**Patellar Tendinopathy**

**Recent Developments toward Treatment**


**Abstract**

Patellar tendinopathy (PT) is a clinical and chronic overuse condition of unknown pathogenesis and etiology marked by anterior knee pain typically manifested at the inferior pole of the patella. PT has been referred to as “jumper’s knee” since it is particularly common among populations of jumping athletes, such as basketball and volleyball players. Due to its common refractory response to conservative treatment, a variety of new treatments have emerged recently that include dry-needling, sclerosing injections, platelet-rich plasma therapy, arthroscopic surgical procedures, surgical resection of the inferior patellar pole, extracorporeal shock wave treatment, and hyperthermia thermotherapy. Since PT has an unknown pathogenesis and etiology, PT treatment is more a result of physician experience than evidence-based science. This review will summarize the current literature on this topic, identify current research efforts aimed to understand the pathological changes in abnormal tendons, provide exposure to the emerging treatment techniques, and provide suggested direction for future research.

Patellar tendinopathy (PT) describes a clinical condition characterized by activity-related anterior knee pain associated with focal patellar tendon tenderness localized to the inferior pole of the patella.\(^1\)\(^2\) PT pain can also manifest at the distal insertion of the patellar tendon over the anterior tibial tuberosity. A challenge to patients and physicians alike, PT is a chronic and degenerative overuse condition triggered by repetitive microtrauma.\(^3\)

Mechanical overload of the tendon is commonly cited as a key component with many other contributing extrinsic and intrinsic factors.\(^4\) Due to the uncertainty surrounding PT, the use of correct terminology is important when describing the condition.

As an overuse injury, PT should not be confused with patellar tendonitis, which is an inflammatory discomfort of the patellar tendon. The term “tendonitis” implies an inflammatory nature to the injury, which is not present in PT. “Patellar tendinosis” is the histopathological term to describe the degenerative presentation characteristic of an overuse injury. A tissue biopsy is needed in order to describe patellar tendon pain as either “tendonitis” or “tendinosis.”\(^1\) For these reasons, “patellar tendinopathy” has been adopted as the correct clinical term for overuse conditions of the patella tendon.\(^1\)\(^4\)

Patellar tendinopathy is a common clinical presentation especially in athletic populations. It is particularly prevalent among elite jumping athletes, such as basketball and volleyball players with rates of 31.9% and 44.6%, respectively.\(^5\) Due to this high prevalence among jumping athletes, PT has historically been labeled as “jumper’s knee.”\(^6\) Since PT-related pain typically persists for 3 years and has been reported to persist for greater than 15 years, athletes developing PT symptoms are often forced to deal with chronic pain, which can reduce training, or even prematurely end their careers.\(^5\)\(^2\) Due to its debilitating effects, understanding and characterizing the symptoms of PT are key for patients.

PT does not have an evidence-based, preferred choice for treatment. Conservative treatment of symptomatic PT focuses on rest, physical therapy, non-steroidal anti-inflammatory drugs (NSAIDs), and eccentric muscle training.\(^7\)\(^9\) In cases that are non-responsive to these modalities, both patients and physicians are left searching for alternatives. Treatment of recurrent PT varies widely and can be broadly grouped into the following categories: exercise training, injection-based
treatments, surgical procedures, and other therapies. Due to its unknown pathogenesis and etiology, treatment is often based on physician experience, exposure, and comfort with a specific treatment modalities. These factors have made the treatment and management of PT resemble more of an art than a science.8 The goal of this review is to identify recent research efforts aimed at addressing PT in order to best inform physicians of the currently available treatment modalities. We will also discuss potential future areas of research with regard to PT.

History and Physical Examination
Athletes with PT typically present with complaints of anterior knee pain that is exacerbated with knee flexion and prolonged activity. Often there is no history of direct trauma to the knee; however, at times, the patient can report a recent increase in activity level. The pain is typically insidious in onset and can be localized to the proximal insertion of the patellar tendon to the patella. In early stages of the disease, athletes complain of pain only after sporting activities; however, as the disease progresses, pain can be present throughout specific activities and in severe cases can be present during daily activities. Athletes will complain of a decrease in athletic performance and an inability to complete training regimens.

