Imaging of Anterior Knee Pain and Maltracking

18

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CONTENTS

Box 18.1. CT

- High radiation dose
- Poor soft issue contrast
- Not indicated in the assessment of anterior knee pain except in exceptional circumstances

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Box 18.2. Radiography

- Indicated in acute trauma
- Has a lower sensitivity for almost all pathologies when compared to MR
- Not routinely indicated in anterior knee pain in the athlete
- Occasionally useful as second line investigation to clarify an abnormality seen on MR

Box 18.3. Ultrasound

- Excellent tool for assessing the superficial soft tissues
- Quick, easy and cheap
- Patient friendly
- Dynamic and Doppler imaging useful
- Direct interaction with patient often helpful

Box 18.4. MRI

- Excellent tool for assessing joint, bones and soft tissues
- Sensitive and specific for most conditions causing anterior knee pain
- Expensive and not very patient friendly
- First line test for assessment of all pathologies of the patellofemoral joint

18.1 Introduction

Symptoms related to the anterior knee are common in the athlete. There are a number of specific conditions of the patellar tendon, patellofemoral joint and Hoffa's fat pad but in many cases of retropatellar pain there is no identifiable cause which has led to the use of the term 'patellofemoral pain syndrome'. Acute injuries of the extensor mechanism account for a minority of cases. Imaging is useful in acute injuries and in a minority of those non-acute cases. In most cases of non specific patellofemoral pain, no imaging is required unless there has been a poor response to standard conservative treatment.

18.2 Acute Trauma to the Extensor Mechanism

The most common acute injury to the anterior knee is patellar dislocation. More unusual injuries include patellar tendon rupture and direct trauma may result in patellar fractures or haemorrhage into the prepatellar bursa. Fractures are rare in the athlete. Patellar fractures are due to a direct blow. In children avulsion fractures of the inferior patella and tibial tubercle may occur.

18.2.1 Acute Dislocation

Acute patellar dislocation may be associated with underlying patellofemoral dysplasia (see below) but in most cases the anatomy is normal. Dislocation usually occurs following a twisting injury to the knee. Typically the patient experiences acute pain and the knee immediately swells. Examination of the knee is difficult in the acute setting and the diagnosis is often not suspected prior to imaging. MRI is an excellent tool for the assessment of the acutely injured knee, as it will demonstrate a surgical lesion and lead to rapid implementation of appropriate treatment. Patellar dislocation can be readily diagnosed on MRI as the signs are specific. At the time of injury the patellar initially subluxes laterally until the medial retinaculum ruptures. The patella then dislocates and its medial aspect impacts against the anterolateral aspect of the lateral femoral condyle. This often results in an osteochondral fragment originating from the medial patellar facet. The typical MR signs are therefore rupture of the medial retinaculum, subcortical edema/haemorrhage in the anterolateral aspect of the lateral femoral condyle with a corresponding 'kissing' lesion in the medial aspect of the patella, with or without an osteochondral fracture (Fig. 18.1). Sometimes the medial retinaculum remains intact (Kirsch et al. 1993).

18.2.2 Patellar Tendon Rupture

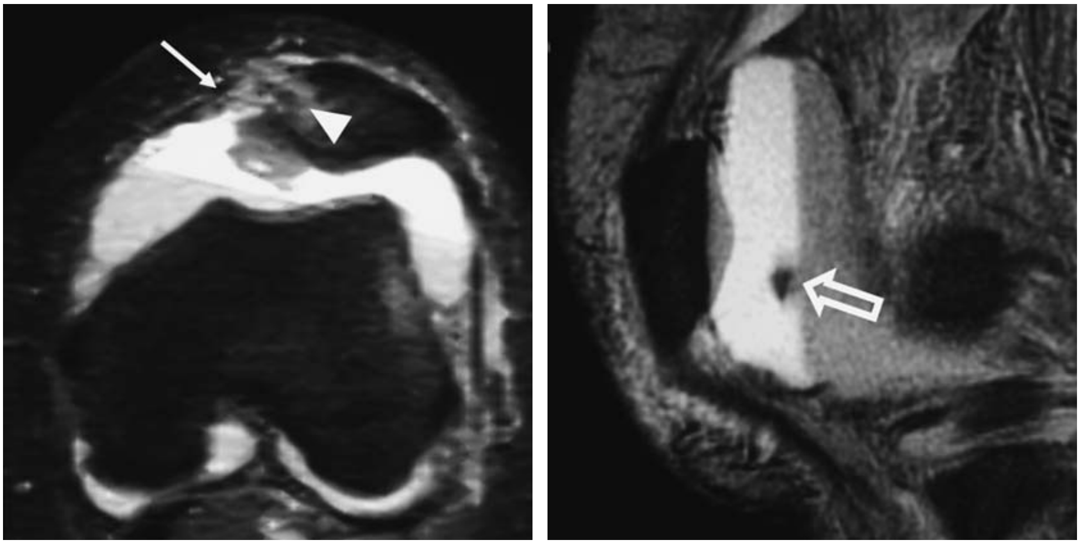
Patellar tendon rupture is rare. Predisposing factors are patellar tendinosis, previous steroid injections, previous ACL repair with patellar graft and certain chronic medical disorders. The patient complains of sudden pain and inability to extend the knee. The tear usually occurs close to the tendon's origin at the inferior pole of the patella. Early surgical repair is indicated so it is important to make a timely diagnosis. Ultrasound is the easiest and quickest method to make the diagnosis and determine the site and extent of the tear although MRI provides similar information (Fig. 18.2) (Matava 1996).

