

CHAPTER 24

Patellofemoral pain

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CHAPTER OUTLINE

- 24.1 Anterior knee pain
- 24.2 What is patellofemoral pain?
- 24.3 Factors that may contribute to patellofemoral pain
- 24.4 Clinical approach
- 24.5 Treatment
- 24.6 Considerations for the adolescent with patellofemoral pain
- 24.7 Patellofemoral osteoarthritis
- 24.8 Patellofemoral instability
- 24.9 Less common causes of anterior knee pain

LEARNING OBJECTIVES

By the end of this chapter you should be able to:

- identify relevant bony and soft-tissue structures at the patellofemoral joint (PFJ)
- differentiate between the two leading causes of anterior knee pain: patellofemoral pain (PFP) and patellar tendinopathy
- discuss PFP in the context of the biopsychosocial model
- describe the key elements of the history and physical examination when assessing the athlete with anterior knee pain
- discuss the value of clinical imaging for the athlete with anterior knee pain
- explain the approach to treating the athlete with PFP, including the available evidence for various treatment options
- recognise patellofemoral instability and differentiate between primary and secondary instability
- list less common causes of anterior knee pain.

24.1 ANTERIOR KNEE PAIN

Anterior knee pain is the most common presenting symptom in many physiotherapy and sport and exercise physician practices.^{1,2} It contributes substantially to the 20–40% of general practice consultations that relate to the musculoskeletal system.³ Anterior knee anatomy is shown in Figure 24.1.

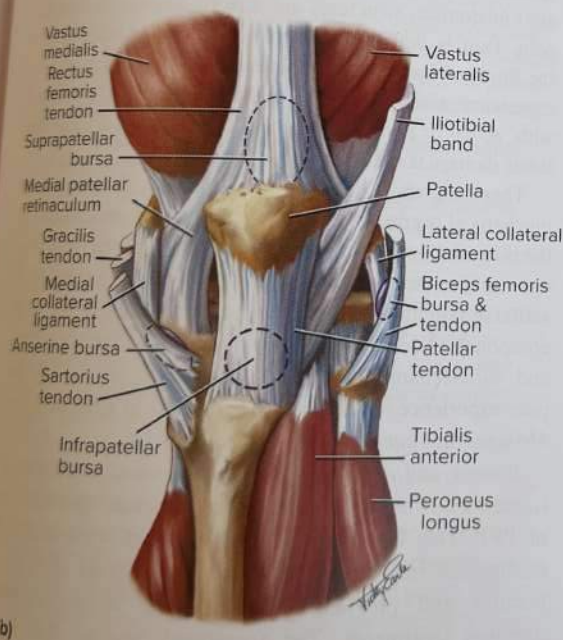


Figure 24.1 Anterior knee: (a) surface anatomy (b) anatomy

There are two main causes of anterior knee pain:

- patellofemoral pain (PFP)
- patellar tendinopathy.

Causes of anterior knee pain are listed in Table 24.1.

TABLE 24.1 Causes of anterior knee pain

Common	Less common	Not to be missed
• PFP • Patellar tendinopathy	• Synovial plica • Pre-patellar bursitis • Quadriceps tendinopathy • Infrapatellar bursitis • Patellofemoral instability • Fat pad impingement • Sinding-Larsen-Johansson lesion in adolescents (Chapter 33) • Tenosynovitis of the upper tibia • Stress fracture of the patella • Osgood-Schlatter lesion in adolescents (Chapter 33)	• Referred pain from the hip • Osteochondritis dissecans • Slipped capital femoral epiphysis • Perthes' disease • Tumour (especially in the young)

Distinguishing between PFP and patellar tendinopathy as a cause of anterior knee pain can be difficult (Table 24.2). Rarely, both conditions may be present.

In this chapter we focus on PFP and in Chapter 25 we look at patellar tendon pain. Note that PFP can be caused by patellofemoral osteoarthritis, which is covered in Chapter 23.

Functional anatomy

At full extension, the patella sits lateral to the trochlea. During flexion, the patella moves medially and comes to lie within the intercondylar notch until 130° of flexion, when it starts to move laterally again.⁴ With increasing knee flexion, a greater area of patellar articular surface comes into contact with the femur, offsetting the increased contact load that occurs with flexion. Loaded knee flexion activities subject the PFJ to loads ranging from 0.5 times body weight for level walking to seven to eight times body weight for stair climbing.⁵

TABLE 24.2 Clinical features of PFP and patellar tendinopathy

Signs	PFP	Patellar tendinopathy
Onset	Running, steps/stairs, hills, any weight-bearing activities involving knee flexion, prolonged sitting	Activities involving jumping and/or changing direction
Pain	Non-specific or vague, may be medial, lateral or infrapatellar, aggravated by activities that load the PFJ	At the inferior pole of the patella, aggravated by energy storage loads such as jumping
Tenderness	Usually medial or lateral facets of the patella but may be tender in the infrapatellar region; may have no pain on palpation due to areas of the patella being inaccessible	Localised to the inferior pole of the patella; without patellar tendinopathy
Swelling	May have small effusion, swelling, suprapatellar or infrapatellar	Tendon may be increased in thickness, no joint swelling
Clicks/clunks	Occasional	No
Crepitus	Common	No
Giving way	Rarely, due to quadriceps weakness/inhibition or subluxation	Rarely, due to quadriceps weakness/inhibition
Knee range of motion	May be decreased in severe cases but usually normal	Normal
Quadriceps contraction in extension	Can be painful, often normal	Often painful
PFJ movement	May be restricted in any direction; commonly restricted medial glide due to tight lateral structures	Normal PFJ biomechanics
Functional testing	Squats, stairs may aggravate; PFJ taping should decrease pain	Decline squats aggravate pain; PFJ taping has less effect

24.2 WHAT IS PATELLOFEMORAL PAIN?

PRACTICE PEARL

"Patellofemoral pain" is the preferred term used to describe pain on and around the patella.

PFP⁶ is not easy to define, as patients experience a variety of different symptoms and physical impairments.⁷⁻⁹ Despite many years of research and international consensus from the patellofemoral research community,⁶ the terminology used varies greatly in the literature, with terms such as anterior knee pain, chondromalacia patella, patellofemoral arthralgia, patellar pain and patellar pain syndrome often used synonymously.^{6, 10, 11}

The term "anterior knee pain" is suggested to encompass all pain-related problems of the anterior part of the knee. By excluding anterior knee pain due to intra-articular pathology, tendinopathies around the knee, bursitis, plica syndrome, Sinding-Larsen-Johansen disease, Osgood-Schlatter disease, neuromas and other rarely occurring pathologies, those who present with anterior knee pain can be diagnosed with what is now called PFP.⁶

PFP is a heterogeneous pain complaint with many features, not dissimilar to unspecific low back pain.⁵ Several anatomical structures may be involved in the pathophysiology, including

subchondral bone, the synovium, the retinaculum and the infrapatellar fat pad.^{12, 13} However, recent research into specific tissue pathology has failed to determine which (if any) anatomical structures are directly associated with the pain. Pain is defined by the International Association of the Study of Pain as "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage",¹⁴ so it is clear that tissue damage is not a prerequisite for pain.

Therefore, while PFP may be initiated by factors such as mechanical overload, over time pain may be present due to the potential threat of tissue damage. Importantly, pain is an emotional experience, regardless of whether it is caused by actual or potential tissue damage, as there is a psychological component. Focusing primarily on the implicated structures and biomechanics neglects this critical aspect of the pain experience.^{2, 15} See also Chapter 10 in *Clinical Sports Medicine 6e: Foundations of Clinical Practice*.

Powers and colleagues¹⁶ have proposed a theoretical framework linking biomechanics to the development of PFP. This framework, based on small cross-sectional studies, may help to systematise a complex range of physical features and provide a rationale for biomechanically oriented treatments. The framework implies that PFP occurs due to peripherally based nociception caused by altered loading of the PFJ.

However, the framework fails to explain some of the classic features of PFP, including pain spanning decades, the limited impact of biomechanically focused treatment on prognosis and that the patient's symptoms may improve substantially despite no changes in their biomechanics.¹⁷

An alternative (or complementary) framework on the aetiology of PFP is the tissue homeostasis model proposed by Scott Dye.¹² Dye's model focuses on the biological factors that may underpin PFP. He proposes that simple overload of tissues associated with the PFJ may cause a range of pathophysiological processes leading to a loss of tissue homeostasis and the knee operating outside of its envelope of function.

This overload could result from a single loading event of sufficient magnitude (such as a fall on the knee) or a series

of repetitive loading events at lesser magnitudes (such as an increase in running volume). In this framework the specific structures involved matter little—management is focused on regaining tissue homeostasis by keeping the PFJ within its envelope of function.

Emerging evidence suggests that PFP should be considered in a framework that encompasses the biological, psychological and social aspects that can influence the perception and maintenance of pain. Neither the biomechanical nor the tissue homeostasis model adequately considers the contribution of these three components to PFP.^{9,18,19} Perhaps it is time to consider PFP in the same light as other persistent musculoskeletal pain complaints; see Box 24.1.

BOX 24.1 The "pain" in PFP

Local and central contributors to PFP

Pain is a complex protective mechanism. Although nociception is an input to the brain that may result in pain, the brain receives many other inputs before deciding to create the sensation of pain, some of which may be far more severe than the level of nociception.

The experience of knee pain is modulated at different sites in the body, both locally and centrally within the brain and spinal cord. This means that both local peripheral nociceptors and facilitated central pain mechanisms may influence the pain that is experienced. While we use terms like PFP, what we really mean is that pain reflects the perception of threat and not the state of the tissues; pain is not "in" the PFJ—that's where it is perceived. Pain is a driver of behaviour to protect tissues (see Chapter 10 in *Foundations of Clinical Practice*).

Do people with PFP have altered peripheral and central pain mechanisms?

Emerging research demonstrates signs of peripheral and central sensitisation in adolescents and adults with PFP.²⁰ The similarities underline the need to consider the wide-ranging impact of PFP. More specifically, research shows that adolescents and adults with PFP display both local and widespread mechanical pressure hyperalgesia (demonstrated by reduced pressure pain thresholds assessed around the knee and on the tibialis anterior muscle and contralateral arm).²¹

Furthermore, in research both adolescents and young adults have shown impaired conditioned pain modulation and facilitated temporal summation of pain, where a higher level of temporal summation of pain is associated with a prognosis of pain.²² Interestingly, despite recovering from PFP (i.e. complete resolution of symptoms) young adults with a history of PFP display altered pain mechanisms compared with controls with no history of knee pain. Such maintained pain sensitivity and facilitated pro-nociceptive mechanisms may shed light on the recurrent nature of PFP.

It is possible that these individuals are at risk of a recurrence of PFP, perhaps at a lower threshold of activity than would normally be required to illicit a pain response,²² and this may in part explain both the poor prognosis and recurrent nature of PFP.

Clinical signs that may suggest facilitated central pain mechanisms

In the clinical setting, the following signs may suggest facilitated central pain mechanisms:

- disproportionate pain, implying that the severity of the pain and the related reported or perceived disability are disproportionate to the nature and extent of the injury
- the presence of diffuse pain distribution, allodynia and hyperalgesia.