The most consistent physical exam finding in these patients is localized tenderness at the inferior pole of the patella. The most specific physical exam test to evaluate for PT is the decline squatting test. In patients with PT, a limited number of pain-free decline squats can be performed.10

Imaging
Both ultrasonography (US) and magnetic resonance imaging (MRI) are used to visualize patellar tendons in patients clinically presenting with symptoms of PT. Ultrasound examination reveals a variety of symptomatic changes in patellar tendons with PT. Under ultrasound, normal tendons appear regular with smooth fiber structure. When patellar tendons with PT are imaged, the sonogram typically reveals an abnormal tendon with localized widening at the point of tenderness with hypoechoic areas and can show neovascularization with increased vascular flow (Fig. 1).11 Neovascularization refers to the growth of new vessels into the tendon with the potential for accompanying nerves, which have been hypothesized as a source of symptomatic pain. One cohort study reported that 60% of participants clinically diagnosed with PT exhibited tendon changes complete with neovascularization under US.11 These types of patients could be indicated to receive sclerosing injection therapy, which will be discussed later.

MRI can also be used to diagnose PT by differentiating between normal and abnormal tendons. An MRI of an abnormal patellar tendon with PT usually reveals both increased signal and tendon size at the site of pathologic tendon changes (Fig. 2). In the case of both US and MRI, it is important to note that abnormal patellar tendon changes visible on a sonogram or MRI can occur asymptomatically. It has been found that asymptomatic patients with sonographic tendon changes do have an increased risk of developing symptoms of PT versus controls moving forward.12 Conversely, both imaging modalities may fail to show abnormal tendon changes in patients with symptoms consistent with PT. Due to the weak relationship between imaging and symptomatology of PT, neither US nor MRI can replace clinical presentation as the preferred method of diagnosis of PT.1

A 2007 study by Warden and coworkers compared the accuracy of MRI and both gray-scale and color-Doppler US.

Figure 1 Gray-scale and color-Doppler ultrasound showing the sonographic findings characteristic of PT. The sonogram reveals the hypoechoic, darken area of the patellar tendon, tendon thickening, and neovascularization.34

Figure 2 MRI scan typical of a symptomatic PT. This MRI reveals a change in signal intensity in the proximal patellar tendon and increased tendon thickness. Both of these MRI findings are characteristic of PT.13
Results indicated that US was more accurate at diagnosing PT than MRI. While the data revealed both gray-scale and color-Doppler US to be 83% accurate, gray-scale US had a higher sensitivity (87% to 70%), and color-Doppler US had a higher positive predictive value (91% to 81%). Thus, Warden and coworkers argued that the most accurate diagnosis would come from complementarily using both gray-scale and color-Doppler ultrasonography.13

Recent Research
Research efforts have taken shape to explore the etiology and pathogenesis of PT. To this end, several studies have focused on extracellular matrix (ECM) changes and receptor expression in PT. Cook and colleagues showed that tendinopathy is associated with changes in the ECM, and recent research has worked to further characterize these changes.14 Specifically, histopathological analysis of abnormal tendons with tendinopathy reveals hypercellularity, hypervascularity, lack of inflammatory infiltrates, and disorganization and loosening of collagen fibrils.15 In 2009, Samiric and associates set out to biochemically compare proteoglycan and collagen composition in normal and abnormal patellar tendons to confirm previous histological tendon studies.6,16-19 This study biochemically verified the previous histological findings including increased sulfated glycosaminoglycans (sGAGs) due to increased deposition of large proteoglycans and collagen changes in pathological tendons. While the study did not find a change in total collagen between normal and abnormal tendons, there was evidence of a down-regulation of Type I collagen and fibromodulin and an up-regulation of Type III collagen and versican. Samiric and associates concluded that the increased ratio of Type III to Type I collagen signifies a change in the metabolic turnover of pathologic tendons.6

Research examining transporter and receptor expression in pathologic patellar tendons has also provided insight into possible contributors to pathogenesis. In 2001, Rolf and coworkers investigated tendon hypercellularity, a characteristic of PT, by tracking the expression of proliferation cell nuclear antigen (PCNA) and platelet-derived growth factor receptor β (PDGFRβ).15 This study found significant hypercellularity resulting from cell proliferation related to the expression of PDGFRβ. With regard to transporter expression, in 2008, Scott and associates discovered that vesicular glutamate transporters (VGluT2) are more widespread and numerous in tenocytes in human tendons inflicted with PT compared to normal tendons.20 As a result of this transporter overexpression, tendons with PT have higher intratendinous levels of glutamate than normal tendons. In part due to glutamate’s role in controlling apoptosis, proliferation, and necrosis, Scott and associates proposed that locally-derived glutamate, possibly from the tenocytes, could play a role in the pathology of tendinosis.

