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Patellar Tendinopathy: Pathomechanics and a Modern Approach to Treatment

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Patellar tendinopathy, a common condition in sport, can be recurrent and resistant to treatment. Risk factors include the level of training, biomechanics, and genetic factors. This review discusses several programs based on eccentric exercise and suggests principles for nonoperative treatment including improving shock absorption, load modification, and adaptation of the tendon to sporting stress. The level of pain that patients are asked to tolerate during tendon-exercise programs varies among programs, and it is unclear what level is optimal to stimulate tendon recovery. Rehabilitation presents several challenges: It can take a long time (3–12 months), exercise prescription in an athlete who is continuing to compete is not straightforward, and guidelines for treatment progression are poor. Nonoperative treatment can fail because of inappropriate exercise prescription and poor athlete compliance. If this occurs and surgical intervention is required, the athlete might still have an unpredictable outcome. Solutions to these problems require additional clinical research.

Key Words: nonoperative management, risk factors, rehabilitation

Key Points:

- Patellar tendinopathy is a recurrent and resistant condition.
- Nonoperative treatment might require more than 3 months rehabilitation.
- Nonoperative treatment requires individually tailored programs.

Introduction

Patellar tendinopathy is a pathological condition of the tendon similar to that found in other tendons susceptible to overuse (eg, Achilles, supraspinatus). Although originally considered inflammatory in nature, overuse tendon injury is better considered a failed healing response.[1,2] This is evident from the hypercellular, blastic process evident in histopathological specimens. Degeneration is associated with cell atrophy,[3] and this is not the case in overuse tendinopathy. Thus, the term *degeneration* is not as accurate as is *failed healing*.[4]

The histopathology of tendinopathy is documented elsewhere.[5] From a clinical perspective, the important pathological process is the failure of the collagen to align or cross-link that decreases load-bearing capacity and impairs tendon function.

Although patellar tendinopathy is deemed a tendon injury, it is a true enthesopathy. The role of enthesopathy in the symptomatology and the

management of this condition is unknown because the enthesis has been minimally investigated and is poorly understood.

Pathomechanics

The lay term for patellar tendinopathy is *jumper's knee*, but it is likely that the tendon is overloaded in landing from a jump. High forces (up to 14 times body weight)[6] and joint velocities (500°/sec)[7] occur in landing. Sport involves both high landing forces and repetitive force application, and repetition might also be a factor in overuse tendon injury.

There have been several investigations into the biomechanics of athletes with jumper's knee. Stiffer landing,[8] better jumping ability,[9] and higher ground-reaction forces at takeoff[10] can be associated with symptoms of patellar tendinopathy.

Risk Factors

Training Schedule

Ferretti et al[11] reported that more than 3 training sessions/wk and the hardness of the surface were both associated with jumper's knee. The number of training sessions might be a reason that elite athletes suffer patellar tendinopathy more than recreational athletes do.[12]

Biomechanics

Although many biomechanical factors have been cited as predisposing to tendinopathy, there have been few investigations of biomechanics in patellar tendinopathy. Some studies suggest a relationship between patellar tendinopathy and anatomical alignment[13] and muscle imbalance.[14]

Decreased ankle dorsiflexion from either joint stiffness or muscle tightness has been shown to be a factor increasing both ground-reaction forces[15] and injuries.[16] General anterior knee pain risk factors have been shown to be quadriceps tightness and weakness, hypermobility of the patella, and activation of the vastus medialis obliquus.[17]

Genetic Factors

Despite claims in the literature that women are more susceptible to tendinopathy than men are,[18] all intervention studies in tendinopathy include more men than women. Men also appear to be more susceptible to asymptomatic ultrasonographic tendon changes, because several studies report twice as many men as women with ultrasonographic tendon changes.[19,20]

Kannus and Jozsa[21] have shown that subjects with blood-group type O were more likely to sustain tendon ruptures than those with other ABO groups. Similarly, subjects with type A blood were less likely to sustain tendon ruptures. This association was not shown in Maffulli's study of tendon ruptures in Scotland.[22] Nevertheless, several studies suggest that genetic factors might cause susceptibility to tendinopathy.[23,24]

Aims of Treatment

Well-researched nonoperative and surgical treatment options for patellar tendinopathy are limited. Nonoperative treatment is therefore based on clinical experience, and surgical techniques vary widely.[25]

Tendon rehabilitation seeks to improve the pain-free load-bearing capacity of the musculotendinous unit (MTU). It is unknown which part of the MTU is affected by rehabilitation, and there is no evidence to show that it improves tendon structure. Symptomatic relief should occur after rehabilitation. However, tendon morphology on ultrasound might not change.[26] See Figures 1 and 2 for ultrasound images of patellar tendinopathy.