Clinical management

If this fits your patient with longstanding PFP and they have not responded to your normal exercise protocol, you might want to consider the following (adapted from Nijs et al.²³):

- be conservative when estimating the initial training load; start with a lower baseline and progress from there, depending on symptom flaring
- monitor symptom flares after exercise and progress exercises depending on the response
- advise the patient that minor symptom flares are natural during the initial stages of exercise therapy, but they should cease once the exercise routine has been established
- advise the patient that increased pain during and shortly following exercise is acceptable but that they should avoid continuously increasing pain intensity over time
- include aerobic exercise as well as motor control training
- exercise the whole body, not just the painful limb (including cross-education and strength training of the other limb)
- add in multiple and long recovery breaks in between exercises.

24.3 FACTORS THAT MAY CONTRIBUTE TO PATELLOFEMORAL PAIN

Although the exact source of the pain in PFP is still unknown, there are several factors associated with PFP that should be considered when assessing the athlete with anterior knee pain, including the knee structure, muscle function and movement patterns.

PFP is probably initiated by increased or unaccustomed loading at the knee. The number of loading cycles and the frequency of loading are important. During weight-bearing activities, any increase in the amount of knee flexion will increase the PFJ load. Changes in the load (e.g. a higher training volume, increased speed of running) may overload the joint structures sufficiently to initiate pain.

Impairment of muscle function both at the knee and remote to the knee is associated with PFP. Quadriceps atrophy is present in people with PFP,²⁴ and impairment in quadriceps strength increases the risk of developing PFP.²⁵

Impairment in lateral trunk, hip abductor, extensor and rotator strength has also been linked with PFP.^{20,26} Recent evidence suggests that strength is not the only important feature, with impairment in muscle power, steadiness and endurance also associated with PFP.^{30,36-38}

Altered movement patterns have traditionally been linked with patellar maltracking, including movement of the patella relative to the femur, and the femur underneath the patella driven by hip or foot movement patterns.¹⁶

At the hip level, weakness or delayed onset of hip abductor and hip external rotator muscles contributes to excessive hip adduction during weight-bearing activities in people with PFP.²⁹⁻³² Reduced peak knee flexion, trunk flexion and cadence are consistently found in individuals with PFP during stair climbing and running.^{30,33,34}

At the foot level, dynamic foot function (e.g. plantar loading) and static foot posture (e.g. increased pronation, navicular drop and arch height mobility) are associated with PFP and may contribute to its development.^{30,32,35-40}

24.4 CLINICAL APPROACH

The clinical approach revolves around a thorough history and physical examination. The role of imaging in PFP is minimal.

History

Several important factors can be elicited from the history of the athlete presenting with anterior knee pain. These include the specific location of the pain, the nature of aggravating activities, the history of the onset and behaviour of the pain, and any associated clicking, giving way or swelling.

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Although it may be difficult for the athlete to be specific about the location of the pain, this provides an important clue as to the likely diagnosis. For example, retropatellar or peripatellar pain may suggest that the PFJ is the likely culprit. Lateral pain localised to the PFJ femoral epicondyle increases the likelihood of iliotibial band syndrome as the diagnosis (see Chapter 25). Patellar tendon pain will be localised to the inferior pole of the patella and the patient can point to it with a single finger. The pain remains localised both at rest and on loading with the decline squat.

PFP is a non-specific pain complaint where the pain is often ill-defined and the location does not point to specific structures. The onset of pain is typically insidious and unrelated to an acute injury. However, it may present secondary to an acute traumatic episode (e.g. falling on the knee) or consequent to another knee injury (e.g. meniscal, anterior cruciate ligament [ACL] or knee surgery).

The patient presents with a diffuse ache, which is usually exacerbated by PFJ loaded activities, such as ascending/descending stairs or running. Sometimes PFP is aggravated by prolonged sitting, but sitting also tends to aggravate patellar tendinopathy symptoms and therefore is not diagnostic of PFP. Pain during running that gradually worsens is more likely to be of patellofemoral origin, whereas pain that occurs at the start of activity, settles after warm-up and returns after activity is more likely to be patellar tendinopathy.

While the pathologies of patellar tendinopathy and PFP may coexist, in practice they rarely present as coexisting clinical entities. Table 24.2 is an aid to differentiate between PFP and patellar tendinopathy based on the clinical history and presentation.

The type of activity that aggravates anterior knee pain also aids diagnosis. Consider two contrasting scenarios that patients may report as causing pain at the infrapatellar region. In one case, the precipitating activity of basketball involves repetitive loading (specifically energy storage and release) of the patellar tendon, suggesting the diagnosis of patellar tendinopathy. In the other, a freestyle swimmer reports pain following tumble turning or vigorous kicking in the pool, where there is no energy storage and release load on the tendon but a forceful extension of the knee, leading you to suspect an irritated fat pad. The mechanism of injury and the aggravating features are critical to an accurate diagnosis.

A history of crepitus commonly suggests PFP.⁴¹ A feeling that the patella moves laterally at certain times suggests patellofemoral instability. An imminent feeling of giving way may be associated with patellar subluxation, PFP or meniscal abnormality. Although frank, dramatic giving way is usually associated with ACL instability (see Chapter 22), giving

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may resulting from pain-induced muscle inhibition is not uncommon in people with various types of anterior knee pain.

A history of previous knee injury or surgery may be important; PFP is a well-recognised complication of posterior cruciate ligament (PCL) injury and ACL reconstruction (see Chapter 22). Patellar tendinopathy may be present after ACL reconstruction using bone-patellar tendon-bone grafts.

Knee pain and/or effusion may result in inhibition of the quadriceps (reduced magnitude and delayed timing of electromyography onset).⁴²⁻⁴⁴ Significant knee swelling is rare in atraumatic anterior knee pain and generally suggests additional intra-articular abnormality. However, a small effusion may be present with PFP.

Previous treatment and the patient's response to it should be noted. If treatment was unsuccessful, it is essential to determine whether the failure was due to incorrect diagnosis, inappropriate treatment or poor patient adherence.

PRACTICE PEARL

Although the history provides valuable information pertaining to extrinsic factors, careful clinical examination is required to evaluate the key contributing factors including the knee structure, muscle function and movement patterns. This comprehensive assessment is crucial in planning treatment.

Physical examination

Examination of the knee is described in Chapter 21, but examination techniques specific to the PFJ are included here.

It is critical to reproduce the patient's anterior knee pain, as the location of tenderness and aggravating factors are key to the differential diagnosis. This is usually done with an activity that loads the PFJ, such as a double- or single-leg squat (Fig. 24.2a).

Palpate the patella, and medial and lateral facets for tenderness (Fig. 24.2b). The contribution of the superficial and deep soft tissues to PFP must also be considered from structural and functional assessment of the patella position and through palpation to gain an impression of the compliance of the lateral and medial soft tissues (Fig. 24.2c).

Carefully assess passive and active movement of the patella in all directions: medial (Fig. 24.2d), lateral, superior and inferior glides, as well as rotations. Although the tests for patella position are not functional and may not be repeatable,^{45,46} clinical examination of the patella position remains a useful tool for clinical decision making.

Manual muscle tests using a hand-held dynamometer (Fig. 24.2e) can confirm strength, power and endurance deficits. Assess the range of motion of relevant joints and muscles using an inclinometer and standard clinical tests (e.g. FABER/Patrick's test). It is important to assess the patient in static postures as well as functional activities.

Some factors may become more obvious during specific functional tasks, such as the step-down or single-leg squat, hopping or landing from a jump, where the postural demands are high. When examining altered movement patterns and assessing biomechanical/gait patterns, it is important to determine whether the patient can correct the movement when asked to focus on it.

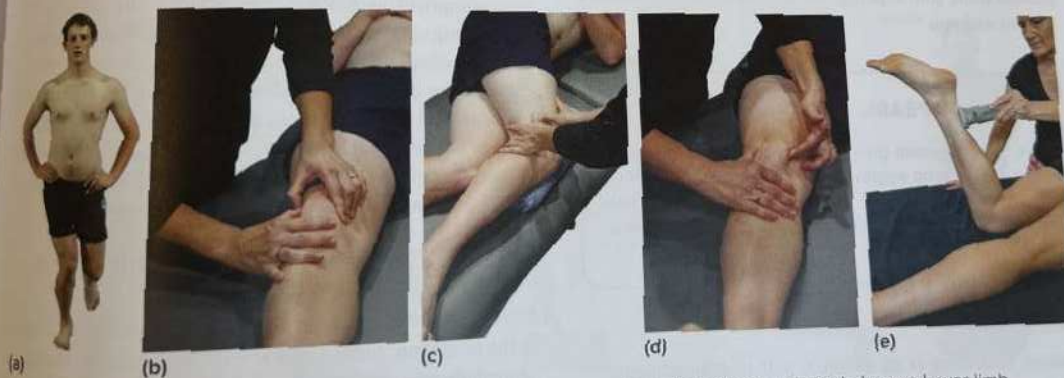


Figure 24.2 Examination of the PFJ. (a) Single-leg squat. Aim to reproduce the patient's pain and observe lower limb alignment, including hip/lumbar/pelvic control, knee control and dynamic foot posture. (b) Palpate the patella, and medial and lateral facets for tenderness. (c) Palpate the iliotibial band and lateral retinacular structures for any reduced compliance. (d) Assess mobility of the patella with medial glide. (e) Test muscle strength (e.g. knee flexion) with hand-held dynamometer.

Investigations

Imaging is not relevant in the diagnosis of PFP but may be useful when differential diagnosis is suspected. Structural imaging includes conventional radiography, ultrasound, CT and MRI. Occasionally, radionuclide bone scan is indicated to evaluate the "metabolic" status of the knee (e.g. after trauma, in suspected stress fracture).

Plain radiography can detect bipartite patella, apophyseal changes at the patellar tendon attachments and osteoarthritis, as well as rule out potentially serious complications such as a tumour or infection. Although CT and 3D CT can assess PFJ morphology, MRI is gaining increasing popularity in the investigation of PFP and the unstable patella.⁴⁷

These imaging techniques can identify features including bone lesions, chondral lesions, tendinopathy and synovitis. However, the importance of such features to symptoms or the progression of disease remains unknown.⁴⁸ Indeed, recent MRI studies have demonstrated no difference in the composition of patellar cartilage between patients with PFP and healthy controls.^{49, 50}

24.5 TREATMENT

Current evidence suggests that non-surgical treatment is the cornerstone of PFP management.^{51, 52} Effective treatment usually integrates different techniques that target physical impairments at the trunk, hip, knee and foot (e.g. muscle weakness), psychological factors (e.g. fear of movement) and poor load management. Interventions such as education, exercise therapy, manual therapy, taping, bracing and foot orthoses can be used in isolation or in combination, depending on the patient's clinical presentation, your expertise and the preferences of both the patient and you.^{51, 53, 54}

PRACTICE PEARL

The first treatment priority is to reduce pain. Managing load and limiting aggravating activities usually suffices. Techniques such as taping should relieve pain immediately; this strongly suggests that the diagnosis is PFP.

Education

Patient education is an essential part of management.^{55, 56} It should be delivered by health professionals—providing patients with health education materials alone is ineffective.⁵⁵ Skilled health professionals can tailor

the education to the individual in single or multiple consultations. The goal is for the athlete to gain knowledge and/or change their behaviour.

Effective educators:

- explain the multifactorial nature of PFP and emphasise the biopsychosocial factors
- advise the athlete how to manage load, modify activity and interpret pain (what is acceptable?)
- advise on self-management, treatment options, and the importance of actively engaging in the rehabilitation process.

