Interpretation of knee radiographs

Introduction

The knee is particularly susceptible to traumatic injury because of the variety of compressive, load-bearing and rotational forces that may act upon it. Injuries may be the result of high-impact trauma such as falls from a height or road traffic accidents, or a result of low-velocity sporting injuries. They may be associated with significant complications such as vascular injury, compartment syndrome, bony non-union, avascular necrosis and osteoarthritis. The majority of fractures are visible on plain radiographs although detectable injuries are sometimes subtle. Simple guidelines are available in order to help decide which injuries do not require investigation with radiographs.

Anatomy

The shaft of the distal femur expands into the medial and lateral femoral condyles separated by an intercondylar fossa. The patella is a sesamoid bone within the quadriceps tendon and lies in the V-shaped trochlear groove of the anterior articular surface of the distal femur. Patellar dislocation usually occurs across the shallower lateral articular facet. Occasionally the patella is bipartite with an unfused superolateral ossification centre.

The inferior articular surfaces of the femur articulate with the central tibial condyles while the peripheral portions are supported by the medial and lateral menisci. The broad tibial plateau tapers into the shaft distally. On its anterior surface is the tibial tuberosity onto which inserts the patellar tendon. The anterior and posterior cruciate ligaments form a cross shape between the inward-facing surfaces of the femoral condyles and the tibial intercondylar area. Along with the medial and lateral collateral ligaments these structures help to stabilize movements of the knee.

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The popliteal fossa is a space formed at the back of the knee. It contains the popliteal artery and vein, and is traversed by the tibial nerve. The common peroneal nerve passes adjacent to the biceps femoris tendon and winds around the neck of the fibula. The suprapatellar bursa is a potential space that lies between the suprapatellar and pre-femoral fat pads. It usually communicates with the knee joint space and can fill with effusion or haemorrhage following trauma.

Imaging

The mainstay of skeletal imaging is the plain radiograph. A minimum of two views are always required which include the anteroposterior and lateral projections. In the setting of trauma a horizontal beam lateral (HBL) view is taken with the patient positioned supine. Following a fracture haemorrhagic marrow may fill the suprapatellar bursa. The fat layers on top of the blood to form a lipohaemarthrosis which is demonstrated on a HBL view. A tunnel view of the intercondylar notch may reveal fractures of the tibial spines or intra-articular loose bodies. Skyline views are used to demonstrate the patellofemoral joint in profile.

Computed tomography (CT) is used in selected cases of complex trauma which may require surgical reconstruction. In particular the degree of depression of tibial plateau fractures may be difficult to assess on plain films alone. Magnetic resonance imaging (MRI) demonstrates the menisci, tendons and ligaments around the knee and is used to assess soft tissues injuries non-invasively. Bone oedema and avascular necrosis are also readily visualized. Ultrasound has a role in evaluating tendinopathy, fluid collections and synovial disease.

Who needs an X-ray?

The majority of knee radiographs are normal. As with other extremity X-rays the use of decision-making protocols have been widely adopted to reduce the number of negative examinations. The Ottawa knee rules reduce the number of normal radiographs by up to a third with no missed fractures found at follow up (Stiell et al, 1997; Jenny et al, 2005). If at least one of these criteria applies (*Table 1*) following an acute knee injury, then routine X-rays should be performed.

In the case of severe or multiple trauma it should be remembered that the standard acute trauma life support protocol should be adopted, and the patient stabilized before imaging extremity fractures. Knee dislocation with signs of vascular impairment should be reduced without delaying for radiographs.

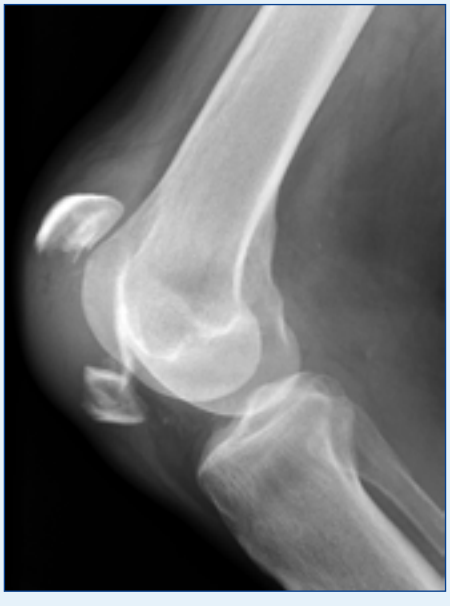
Patella fractures and dislocation

Fractures of the patella are relatively common and often result from direct blunt trauma or from forceful quadriceps contraction. Transverse fractures are most commonly seen and usually occur across the middle of the patella (*Figure 1*).

