Jumper’s knee, or patellar tendinopathy, is the clinical term used to describe patellar tendon pain, swelling, and/or dysfunction resulting from acute injury or, more commonly, chronic overuse. This condition is prevalent among athletes and often becomes chronic and disabling because there is no recognized reliable treatment for chronic cases. The purpose of this article is to review the literature to characterize the incidence, pathophysiology, and various treatment options available for patellar tendinopathy, with an emphasis on definitive procedures that remove the diseased tissue.

INCIDENCE AND ETIOLOGY

Recent studies estimate the overall prevalence of patellar tendinopathy to be 8.5% among recreational athletes and as high as 13% to 20% among elite athletes. Consequently, patellar tendinopathy results in significant disability, time lost from competition, and increased health care expenditures. The etiology of patellar tendinopathy is thought to be multifactorial, comprising both intrinsic and extrinsic risk factors. Extrinsic risk factors include training errors (eg, abrupt change in training regimen), environmental conditions, and footwear. Intrinsic factors include quadriceps and hamstrings inflexibility, tall height, increased patellar lateral-medial mobility, increased knee laxity, limb-length discrepancy, and patella alta. Patellar tendinopathy has been found to be nearly twice as common in male athletes as compared with their female counterparts. Male volleyball and basketball players are at the greatest risk, with up to 45% and 32% of elite male athletes, respectively, affected by patellar tendinopathy during their careers. Not surprisingly, soccer players, sprinters, and participants in jumping sports are also at higher risk for the development of patellar tendinopathy.

PATHOPHYSIOLOGY

Although tendinopathy was historically believed to result from chronic inflammation (ie, tendinitis), recent histologic studies have documented a paucity of inflammatory cells in chronic tendinopathy. It is now generally accepted that chronic...
tendinopathy reflects a degenerative condition secondary to repetitive microtrauma and incomplete healing. Histologically, this manifests as tendinosis: disorganized collagen, increased amounts of ground substance, hyperplasia of fibroblasts, and neovascularization.\textsuperscript{1,2,8-11} Despite our improved histological understanding of this disease process, the exact pain generator remains indeterminate at this time. Possibilities described in the literature include imbalanced mechanical stresses, painful surrounding tissues, neurogenic pain, inflammatory mediators associated with the degenerative tissue, and/or the process of pathologic neovascularization itself.\textsuperscript{1,2,8,10,12-16} This current recognition of patellar tendinopathy as a chronic, degenerative condition reflecting an incomplete healing response should be used to guide decision making when treating chronic, refractory cases. One practical consideration is earlier definitive intervention in those with a refractory condition.

**DIAGNOSIS**

Although the term jumper’s knee may refer to tendinopathy affecting any portion along the patellar tendon, the most common and classically affected area involves the proximal patellar tendon at its junction with the inferior pole of the patella.\textsuperscript{1,4} Patients typically present with patellar tendon pain, swelling, and/or activity limitations associated with running, jumping, squatting, or, in severe cases, walking.\textsuperscript{1,4} The diagnosis of patellar tendinopathy is usually straightforward following a skilled history and physical examination, including screening for identified intrinsic and extrinsic risk factors. The patient can readily identify the site of focal pain. Radiographs can be obtained when appropriate, primarily to exclude osseous disorders resulting in anterior knee pain, such as osteochondritis dissecans.

When clinically indicated, magnetic resonance imaging (MRI) will typically demonstrate focal or diffuse patellar tendon thickening along with increased T2 signal reflecting intratendinous edema (Figure 1). Partial-thickness tearing may manifest as markedly increased T2 signal and may be accompanied by detectable fiber disruption. However, MRI differentiation of high-grade tendinosis from partial-thickness tears is unreliable. Ultrasound generally provides excellent intrinsic tendon detail. Tendinosis typically demonstrates focal or fusiform tendon thickening and reduced echogenicity (hypoechogenicity). Increased interfibrillar distance reflects increased extracellular fluid and ground substance separating intact collagen bundles.\textsuperscript{1,2,8-11} In the setting of partial-thickness tearing, ultrasound readily demonstrates the additional finding of collagen fiber disruption (Figure 2). Furthermore, in chronic cases, ultrasound may detect tendon neovascularization, which has been hypothesized to be a potential pain generator. Cortical irregularities affecting the inferior patellar pole may be detected in severe cases and are easily seen on radiographs, MRI, or ultrasound. In general, the severity of structural changes frequently parallels clinical symptoms, although there is noteworthy interindividual variability.