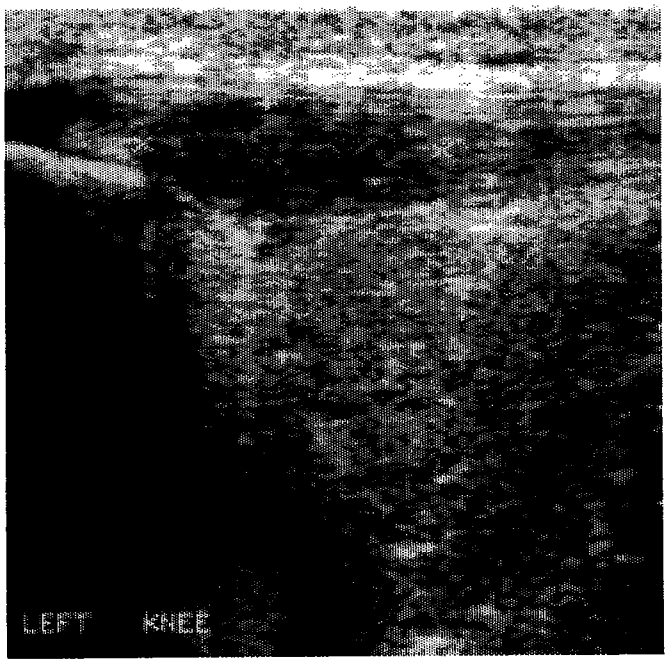

Figure 1 A classic sagittal ultrasound of patellar tendinopathy, with the swollen, hypoechoic area adjacent to the patella.

Figure 2 An ultrasound of the same tendon as in Figure 1, in the axial plane, with the swollen, hypoechoic area in the center of the tendon.

Nonoperative Treatment

Eccentric exercise remains the cornerstone of tendon rehabilitation, because eccentric contractions are those used predominantly in jumping sports.[27] This treatment was first proposed and studied by Curwin and Stanish,[28] who reported symptomatic improvement in the first few weeks of a graduated eccentric exercise program. Other studies support this.[29,30]

Clinical Rehabilitation

There are several components of rehabilitation for patellar tendinopathy. Each individual might respond to a different combination of interventions, and the clinician is responsible for both the correct prescription and the correct progression of a rehabilitation program.

Load Reduction. Rest has been advocated for settling inflammation in tendinopathy.[31,32] This is inappropriate advice for tendon injuries because it decreases the tendon's ability to bear load.[33]

Symptomatically, however, it might become impossible for the athlete to continue to fully load the tendon. Continued abusive load might increase symptoms, although it is unclear whether it also increases tendon

damage. Simply put, load should be reduced to a level that is symptomatically appropriate and to a point at which the MTU can function satisfactorily.

Load Adaptation. Adapting the MTU to tolerate increased load without symptoms is central to a rehabilitation program. This is achieved by a progressive increase in musculotendinous load. Adding weight, speed, height, and endurance or combinations of these can increase load. Specific programs emphasize different aspects of load, although there is no evidence that any 1 offers superior results. Curwin and Stanish[28] emphasized speed, whereas Alfredson et al[34] advocate weight increments. Nirschl[24] stresses endurance for rehabilitation of the extensor tendons of the elbow.

It is essential to assess which of these aspects of tendon function is lacking in each patient so that exercise prescription can be tailored appropriately. Rehabilitation must address the strength and function of the whole limb, and lumbopelvic stability must be emphasized.

Single-leg work is important because pain and weakness cause unloading of an affected leg, hence allowing the unaffected leg to dominate the exercise. Similarly, squats place limited load on the quadriceps mechanism because both the calf complex and the gluteal muscles contribute significantly to the exercise. Recent work has indicated that the use of a 25° decline board limits the work of the calf muscle and can increase load on the patellar tendon.[35-36]

Improving the Shock-Absorbing Capacity of the Limb. Because patellar tendinopathy occurs mostly in athletes in jumping sports, improving shock absorption on landing is critical in the rehabilitation process. Enhancing shock absorption below the knee (foot function, calf-muscle strength, and ankle dorsiflexion) will decrease the amount that occurs at the knee.

Poor foot mechanics and structure should be addressed with either shoe and/or orthotic intervention. Calf-muscle strength and endurance are also critical, because repeated landings will induce fatigue, so a comprehensive calf-muscle-strengthening program is essential.

A large range of ankle dorsiflexion allows maximal shock absorption. Because jumping athletes are often afflicted with ankle-joint degeneration or impingement, rehabilitation must include the ankle joint.

For maximal shock absorption, the gluteal muscles must have good function. Although the gluteus medius is very often adequately rehabilitated, the gluteus maximus is not and should be included in a rehabilitation program.

Rehabilitation Program

The program should include parts of the following components; however, this is not an exclusive list of appropriate exercises.

Initial strength should include weight work such as leg press and leg extension, as well as simple weight-bearing activities such as lunges, calf raises, and step-ups. As the program progresses, speed is added, and

weight-bearing exercises should include incremental speed increases. Activities such as skipping and running should be included toward the end of this part of the program. The final aspect needed to complete rehabilitation is sport-specific strength training, and running, sprinting, and change-of-direction exercises are essential components of this. It is important to iterate that each athlete will respond differently to rehabilitation, and each program must be tailored to the individual athlete. "Recipe" approaches to tendon rehabilitation will fail to capitalize on the potential for recovery.

