chronic tendinopathies, including patellar tendinopathy (Chung & Wiley, 2002; Lohrer et al., 2002; Rompe et al., 2002). Some studies regarding use of ESWT for treating lateral elbow pain report side effects such as: temporary reddening of the skin, pain in the treated area, minor hematomas, migraines, and syncope (Buchbinder et al., 2005; Haake et al., 2002). Further research is warranted to resolve the inconsistent findings observed in other insertional tendinopathies and to assess the long-term outcomes and comparative efficacy of ESWT for patellar tendinopathy relative to alternative treatment modalities.

Corticosteroid Injection Therapy

The use of corticosteroid injection therapy is a very debated topic in the treatment of tendinopathy. A great deal of studies have shown that this method is effective in short-term management of pain in tendon overuse injuries, while others could not demonstrate any effect (Aicale et al., 2020; Capasso et al., 1997; Schwartz et al., 2015). Unfortunately, corticosteroid injections come with a high percentage of adverse effects. As was indicated in the studies by Chen et al.; Hart; and Haraldsson et al.; up to 82% corticosteroid trials in tendons demonstrated adverse effects. Most common adverse effects are: tendon rupture, atrophy and decreased tendon strength (Chen et al., 2009; Haraldsson et al., 2006; Hart, 2011). The study by Hart also showed that they are effective in the short-term, but not superior to other therapies in the long-term (Hart, 2011). Taking into account the fact that Patellar Tendinopathy is a non-inflammatory condition and the risk behind corticosteroid injections regarding tendon strength and collagen synthesis, the role of this method of treatment should be reassessed.

NSAIDs

The use of nonsteroidal anti-inflammatory drugs (NSAIDs) in the management of chronic tendinopathies remains a subject of debate in the literature, primarily because histological studies reveal that tendinopathic tissue contains few, if any, inflammatory cells (Ribbans &

Collins, 2013). While some authors have reported that NSAIDs may facilitate tendon healing, others suggest that these agents can inhibit tendon cell migration and proliferation, thereby impairing the repair process (Aicale et al., 2020; Forslund et al., 2003; Tsai et al., 2007; Weiler, 1992). Additionally, by alleviating pain, NSAIDs may mask early symptoms, potentially leading patients to continue activity and exacerbate tendon damage, ultimately delaying recovery. Therefore, in the absence of conclusive evidence regarding the actual effects of NSAIDs in tendinopathy, their routine use in the management of patellar tendinopathy cannot be considered evidence-based.

Cryotherapy

Ice therapy is mostly used in patients with PT for its short-term analgesic effect and vasoconstricory effect on the neovascularization within tendinosis. However, its use should be discouraged before participating in sports, because of possible masking of pain symptoms and subsequently – re-injury (MacAuley, 2001; Rivenburgh, 1992; Wilson & Best, 2005). Cryotherapy can be effective in the early stages of tendinopathy, where there is an ongoing inflammatory process, by reducing the inflammatory response.

2. Surgical methods

Many athletes with patellar tendinopathy (PT) respond favorably to conservative, non-operative management; however, surgical intervention may be warranted in cases where symptoms and functional impairment persist beyond approximately six months of conservative therapy (Aicale et al., 2020; Everhart et al., 2017; Muaidi, 2020; Schwartz et al., 2015). Although there is no universally accepted gold standard for PT management, surgical treatment - either open or arthroscopic - remains a viable option when non-operative approaches fail to yield satisfactory results (Brockmeyer et al., 2015; Dan et al., 2019). Reported success rates for surgical management of chronic proximal PT generally exceed 80%, with systematic reviews indicating rates of approximately 91% for arthroscopic procedures and 87% for open surgery (Brockmeyer et al., 2015; Verheyden et al., 1997). Moreover, the average time to return to pre-injury activity has been shown to be significantly shorter following arthroscopic treatment (around 3.9 months) compared with open surgery (approximately 8.3 months) (Brockmeyer et al., 2015). Despite these findings, some studies, such as that by Aicale et al., have reported comparable return-to-sport rates between the two approaches (Aicale et al., 2020). While both techniques can provide favorable outcomes, the literature offers no definitive evidence