Explain the multifactorial nature of PFP

Having a better understanding of the condition may help address the athlete's misbeliefs and manage their expectations.⁵⁷ Explain that PFP is a complex condition influenced by a range of biopsychosocial factors.⁵⁸ Biomechanically, it is often related to muscle strength and abnormal patellar tracking.¹⁶

Psychological factors such as anxiety, fear of movement and pain catastrophising are associated with higher levels of pain and lower functional capacity.^{58–60} Social factors such as reduced physical activity also play a role and should be discussed.⁶¹

This comprehensive approach acknowledges that PFP is not just a localised knee issue, but a condition affected by a complex interplay of factors across the biopsychosocial spectrum.

Advise on managing load, activity and pain

A key to managing PFP is managing load: progress activity gradually, avoid sudden spikes in intensity and adjust activities based on how the patient responds. As PFJ load varies with different tasks, consider what task provides the appropriate load when you progress the athlete. A pain monitoring system⁶² (e.g. where pain is recorded on a numerical pain scale) may guide activity or exercise modification and enhance adherence to the rehabilitation program. Pain levels up to 5/10 momentarily during exercise or immediately following exercise are acceptable and somewhat expected at the initial stages of rehabilitation, but should not extend to the following morning.

Advise on self-management, treatment options and active engagement

Include treatment options and self-management strategies in the education, such as how to effectively manage load and immediate pain-relief strategies (e.g. taping). Co-developing a tailored management plan with the patient and monitoring progress encourages active engagement and fosters patient empowerment in the rehabilitation program.⁶⁰

Exercise

Exercise therapy is a proven component of PFP management. Level 1 evidence supports the use of combined interventions (combination of hip-and-knee-targeted exercise therapy, quadriceps biofeedback, knee joint mobilisation and patellar taping)⁶³ as well as exercise programs in isolation.^{54,63-66}

Knee- or hip-targeted exercise therapy seems to produce equivalent improvements in pain and function for patients with PFP.⁶⁷ Evidence suggests that they may be used in combination to produce greater improvements in pain and function.⁵⁴ The usual components are discussed below.

Strengthening/endurance building for lower limb and trunk muscles

Adequate strength and endurance—especially in the quadriceps, hip, trunk and triceps surae muscles—is likely to be important for all patients. There is limited evidence comparing different exercise dosages in PFP exercise programs, but in one randomised clinical trial a higher dose of exercise (3x/week, 3 x 30 reps, 9 exercises, 60 mins) was reported to be more effective than a lower dose (3x/week, 2 x 10 reps, 5 exercises, 20 mins) for patients with PFP.⁶⁸

Strengthening programs can be commenced early in the patient's rehabilitation and progressed according to their response and American College of Sports Medicine guidelines.⁶⁹ A randomised clinical trial reporting improvements in pain at 1-year post-rehabilitation used exercise intensities of >70% of 1 repetition maximum (1 RM).⁷⁰ This exercise prescription is consistent with recommendations that novice to intermediate individuals train with loads corresponding to 60–70% of 1 RM for 8 x 12 repetitions to maximise strength gains.

In most cases, home-based exercises, including the use of resistance bands and body-weight exercises, are appropriate in the early stages of rehabilitation.⁶⁶ When commencing any resistance exercise program, low to moderate intensity is recommended to facilitate muscle function improvements (strength and endurance).

However, progressing from home-based to gym-based exercises may be an important step in the management of PFP, particularly for athletes who want to return to activities where knee and other lower limb joint forces increase significantly (e.g. high-impact sports and running).⁷¹ You may need to develop a resistance program that the athlete has the skills and knowledge to progress independently beyond the supervised rehabilitation.

Knee-targeted exercise therapy strategies

In the past, the vastus medialis oblique has been the focus of targeted exercise. However, evidence suggests that patients cannot activate the vastus medialis oblique in isolation and that no exercise appears to be preferential for its activation from the other components of the quadriceps muscle. Most people will not require a specific focus/emphasis on their vastus medialis oblique.

Initially, knee-targeted exercises may commence in a sitting position with the knee at 90° and the foot on the floor. To ensure that the quadriceps are trained in a position where they are required to function, the patient should begin training in a weight-bearing position and perform functional exercises with steadily increasing load and difficulty as soon as possible.

Progression is based on their ability to maintain control and on the absence of significant pain (2–3/10). Lower load tasks may include lunges, squats and step-ups (Fig. 24.3). Further progression can be made from minimal

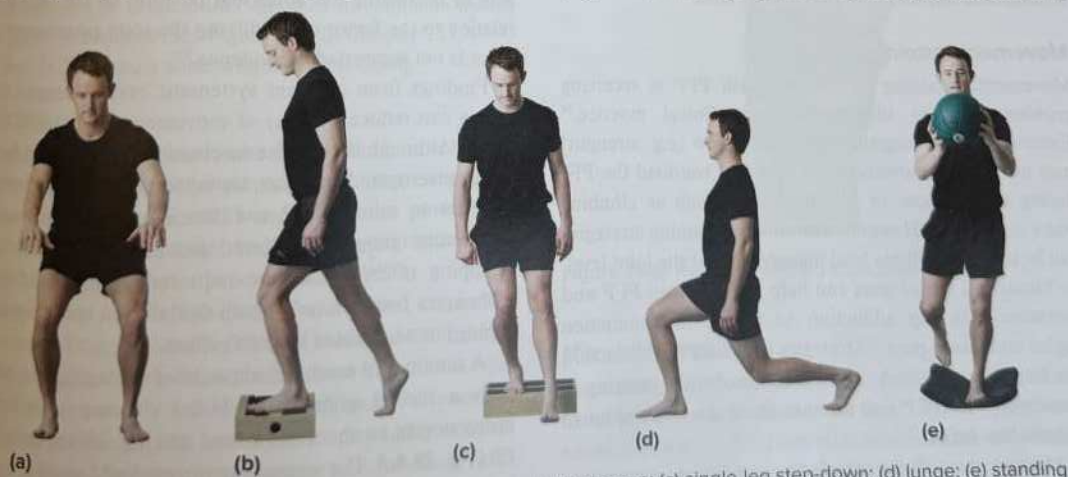


Figure 24.3 Graded quadriceps exercises: (a) double-leg squat; (b) step-up; (c) single-leg step-down; (d) lunge; (e) standing on one leg, with single-leg squat catching a ball.

weight-bearing (using a handrail or other support) to full weight-bearing (eventually including added loading) and through various knee flexion ranges.

The final aim of knee-targeted exercise therapy is to achieve a carryover from functional exercises to functional activities. The patient should perform small numbers of exercises frequently throughout the day. A series of graded quadriceps exercises is shown in Figure 24.3.

Hip-targeted exercise therapy strategies

Although the mechanism for hip-targeted exercises has not been definitively established, the hip abductors, external rotators and extensors are thought to stabilise the lateral pelvis and control excessive internal hip rotation and adduction during physical activity. Hip-targeted exercise therapy has been associated with pain reduction in patients with PFP.⁷²

The principles for hip-targeted exercise therapy are the same as for knee-targeted exercise therapy, with exercises performed initially in non weight-bearing positions and then progressed to weight-bearing positions. It is critical to ensure that the targeted muscles are being activated during the exercise program. For example, if your assessment reveals hip external rotator weakness, the exercise program should focus on strengthening the hip external rotators.

Some patients may require retraining of their movement patterns during functional or potentially aggravating activities.⁷³ Further information on movement (and running) retraining is available in Chapter 17.⁵³

Adjunct interventions

Treatment adjuncts (passive and active) can be used in combination with exercise or used as self-management strategies to improve pain in the short term.

Movement retraining

Movement retraining for patients with PFP is receiving growing attention in research and clinical practice.⁷⁴ Exercise therapy targeting muscle function (e.g. strength) may not change movement patterns that overload the PFJ during specific low- or high-load tasks such as climbing stairs or running. However, movement retraining strategies can be used to facilitate load management at the joint level.

Visual and verbal cues can help runners with PFP and excessive peak hip adduction to reduce hip adduction angles and lessen pain.⁷⁵ Strategies to reduce hip adduction are important as peak hip adduction during running is associated with PFP and exercise alone does not seem to address this deficit.⁷⁵

Movement retraining can also be an adjunct intervention in the final stage of exercise-based interventions to return

to high-loaded activities involving knee flexion during full weight-bearing (e.g. stair descent, deep squats) or higher intensity activities such as running. Patients will need additional training to facilitate progression to these high PFJ loading activities. Motor control, strength and endurance in the quadriceps and global muscles (e.g. triceps surae, hip and trunk muscles), balance and coordination should be trained in these higher loading tasks.

Exercise choice and progression decisions are based on the patient's needs, their ability to control movements and (and running) retraining is available in Chapter 12 in *Foundations of Clinical Practice*.⁵³

In-shoe foot orthoses

In-shoe foot orthoses have been shown to improve pain and physical function in patients with PFP in the short term when compared with sham treatment.⁷⁶ The mechanisms underpinning the clinical effects are unclear, with greater midfoot width mobility not associated with greater patient-perceived improvement using foot orthoses versus hip exercises.^{77,78}

If either anti-pronation taping or an orthosis reduces pain during aggravating activities, it provides a clue as to whether the patient is more likely to respond to orthoses.⁷⁹ Additionally, you might consider customised foot orthoses or changing footwear, although the efficacy of these interventions is unknown. These interventions are discussed in Chapters 12 and 17 of *Foundations of Clinical Practice*.

Taping

Taping is widely used in clinical practice as an adjunct intervention for PFP. The long-held assumption that taping acts by correcting the abnormal position of the patella in relation to the femur or modifying the joint proprioceptive input is not supported by evidence.⁸⁰

Findings from a recent systematic review suggest that taping can reduce the fear of movement for patients with PFP.⁵⁸ Although the precise mechanism of the effect is still being investigated, patellar taping is an effective interim measure to relieve PFP and can increase adherence to an exercise program. Tailored patellar taping with rigid strapping offers immediate pain reduction, while other techniques result in only small (untailored medial patellar taping) or negligible (Kinesio) effect.

A commonly used technique involves taping the patella with a medial glide (Fig. 24.4a). It may also require correction of an abnormal lateral tilt (Fig. 24.4b) or inferior tilt (Fig. 24.4c). The taping is performed with rigid strapping tape. It is important that you can recognise a posteriorly displaced inferior pole of the patella, as taping the patella too



Figure 24.4 Apply taping to the patella. (a) medial glide, (b) medial glide, (c) medial glide, (d) medial glide, (e) medial glide, (f) medial glide, (g) medial glide, (h) medial glide, (i) medial glide, (j) medial glide, (k) medial glide, (l) medial glide, (m) medial glide, (n) medial glide, (o) medial glide, (p) medial glide, (q) medial glide, (r) medial glide, (s) medial glide, (t) medial glide, (u) medial glide, (v) medial glide, (w) medial glide, (x) medial glide, (y) medial glide, (z) medial glide.

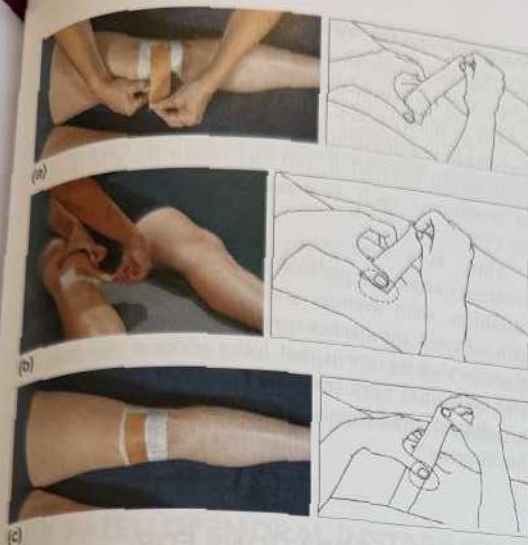


Figure 24.4 Patellar taping techniques. (a) *Medial glide.* Apply tape to the lateral aspect of the patella. Glide the patella medially and anchor the tape to the skin over the medial aspect of the knee. When taping is completed, skin creases should be evident on the inside of the knee, indicating adequate tension on the patella. (b) *Correction of lateral tilt.* Apply tape to the medial aspect of the patella and secure to the soft tissue on the inner aspect of the knee. (c) *Correction of inferior tilt.* Apply tape across the superior pole of the patella with sufficient firmness to elevate the inferior pole.

low will increase the patient's symptoms. Taping to "unload" the fat pad (effectively to "lift" the patella away from the fat pad) can also be done, either alone or in conjunction with the above techniques (see Figure 25.9 in Chapter 25).