18.2.3 Prepatellar Bursa

Prepatellar bursitis is a common condition in the general population, particularly in occupations requiring kneeling. In the athlete the commonest problem is an acute haemorrhagic bursitis resulting from a direct blow. The diagnosis is usually obvious on clinical inspection and can be easily confirmed on ultrasound or MR (Fig. 18.3) (Larson and Osternig 1974).

18.2.4 Fractures

Fractures are an uncommon cause of anterior knee pain. In the adult patellar fractures may occur secondary to a direct blow. In the child, the patellar sleeve avulsion fracture is a rare but important lesion in which the unossified inferior pole plus a small amount of bone is avulsed along with a sleeve of retropatellar articular cartilage and periosteum (Hunt



a b

Fig. 18.1a,b. Acute patellar dislocation. **a** Proton density fat suppression axial; **b** Sagittal T2 gradient echo MR image showing. tear of the medial retinaculum (*arrow*), high signal in the anterolateral aspect of the lateral femoral condyle and medial aspect of the patella (*arrowhead*) and patellar osteochondral fracture floating on fluid/fluid level (*open arrow*)

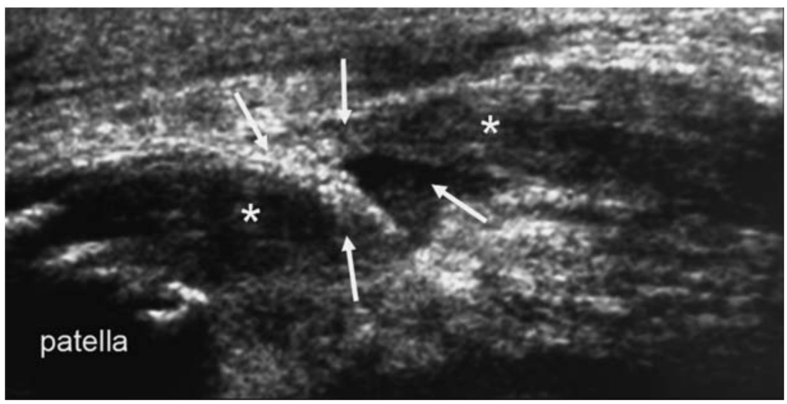


Fig. 18.2. Patellar rupture. Sagittal ultrasound shows a defect in the proximal portion of the tendon (*arrows*). The asterisk marks the free ends of the tendon

Fig. 18.3. Pre patellar bursa. Sagittal proton density fat suppressed MR image showing high signal in the prepatellar bursa following trauma (*arrow*)

Fig. 18.4. Avulsion fracture of the tibial tubercle. The fragment has rotated nearly 180°

and Somashekar 2005). This fracture requires fixation. Another rare fracture is avulsion of the unfused tibial tubercle (Fig. 18.4).

18.3 Anterior Knee Pain Without Acute Trauma

Anterior knee pain is common complaint in the athlete and general population. In most cases symptoms are due to pathology of patellar tendon, patellofemoral joint or Hoffa's fat pad. Most patients do not require any imaging. In certain circumstances imaging will help to make a diagnosis, assess the degree of abnormality or guide therapy. MRI and ultrasound are the most useful techniques in investigating anterior knee pain. Plain films have a limited role and are not required in most cases. Ultrasound is the easiest method of investigating suspected patellar tendon pathology. MRI is used for suspected patellofemoral problems and when the symptoms are non specific.

18.3.1 Disorders of the Patellar Tendon

The patellar tendon is vulnerable to overuse type injuries. In the adolescent the commonest condition is Osgood Schlatter's disease which is a traction injury at the tibial tubercle. The condition is more common in males and is associated with running sports. A tender bony swelling at the tibial tubercle is found on clinical inspection. Imaging is rarely required and is usually requested to reassure the patient or their parents that there is no sinister pathology. Plain films will show fragmentation of the tibial tubercle, accompanied by some soft tissue swelling representing thickened tendon and fluid in the deep infrapatellar bursa. Ultrasound is often preferred as it does not involve ionizing radiation and will demonstrate the soft tissue component to better effect (Fig. 18.5) (Blankstein et al. 2001). Sinding-Larsen Johansson syndrome is a similar traction type injury that occurs at the proximal end of the tendon. Plain film shows fragmentation of the inferior pole of the patella. The appearances on ultrasound and MR are similar to Osgood Schlatter's disease with fragmentation of the inferior pole of the patella and widening of the adjacent tendon with edema and hypervascularity (Fig. 18.6). These two conditions have a good prognosis and resolve with conservative management. In contrast, the condition termed jumper's knee (patellar tendinosis) can be much more troublesome. This condition occurs in the adolescent and young adults and can become chronic. The pathology is degeneration of the proximal tendon directly adjacent to the