Further research needs to be done to identify and characterize the biochemical changes and their mechanisms present in PT. Research should continue to explore intratendinous and extracellular changes in PT, mechanisms for hypercellularity, and the source and role of glutamate in tendinopathy pathogenesis.

Exercise Training and Bracing
Eccentric muscle training became a mainstay in conservative treatment for various types of tendinopathies, mainly due to studies evaluating Achilles tendinopathy. In these studies, eccentric strength training proved to be effective in reducing pain associated with neovascularization present in Achilles tendinopathy.21,22 The mechanism is not well understood but supports the theory that eccentric strengthening reduces blood flow through neovessels and eventually causes them to collapse. This collapse of neovessels may then eliminate the role accompanying nerves can play in causing symptomatic pain through ischemia. Eccentric strength training has since been expanded to treat other tendinopathies with beneficial results.23,24 Furthermore, the technique of eccentric training has been refined to more effectively treat PT. In 2004, Purdam and colleagues published a pilot study of eccentric decline squat training to address PT.25 Results indicated that eccentric squats on the decline board resulted in a statistically significant reduction in pain that was not seen in the standard eccentric training squat group. The benefits of eccentric decline squats were later confirmed in a subsequent study.26 Eccentric strength training is now considered a key aspect of conservative treatment for PT.9,8

Kongsgaard and associates compared the effects of eccentric decline squat training, corticosteroid injections, and heavy slow resistance training in treating PT.5 Results indicated that all three treatments result in short-term improvement at 12 weeks. Corticosteroid injections, however, were not able to maintain the same improvement at the 6-month follow-up as the eccentric training and heavy slow resistance treatments modalities. Interestingly, heavy slow resistance training also resulted in the reduction of abnormal tendon changes characteristic of PT. This study signals the need for more investigation into heavy slow resistance training to promote the reduction of PT tendon changes.

Success of eccentric training led Fredberg and coworkers to study the benefits of prophylactic eccentric training to reduce the risk of developing PT.13 Since eccentric strength training has been shown to reduce abnormal ultrasound characteristics in tendons with PT, it was logical to hypothesize that this training could prophylactically reduce ultrasound characteristics in asymptomatic abnormal tendons of soccer players and reduce the risk for these tendons to become symptomatic in the subsequent year. Unfortunately, Fredberg and coworkers did not find that eccentric training could be used as prophylaxis. In fact, the results showed that eccentric training actually increased the risk of developing symptoms or injury in asymptomatic players with ultrasonographically abnormal patellar tendons. In this way, Fredberg and
coworkers showed that eccentric training should only be used on symptomatic PT.

Bracing and patella taping is sometimes used in conjunction with eccentric training and activity modification for the treatment of PT. Chopat straps and knee taping techniques, such as Kinesio® taping and McConnell taping, have all been utilized to reduce anterior knee pain in these patients. The goal of bracing and taping is to reduce pain by increasing the patellofemoral contact area, thereby decreasing joint stress. These modalities are likely better served for treatment of patellofemoral pain syndrome rather than chronic patellar tendinopathy as they do little to unload the insertion of the patella tendon to the patella.28

Injection Therapies

A variety of injection and needle-based therapies have emerged in the literature as alternatives to treat PT. These range from dry needling and autologous blood injections to platelet-rich plasma (PRP) therapy, sclerosing, and high volume injections.