supporting the superiority of one method over the other. Nevertheless, arthroscopic procedures are generally preferred due to their minimally invasive nature and shorter rehabilitation period (Brockmeyer et al., 2015). It should be noted, however, that in clinical practice, the outcomes following patellar tenotomy appear to be more variable, and the high success rates reported in some studies (80–90%) are not consistently replicated (Coleman et al., 2000; Cook et al., 1997; Pierets et al., 1999).

REVIEW OBJECTIVE

The aim of this study is to summarize the existing clinical trials and systematic reviews regarding Patellar Tendinopathy treatment approaches. We intend to provide a better uptake of managing this condition. Treatment options will be presented sequentially to more advanced methods, all summarized in the Table. 1.

Table. 1 Comparison of Treatment Methods

(Aicale et al., 2020; Andriolo et al., 2019; Anitua et al., 2005; Bahr et al., 2006; Breda et al., 2021; Brockmeyer et al., 2015; Cannell et al., 2001; Capasso et al., 1997; Chen et al., 2009; Chung & Wiley, 2002; Coleman et al., 2000; Cook et al., 1997; Jill L. Cook et al., 2001; Dan et al., 2019; de Mos et al., 2008; Everhart et al., 2017; Ferrero et al., 2012; Forslund et al., 2003; Gosens et al., 2012; Haraldsson et al., 2006; Hart, 2011; Jain & Gulati, 2016; Jensen & Di Fabio, 1989; Jonsson & Alfredson, 2005; Kannus et al., 1997; Lohrer et al., 2002; MacAuley, 2001; Masiello et al., 2023; Muaidi, 2020; Pierets et al., 1999; Ribbans & Collins, 2013; Rivenburgh, 1992; Rompe et al., 1997; Schwartz et al., 2015; Tsai et al., 2007; Verheyden et al., 1997; Visnes et al., 2005; Weiler, 1992; Wilson & Best, 2005; Young et al., 2005)

METHOD	INFORMATION	PROS	CONS
Patient education	Education about preventing further deterioration and overuse as well as about biomechanically optimal movement.	Cheap, easy method. Patient knowledge and cooperation may prevent them from recurrence of symptoms after treatment.	Must be combined with other treatment options. Patient motivation and cooperation is needed. Possible lack of knowledge of the

			doctor or using unclear language for patients, may result in adverse effect.
NSAIDs	Reducing pain and inflammation in the early stages of injury	Good addition to physical therapy to allow patient to exercise without pain. Quick pain relief.	Typical NSAIDs adverse effects – abdominal pain, diarrhoea, possible renal damage. Only short-term benefits. Use is not generally recommended because of lack of inflammatory process.
Physiotherapy	Includes eccentric exercise therapy focused on decline squats and progressive tendon-loading exercises	Great in the long-term results, especially when combined with other conservative methods. Golden standard of rehabilitation. No side effects when performed correctly. Individual approach based on patient needs.	Works best when performed under the supervision of a qualified specialist to ensure proper technique of movement. Requires patient time and energy investment and regularity. Possible absence of immediate results.
Cryotherapy	Reducing pain and inflammation in the early stages of injury	Can be effective in acute tendinopathies by reducing pain and inflammatory response	Use should be discouraged before participating in sports because of the risk of re-injury