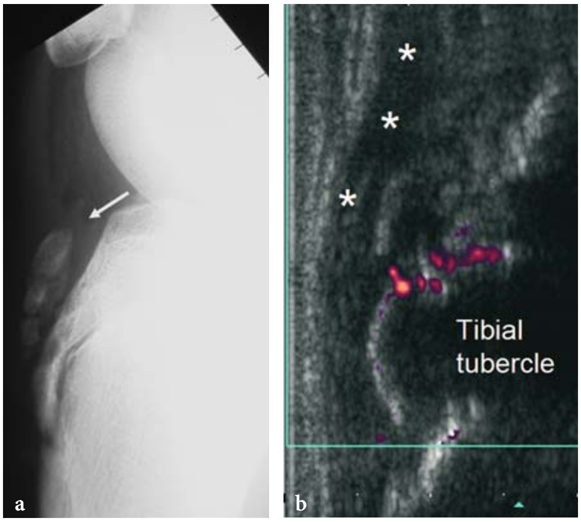


Fig. 18.5a,b. Osgood Schlatter's disease. **a**) plain film; **b**) ultrasound showing fragmentation of the tibial tubercle. An infrapatellar effusion can be seen on the radiograph (*arrow*). On ultrasound the distal end of the tendon is seen to be widened and hypoechoic. There is hypervascularity around the bony fragments. Asterisks mark the tendon

inferior pole of the patella. The probable mechanism of injury is impingement of the tendon by the inferior pole of the patella. The abnormality is typically confined to the deep surface of the central portion of the tendon. The diagnosis and management is usually based solely on clinical evaluation. When imaging is indicated ultrasound is the technique of choice. A focal swelling of the tendon with hypervascularity is seen adjacent to the inferior pole of the patella (Terslev et al. 2001). Calcification is not uncommon. On MRI the abnormal portion of the tendon returns increased signal on all sequences (Fig. 18.7). Imag-

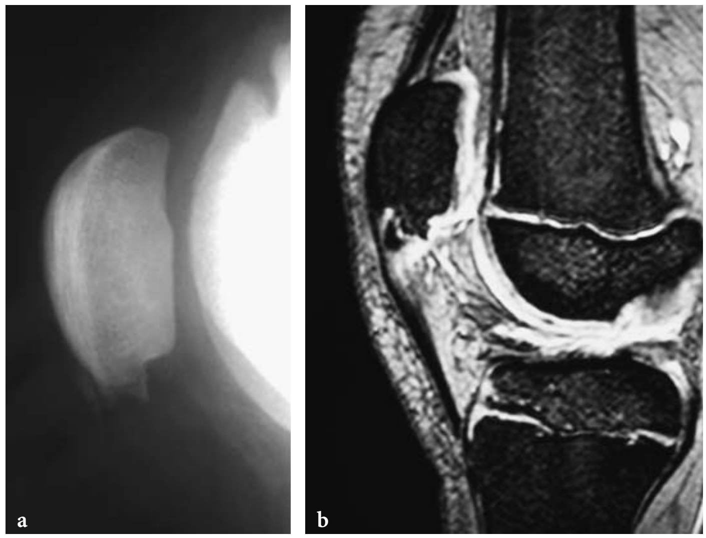


Fig. 18.6a,b. Sinding-Larsen Johansson syndrome **a** plain film; **b** T2 gradient echo sagittal image showing fragmentation of the inferior pole of the patella. On MRI there is bony fragmentation and high signal in the adjacent tendon