Multiple studies have examined the benefits of ultrasound-guided dry needling to fenestrate tendons with PT.29,30 Housner and associates looked at the variety of injection therapies and found needling and physical disruption of the tendon to be the common attribute of the treatments.29 In this retrospective study, they found that 72% of tendons treated with dry needling were able to return to desired activity level by the 45-month follow-up. Housner and associates proposed that the dry needling physically breaks up possible degenerative changes characteristic of PT, causes bleeding at the bone-tendon boundary, and may allow for healing components to act on the abnormal tendon. More research must be done to determine whether tendon recovery occurs as a result of the treatment or simply due to the passage of time due to long-term follow-up period utilized in this study. A second study combined ultrasound-guided dry needling with autologous blood injections for treating patellar tendinosis.30 In this study, James and colleagues emphasized the need for injections to be under ultrasound guidance and reiterated the call for randomized controlled trials to confirm the positive results of autologous blood injections.

A recent pilot study by Kon and coworkers investigated the benefits of applying PRP therapy to treat PT.31 PRP treatment involves reinjecting a concentration of autologous growth factors derived from blood into an injury site. Kon and coworkers reported 80% satisfaction resulting from PRP treatment of PT in this study with statistically significant improvement both at the end of PRP therapy and the 6-month follow-up. The investigators cautioned that stretching and strengthening therapies play an essential role in rehab following PRP treatment. Since the Kon and coworkers’ study was a pilot study, randomized controlled trials are needed to confirm the use of PRP to treat PT. As research continues to explore the use of PRP in PT, it is important to use a standard classification system like the PRP “PAW” classification system, proposed by DeLong and colleagues to facilitate comparing published results.32 This classification system emphasized the importance of detailing the platelet concentration, activation method, and the presence of white blood cells in PRP treatments to allow comparison of PRP treatments and studies.

Sclerosing injections attempt to disrupt the neovascularization that is present in many cases of PT. These injections are ultrasound-guided to insure localization around the site of neovascularization. Previous studies had shown that the presence of neovascularization in abnormal tendons was related to increased tendon pain compared to abnormal tendons without neovascularization.14 In this way, the sclerosing agent should eliminate neovascularization and decrease the pain associated with PT. It has been hypothesized that new nerves may also follow the neovascularization, and this may play a role in causing the associated pain. The nerves may be affected directly by the sclerosing injection or indirectly through ischemia with the elimination of neovessels.21 In two key studies, Hoksrud and associates injected polidocanol to sclerose neovascularization in tendons diagnosed with PT.33,34 Their 2006 randomized controlled trial followed up on a previously successful pilot study21 and found that polidocanol injections had an 84% success rate after 12 months.34 This study seems to clearly establish polidocanol injections as a treatment alternative that must be considered in chronic PT. In a second study, Hoksrud and associates followed patients after sclerosing treatment to determine the prevalence of neovascularization and post-treatment ultrasound tendon condition.31 Interestingly, they found that while symptoms and pain had improved as a result of the treatment, there was no relationship between post-treatment ultrasound characteristics and reduction in symptoms. In spite of the published success of sclerosing injections, the investigators argued that this confirms the unclear association between structural changes, neovascularization, and symptoms.

High volume ultrasound-guided injections also target the neovascularization in abnormal tendons similar to sclerosing injections. In high volume injections, the goal is to mechanically hinder the neovascularization process by injecting a large volume of fluid between the deep aspect of the patellar tendon and Hoffa’s body. In a small pilot study (N = 9), Crisp and coworkers found that high volume injections significantly out-performed the standard eccentric training therapy.3 The investigators did caution, however, that four of the patients did not realize a long-term reduction in PT symptoms. They proposed that neovascularization may not be the only reason for PT symptoms, which could explain sclerosing injections not being effective in all cases of PT as found in other studies. Crisp and coworkers remarked that it would be interesting to repeat a diagnostic ultrasound on cases in which high volume injections were ineffective
in treating PT. Future research should investigate whether neovascularization has occurred in patients receiving either sclerosing injections or high volume injections to determine if neovascularization is responsible for the recurrence of PT symptoms.

**Alternative Treatment Modalities**

Recently, attention has been given to alternative treatment options for those patients who have failed a course of conservative management and who do not yet wish to undergo surgery. These modalities include treatments such as hyperthermia thermotherapy, extracorporeal shock wave therapy (ESWT), and TOPAZ radiofrequency coblation.