**Figure 1:** Sagittal T2-weighted magnetic resonance image of an athlete with chronic patellar tendinopathy. The arrow indicates the typical findings of proximal patellar tendon swelling and increased T2 signal adjacent to the inferior patellar pole. In this case, the absence of fibers is seen within the region of T2.

**Figure 2:** Ultrasound image of chronic patellar tendinopathy. Note the diffusely hypoechoic (darker than normal) patellar tendon (PT) extending from the inferior patellar pole. Intratendinous calcifications (asterisk) are seen at the enthesis, correlated with the patient’s point of maximal tenderness. Left is cephalad, right is caudal, top is superficial/ anterior, and bottom is deep/posterior. Abbreviation: PAT, patella.

**NATURAL HISTORY**

Patellar tendinopathy often results in protracted symptoms and consequent disability. The mean duration of symptoms reported in the literature across all sports is 19 months among recreational athletes and 32 months among elite athletes.\textsuperscript{5,5} Approximately one-third of all patients presenting with patellar tendinopathy may be unable to return to their respective sport for 6 months or longer.\textsuperscript{17} Furthermore, symptoms have recurred in up to 23% of all elite athletes following successful treatment.\textsuperscript{18} One long-term investigation reported that 53% of patients reported retiring from their sport over a 15-year follow-up period due to refractory or recurrent symptoms.\textsuperscript{7,17} These are trends that are simply unacceptable in today’s environment.

**NONSURGICAL TREATMENT OPTIONS**

**Nonprocedural Treatments**

Patellar tendinopathy is initially managed through aggressive nonoperative interventions, including activity modification, identification and mitigation of identifiable risk factors, and physical therapy, in particular eccentric strengthening exercises.\textsuperscript{2} More specifically, an appropriately performed, progressive strengthening program of eccentric squats on a 25° decline board has a reported success rate of 50%
to 70% in the treatment of patellar tendinopathy.\textsuperscript{19-24} The most commonly cited regimen consists of performing 3 sets of 15 repetitions twice daily over a 12-week period.\textsuperscript{19,24} Load is added based on ease of completing the prescribed repetitions. It is noteworthy that eccentric exercises often elicit pain and soreness, with some patients worsening before they improve. Appropriate counseling and supervision are recommended. Finally, although the recovery with this treatment modality is unpredictable and often prolonged, definitive treatment options are offered with hesitation due to the prolonged nature of the recovery after such treatment.

**Ultrason-Guided Nonsurgical Procedural Treatments**  
For refractory cases, various peritendinous and intratendinous treatments have been used prior to consideration of surgical intervention. Many of these have been recently reviewed elsewhere, and a detailed discussion is outside the focus of this review. These include dry needling (also known as tendon fenestration),\textsuperscript{25} autologous blood injection,\textsuperscript{7,25-28} platelet-rich plasma (PRP) injection,\textsuperscript{7,25,27-32} high-volume paratenon injection, corticosteroid injection, neovessel ablation with sclerosing agents,\textsuperscript{19,23,29,33} and aprotinin injection.\textsuperscript{29,34} The use of ultrasound has gained popularity as an adjunct with these injections because it allows the clinician to identify the pathologic region within the tendon, accurately deliver the therapeutic agent, and monitor the healing response and success of the intervention.

**Ultrason-Guided Dry Needling.**  
Ultrason-guided dry needling, also known as percutaneous needle tenotomy (PNT) or tendon fenestration, involves repetitive passing of a needle through diseased tendon with a goal of producing a localized, controlled injury. It is believed that this trauma stimulates bleeding, reinitiates the inflammatory healing response, and eventually results in the release of growth factors and cytokines, similar to those seen with PRP and autologous blood injections. Although data are limited, published reports have generally reported favorable results using ultrasound-guided PNT to treat chronic patellar tendinopathy.\textsuperscript{35,36} In 2007, James et al\textsuperscript{37} reported a success rate of greater than 90% in a cohort of 47 patients managed with 2 treatments administered 4 weeks apart. In 2009, Housner et al\textsuperscript{38} reported a reduction in visual analog scale (VAS) scores from 5.8±0.6 at baseline to 2.2±0.7 at 12 weeks, with no reported complications. Ultrasound-guided PNT appears to be a safe procedure that may lead to symptomatic improvement in some patients with refractory patellar tendinopathy. However, the precise mechanism of action remains unknown because histologic studies are lacking. A potential limitation of PNT is that the technique relies on the body to remove the tendinopathic tissue, the success of which may vary depending on patient and disease-specific factors.