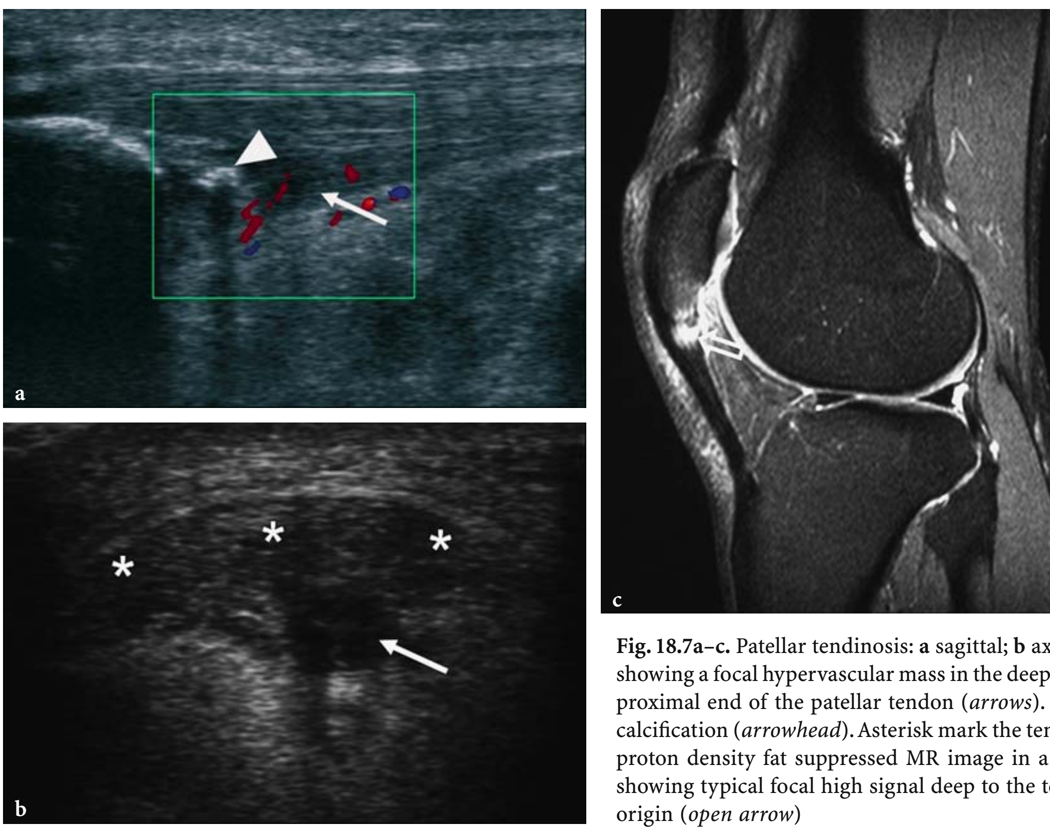


Fig. 18.7a–c. Patellar tendinosis: **a** sagittal; **b** axial ultrasound showing a focal hypervascular mass in the deep portion of the proximal end of the patellar tendon (*arrows*). There is some calcification (*arrowhead*). Asterisk mark the tendon; **c** sagittal proton density fat suppressed MR image in a different case showing typical focal high signal deep to the tendon near its origin (*open arrow*)

ing evidence of patellar tendinosis in asymptomatic athletes is a risk factor for developing symptoms in the future (Fredberg and Bolvig 2002; Gisslen and Alfredson 2005).

A common finding on MRI is impingement of the lateral aspect of the patellar tendon on the anterolateral articular margin of the lateral femoral condyle. Some minor high signal may be detected in the fat that is interposed between the tendon and the condyle. Although this entity may be seen in patients with anterior or anterolateral pain (Chung et al. 2001), it is so common a finding on routine MRI that its significance is open to question (Fig. 18.8).

Fig. 18.8. Patellar tendon 'impingement'. Sagittal T2 gradient echo MRI demonstrating impingement of the most lateral aspect of the proximal patellar tendon on the lateral femoral condyle. There is high signal seen deep to the tendon at the site of impingement (*arrow*)

18.3.2 Iliotibial Band Friction Syndrome

Iliotibial band friction syndrome is a common condition seen in runners and is due to impingement of the band against the lateral aspect of the lateral femoral condyle. The clinical picture is typical with focal lateral pain on running. Imaging is not required in the classical case. On T2 weighted MRI ill-defined or fluid like high signal is seen in the space between the iliotibial band and the lateral condyle. The band itself usually appears normal (Fig. 18.9) (Muhle et al. 1999).

18.3.3 Synovial Plica

Impingement of the medial patellar plica between the patella and the medial condyle has been implicated as a cause of anterior knee pain. The patient may experience pain, clicking and pseudolocking and tenderness over the medial plica. Visualization of the normal plica on MRI is very common in patients with an effusion. In medial patellar plica syndrome the plica is seen to be thickened. This is best appreciated on the axial images. In the absence of fluid the thickened plica may appear as a low signal intensity mass in the medial recess (Jee et al. 1998) (Fig. 18.10).

18.3.4 Hoffa's Fat Pad

Hoffa's fat pad lies deep to the patellar tendon and has an apex pointing toward the ACL insertion. Cysts, neoplasms and inflammatory conditions are sometimes seen in the fat pad (Saddik et al. 2004). The

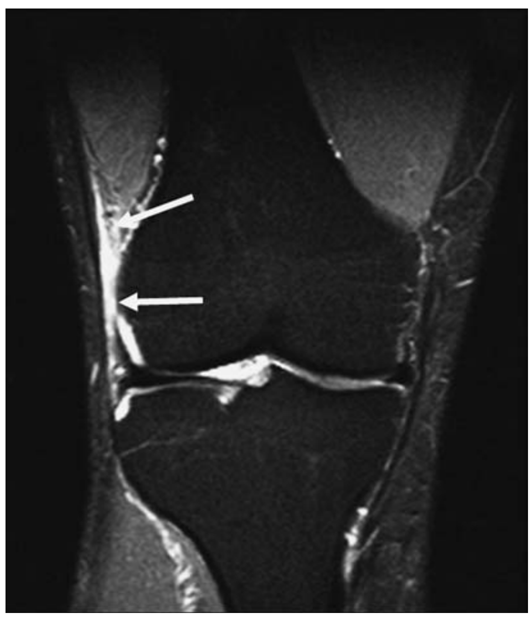


Fig. 18.9. Iliotibial band syndrome. Coronal proton density fat suppressed MRI showing high signal deep to the iliotibial band (*arrows*)

Fig. 18.10. Medial patellar plica. Axial MRI showing low signal mass in the medial synovial recess. In this case there is an associated bony spur seen at the site of impingement

Fig. 18.11. Infrapatellar plica. Sagittal proton density fat suppressed MR image demonstrating a normal infrapatellar plica (*arrows*)

concept of Hoffa's fat pad impingement syndrome is controversial but edema is sometimes seen in the pad without any obvious explanation. The normal infrapatellar plica can be frequently identified on MRI as it runs through the fat pad and attaches to the inferior pole of the patella (Fig. 18.11). Occasionally high signal is seen surrounding the plica on MRI (Cothran et al. 2003). Whether this abnormality itself is related to symptoms is open to question. The most common lesion found in the fat pad is a ganglion (Fig. 18.12). Ganglia are usually found on MRI but US is useful to confirm their cystic nature. Ultrasound guided aspiration and injection of steroid may be beneficial. The commonest solid tumours are the nodular form of pigmented villonodular synovitis (PVNS) and synovial osteochondromatosis. Nodular PVNS contains haemosiderin and fibrosis which is seen as low signal intensity on T2 weighted images (Fig. 18.13). Synovial osteochondromatosis is usually calcified to a varying degree but otherwise imaging features are non-specific (Fig. 18.14) (Helpert et al. 2004).