Hyperthermia thermotherapy utilizes a deep tissue-heating source along with a superficial cooling device to warm deeper tissues while leaving the superficial tissues cool. A 2002 randomized controlled trial by Giombini and colleagues compared the efficacy of hyperthermia at 434 MHz to conventional ultrasound therapies in the treatment of tendinopathies. This treatment was adapted from effective utilization of hyperthermia in the early treatment of muscle injuries. While the investigators acknowledge the debate regarding the indication for hyperthermia thermotherapy, they tout the ability to increase circulation and cellular metabolism and assert that deep heating has long been considered part of the treatment of tendinopathies. Thus, hyperthermia thermotherapy could possibly be indicated by the findings from the previously mentioned Samiric and associates study, which proposed a decrease in metabolic turnover as the explanation for increased sGAG deposition in abnormal tendons. Giombini and coworkers found that while both hyperthermia at 434 MHz and ultrasound produced statistically significant reductions in pain on palpation and on isometric contraction, hyperthermia significantly outperformed ultrasound in the remission of symptoms during isometric contraction and overall satisfaction.

Although its mechanism is not well understood, ESWT has been utilized in clinical treatments for soft tissues and orthopaedics for a decade. In 2007, Vulpiani and colleagues published a pilot study to explore the efficacy of using ESWT to treat PT. In this pilot study, ESWT produced a significant reduction of initial pain symptomatology at 1 month, which continued to improve until 2 years after treatment. Satisfactory results were found in 43.4%, 63.9%, and 68.8% of tendons receiving ESWT at the 1-month, short-term, and 2-year follow-up exams. As a result, the pilot study seems to support ESWT as a valid therapy for PT. A key benefit of ESWT, which Vulpiani and colleagues made sure to note, is that it does not contraindicate subsequent surgical treatment if found ineffective. The investigators of this review believe that the effects of shock wave treatment on human tendons should likely be investigated in the future since the mechanism of ESWT is not well understood. As a pilot study, these results need to be confirmed through randomized controlled trials in order to gain evidence-based support.

TOPAZ radiofrequency coblation has been reported in the literature for use for treatment of calcific plantar fasciitis, lateral epicondylitis, and rotator cuff tendonitis. Through the use of the minimally invasive radiofrequency probe, microtenotomy is performed, which is thought to promote an angiogenic healing response. Although there is currently no data to support its use on patients with PT, the fact that there is evidence supporting its use for other chronic tendon conditions with similar pathogenesis has led some surgeons to anecdotally turn to this treatment modality as a last resort. Further studies are needed in order to evaluate its effectiveness and safety in this patient population.

**Surgical Management**

Surgical treatment for PT tends to be viewed as a last resort due to the variety of conservative and less invasive treatments available. With this in mind, PT is often chronic and refractory to more conservative treatments leaving surgical intervention as the sole remaining alternative. It has been estimated that 10% of PT in athletes requires surgical intervention. Despite this fact, there remains a lack of consensus on the ideal surgical approach.

Traditionally, the gold standard for surgical treatment of PT involved open debridement of the inferior pole of the patella, as well as debridement of the patella tendon. With recent advancements in knee arthroscopy, arthroscopic treatment of PT has become more common. This typically involves arthroscopic debridement of the adipose tissue of the anterior fat pad of the knee, debridement of any abnormal patellar tendon, and longitudinal tenotomies with or without excision or drilling of the inferior pole of the patella. As per Santander and coworkers, this arthroscopic approach attempts to treat the symptomatic pain of PT, while allowing a quicker return to normal activity. In this study, it was found that 82% of study participants were able to return to their previous activity level, which was comparable to results of previous reported open surgery. Despite these findings, this study had limitations, including a small study population and lack of a control group. In addition, a small number of elite athletes were in the study population, which did not allow the merits of the arthroscopic procedure to be evaluated on patients with high activity and load on their tendons. Regardless of these limitations, the main goal of arthroscopic treatment of PT is underscored—to surgically address symptomatic pain, while allowing a quicker return to normal activity. This potential for a quicker return to activities with arthroscopic debridement has led to the increasing number of arthroscopic procedures performed in this patient population.