Box 24.2 contains some useful tips on taping.

Bracing

Knee braces (Fig. 24.5) customised to produce biomechanical effects (e.g. reduce patellar displacement, increase patellar contact area⁸¹ and reduce PFJ stress)⁸² do not provide any benefit over a "sham" knee sleeve or a general quadriceps strengthening program for patients with PFP.⁸³

However, a recent high-quality randomised controlled trial reported that a commercial knee brace led to clinically important reductions in fear of movement for patients with PFP compared with a wait-and-see approach.⁸⁴ Braces are less specific than taping and do not specifically address tilt or rotation, but they may have a role for those who are unable to wear tape or who suffer recurrent patellar subluxation or dislocation.

BOX 24.2 Taping tips

- Assess the effect of patellar taping immediately using a pain-provoking activity such as a single- or double-leg squat. If the tape has been applied correctly and is going to be a useful treatment option, the post-taping squat will be less painful. If all or some pain persists, alter the tape, possibly including a component for tilt or rotation, or both. If the tape does not substantially reduce (by at least 50%) the patient's pain, revisit the initial diagnosis.
- If the patient can perform strengthening exercises pain-free without tape, exercises alone will usually correct the abnormality. However, most people require tape initially to perform exercises and continue their sporting activities. Patients with acute PFP may initially need tape applied for 24 hours a day until the condition settles. The tape time can then be gradually reduced.
- Adverse skin reactions can occur beneath the rigid tape. It is important to shave the area to be taped and apply adhesive gauze tape (Hypafix® or Fixomull®) beneath the rigid strapping tape. For those with extremely sensitive skin, an extra protective barrier or plastic skin can be applied before the gauze tape. If skin irritation still occurs, advise the patient to remove the tape. Treatment with a hydrocortisone cream may be necessary. Patients with fair skin seem to have particularly sensitive skin and need to be monitored closely.



Figure 24.5 Patella stabilising knee brace

Manual therapies

Manual therapies, such as joint and soft-tissue mobilisation, manipulation and massage, may relieve symptoms associated with PFP.⁸⁵ Joint mobilisation and manipulation can include patellofemoral or tibiofemoral joint glides and lower quadrant manipulations, while soft-tissue therapies

might involve massage of tight lateral retinacular structures or the fascia/muscles of the thigh (predominantly anterolateral). Applied passively by either the patient or clinician, these techniques are designed to optimise movement and facilitate the exercise program.

When applied by the clinician, the patient may be in a side-lying position with the knee flexed. Glide the patella medially using the heel of your hand for a sustained stretch (Fig. 24.6). Other simple stretching techniques can be performed by the patient, usually sitting with the knee flexed approximately 30–90°. Studies evaluating the efficacy of such techniques applied in isolation do not show benefit,⁶³ supporting the clinical practice to include manual therapy as part of a combined approach to management, rather than in isolation.



Figure 24.6 Mobilisation of the patella (supine or side-lying)

Also pay attention to improving the compliance of the hip flexors, quadriceps, hamstring and calf muscles, as well as the iliotibial band if required, through stretches, soft-tissue techniques (Fig. 24.7) or dry needling. Restoration of optimal muscle and fascial length is the goal. Further detail on soft-tissue techniques including dry needling can be found in Chapter 25 in *Foundations of Clinical Practice*.

Evidence for these interventions can be found at www.clinicalsportsmedicine.com.



Figure 24.7 Soft-tissue therapy—myofascial tension of the iliotibial band

Surgery—to be avoided

Experienced clinicians will have observed that surgery is now much less common for PFP than it was 30 years ago. This is probably due to the availability of evidence-based, exercise-based physical interventions. To date, no surgical randomised controlled trial has shown the effectiveness of treatments such as chondroplasty or lateral release for PFP.

Thus, at a time when systematic reviews (level 1 evidence) argue for physical or exercise therapies for this condition, such avenues should be tried repeatedly, and with different approaches before being abandoned in favour of surgery—a treatment that lacks evidence. We note that poor outcomes have been reported after PFP surgery and our clinical impression is that patients may be worse after that surgery.⁸⁶

24.6 CONSIDERATIONS FOR THE ADOLESCENT WITH PATELLOFEMORAL PAIN

Experiencing PFP as a 13-year-old can be quite different from experiencing it as a 28-year-old. Thus, adolescents require special considerations to optimise their outcomes and support them (and those close to them—family, sporting groups and school). Optimising outcomes involves addressing not only the physical aspects but also the psychological and social factors that can influence their experience and recovery.

The first step is getting their parents involved in the management of their symptoms. Managing a persistent pain condition can be challenging for adolescents and involving their parents is often crucial to help them navigate the situation successfully.⁸⁷

For example, most adolescents with PFP have a great desire to continue being part of their sporting team and associated social circles. What will they do if they are asked to reduce their sports participation for a short period? Will they comply, or will it be too difficult being away from their team? The roles of the parent, coach and clinician can be vital to help the adolescent to remain part of the team despite being unable to participate at their usual level. Collaboration between the adolescent, parents, coach and clinician is key to ensure successful management.⁸⁸

Importantly, research demonstrates that compliance with exercise-based interventions is poor among adolescents.⁸⁹ Enlisting the parents' support to help with compliance can be vital. This can be achieved by discussing with them how they can best support their child.

Note that most research is based on adults, and we should be careful extrapolating the findings to the adolescent population. To date the key finding is that patient education and activity modification may be more relevant among this population, while exercise therapy targeting the hip and knee muscles may not be as effective among adolescents as in adults.¹³

24.7 PATELLOFEMORAL OSTEOARTHRITIS

Patellofemoral pain may lead to the development of patellofemoral osteoarthritis, which is probably under-recognised clinically. It may also develop following ACL injury and surgery. Patellofemoral osteoarthritis is discussed more fully in Chapter 23.

24.8 PATELLOFEMORAL INSTABILITY

As is the case with the shoulders, "instability" is not a synonym for "dislocation". It describes excessive joint range of motion (and is often referred to as subluxation). Patellofemoral instability may be primary (patellar subluxation) or secondary (due to previous acute patellar dislocation; see Chapter 22).

Primary patellofemoral instability

Factors that predispose to primary patellofemoral instability include patella alta (a patella that is located more superiorly than normal), trochlear dysplasia and generalised ligamentous laxity. Patients usually describe a sensation of instability (the patella moving or slipping) and the pattern of tenderness around the patella may be similar to PFP, or more generally distributed. Examination reveals patellar hypermobility with apprehension and pain when you push the patella laterally.

Treatment

PRACTICE PEARL

Rehabilitation to improve active support for the patella is paramount, as dominant predisposing factors such as bony morphology and ligamentous laxity cannot be modified. Active support refers to muscular control at the knee and proximally (hip, pelvis). This affects the patient's movement pattern and reduces the lateral (dislocating) force on the patella.

Treatment parallels that for PFP. The aim of acute management is to reduce pain and swelling. Patellar taping in combination with a knee extension brace may provide temporary immobilisation after an initial episode.

The patient may use crutches for either partial or non weight-bearing. Rehabilitation requires a comprehensive multimodal approach, as outlined for PFP (above), to be commenced as soon as possible.

In an acute situation, biofeedback and/or electrical stimulation may be required as an adjunct to quadriceps retraining. Taping (and/or bracing) may be part of long-term management. It is also vital to address any other relevant muscle function impairments (e.g. trunk and lower limb strength and endurance) and altered movement patterns while providing advice to avoid aggravating activities and ensure graduated loading.

Surgery is rarely indicated. Surgical approaches aim to correct the predisposing factors, and techniques used include arthroscopic medial plication. Bony realignment procedures including trochleoplasty have largely lost popularity in Scandinavia and Australia, but are performed in the US and elsewhere.

These interventions often do not have favourable outcomes, so should only be considered if a properly managed conservative program fails. If the athlete does opt for surgery, an intensive rehabilitation program is vital.

Secondary patellofemoral instability

Secondary patellofemoral instability results from a primary dislocation episode (see Chapter 23 for acute management) which ruptures the medial patellofemoral ligament—the main static restraint to lateral patella translation. It acts like a guy rope on a tent. Individuals with persistent patellofemoral instability after an acute dislocation may require additional investigations. Radiographs may reveal osteochondral damage to the articular surface of the patella and femur, as well as predisposing anatomical abnormalities.

Arthroscopy may be required to remove a loose osteochondral fragment and, if appropriate, the medial patellofemoral ligament may require reconstruction.⁹⁰ Surgery should be followed by intense rehabilitation, following the same guidelines as for primary patellofemoral instability.

There is evidence that in adults, surgical management of primary patellar dislocation decreases the risk of recurrent dislocation.⁹¹ However, a 2023 systematic review demonstrated no difference in outcome comparing surgery with conservative management for adolescents and children following patellar dislocation.⁹²

24.9 LESS COMMON CAUSES OF ANTERIOR KNEE PAIN

PFP and patellar tendon injuries (Chapter 25) make up the two most common causes of anterior knee pain in athletes. Other less common causes of anterior knee pain are considered in Chapter 25. Here we touch on two conditions often mistaken for PFP—synovial plica syndrome and bipartite patella.

Synovial plica syndrome

The importance of the synovial plica, a synovial fold found along the superomedial edge of the patella (see Fig. 24.8), has been a matter of considerable debate. An inflamed plica may cause variable sharp pain located anteriorly, medially or posteriorly.

The athlete may complain of sharp pain on squatting, and it can mimic quadriceps tendinopathy. On examination, the plica is sometimes palpable as a thickened band under the medial border of the patella and will often be tender.

Only consider it as the primary cause of the symptoms if the patient fails to respond to appropriate non-surgical management for PFP (for a minimum of 12 weeks). In that case, a corticosteroid injection into the plica can be considered. Arthroscopy and removal of the synovial plica should be reserved for cases that have persistently not responded to non-surgical approaches.

Bipartite patella

Bipartite patella is a congenital condition that occurs when the two bones of the patella do not fuse together as they

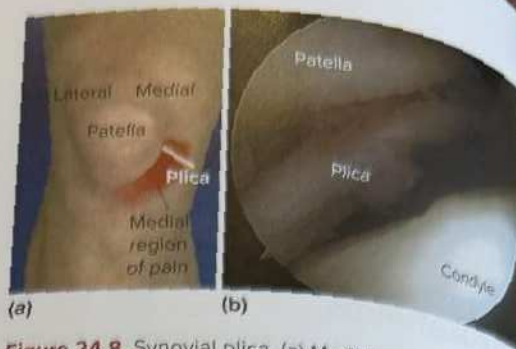


Figure 24.8 Synovial plica. (a) Medial synovial plica presents with pain in the region highlighted (red). A band of tissue may be palpable (+/- tender) running from the medial patella to the epicondylar region (white). (b) A frayed, thickened synovial plica photographed at arthroscopy. It catches between the patella and the femoral condyle.

normally would during early childhood. It is relatively common, affecting about 2–5% of the population, and is usually asymptomatic. However, in athletes, especially adolescents, it can become symptomatic following heavy loading activities, such as downhill running.