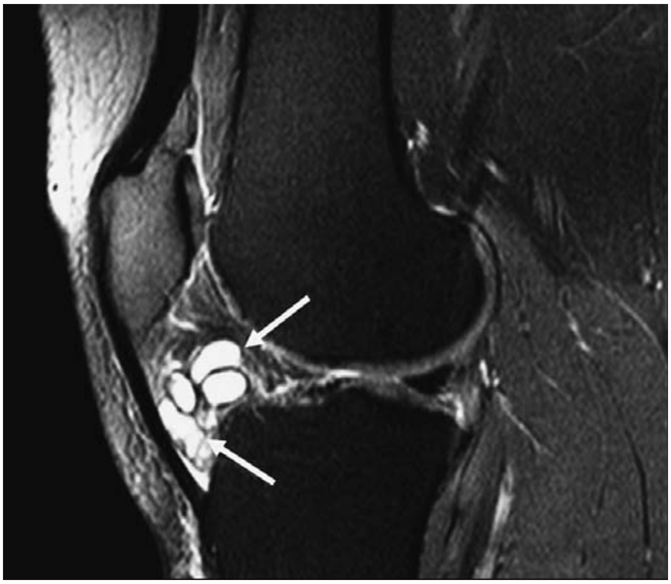


Fig. 18.12. Hoffa's fat pad ganglion. Sagittal proton density fat suppressed MR image showing lobulated cystic mass (*arrows*)

a b

Fig. 18.13a,b. Nodular PVNS: **a** axial T1; **b** coronal proton density fat suppressed T2 weighted MR image shows a well defined mass (*arrows*) in Hoffa's fat pad which contains some low signal intensity on the fat suppression images representing haemosiderin and fibrosis

Fig. 18.14. Synovial osteochondromatosis. Sagittal proton density fat suppressed MR image showing a well defined high signal mass (*arrows*) containing low signal foci representing calcification

18.3.5 Patellofemoral Joint

Definable conditions of the patellofemoral joint that cause anterior knee pain are chondromalacia, osteochondritis dissecans, and patellar maltracking. 'Patellofemoral pain syndrome' is a term is usually reserved for cases of retropatellar knee pain without an identifiable cause.

18.3.5.1 Patellofemoral Pain Syndrome

The underlying pathology may be chondromalacia or clinically occult patellar malalignment. The term merely describes a clinical picture and is not a true syndrome. This entity is common in athletes and non-athletes alike. The condition is much more common in females. Imaging is rarely required as achieving a more specific diagnosis does not usually alter management. Most patients have normal imaging including normal patellofemoral anatomy. A proportion of patients will have demonstrable chondromalacia of the retropatellar cartilage and some will have anatomical abnormality predisposing to maltracking of the patella. Imaging is indicated if symptoms are atypical or persistent, mainly to rule out treatable pathology such as osteochondritis dissicans. If maltracking is suspected and surgery is being considered then MRI is useful to document any dysplasia. Dynamic imaging is useful to detect and quantify maltracking. Imaging is not indicated for suspected chondromalacia although macroscopic lesions may be reliably seen on good quality MRI (Fig. 18.15).

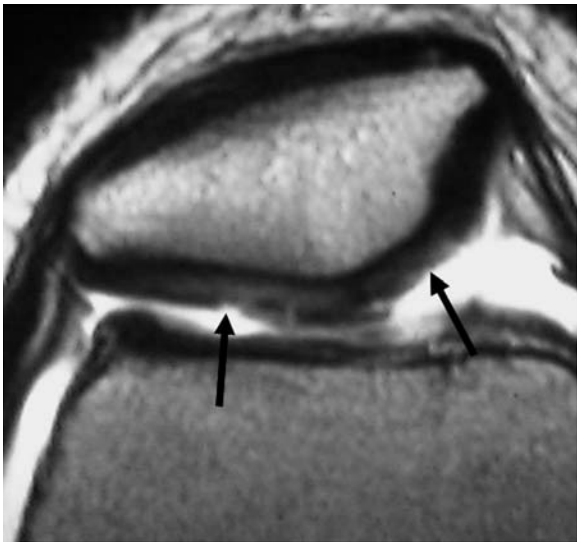


Fig. 18.15. Chondromalacia. Axial T2 fat suppressed MR image showing small defects in the articular cartilage (*arrows*)

18.3.5.2
Bipartite Patella

Bipartite patella is a normal variant where there is a small separate ossification at the superolateral aspect of the patella. Bipartite patellar can be easily identified on plain films and MRI. Symptomatic case are very rare but is persistent localized pain following injury has been reported (Iossifidis and Brueton 1995). On MRI, edema either side of the divide between the accessory ossification and the main body of the patella may be encountered (Vanhoenacker et al. 2002) (Fig. 18.16).