**Extracorporeal Shockwave Therapy.**  
Extracorporeal shockwave therapy (ESWT), best known as a method of treating urolithiasis, has also been proposed to treat chronic patellar tendinopathy, although the precise mechanism of action remains unknown.\textsuperscript{38-44} Prior animal studies have demonstrated an increased expression of neoangiogenic growth factors such as endothelial nitric oxide synthase (eNOS), vessel endothelial growth factor (VEGF), and proliferating cell nuclear antigen (PCNA) as a result of ESWT treatment.\textsuperscript{38,43} The resulting neoangiogenesis is hypothesized to lead to cellular proliferation and eventual tissue regeneration.\textsuperscript{37,38,41,43} Yet other authors speculate that ESWT may relieve pain via hyperstimulation analgesia or through selective inhibition of small, unmodeled pain fibers without effect on larger, myelinated motor fibers.\textsuperscript{39,40} In 2009, Van Leeuwen et al\textsuperscript{42} performed a review of 7 articles published between 2000 and 2007 that examined the effects of ESWT on patellar tendinopathy. Three of the studies were nonrandomized; 2 had no control group; 1 was retrospective; 1 randomized, controlled trial (RCT) was only single-blinded; and most of the studies suffered from small study groups and short-term follow-up.\textsuperscript{42} Despite these limitations, the authors estimated the overall success rate of ESWT to be 74.7% in the treatment of chronic patellar tendinopathy.\textsuperscript{42} Since that time, studies have continued to vary widely in methodology and results. Wang et al\textsuperscript{43} reported in a Level II RCT that ESWT was more effective than conservative management, but the recurrence rate was notably high in both treatment groups. Two other RCTs in the literature have reported conflicting results.\textsuperscript{40,41} At this time, ESWT is an interesting concept with conflicting outcomes and few long-term data on efficacy.
morbidity and achieve an earlier return to sport. The definitive procedures reviewed here reflect the evolution of procedures to address patient expectation.

Open Surgical Treatment. Based on the currently available literature, open surgical debridement has been reported as successful in 45% to 100% of cases of chronic patellar tendinopathy. In 2000, Coleman et al performed a literature review of 19 outcome studies and 1 abstract, all assessing open surgical management of proximal patellar tendon tendinopathy. The authors reported an overall success rate of 50% to 100%, coinciding with the results of previous authors.

In 2006, Bahr et al performed an RCT comparing conservative eccentric therapy vs open debridement and reported equally disappointing success rates of 55% and 45%, respectively.

More recently, Gill et al reported their retrospective results of 34 consecutive patients treated with combined arthroscopic and open surgical debridement. A diagnostic arthroscopy was performed prior to the open portion of the procedure to assess intra-articular pathology, and an arthrolysis was performed as indicated. The patellar tendon was then treated through an open approach. At a mean follow-up of 3.8±1.6 years, the authors reported average 5-point reduction in VAS scores and an overall success rate of 82% (defined as a complete or mostly satisfied patient response). All patients in the study were reported to return to their preinjury Tegner activity levels.

Although numerous possible explanations exist for the broad range of reported results with open surgical debridement, a partial explanation may be the wide variability of intraoperative and postoperative treatments. In 2002, Ferretti et al described an open technique, similar to Blazina et al, where a cortical bone block was excised from the inferior pole of the patella and the central portion of the patellar tendon was debrided. Postoperatively, weight bearing and range of motion were progressively advanced over a 6-week period, as permitted by pain. At a mean follow-up of 5 years, the authors reported 85% overall good or excellent results, and 82% of patients were able to return to pre-injury sports levels for more than 5 years postsurgery. These results were felt by many to have affirmed the success of combining excision of the inferior pole of the patella with debridement of the patellar tendon. However, in 2006, Kaeding et al reported a multivariate systematic review of open surgical management in which they demonstrated an overall success rate of 87% and a 71% return to sport. When stratified based on specific intraoperative techniques, the authors found that excision of the extra-articular portion of the inferior patella leads to a success rate of only 70.9%, compared with a success rate of 91.7% without excision. In addition, their review suggested that closure of the paratenon leads to a success rate of 84.8%, compared with 91.5% success without paratenon closure. Finally, extended postoperative immobilization was found to result in a success rate of 82.4%, compared with 94.9% success with early mobilization. These results have called into question 3 technical and rehabilitative strategies: the need to excise the inferior pole of the patella, to close the paratenon, or to require immobilization postoperatively for extended periods of time.

However, due to the wide range of study heterogeneity, even these summary observations should be interpreted with caution. Randomized, controlled trials are necessary before any definitive conclusions may be drawn regarding the effect of various surgical techniques on subsequent patient outcomes and satisfaction.