Diagnosis can be made on radiography or MRI. Initial treatment options include rest, exercises (stretching and strengthening), non-steroidal anti-inflammatory drugs, bracing and immobilisation. Surgery, such as open or arthroscopic excision, lateral retinacular release or open reduction internal fixation, is rarely necessary.⁹³

KEY POINTS

- Anterior knee pain is one of the most common musculoskeletal conditions. The two most common causes are PFP and patellar tendinopathy, which have similar attributes, but rarely occur together.
- As with other chronic pain conditions, PFP may best be understood through a biopsychosocial lens. Tissue damage does not fully explain the pain experience for people with PFP.
- The onset of PFP often coincides with an increase in training or exercise. This makes load management a key part of treatment.
- Impairments in muscle function may also contribute to the development of PFP, so muscle strengthening and movement retraining are also an important part of treatment.
- Medical imaging is of relatively little value in diagnosing and treating anterior knee pain. Obtaining a comprehensive history and conducting a skilful focused physical examination are crucial for treating the athlete with anterior knee pain.
- Key clinical clues in the history and presentation of symptoms can guide you to differentiate between PFP and patellar tendinopathy.

- Conservative treatment is the cornerstone of addressing PFP. Priorities include an initial reduction in pain and swelling, followed by a targeted exercise program.
- Tailored rigid patellar taping should immediately reduce pain.
- Adjunctive therapies that may be combined with an exercise program include manual therapy, needling, joint mobilisation and stretching.

REFERENCES

References for this chapter can be found at www.mhprofessional.com/CSM6e



Scan here to access additional resources for this topic and more provided by the authors

- Surgical interventions should be considered a last resort. Has the patient seen a non-operative specialist in patellofemoral pain?
- Patellar instability shares some similarities with PFP, but is caused by a different mechanism. Treatment strategies are similar.
- Less common causes of anterior knee pain that may be mistaken for PFP include synovial plica syndrome and bipartite patella.

CHAPTER 25

Patellar tendinopathy

with KARIN SILBERNAGEL and PAUL BLAZEY

CHAPTER OUTLINE

- 25.1 Patellar tendinopathy
- 25.2 Clinical approach
- 25.3 Management
- 25.4 Less common causes of anterior knee pain

LEARNING OBJECTIVES

By the end of this chapter you should be able to:

- differentiate between patellar tendinopathy and other sources of anterior knee pain
- recognise risk factors for developing patellar tendinopathy
- conduct a comprehensive assessment of the athlete with anterior knee pain
- engage in shared decision making to determine whether the athlete can continue to play sport while undergoing rehabilitation
- prescribe a course of exercise-based rehabilitation, supported by management of the athlete's training load, biomechanical corrections and possible adjunct therapies
- monitor the athlete's rehabilitation progress across various domains
- recognise less common causes of anterior knee pain.

In this chapter, we outline how management of the athlete with patellar tendinopathy requires thorough clinical and functional assessment and detail how an appropriate loading prescription is the bedrock of long-term management.

25.1 PATELLAR TENDINOPATHY

Substantial advances have been made in the management of patellar tendinopathy in the past few decades. In the 5th edition of *Clinical Sports Medicine*, we noted that patellar tendinopathy greatly impaired the career of tennis great, Steffi Graf. Reflecting the improvement in management, Rafael Nadal managed the condition since at least 2009 and carried it to win many more Grand Slam titles. Patellar tendinopathy need not end a professional career, but it does require skilled management.

Nomenclature

Patellar tendinopathy is also known as “jumper’s knee” due to its prevalence in jumping sports.^{1–3} A consensus statement on clinical terminology recommended that the term “tendinopathy” be used for conditions with persistent tendon pain and loss of function related to loading activities.⁴

Patellar tendinopathy can occur at both the origin and insertion of the patellar tendon (Fig. 25.1) and should be differentiated from quadriceps tendinopathy, patellofemoral pain and Osgood-Schlatter disease (in adolescents).

Risk factors for patellar tendinopathy

Relative excess mechanical load is the key risk factor for developing patellar tendinopathy. Activities that place high, repetitive stress on the patellar tendon, such as basketball, volleyball, soccer and jumping sports (e.g. high jump or triple jump), increase the risk of patellar tendinopathy. Downhill running causes the quadriceps to place large braking loads on the anterior knee and can cause patellar tendinopathy (but more often patellofemoral pain).

In addition, poor lower-limb biomechanics, including improper alignment of the hip, knee or foot, may increase the likelihood of developing patellar tendinopathy due to the increased forces across the anterior knee.⁵ Muscle flexibility or strength imbalances, such as weak hip or quadriceps muscles, reduced hamstring or quadriceps flexibility and poor ankle dorsiflexion, may contribute to patellar tendinopathy by creating excess strain on the tendon, but the evidence for these being modifiable risk factors is unclear.⁶

Extrinsic factors that may further exacerbate the risk of developing patellar tendinopathy include not performing a warm-up (or having a sub-par warm-up routine); improper



Figure 25.1 Sites of tendon pathology in the knee extensor mechanism. The most common presentation is patellar tendinopathy. Pain at the distal tendon (tibial tuberosity) can be associated with spondyloarthropathies.

training technique such as “stiffer landings” characterised by higher knee angular velocities, faster ankle plantar flexor and knee extensor moment development, and higher loading rates during landing;⁷ and a sudden increase in training intensity +/- duration.

Finally, being overweight or having a high body mass index (BMI) can increase the load on the tendon during physical activity, increasing the potential to develop tendinopathy.

Clinical features

Table 25.1 outlines the common features on history taking and physical examination of patellar tendinopathy. The key to making an accurate clinical diagnosis is that the athlete complains of well-localised (focal) pain in the tendon close to the distal pole of the patella, or at the distal attachment to the tibia (less common); see Figure 25.1. Pain in the mid-substance is rarely reported. Athletes will report that their pain and stiffness are load-related and aggravated by jumping, changing direction and decelerating. The hallmark sign of patellar tendinopathy is that the athlete’s pain and stiffness dissipate following a warm-up.

TABLE 25.1 Clinical features of patellar tendinopathy

Clinical feature	Often found in patellar tendinopathy
Onset	Following activities involving running with repetitive jumping, sharp change of direction or downhill
Pain/stiffness	Located at the inferior pole of the patella, but decreases or disappears following warm-up
Tenderness	Localised to the inferior pole of the patella, although can be tender in athletes without tendinopathy
Swelling	May have thickening of the tendon, but no joint swelling
Crepitus	No
Giving way	Rare—only following long-term quadriceps weakness or inhibition
Knee range of motion	Normal
Patellofemoral joint movement	Normal
Functional testing	Athletes are likely to report pain with decline squat testing, or during resisted knee extension

25.2 CLINICAL APPROACH

You can evaluate tendinopathy using nine core domains that reflect the athlete's physical, psychological and overall wellbeing.⁸ The domains are:

- the athlete's rating of the condition
- pain on activity/loading
- participation in daily activities, work and sport
- function (a subjective rating from the athlete)
- psychological factors
- disability
- physical function (an objective rating including aspects such as muscle strength)
- quality of life
- pain over a specified time frame.

Much of the information that informs your assessment of the domains can be captured during the patient subjective assessment or using appropriate patient-reported outcome measures (PROMs).

Physical examination

To assess physical function, assess for weakness of the lower-limb muscles, including the calf, quadriceps, hamstring and gluteal muscles. A loss in muscle strength in any of these muscle groups can result in dysfunction of the kinetic chain, especially in its ability to function as a coordinated spring or its "plyometric capacity" (important for running and jumping tasks). Assessing lower limb symmetry during running or jumping (e.g. using force plates) may also be useful, as asymmetry can overload one side of the body. Strength and plyometric deficits may predispose to or be a consequence of pain, but either way they are important to assess so that they may be addressed during rehabilitation.

Some athletes with patellar tendon pathology are not tender on palpation at the junction between the patellar tendon and the patella, so testing through palpation alone does not have perfect sensitivity. However, most athletes with patellar tendinopathy will be tender on palpation, especially at the inferior pole of the patellar tendon (Fig. 25.2), so it is useful to assess for pain on palpation to support an accurate diagnosis. Pain on palpation should not be used as a reliable outcome measure to assess the response to rehabilitation.⁹

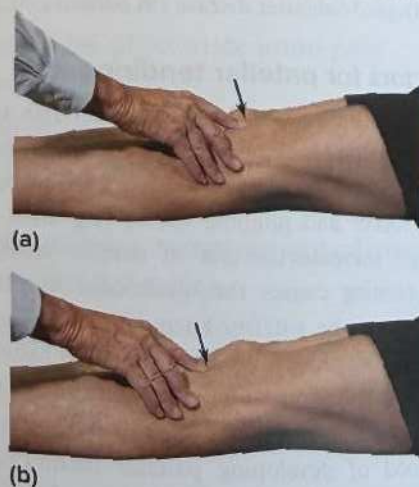


Figure 25.2 Patellar tendinopathy is most often associated with pain at the inferior pole of the patella (a), but may occasionally present at the insertion of the patellar tendon onto the tibial tubercle (b).

PRACTICE PEARL

Pain on palpation is a useful screening test: this may be patellar tendinopathy.

To make a clinical diagnosis of patellar tendinopathy you should be able to reproduce the athlete's focal pain when placing high loads on the tendon. The single-leg decline squat places the highest loads on the patellar tendon¹⁰ and can be considered as the best test for those who can tolerate higher loads (Fig. 25.3). For those who can tolerate symptoms, you can assess function using progressively higher tendon loads through functional activities such as a low step-down (10 cm), two-leg full depth squat, two-leg forward repeated jump and one-leg repeated forward hop (see Box 25.2 later in the chapter for a list of progressive tendon loading exercises).



Figure 25.3 The decline squat maximises patellar tendon load and can be used for diagnosis, monitoring and treatment. Arrow indicates that the athlete flexes the knee in the decline squat.

Use functional tests to assess the athlete's ability to complete the task with good form and whether the test reproduces their pain. In patellar tendinopathy the pain should remain localised. If the pain becomes diffuse, for example if the pain spreads to other areas of the knee with loading, consider other diagnoses.

Investigations

The patellar tendon is frequently thickened in its proximal central portion (area of tenderness) and this can be visualised using ultrasound or MRI. Any tendinopathic changes on imaging must be correlated with the athlete's presentation (particularly pain) and any recent change in their activities (e.g. higher tendon loads). Ultrasound can be performed in the clinical consultation, which enables correlation between the imaging and clinical symptoms.



Figure 25.4 Ultrasound images of patellar tendon (outlined) in the axial plane: (a) healthy tendon in an asymptomatic athlete; (b) pathological tendon (abnormally large cross-sectional area) in a symptomatic athlete.

It also enhances clinician-athlete communication and provides an opportunity for athlete education.

In sports such as volleyball and basketball, up to 50% of asymptomatic players have patellar tendon imaging "abnormalities". These load-related changes do not constitute "pathology" on their own. However, asymptomatic individuals with these ultrasound changes have a five-times greater risk of developing patellar tendinopathy.¹¹

Structural and mechanical changes in tendons affect quadriceps performance and lower extremity function.¹² Cross-sectional area can be assessed using ultrasound and it provides a useful way to monitor the tendon during treatment: decreasing cross-sectional area is a sign of tendon recovery (see Fig. 25.4).