18.3.5.3
Osteochondritis Dissecans

Osteochondritis dissecans is a disease of childhood and adolescence. It is more common in the athletic individuals and is due to repetitive loading on the articular surface. In the knee, the lateral aspect of the medial femoral condyle, the weight bearing portion of the lateral femoral condyle, the patella and the trochlear groove are typical sites (Peters and McLean 2000). The patient may present with anterior pain when the lesion involves the patellofemoral joint or the anterior aspects of the femoral condyles. Osteochondritis dissecans can usually be identified on plain films but MRI is more sensitive. Radiographically osteochondritis dissecans is seen as a subchondral lucency which may contain a density representing the osteonecrotic fragment. Intra-articular loose bodies may also be seen. On MRI the defect may be seen to be filled with fibrocartilage or to contain the necrotic fragment (Fig. 18.17). The generally accepted criteria for diagnosing an unstable lesion is high signal lying deep to the fragment and breach of the articular cartilage (De Smet et al. 1997). Accurate staging of osteochondritis dissecans usually requires arthroscopy. Normal irregularity of the posterior aspect of the medial femoral condyle in children may simulate osteochondritis dissecans (Gebarski and Hernandez 2005).

18.3.5.4
Patellar Maltracking

Patients with maltracking may present with non-specific retropatellar pain or symptoms of patellofemoral joint instability including dislocation. Imaging is useful in suspected acute patellar dislocation (see above) and in patients with chronic patellofemoral instability who are being considered for surgery.

Patients with chronic instability usually suffer from some degree of patellofemoral dysplasia with one or more of the following adverse anatomical features: a high riding patellar (patella alta); a flat trochlear groove; a laterally positioned tibial tubercle. The relative importance of each of these measurements depends on the surgical options available. The most popular operation for maltracking is medial or anteromedial transfer of the tibial tubercle (Bellemans et al. 1997). Refashioning the trochlear groove (trochleoplasty) is not universally favoured but has its

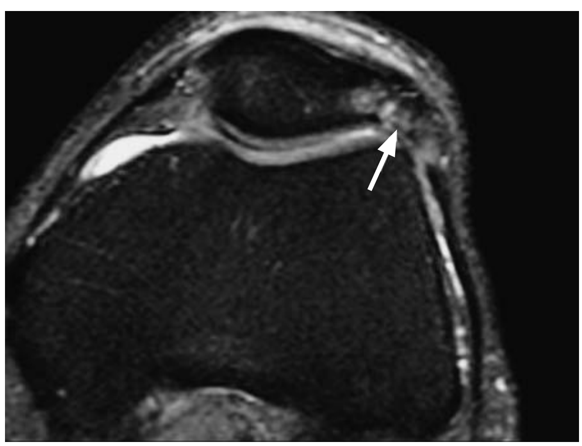


Fig. 18.16. Bipartite patella. Axial fat suppressed MR image showing bipartite patella (*arrow*) with edema either side of the division between the two ossicles

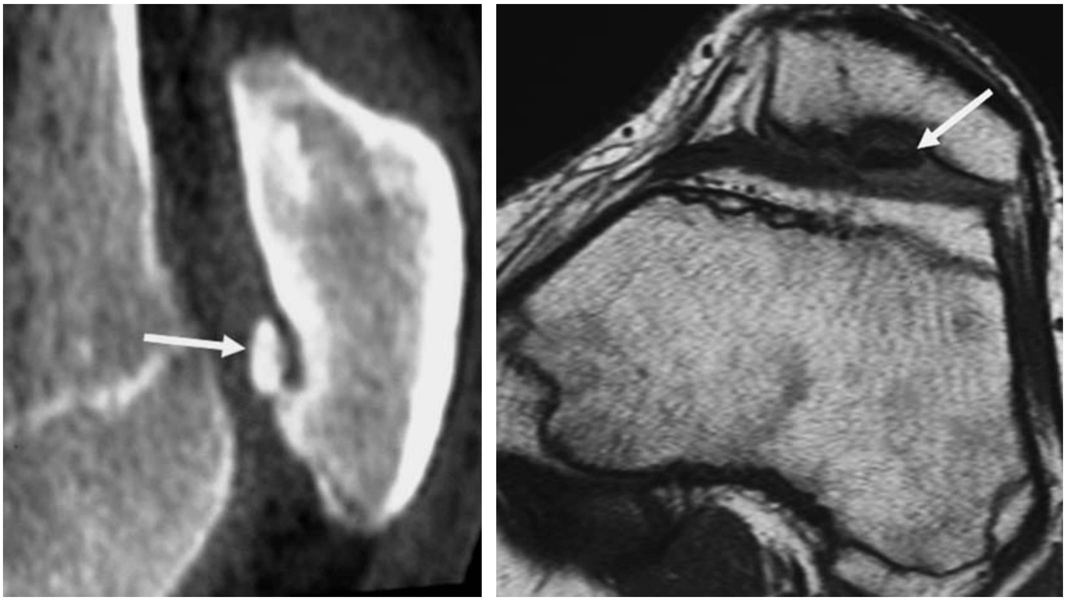


Fig. 18.17a–c. Osteochondritis dissecans of the patellofemoral joint: **a** sagittal reconstruction CT; **b** axial T1 MR image showing a focus of necrotic bone in an articular defect (*arrows*); **c** Sagittal T2 gradient echo MR image showing similar lesion of the trochlear groove