Arthroscopic Surgical Treatment. Similar to open debridement, arthroscopic techniques are believed to serve as a definitive form of treatment for patellar tendinopathy, but with the potential additional benefits of reduced complications, reduced postoperative pain and stiffness, and a more rapid return to activity. In 2000, Coleman et al performed the first comparison study of open vs arthroscopic patellar debridement. The authors concluded that there were no statistically significant differences between the 2 techniques. However, they noted non-statistically significant trends with respect to symptomatic improvement at final follow-up, Victorian Institute of Sport Assessment-Patella (VISA-P) scores, and rate of return to preinjury activity, all favoring arthroscopy. This study was most likely underpowered to detect statistically significant differences in many of these parameters.

More than a decade later, Marcheggiani Muccioli et al reviewed 21 surgical outcome studies comparing open vs arthroscopic management of patellar tendinopathy. Similar to Coleman et al, they reported non-statistically significant trends favoring arthroscopic treatment in terms of overall success rate and rate of return to sports.

In 2006, Ogion et al described the technique of arthroscopic patellar release (APR) and reported a retrospective review of their experience with 15 patients treated with this technique. The authors described the APR procedure as a partial synovectomy, resection of hypertrophic portions of the infrapatellar fat pad, and denervation of the inferior pole of the patella, including the patellar tendon insertion, with a bipolar electrocautery device. There was no formal arthroscopic osteoplasty (excision of the extra-articular distal pole of the patella) or excision of tendon performed during the procedure. At a mean follow-up of 41 months, 13 of the 15 patients reported a complete resolution of symptoms (87% success rate), all within 3 months of treatment. The mean Blazina score (scale ranging from 0 for no pain during sporting activities to 4 for pain at an unsatisfactory level during sporting activities) improved from 3.7 preoperatively to 0.4 at final follow-up.

In 2008, Lorbach et al reported their experience with arthroscopic osteoplasty in 20 patients with chronic tendinopathy.
They hypothesized that proximal patellar tendinopathy may be secondary to impingement of the inferior pole of the patella against the patellar tendon. Based on this theory, arthroscopic osteoplasty was performed without a formal patellar tendon debridement. At 24-month follow-up, 90% of patients demonstrated good or excellent results, despite the continued presence of tendinopathic tissue on repeat MRI and recurrence of inferior patellar osteophytes in a number of patients. The authors postulated that their positive clinical outcomes may have resulted from debridement of both the patella and patellar tendon at the time of the procedure.46

In 2009, Cucurulo et al45 performed a retrospective, multicenter review of 15 patients who underwent arthroscopic patellar tendon debridement vs 49 patients who underwent various open surgical techniques. Osteoplasty was performed in 39 of 49 open procedures and 2 of 15 arthroscopic procedures. At an average final follow-up of 22 months, 80% of the patients in the arthroscopic group reported a Blazina score of 0 or 1 compared with 88% of the patients in the open surgery group. Patellar pain improved in 100% of the arthroscopic group compared with 92% in the open group. Average delay prior to initiation of training was 5 months (range, 3-18 months) in the arthroscopic group compared with 7 months (range, 3-18 months) in the open group. The authors concluded that although there was a tendency toward faster recovery with arthroscopic management, neither treatment modality was found to be more successful than the other.55

In 2011, Pascarella et al52 reported the results of 64 patients (42% of whom were professional athletes) who underwent an arthroscopic debridement of Hoffa’s fat pad, debridement of the pathologic portion of the patellar tendon, and an osteoplasty. All patients were followed for a minimum of 3 years, and 45% were available for long-term follow-up to 10 years. Average Lysholm score increased from 51.3 preoperatively to 95.5 at 3 years and remained at 92.3 at 10-year follow-up. Average VISA-P score increased from 35.3 to 69.8 at 3 years and remained at 69.4 at 10-year follow-up. All patients were able to return to sports within 3 months, but only 70% of the 27 professional athletes were able to return to sporting activity at their same preinjury level. Of interest, and uncommonly reported, seven (11%) patients developed a recurrence of symptoms, and there was a 9.6% overall failure rate.52

More recently, Alaseirlis et al56 reported a prospective experience of arthroscopic management of 11 elite athletes treated with debridement of the patellar tendon, cauterization of visible neovascularization, and osteoplasty. Postoperatively, all patients were placed in a hinged knee brace locked in extension and were made nonweight bearing for 3 weeks, followed by a progressive rehabilitation program. At 24-month follow-up, 81% of these athletes were satisfied, and all were able to return to their previous level of sporting activity.56 During this same period, Maier et al53 prospectively analyzed 30 competitive athletes who underwent APR using a technique similar to that of Ogon et al,51 with an average of 4 years of surveillance. The patients were placed on a regimen of open-kinetic-chain exercises for 2 weeks and closed-kinetic-exercises at 3 weeks and were allowed to return to competition at 7 weeks. Blazina, VISA-P, and subjective knee function scores significantly improved, with approximately 80% of patients rating their knee function as good to excellent, 80% returning to sports within 6 months, and only 10% rating their knee as unsatisfactory.53