Acceptable Level of Pain in a Rehabilitation Program. Because it is unclear what mechanism is responsible for pain production in tendinopathy,[37] it is difficult to interpret the significance of pain in the rehabilitation process. Pain inhibits musculotendinous function[38]; hence, one could argue that pain should not be allowed. Others argue that pain guides the practitioner to the load that is detrimental to the tendon, although there is no evidence for this.[28] Alfredson's eccentric Achilles-tendon-strengthening program[34] permits pain and, in fact, suggests that the success of the program is a result of exercising through pain. Currently, it is impossible to know whether tendon pain is essential or detrimental in rehabilitation.

Program Length. If the goal of therapy were to return imaging to normal, then rehabilitation might never end.[39,40] If collagen synthesis is the goal, then a prolonged recovery time is also indicated. Similarly, pain relief is an imperfect measure of tendon recovery, because rest achieves this without increasing the load adaptation of the MTU.

The best guide to recovery is the ability of the MTU to bear appropriate load. It is rare for this to take less than 3 months—it often takes 6–12 months.[41] Some athletes are never able to repetitively load the tendon to a desirable level. Adapting their training load might allow uninhibited competition. These athletes might need fewer training sessions per week, shorter sessions, or relief from 1 or more provocative training exercises.

Progressing Treatment. The decision to progress treatment should ideally be based on both subjective and objective signs. The VISA score[42] offers an excellent measurement of both subjective and functional signs and should be administered at least monthly.

There are few reliable objective signs of tendon healing. Palpation is not effective, because tenderness can precede symptoms[43] and remain after the athlete returns to normal function. Similarly, imaging can remain unchanged for extended periods and appears not to reflect the current or future symptomatic status.[39,44] A specific loading test for the patellar tendon might be the decline squat,[35] but further work in this area is needed.

Maintaining Fitness. Patellar tendinopathy is a condition that allows ongoing fitness work. Swimming, running in water, cycling (especially stationary), and stepping machines are excellent means of doing this without significant tendon load.

Rehabilitating the Competing Athlete. Rehabilitation becomes problematic when an athlete can continue to train and play. The athlete loads the

tendon maximally and perhaps provocatively in training and competition. Adding rehabilitative load to these athletes might increase symptoms. Hence, some of the training load should be replaced by appropriate rehabilitation. Nursing the player through to the end of the season and then starting aggressive rehabilitation in the off-season has proven successful.

Failure to Respond

Nonoperative tendon rehabilitation might fail to improve symptoms, and the reasons can be athlete- or practitioner-centered. Tendon rehabilitation requires excellent compliance from both the athlete and the clinician over an extended period.

Many athletes find long-term compliance difficult, especially if their symptoms are minimal. This compliance must extend to maintaining strength after their return to sport. Recurrence is a common problem in patellar tendinopathy,[41] and the athlete should never allow the MTU to weaken.

Failure can arise from clinicians prescribing programs that lack eccentric exercises or adequate load increases. Similarly, failure to rehabilitate the whole limb can adversely affect rehabilitation. Of course, differential diagnosis is critical, and patellofemoral pathology and fat-pad impingement[45,46] can mimic tendinopathy.

There is a group of athletes who fail to respond despite what appears to be an appropriate program undertaken with full compliance. These patients usually cannot progress far into a program and fail in the early stages. Some athletes can progress fully through rehabilitation but are unable to return to their previous competitive levels. Other interventions might be indicated for these athletes (eg, corticosteroids, aprotinen, prolotherapy), but surgical intervention probably remains the best option for them.

Surgical Treatment

Surgery on the patellar tendon was described in 1973.[47] Since that time, many different techniques have been reported.[25] Open patellar tenotomy is the most common surgical procedure.[47] Other techniques include surgery directed at the enthesis (drilling, scarification),[30,48,49] extensor-mechanism surgery,[50-52] and longitudinal tenotomy.[53] Less invasive procedures such as dry needling and percutaneous tenotomy might offer "interim" management between nonoperative and surgical treatment, although the few investigations into these procedures have not indicated that they are more or less successful than standard surgical treatment.[53]

Good and excellent outcomes vary from 100%[54,55] to 50%.[51] Coleman et al[56] have separated symptomatic recovery from return to sport, reporting that 90% have relief of symptoms but that only about 60% ever return to their previous level of activity. Surgery should only be considered when an

adequate nonoperative treatment program has failed. The appearance of the ultrasound image should not be an indication for surgery in the patellar tendon, even if categorized into pathology subgroups such as cystic and calcific tendinopathy. These images can be seen in asymptomatic athletes[19,20] and do not indicate a poor clinical outcome for the tendon.

Conclusion

There are clinically based treatment options available for patellar tendinopathy. However, there is much that remains poorly understood and researched. Failure rates for both nonoperative and surgical treatment options are unacceptably high. Improved management of patellar tendinopathy clearly relies on significant research advances

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