advocates (Verdonk et al. 2005). Popularity of lateral retinaculum release alone has waned in light of evidence questioning the effectiveness of the operation in maltracking without tibial tubercle transfer (Panni et al. 2005). MRI will identify and quantify the anatomical abnormalities. The degree of patellar alta is assessed on sagittal images by calculating the ratio of the maximum length of the patella by the minimum length of the posterior surface of the patellar tendon. This ratio should be under 1.3–1.5 (Fig. 18.18) (Miller et al. 1996; Shabshin et al. 2004). The trochlear groove is best assessed on the axial scans. The groove may be shallow, flat or even convex in its most proximal part (Fig. 18.19). The relative position of the tibial tubercle is clinically estimated by measuring the Q angle, that is, the angle between a line drawn from the anterosuperior iliac spine to the centre of the patella and a line drawn from the centre of the patella to the tibial tubercle. This is a difficult angle to estimate on MRI because of the double obliquity of the tendon. A more realistic method is to measure the tibial tubercle-trochlear groove (TT-TG) distance which approximates the Q angle. This is the distance between the position of the trochlear groove and the

Fig. 18.18. Patellar alta. Sagittal proton density fat suppressed MR image demonstrating a high riding patella

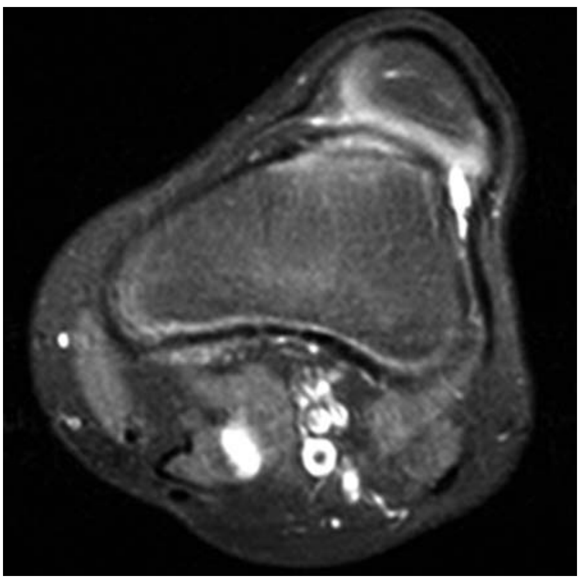


Fig. 18.19. Patellofemoral dysplasia. Axial proton density fat suppressed MR image through the proximal part of a dysplastic convex trochlear 'groove'

tibial tubercle in the sagittal plane. In practice two slices are selected on an axial scans, one at the level of the trochlear groove and one at the level of the attachment of the patellar tendon at the tubercle. The two slices are superimposed. A baseline is drawn along the back of the femoral condyles. Two lines are drawn perpendicular to this baseline, one through the tibial tubercle and one through the deepest point of the trochlear groove. The TT-TG is the distance between these two lines (Fig. 18.20). The upper limit of normal is about 1.7–1.8 cm. In almost all cases – with a value above 2 cm – maltracking can be demonstrated on dynamic imaging (Dejour et al. 1994; McNally et al. 2000). Patients with high TT-TG distance are likely to benefit from tibial tubercle medialisation.

In patients with suspected chronic instability it may also be helpful to document whether or not a patient is indeed maltracking. In some cases this may be obvious on clinical examination but often imaging is required, particularly in obese patients and those with relatively minor degrees of maltracking. Lateral subluxation may be demonstrated on skyline radiographs but this is an insensitive test as maltracking

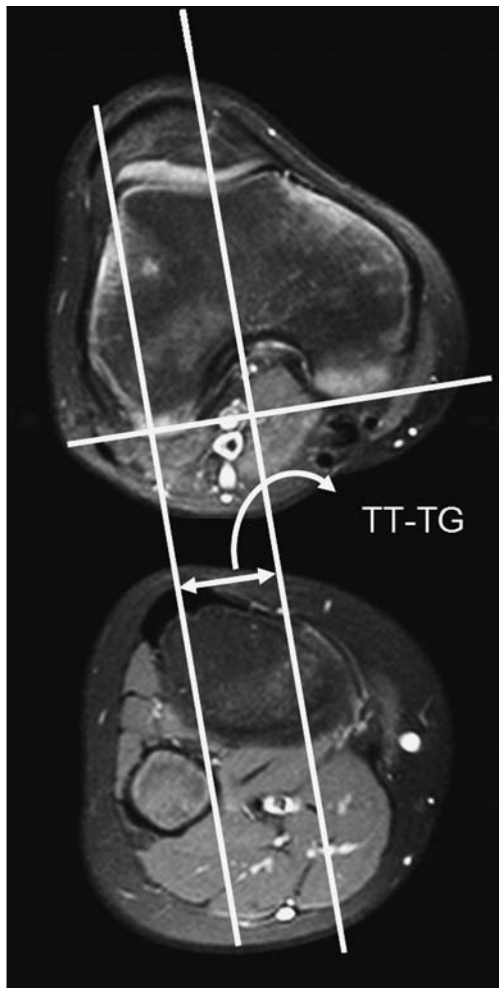


Fig. 18.20. Laterally positioned tibial tubercle. The TT-TG distance is 2.1 cm, which is above the normal range