25.3 MANAGEMENT

Management will vary depending on whether the athlete can keep competing in their sport or finds the symptoms severe enough to withdraw from competition to focus on rehabilitation. Three factors determine whether they can keep competing:

- pain severity
- impact on function
- performance level (Table 25.2).

TABLE 25.2 Scenarios demonstrating the utility of the three factors (pain, function, performance level) that support shared decision making in the presence of patellar tendinopathy

Scenario	Pain	Function	Performance level	Clinical decision	Management strategy
Scenario 1 (often long term)	Severe	Severely limited, even with activities of daily living (walking up/down stairs)	Poor	Unable to compete—athlete understands they cannot play	Begin comprehensive out-of-competition rehabilitation program
Scenario 2 (often medium term)	Tolerable and stable	Moderately to severely limited	Adequate	Continue to compete but modify training/competition based on pain monitoring model; athlete may be at risk of aggravating the tendon or suffering further injury (due to compensatory movements, etc.)	Maintain or improve function via tendon loading exercises; evaluate sports biomechanics and address deficits if possible, or maintain stable pain levels and address biomechanical deficits in the off-season
Scenario 3 (more recent onset of symptoms)	Fluctuates based on activity level	Minimally to moderately limited	Normal to minor deficits	Continue to compete, guided by pain monitoring model	Maintain function via tendon loading exercise; tendon loading needs to be modified to account for symptoms more than in scenario 2; assess sports biomechanics and address deficits if possible, or maintain stable pain levels and address biomechanical deficits in the off-season

Often, athletes will want to keep competing and while sometimes it is appropriate to support this, there are times when the better shared decision is for the athlete to withdraw from training and competition to undergo comprehensive rehabilitation. The athlete's decision to withdraw from training and competition should be framed with a focus on improving future performance, or beginning the next competition with minimal/no tendinopathy symptoms.

Monitoring tendinopathy to support clinical decision making

Tendinopathy should be measured against nine core health-related domains (see Section 25.2).⁸ PROMs that

target four of these domains (pain over time, quality of life, participation and psychological factors) are listed in Table 25.3.

Pain on loading, physical capacity and function testing (hallmarks of traditional clinical assessment) remain important. Pain while performing the single-leg decline squat (Fig. 25.3) is particularly useful. Additional physical capacity and function outcome measures to consider are listed in Table 25.4. In athletes, some of the physical capacity measures will overlap with performance tests.

Subjective ratings of pain and functional capacity, as well as the impact on psychological factors, can be measured

TABLE 25.3 Patellar tendinopathy PROMs

Domain	Outcome measure	Description
Pain/symptom severity	Victorian Institute of Sports Assessment Patellar (VISA-P) questionnaire	8-item questionnaire with score 0–100 (higher score means fewer symptoms and greater function)
Quality of life	Knee injury and Osteoarthritis Outcome Score–Quality of Life subscale (KOOS-QOL)	4-item subscale of the KOOS outcome measure
Participation	Knee injury and Osteoarthritis Outcome Score–Activities of Daily living and Sports subscales (KOOS-ADL, KOOS-Sport)	17-item (ADL) and 5-item (Sport) subscales of the larger KOOS outcome measure assessing different participatory constructs
Psychological factors	Depression, Anxiety and Stress Scale (DASS-21)	21 questions in 3 subscales with score 0–63 (higher score indicates greater degree of negative emotional state)

TABLE 25.4 Clinical tests to measure the athlete's pain, physical capacity and function

Pain, physical capacity or function tests	Measurement tool
Pain with loading	Ask the athlete to assess their pain during the single-leg decline squat on a numerical pain rating scale. Document the amount of pain and the range at which the pain occurs.
Quadriceps strength	Quadriceps maximal voluntary isometric contraction Use an isokinetic dynamometer to assess knee extension strength (suggested measures taken at 90° hip flexion and 60° knee flexion for repeated testing purposes).
Hip/ankle strength	Use an isokinetic dynamometer looking at hip flexion, extension, abduction/adduction and internal/external rotation. Pay particular attention to force production of the ankle plantar flexors as the key muscle group attenuating ground reaction forces during gait.
Kinetic chain assessment	Observe kinematics during landing. This may be supplemented with 3D-motion analysis and force plates for more objective data to look for risk factors such as "stiff" landings during jumping tasks.
Single-leg counter-movement jump	Measure jump height and compare bilaterally. How to measure: single-leg jump from standing with hands behind back to prevent compensatory arm swing. Measurement usually requires force plates, wearable technology or phone application with appropriate video analysis tool.
Single-leg drop counter-movement jump	Measure jump height after "dropping" off a 20 cm high box and then jump as high immediately after landing.
Limb symmetry index	Use force plates or wearable technology (e.g. some commonly available sports watches).

daily or weekly depending on the clinical need and resources available. You may choose to pair these measures with less frequent assessments using validated PROMs such as the VISA-P (condition specific)¹³⁻¹⁵ or KOOS (joint or region specific).¹⁶

Allowing the athlete to continue playing in-season

There are many situations where the clinical team (clinician, athlete and coach) will attempt to keep the athlete playing (e.g. during a key competition phase for the athlete or team). You should discuss the key elements of treatment with the athlete and explain that they are unlikely to have complete relief of pain during the season. The coach should monitor performance, and together the clinical team can adjust treatment and competitive demands to account for pain and symptoms.

In-season management of patellar tendinopathy requires maintenance (or improvement) of strength in the affected muscle-tendon unit and the rest of the kinetic chain (muscles that support the dynamic movements associated with the athlete's sport). Overall load reduction (accounting for both competitive and occasionally lifestyle-related loads associated with physical activity), correction of biomechanical factors, and adjunct therapies such as soft-tissue therapy to the affected muscle (not the tendon) are also appropriate.

Tendon-loading exercises will need to be adjusted since adding more load to training without adjusting overall

load may be detrimental (i.e. it can increase rather than decrease symptoms). The tendon is frequently subjected to repetitive loads during training and competition, so a judgment call needs to be made whether the additional stress provided by resistance training is best advised (Box 25.1).

Is there a role for corticosteroid injections as part of in-season management? While they can provide almost immediate and short-term pain relief, they are also associated with worse long-term (12-month) outcomes in tendons compared with "wait-and-see" treatment.¹⁷⁻¹⁹

Therefore, the hallmarks of in-season management of patellar tendinopathy are relative load reduction, biomechanical correction and exercise rehabilitation (+/- specific tendon loading exercises).

Relative load reduction: activity modification

There are numerous ways of reducing load on the patellar tendon. Athletes should modify their training and perhaps game time, reducing the amount of jumping or sprinting in a session, the number of high-load days each week or the total weekly training hours.

Absolute rest is contraindicated as it is detrimental for recovery and the athlete's overall functional capacity and health. Continued activity that does not include large amounts of jumping, changes of direction or deceleration is critical to maintain tendon integrity, kinetic chain function and cardiovascular fitness. Understanding the different magnitudes of load placed on the patellar tendon during

BOX 25.1 Dr Karin Silbernagel's pain monitoring model

Many practitioners use Dr Karin Silbernagel's pain monitoring model¹ to help manage tendinopathy in athletes who are competing. This relies on understanding that pain and stiffness during rehabilitation are normal. However, severe symptoms are not and may indicate a more reactive phase of the tendinopathy that could benefit from reducing load and focusing on rehabilitation away from competition.

The pain monitoring model divides pain intensity into safe (0–2), acceptable (>2 up to 5) and high-risk (>5) zones based on the athlete's perception of their pain using a numerical pain rating scale (0–10). However, as clinical decisions whether to continue activity are generally based on a pain score above or below 5/10, we suggest instead that an acceptable/unacceptable cut-off is considered on a case-by-case basis, so that the level of tolerance is individualised for each athlete (Fig. 25.5).

Have the athlete monitor their symptoms for 24 hours after exercise and evaluate their pain response. If pain

remains below their acceptable threshold (e.g. 5/10) and is stable or decreasing, they may progress their exercise and sport-specific activity levels. If the pain is above their acceptable threshold and/or is increasing gradually, they should regress their current exercises/activities, or maintain but not increase their current level (if able to do so).

Using the pain monitoring model enables the athlete to adjust their activity levels intuitively, allowing for ad-hoc recovery days between heavy exercise loads.

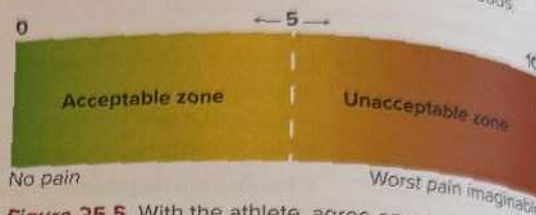


Figure 25.5 With the athlete, agree on an acceptable pain threshold and use the scale to adjust activities based on the athlete's 24-hour response to activity/load

various activities will guide what exercises to perform and how to progressively return to sporting activities (see Box 25.2 later in the chapter).

Since patellar tendinopathy is an overuse condition, it is important to adjust running and jumping activity during rehabilitation to achieve recovery without making the condition worse. Use the pain monitoring model to help decide how much running and jumping the athlete can maintain as they undergo rehabilitation. It is vital that the athlete and coach plan for recovery days from heavy loading activity.

Alongside the pain monitoring model, you might consider using ratings of perceived patellar tendon exertion (rated on the Borg scale). This recommendation is based on the premise that the tendon might need additional recovery time beyond that which is apparent from resolution of tendinopathy symptoms and muscle soreness. Using a tissue-specific rating of perceived exertion can help guide the need for recovery days between heavy loading activities. Table 25.5 demonstrates a way of classifying activities and using pain to support decisions

TABLE 25.5 Guide for planning recovery days from activities that place a heavy load on the patellar tendon

	Classification of activities		
	Light	Medium	High
Pain level during activity, NPRS 0–10	1–2	2–3	4–5
Pain level after activity (next day), NPRS 0–10	1–2	3–4	5–6
The athlete's RPE (with regard to their tendon) 0–10	0–1	2–4	5–10
Recovery days needed between activities	0 (can be performed daily)	2	3
Examples of activities	Walking, cycling, light jogging on flat surface	Submaximal plyometric activities, mainly 2-leg jumps	20–30 min of sports activity on the field (basketball, volleyball) at pre-injury level of participation

NPRS, numerical pain rating scale; RPE, rate of perceived exertion.

over how many recovery days are required before the next bout of heavy-loaded training or exercise.

Biomechanical correction

To help the athlete improve the energy-absorbing capacity of the limb, consider not only the knee but also the hip and ankle. The calves are critical in absorbing the initial load transferred to the body during landing (e.g. during running or jumping). Improving the capacity of the calves to absorb loads can reduce the load transmitted to the knee.²⁰ Biomechanical studies reveal that around 40% of landing energy is transmitted proximally, to the knee and above.^{21,22} Thus, the calf complex and especially the soleus must function well to prevent excessive load being placed on the patellar tendon.