Both open and arthroscopic surgical procedures can be effective in the treatment of recalcitrant patellar tendinopathy, with approximately equal results reported for both techniques. Arthroscopic management, when compared with open surgery, was previously theorized to offer a more rapid return to sporting activity, an increased overall success rate, and a relative reduction in morbidity, complications, and postoperative pain and stiffness. However, these advantages have not been consistently demonstrated in the literature.45,46,50-55 In the current authors’ review of the literature, they found the overall cumulative average of all previously reported success rates in the currently available literature to be approximately 81% (range, 45%-100%) for open procedures and 91% (range, 86%-96%) for arthroscopic procedures.35,36,46,50,54,55 Although not reported in all studies, return-to-sport rate was approximately 77% (range, 16%-91%) for open procedures and 81% (range, 46%-100%) for arthroscopic procedures.45,55

Average reported time to return to sporting activities was approximately 5.6 months for open procedures and 5 months for arthroscopic procedures (Table).55

Furthermore, although it has been suggested that patellar osteoplasty may be a beneficial adjunct to surgical management, the role of exciting the distal patellar pole remains indeterminate, and numerous studies have reported good clinical results without it.46,51-53,55,56

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<th>Table</th>
<th>Cumulative Mean of All Prior Reported Results for Definitive Management in the Currently Available Literature</th>
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<td>Result</td>
<td>Open Procedures</td>
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<tr>
<td>Success, mean (range)</td>
<td>81% (45%-100%)</td>
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<tr>
<td>Return to sports, mean (range)</td>
<td>77% (16%-91%)</td>
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<td>Time to return, mean (range), mo</td>
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current authors’ conclusion is that it is not essential. Their interpretation of this literature is depicted in Figure 3.

A final observation is that, although both open and arthroscopic techniques to treat patellar tendinopathy are considered definitive, both procedures must be performed in an operating room or outpatient surgery center, require general or regional anesthesia, are associated with well-documented risks of surgical morbidity, and have significant financial implications.

Percutaneous Ultrasonic Tenotomy. Percutaneous ultrasonic tenotomy (PUT) is a novel and recently introduced technique that has been demonstrated to represent a less invasive, highly effective treatment for epicondylitis. It also has recently been introduced as an alternative to arthroscopic and open surgical procedures in the treatment of chronic refractory patellar tendinopathy, unresponsive to standard nonoperative management (Figure 4). Similar to both open and arthroscopic surgical treatment, PUT has the ability to debride the tendinopathic tissue, but it shares the benefit of being minimally invasive like the other ultrasound-guided treatments. In addition, it has the potential benefit of being performed in an office setting, without requiring an operating room or the associated staff and expense. The procedure is performed under local anesthesia and ultrasound guidance.

The ultrasonic probe is inserted into the hypoechoic region of the patellar tendon and activated to emit ultrasonic energy. The pathologic tissue is tenotomized and aspirated through a process thought to be similar to phacoemulsification, a process presently used in cataract surgery. Preliminary reports suggest that the technique is as successful as any of the more formal operative interventions. Yet, although ultrasound-guided PUT appears to have the potential to serve as a definitive form of management of recalcitrant jumper’s knee (a role that until now has been reserved for either open and arthroscopic surgery), it remains a new and unproven technology. Further high-level clinical studies are required before any conclusions can be made.

CONCLUSION

Jumper’s knee is a common cause of anterior knee pain among active populations. Symptoms typically occur in the setting of chronic, degenerative changes within the patellar tendon, the presence of which may be confirmed by ultrasound or MRI. This is well known to be career ending, and at least 10% of cases become refractory and require surgical intervention directed at debridement and removal of the pathologic tissue within the tendon. Open and arthroscopic management of chronic patellar tendinopathy have been reported to achieve similar satisfactory results in most patients based on the currently available literature. Percutaneous ultrasonic tenotomy is a recently introduced, minimally invasive alternative that is performed under local anesthesia and appears to be comparable with definitive surgical management. As such, it offers numerous potential, but not yet proven, advantages compared with open and arthroscopic techniques. This technique has the ability to debride and remove pathological tendon tissue, features previously only attained by performing arthroscopic or open surgery, but with the potential added benefits of minimal patient morbidity and expense previously associated with traditional definitive surgical procedures.

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