Extracorporeal shock wavetherapy	Generator-transmitted sound waves focused on the center of the influenced zone. Pain relief and improved healing.	Non-invasive. Can be helpful in combination with other conservative methods in chronic patients	No significant improvements when using this method alone. Limited research resources. Side effects including temporary reddening of the skin, minor hematomas, pain in the treated area, syncope and migraines.
Corticosteroid injections	Reducing pain and inflammation.	Quick, short-term pain relief. Easy to use and low in cost.	Debatable research. Risk of severe adverse effects including tendon rupture. Ineffective long-term.
PRP injections	Contain pro-inflammatory agents designed to improve tendon healing and tissue regeneration.	Autologous method minimizing the risk of adverse immune or inflammatory reaction. Reduces pain and improves clinical function. Relatively easy to prepare and administer. Minimally invasive and cost effective.	Inconclusive evidence. More studies required to assess clinical importance. Not effective in short-term pain relief, multiple sessions needed.
Arthroscopic surgery	A couple of small incisions are made. Low medial and lateral portals as well as supero-lateral portal are used to better	Small incision. Possible identification of other potential intra- and extraarticular pathologies. Quicker return to sport and	Requires more skills from the surgeon.

	visualize of the distal patellar pole and proximal part of the patellar tendon.	better clinical outcome when compared with open surgery	
Open surgery	Midline skin incision over the patellar tendon. Removal of the damaged portion of the tendon.	Most known surgical method – a lot of available research. Possible identification of other potential intra- and extraarticular pathologies.	Worse clinical outcomes and longer time to return to pre-injury activity compared to arthroscopic surgery. Worse aesthetical outcome.

CONCLUSION

Patellar tendinopathy (PT) represents a prevalent and significant challenge among athletes, particularly those engaged in jumping sports such as volleyball and basketball. The diagnosis of PT is primarily clinical; however, advances in imaging modalities - such as ultrasonography (US) and magnetic resonance imaging (MRI) - have enhanced diagnostic precision and facilitated the assessment of disease severity. Contemporary understanding of PT emphasizes its non-inflammatory, degenerative nature, prompting a paradigm shift away from anti-inflammatory interventions toward comprehensive rehabilitation strategies centered on eccentric exercise. Preventive approaches remain an essential aspect of management. While eccentric exercises are not recommended prophylactically during the training season for asymptomatic athletes presenting with pathological imaging findings, proprioceptive and balance training have been identified as effective preventive methods in jumping sports. Among therapeutic options, conservative management is considered the first-line approach, encompassing eccentric exercise programs, platelet-rich plasma (PRP) injections, and progressive tendon-loading exercises (PTLE), the latter showing encouraging clinical outcomes. Nonetheless, the efficacy of combining these modalities with other conservative treatments is not yet well established, and no universally accepted treatment protocol currently exists. In cases where pain and functional impairment persist beyond six months of conservative therapy, surgical intervention is typically indicated. Importantly, the pathophysiology of pain in PT remains incompletely understood, suggesting possible biochemical or neuropathic mechanisms

that warrant further investigation. The existing literature is limited by methodological inconsistencies, small sample sizes, and reliance on self-reported data, all of which constrain the reliability and generalizability of current findings. Consequently, rigorously designed, large-scale clinical trials comparing both conservative and surgical modalities are urgently needed.

Disclosure

Author's contribution

Conceptualization: Kamil Swoboda; Methodology: Michał Olejnik, Kamil Tomasz Pielusiński; Software: Piotr Artur Górka; Check: Karolina Brankowska, Aleksandra Włodarczyk; Formal analysis: Zuzanna Wiater, Szymon Domagała, Alicja Pyzik; Investigation: Kamil Swoboda, Marta Jakubowska, Michał Olejnik; Resources: Aleksandra Włodarczyk, Kamil Tomasz Pielusiński; Data curation: Marta Jakubowska, Zuzanna Wiater; Writing-rough preparation: Kamil Swoboda, Piotr Artur Górka, Karolina Brankowska; Writing–review and editing: Kamil Swoboda, Kamil Tomasz Pielusiński, Alicja Pyzik; Visualization: Aleksandra Włodarczyk, Marta Jakubowska; Supervision: Kamil Swoboda; Project administration: Michał Olejnik, Karolina Brankowska

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