Biomechanical correction should include assessment of both anatomy and function.^{23,24} Landing with a stiffer pattern is common in athletes with patellar tendinopathy and this pattern increases knee joint loading. Better landing technique can decrease patellar tendon load. Compared with flat-foot landing, forefoot landing generates lower ground reaction forces and, if this technique is combined with a large range of hip or knee flexion, vertical ground reaction forces can be reduced by a further 25%.²⁰ Landing with the body's centre of mass over the foot and with the ankle dorsiflexed may decrease patellar tendon load.^{22,25}

Anatomical variants that may contribute to persistent patellar tendinopathy include limited ankle dorsiflexion and hallux rigidus. Tight hamstrings, quadriceps and calf muscles may increase the load on the patellar tendon. Allowing the trunk to flex on landing decreases patellar tendon loading.²⁶ However, focusing solely on biomechanical correction without addressing kinetic chain strength and capacity will ultimately deliver an undesired outcome.

For distance runners with patellar tendinopathy, a lower profile running shoe can reduce patellar tendon forces leading to less pain. The lower heel-to-toe drop and reduced stack height facilitate forefoot landing and shift forces from the knee to the ankle (mostly the calf and Achilles complex).^{27,28} Note that this shoe type can aggravate Achilles, tibialis posterior or peroneal tendinopathy.

Exercise rehabilitation

Exercise rehabilitation is the cornerstone treatment for tendinopathy in general and patellar tendinopathy specifically. Several protocols described in the literature (isometric exercise, decline squat protocol, eccentric exercise protocol, heavy or moderate slow resistance

exercise) seem to have similar outcomes. The underlying premise behind the various exercise programs is that the tendon needs to undergo mechanical loading to promote structural remodelling, relieve symptoms and improve function.

Loading that promotes increased strain (stretch) of the tendon for longer durations seems to result in superior results, but in recent studies comparing loading protocols they all showed similar outcomes. In general, the type of muscle contraction used to load the tendon does not seem to influence the outcome, so focus on progressing the load of exercise based on the individual's deficits and response to the program (Box 25.2).

PRACTICE PEARL

Aim to progress quickly to single-leg (affected leg) exercises to prevent the athlete unloading the affected tendon in "double leg" activities.

Therapists often have concerns as to when and how they should begin a strengthening program. Start by assessing the athlete's pain using the pain-monitoring model (Box 25.1).^{1,30}

Even an athlete with the most severe case of patellar tendinopathy should be able to begin some weight-based strength exercises, and calf strength and isometric quadriceps work, immediately. Reassure them that this should have a positive effect on subsequent symptoms. If their pain is under control, it is essential to monitor the ability of the limb to complete the exercises with control and quality.

Athletes with patellar tendinopathy tend to "unload" the affected limb to avoid pain, so they commonly have not only weakness but also abnormal motor patterns that must be reversed. Aberrant motor patterns such as "stiff landing" mechanics and poor pelvic control are among the most common. For example, weight-bearing exercises should repeat sport-specific or adjacent exercise patterns. While the athlete is performing these exercises, you can watch and help correct movements such as contralateral pelvic drop or "cheating" (favouring a side when the movement should be symmetrical). You should incorporate single-leg exercises early. Thus, exercises that target the quadriceps specifically, such as single-leg knee extensions, may have a place in the rehabilitation of patellar tendinopathy.

BOX 25.2 Progressive loading of the patellar tendon

Progressive tendon loading is effective for improving patellar tendon function and pain.²⁹ Knowing which exercises place the most load on the patellar tendon is informative when making decisions about when to progress athletes from one exercise to the next. Progressive tendon loading can broadly be broken down into four stages for exercise prescription: (1) isometrics, (2) isotonic, (3) plyometrics and (4) sport-specific exercises (see Table 25.7 later). It is important to maintain exercises from stages 1 and 2 throughout the rehabilitation program, as examples such as the Basas Spanish squat, despite being a stage 1 isometric, place a high load on the tendon (see Box 25.3), promoting tendon adaptation.

Exercises that load the patellar tendon have been assigned intensity scores (a loading index) based on their respective loading peak (highest force of a single repetition), loading impulse (a measure of the total force produced over time during each repetition) and loading rate (the fastest acceleration in force during a repetition).¹⁰

Figure 25.6 lists exercises for three of the four stages. Note the higher-load (green boxes at the top) and lower-load (green boxes at the bottom) exercises: these provide options to progress loading for athletes with patellar tendon pain. Use the pain monitoring model (Box 25.1) to assess the athlete's response to load; this allows you to titrate the exercise prescription.

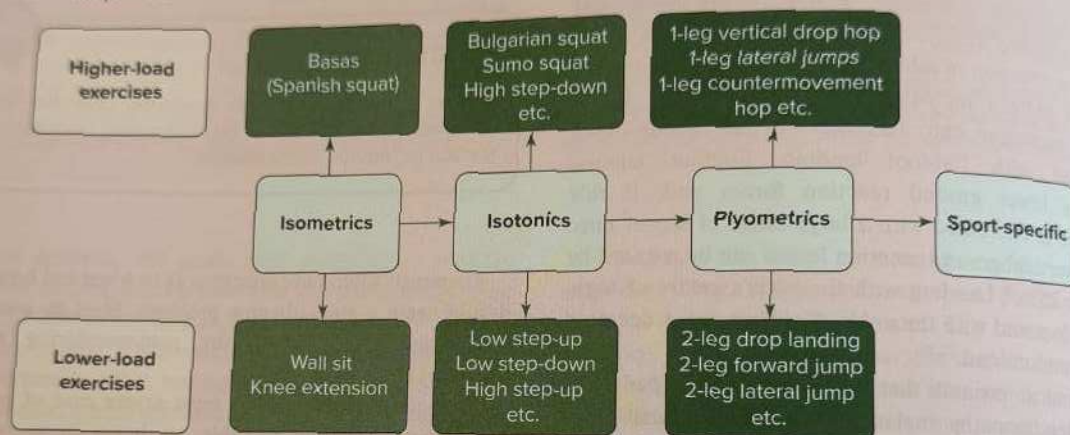


Figure 25.6 An approach to progressive loading of the patellar tendon, mixing the "jumper protocol" with exercise-specific data from the patellar tendon loading indices of Scattone-Silva et al.¹⁰

Common errors in rehabilitation strength programs are listed in Table 25.6.

Which exercises you chose will depend on the equipment available, the athlete's previous and current activity levels and their sport-specific demands (i.e. if a sport requires high plyometric loads, the athlete will need to be prepared accordingly during rehabilitation).

The Basas Spanish squat (Box 25.3) is a challenging exercise to perform because of the long isometric hold (the time under tension for the quadriceps muscles) but it is often less painful than other exercises. It is proposed that it should be used during all stages of rehabilitation.

End-stage exercises (such as those listed as "high load" in Figure 25.6) can provoke tendon pain and are only

TABLE 25.6 Reasons why rehabilitation programs may fail at various stages

Early failure	Late failure
Insufficient strength training	Failure to monitor the athlete's symptoms
Progression of rehabilitation program is too quick	Rehabilitation and strength training end on return to training, instead of continuing throughout the athlete's return to sport
Inappropriate loads during rehabilitation (too little, too much)	No speed rehabilitation Plyometrics training performed inappropriately and is not tolerated or unnecessary

BOX 25.3 The case for isometrics such as the Basas Spanish squat

One of the difficulties with using exercise to load the tendon (produce strain on the tendon) is knowing whether the exercise actually strains the tendon. Muscle inhibition (particularly of the quadriceps) due to pain often results in other muscle compensating to maintain the athlete's overall force production.

The Basas Spanish squat (Fig. 25.7) has promising results. Performing the squat with superimposed neuromuscular electrical stimulation enhances its efficacy. The strain in the patellar tendon doubles when the Basas Spanish squat is performed with neuromuscular electrical stimulation versus without.



Figure 25.7 Basas Spanish squat

recommended after a thorough rehabilitation period and when the athlete's sport demands intense loading (e.g. volleyball). For some sports it may not be necessary to add potentially aggravating activities such as jump training to the rehabilitation program.

Irrespective of whether the athlete is "in" or "out" of their competitive season, the overall strategies are the same. First, thoroughly evaluate the athlete, then educate the athlete and others involved in their care (parents, coaches) on the expectations and plan for treatment. Discuss the key elements of management and time frames for recovery/ eventual return to sport with the athlete, emphasising that there are no short cuts to the recovery of function. Shared decision making is important for compliance and success of treatment.

A four-stage progressive tendon-loading protocol

A four-stage progressive tendon-loading protocol (as per Box 25.2) marries gradual increases in load with the pain monitoring model to track symptoms. This marriage of tendon loading and pain monitoring is superior to the eccentric decline squat protocol and has similar outcomes to other tendon-loading protocols.^{30, 31}

The appropriate stage to initiate the program is based on symptoms, functional deficits and whether or not the athlete is continuing to compete. It is important to progress or regress exercises based on the individual's response. Exercises from stages 1 and 2 should be continued even after the athlete fully returns to sport as a preventive measure. Table 25.7 outlines the four stages.

TABLE 25.7 Four-stage progressive tendon-loading protocol

Stage	Goal	Exercises	Exercise parameters
Stage 1 (0–4 weeks)	Manage symptoms and reduce overall load Address deficits found during evaluation	Isometric exercises, leg extension, leg press, Basas Spanish squat	5 x 45 secs at 60° knee flexion at 70% of maximal voluntary isometric contraction 5–7 days per week
Stage 2 (2–6 weeks)	Recovery phase with progressive tendon loading and isotonic (dynamic) exercises	Leg extension, leg press, squat, step-ups and step-downs (Fig. 25.6)	Progress from 3 x 10 reps with lighter load to 3 x 15; progress knee range of motion in the exercises chosen 3–5 days per week
Stage 3 (4–12 weeks)	Rebuilding phase with progression to energy storage (plyometric activities)	Two-legged jump variations (drop jump, forward, sideways, etc.), progressing to single-leg drop-hop, countermovement jump, hurdles, etc.	Continue isotonic exercises but progress from 15 reps lighter weight to 6 reps with heavier weights as tolerated; progress from double- to single-leg activities; include light amounts of plyometric work starting at 2 x 6 reps per exercise. 2–3 days per week
Stage 4 (12+ weeks)	Return to unrestricted sports participation	Sport-specific exercises	Progress from return to field (individually) to return with team (restrictions), to full participation

Adjunct treatments for patellar tendinopathy

Adjunct treatments to support symptom relief and facilitate the effectiveness of the hallmark patellar tendinopathy treatments outlined above are common, even if not all are well supported by research.

Neuromuscular electrical stimulation

Neuromuscular electrical stimulation has emerged as a potential adjunct to consider alongside progressive tendon loading. Neuromuscular inhibition of the quadriceps can accompany patellar tendinopathy and may inhibit effective rehabilitation as the athlete struggles to voluntarily load the area without shifting forces to surrounding muscles.¹² Neuromuscular electrical stimulation applied to the quadriceps during maximal voluntary contraction can ensure that all motor units are recruited and the athlete is able to circumvent any inability to fully recruit the desired muscles. This ensures maximal loading to the patellar tendon, which in turn may support additional healing (via increased tenocyte activation).

PRACTICE PEARL

Neuromuscular electrical stimulation applied to the quadriceps during exercises can help ensure that the athlete effectively loads through the quadriceps and patellar tendon during exercise rehabilitation.

Soft-tissue therapy, cryotherapy, pharmacotherapy and taping

Massage can be used for muscle soreness resulting from resistance training, but ice is of little benefit during rehabilitation. Medications and taping generally have limited value in the rehabilitation of tendinopathy, and medications such as non-steroidal anti-inflammatory drugs may even be detrimental to the long-term resolution/healing of tendons.^{32,33}

Injection therapy

Neovascularisation is a cornerstone of degenerative tendon pathology and is the target of treatment by Alfredson and Ohberg's sclerosing injection.³⁴ In a randomised controlled trial of elite athletes with patellar tendinopathy, sclerosing injections with polidocanol improved knee function and reduced pain.^{35,36} Polidocanol has a neurotoxic effect that may underpin its effectiveness, rather than altering the vascularity.³⁷ This is supported by research showing that tendons that have substantial vascularity can remain pain-free.