When surgically approaching patients with PT, the inferior pole of the patella is the subject of debate—debridement versus excision. Lorbach and associates attempted to definitively answer this question in 2008, when they designed two separate studies focusing on the role the inferior pole of the patella plays in the pathology of PT. Their data showed that...
the PT group had a significantly longer non-articular inferior patellar pole compared to that of the control group. These findings support a theory that a mechanical impingement may be involved in the development of PT; this theory was previously proposed by Johnson and colleagues. Despite the contrast with previous studies regarding the inferior patellar pole, their second study also showed a significant reduction of symptoms from arthroscopic resection of the inferior aspect of the patella. Additional research must be done to conclusively show whether a difference in the length of the inferior patellar pole exists in patients developing PT and whether it plays a role in its pathogenesis and symptomatology.

Postoperative Rehabilitation

Postoperative rehabilitation following surgical treatment of PT is varied. Some protocols suggest prolonged postoperative casting, whereas others recommend early range of motion. As suggested by the reported variation in the literature, it can be deduced that no one regimen is universally successful. Despite this, Shelbourne and coworkers applied the universal orthopaedic concept that increasing stress across biologic tissue can promote and optimize healing and evaluated the application of aggressive postoperative rehabilitation techniques on recovery following patellar tendonectomy for PT. Their study utilized a rehabilitation regimen currently used for ACL patellar autograft donor sites, which included immediate range of motion, full flexion, and immediate high-repetition, low-resistance quadriceps muscle exercise. This analysis showed the application of patellar tendon donor site rehabilitation for ACL reconstruction to the site of patellar tendonectomy to be effective with 87.5% (14/16 patients) of patients returning to their previous activity level. The time required to return to a high activity level was between 3 months and 1 year. It has long been confirmed that stressing patellar tendons can aid in healing and recovery from injury. This research by Shelbourne and coworkers could represent a shift in rehabilitation for surgical treatment of PT that would allow for a quicker and more effective return to activity.

Limitations

While this review summarizes PT research and treatment today, it has several limitations that restrict our ability to effectively draw conclusions and make treatment recommendations. Much of the current research investigating treatment alternatives for PT consists of pilot studies with small sample sizes with or without a control population. The lack of randomized controlled trials and large treatment comparison studies makes it difficult to compare results across studies and provide treatment recommendations. Differing protocols in literature investigating the same PT treatment also complicate comparison. In this review, effort was made to include randomized controlled trials and draw conclusions wherever possible to direct further research. In addition, the retrospective nature of a few studies introduced recall bias. It is also important to note that while PT can be a chronic condition, Vulpiani and colleagues asserts that non-surgical treatments can be effective in up to 90% of PT cases. It is possible that rest, as a component of conservative treatment, can be at least partly responsible for a given treatment result. This should only further highlight the need for randomized controlled trials to minimize this concern. In light of these challenges, this review attempts to provide exposure for treatment alternatives and raise physician awareness.

Conclusions

As a common chronic overuse condition, PT can be debilitating for many patients and in particular, athletes. Because of its unknown pathogenesis and etiology, PT can be equally as difficult for physicians without a clear, evidence-based treatment of choice. For this reason, treatment selection often relies on physician comfort with and exposure to a particular method. This review attempts to address this uncertainty by summarizing recent research, providing exposure for a variety of published treatments, and giving recommendations for future research. Recent research efforts have investigated biochemical changes in abnormal tendons, confirmed the benefits of eccentric decline training, and explored the benefits of new treatments, including heavy slow resistance training, dry-needling, sclerosing injections, platelet-rich plasma therapy, arthroscopic surgical procedures, resection of the inferior patella pole, extracorporeal shock wave treatment, and hyperthermia thermotherapy. At this point, the literature supports the use of eccentric decline training for the treatment of PT, but does not support prophylactic eccentric training to lower the risk of developing PT. Heavy slow resistance training, sclerosing injections, arthroscopic surgery, and surgical resection of the inferior patellar pole appear to be promising based on existing research but still need further confirmation. The remaining treatments explored in this review require further research to become evidence-supported therapies for PT. Additional studies, especially large sample, randomized controlled trials, are needed to verify the efficacy of many of these treatments and allow for comparison between therapies. As research identifies beneficial therapies for PT, studies will be needed to provide indications for treatment providers and provide evidence-based guidance for physicians treating PT.

Disclosure Statement

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