is maximal from 30° of flexion to full extension. CT or MRI has the advantage of being able to provide axial images of the knee within this range of flexion. The two main methods are pseudodynamic and true dynamic imaging. In the former, static axial sections are obtained through the patella with the knee in various degrees of flexion. The images are then compiled into a cine loop which can be viewed on the monitor. The disadvantage of this method is that it a poor simulation of patellar movement during active knee extension. Dynamic imaging acquires data while the knee is actually moving. One method is to acquire multiple rapid axial images through the patella as the knee is slowly extended. We use a deflatable beach ball jammed between the shins and the roof of the magnet to help control the rate of extension. A continually repeated series of around five axial images and one sagittal image are obtained through the patella during extension. For each series the slice through the centre of the patella is selected and a cine loop created (Fig. 18.21). The sagittal slices can also be compiled into a cine loop to document the range of excursion achieved by the patient. Interpreting the cine loop is subjective. We divide the cases into three grades. Grade one, which represents the mildest form of maltracking is common in the asymptomatic population, whereas grade three is almost always associated with symptoms (O'Donnell et al. 2005).

18.3.5.5 Lateral Patellar Compression Syndrome

In this condition there is little subluxation but abnormal pressure on the lateral facet, supposedly due to a tight lateral retinaculum. The diagnosis is usually clinical but tilting of the patella without subluxation may be seen on dynamic imaging. Patients may respond to lateral retinaculum release (Panni et al. 2005).

18.4 Conclusion

Most cases of anterior knee pain originate from the patellar tendon, Hoffa's fat pad or the patellofemoral joint. Most cases do not require imaging. Acute traumatic pain requires plain films to exclude fracture supplemented by MRI if patella dislocation is considered a possibility. Soft tissue overuse injuries of the patellar tendon are best assessed by ultrasound. MRI is the technique of choice for assessing the patellofemoral joint and abnormalities of Hoffa's fat pad. Plain films are of limited value in the assessment of chronic anterior knee pain.

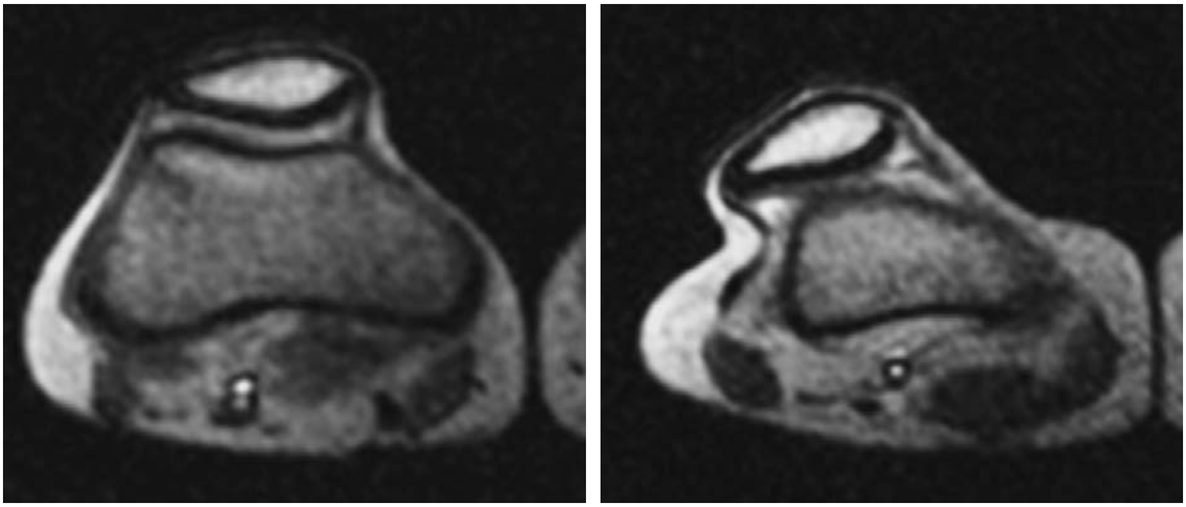
a  b

Fig. 18.21a,b. Patellar maltracking. Axial images with one second acquisition time in: **a** 30° of flexion; **b** full extension. There is lateral subluxation and tilt of the patella in extension

Things to Remember

1. The triad of MRI findings found in patellar dislocation is specific for this injury.
2. Ultrasound is an excellent method of assessing the patellar tendon and other superficial soft tissue injuries. No other imaging is required in the vast majority of cases.
3. 'Patellofemoral pain syndrome' merely describes a symptomatic state. Imaging is usually not required.
4. Patellofemoral dysplasia, a complex disorder involving the position of the patella and the tibial tubercle and the shape of the trochlear groove, is best assessed by MRI.
5. True dynamic imaging is possible with MRI to demonstrate maltracking.

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