In one randomised trial comparing a corticosteroid injection with a placebo injection, the corticosteroid

improved symptoms so much that all 12 athletes who had the placebo injection subsequently received the active agent. Note that after initial improvement, 50% of athletes in the corticosteroid group failed to return to sport and were referred for surgery.³⁸

Blood injection therapy (autologous blood, platelet-rich plasma) is being used clinically, but controlled trials show no additional benefit over placebo injection.³⁹ Prolotherapy and high-volume injections with the addition of tendon cells are being used clinically with little or no quality research to show their efficacy.

Surgery

The only randomised trial comparing surgical treatment and non-surgical management of patellar tendinopathy was published in 2006.⁴⁰ Excision of abnormal tendon tissue provided no benefit over a 12-week eccentric training program. After surgery, return to sport at the previous level cannot be guaranteed (60–80% likelihood).^{41,42} Time to return to the previous level of sport, if achieved, is likely to take between 6 and 12 months.^{41,42} In short, rehabilitation takes time; surgery is *not* a quick fix.

Sudden, acute patellar tendon pain

It can be tempting to use the term "partial tear" clinically when an athlete has a sudden episode of tendon pain that may be rather disabling but the tendon is intact—not a frank tendon tear. However, ultrasound and MRI cannot differentiate between baseline tendinosis (tendinopathy) and a macroscopic partial tear.^{43,44} Thus, we caution against using the term "partial tear" based on imaging, and encourage the athlete to think of it as a "flare-up" of their tendinopathy rather than an escalation to a more severe condition.

This type of clinical episode can be managed as patellar tendinopathy is managed and most patients do well. If pain and dysfunction seem abnormal for more than 2 weeks beyond the acute episode, further imaging may be justified.

25.4 LESS COMMON CAUSES OF ANTERIOR KNEE PAIN

Chapter 24 deals with patellofemoral pain, synovial plica syndrome and bipartite patella, but there are several other potential causes of anterior knee pain you should be aware of.

Bursitis

There are several bursae around the knee joint (Fig. 25.8). The most commonly affected bursa is the pre-patellar bursa. Pre-patellar bursitis presents as a superficial swelling on the anterior aspect of the knee. This must be differentiated from an effusion of the knee joint. Acute infective pre-patellar



Figure 25.8 Bursae around the knee joint

bursitis, common in those who kneel a lot, should be identified and treated quickly. Infrapatellar bursitis can also cause anterior knee pain that may mimic patellar tendinopathy; this bursa forms part of an enthesis organ of the distal insertion and thus can be challenging to treat. Pes anserinus bursitis is often associated with an underlying rheumatological condition.

Mild cases of bursitis can be treated by reducing compressive forces on the bursa (often by reducing exercise-related activities) and with non-steroidal anti-inflammatory drugs. More severe cases require aspiration and infiltration with a corticosteroid agent and local anaesthesia, followed by appropriate treatment of the enthesitis, if appropriate.

Although rare, be mindful of the risk of septic bursitis. Athletes with bursitis who present with a red, hot, swollen anterior knee and other common infection signs (e.g. fever) may require needle aspiration to test the fluid for infection. If infection is present, they require antibiotics, further needle aspiration to drain the infected fluid, and in some cases surgery to remove the bursa.

Quadriceps tendinopathy

Pain arising from the quadriceps tendon at its attachment to the patella occurs mainly in older athletes or in weightlifters, as the quadriceps tendon is loaded more in deep squat positions. It is characterised by tenderness at the superior margin of the patella and pain on resisted quadriceps contraction. Treatment follows the same principles as treatment for patellar tendinopathy. The differential diagnosis includes suprapatellar pain of patellofemoral joint origin, synovial plica syndrome and bipartite patella (see Chapter 24). Rupture of the entire

quadriceps attachment to the patella is not uncommon in middle-aged men (especially those with a history of steroid use) and requires surgery and extensive rehabilitation.

Fat pad irritation/impingement

Fat pad syndrome was reported in JAMA by Hoffa in 1904 as a condition where the *infrapatellar fat pad* was impinged between the patella and the femoral condyle due to a direct blow to the knee.⁴⁶ More commonly, fat pad irritation occurs with repeated or uncontrolled hyperextension of the knee where it is impinged between the femur and the tibia. The condition can be extremely painful and debilitating, as the fat pad is one of the most pain-sensitive structures in the knee.⁴⁷

Chronic fat pad irritation is relatively common but often goes unrecognised. The pain can be exacerbated by extension manoeuvres, such as straight-leg raises and prolonged standing.

Clinical findings include localised tenderness (at the inferior pole of the patella, deep to the tendon) and puffiness in the fat pad with the inferior pole of the patella appearing to be (or actually being) displaced posteriorly. Pain may be reproduced with active knee extension or passive overpressure in extension. Contracting the quadriceps with the knee extended may aggravate the pain during the acute phase. There may be quadriceps weakness. Patients often have hyperextension of the knees (genu recurvatum) associated with increased anterior pelvic tilt.

Treatment should be directed to improve the control, strength and endurance of local (vasti), proximal and distal muscles, as well as retraining to avoid uncontrolled and excessive terminal knee extension manoeuvres.

A popular clinical approach consists of treating the inferiorly tilted patella by taping across the superior surface of the patella to lever the inferior pole forward and relieve impingement of the fat pad (Fig. 25.9a). Unloading of the fat pad may relieve the symptoms further. To unload the fat pad, place a "V" tape below the fat pad, beginning at the tibial tubercle and coming wide to the first medial (one piece of tape) and then the (second piece of tape) joint lines. As you pull the tape towards the joint line, the skin is lifted towards the patella, shortening the fat pad (Fig. 25.9b).

Improving lower limb biomechanics is often helpful. Surgery should be avoided if possible.⁴⁸

Osgood-Schlatter lesion

An Osgood-Schlatter lesion is an osteochondrosis that occurs at the *tibial tuberosity* in adolescents as they progress through puberty. It is much more common among boys of about 13–15 years (but these ages vary) than girls (aged about 10–12). It is caused by excessive traction on the soft apophysis

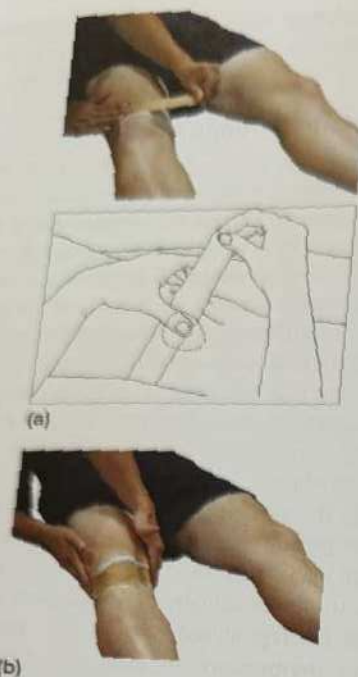


Figure 25.9 Taping techniques to relieve fat pad impingement. (a) Patellar taping to correct inferior tilt. Apply tape across the superior pole of the patella with sufficient firmness to elevate the inferior pole. (b) Fat pad unloading tape. Apply two pieces of tape so they make a "V" from the tibial tuberosity to the joint lines. The fat pad region is pinched to unload the fat pad while applying the tape. This taping technique can be combined with the one shown in (a).

of the tibial tuberosity by the powerful patellar tendon. It occurs in association with high levels of activity during a period of rapid growth and is associated with a change in the tendon. Longitudinal imaging of the tendon in adolescents without pain shows that the attachment transitions to a normal osteochondritic.⁴⁹ As with all tendon-related pain, be careful not to diagnose based on imaging findings alone.

Treatment consists of reassurance that the condition is self-limiting and prescription of muscle strength and flexibility exercises. Whether or not to play sport depends on the severity of symptoms. Children with mild symptoms may continue playing some or all sport; others may choose some modification of their programs (similar to the treatment outlined for patellar tendinopathy management of in-season athletes).

If the child prefers to cease sport because of the pain, that decision should be supported. Usually, rest will resolve all painful symptoms, but a return to activity often exacerbates them again, and total rest is likely to have other detrimental effects on growth and maturation of the adolescent's musculoskeletal system. Further reassurance should be provided that the amount of sport played does not seem to affect the time taken for the pain to completely disappear (usually once long bones such as the femur have ceased growing).

Sinding-Larsen-Johansson lesion

This rare lesion is part of the group of osteochondroses found in adolescents. It is a clinically unimportant differential diagnosis in young patients with pain at the inferior pole of the patella, who can actually have patellar tendinopathy at a young age.

KEY POINTS

- Patellar tendinopathy was commonly called "jumper's knee" because of its association with repetitive mechanical loading from jumping or sprinting sports.
- In addition to repeated loading of the tendon, patellar tendinopathy is associated with downhill running, improper biomechanics, strength and/or flexibility deficits and higher BMI. Sudden increases in training and improper training technique may also contribute to the development of patellar tendinopathy.
- The key finding associated with patellar tendinopathy is focal pain in the tendon near the inferior pole of the patella.
- The history should include the athlete's rating of their condition, pain description, training history and impacts on their quality of life.
- The physical examination should assess for weakness in the muscles of the lower limb. Pain may be reproduced with a single-leg decline squat.

The patellar tendon may show increased cross-sectional area on imaging in athletes with patellar tendinopathy, but asymptomatic athletes may have the same findings. Imaging should be interpreted in the context of symptoms, recent changes in training and ability to tolerate normal activities.

The first priority in managing patellar tendinopathy is deciding whether the athlete will continue to train and compete while undergoing rehabilitation. This decision is made using a shared decision-making approach.

Athletes who opt to continue playing sport during rehabilitation should be advised that total symptom resolution is unlikely. Therapeutic tendon loading should be prescribed in the context of overall sport-related training volume.

The pain monitoring model provides a useful framework for managing an athlete's load and progression during rehabilitation.

- While overall load may need to be reduced for athletes with patellar tendinopathy, targeting reductions in jumping, sprinting, changes of direction and/or deceleration may have the most impact.
- Absolute rest for the athlete with patellar tendinopathy is not advised.
- Changes to an athlete's biomechanics can support recovery. The ankle, knee and hip should all be

considered. Jump landings, foot strike during running and ankle mobility are important targets.

- Exercise forms the cornerstone of patellar tendinopathy rehabilitation. There appears to be comparable effectiveness across muscle contraction types and exercise protocols. Progressing to single-leg exercise as quickly as possible is key.
- Bursitis is among the less common causes of anterior knee pain. The pre-patellar bursa is most commonly affected. Infective cases should be treated immediately, but mild cases respond well to conservative management.
- Quadriceps tendinopathy occurs mainly in older athletes and weightlifters. Treatment is similar to that for patellar tendinopathy.
- Irritation to the fat pad may occur in athletes with genu recurvatum and/or an anterior pelvic tilt. Treatment involves building strength and control to avoid uncontrolled hyperextension of the knee. Taping may be useful during treatment.
- An Osgood-Schlatter lesion is an osteochondrosis at the tibial tuberosity, often seen in adolescent males. It is a self-limiting condition that can usually be managed with strength building and flexibility work.

REFERENCES

References for this chapter can be found at www.mhprofessional.com/CSM6e

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