Table 1. The Ottawa knee rules for obtaining plain radiographs

Age 55 years or older
Tenderness at the head of the fibula
Isolated tenderness of the patella
Inability to flex to 90°
Inability to weight bear both immediately and in the emergency department (take four steps)

Figure 1. A lateral knee radiograph showing a widely displaced transverse fracture of the patella.



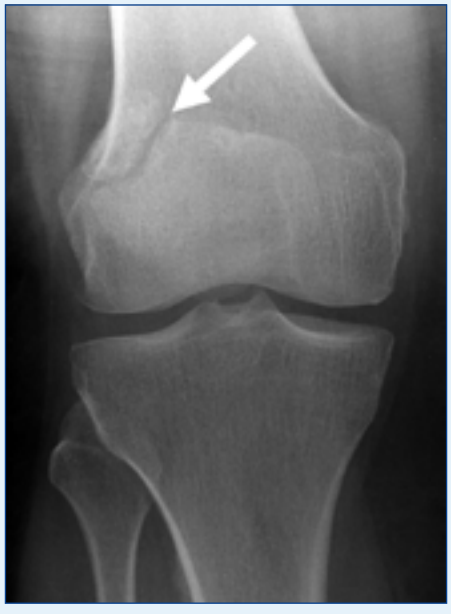
Comminuted fractures may occur and are sometimes stellate in appearance. Osteochondral fractures, comprising a fragment of cartilage and bone, occur more commonly in adolescents and may give rise to loose intra-articular bodies. A potential pitfall is mistaking a bipartite patella for a fracture. This normal variant can be distinguished by its well-corticated margin, which is usually in the superolateral quadrant (*Figure 2*).

Patella dislocations usually displace laterally and spontaneously reduce. Recurrent dislocations may be associated with developmental abnormalities of the patella and trochlear groove. Traumatic dislocations are associated with soft tissue injuries and osteochondral fractures.

Femoral condyle

Most fractures of the femoral condyles result from high impact trauma, although in the elderly a fall onto a flexed knee may be sufficient. Fractures may be extra-articular or involve one or both condyles. Additional injuries may occur to the femoral neck, shaft or acetabulum and surrounding ligaments. Radiographs should therefore include the pelvis, femur and knee. Minimally displaced condylar fractures may be easily missed and the frontal and lateral views should be carefully examined. Fractures may be comminuted and intra-articular extension should be noted.

Figure 2. A frontal knee radiograph demonstrates a bipartite patella with an unfused ossification centre in the superolateral quadrant (arrow).



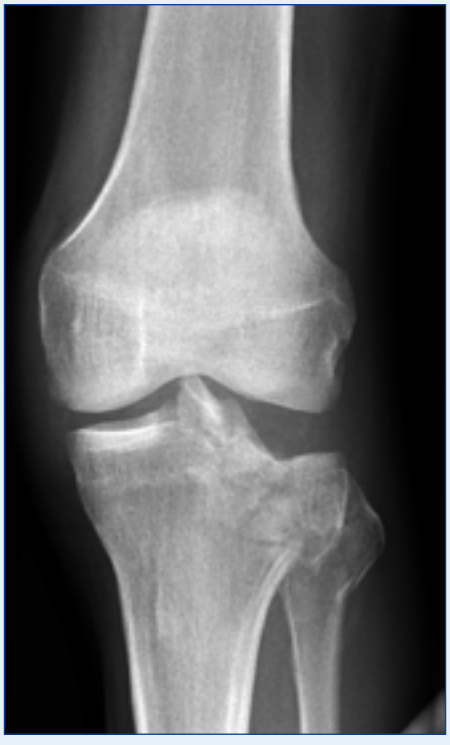
Tibial plateau

These injuries result from a lateral force on the knee joint combined with axial loading. The location of the fracture depends on the degree of knee flexion. A typical mechanism is a pedestrian being struck by the bumper of a car. There may be associated soft tissue injuries. Tears of the medial collateral ligament and the anterior cruciate may complicate lateral plateau fractures. Alternatively, tears of the lateral collateral or cruciate ligaments may accompany medial plateau injuries. High velocity injuries may lead to neurovascular damage and compartment syndrome.

The key finding on the plain radiographs is depression of the tibial plateau (*Figure 3*). On normal frontal view the femoral condyles and upper tibia are in alignment. In a tibial plateau fracture the tibial margin is displaced so there is a step at the level of the knee joint. A perpendicular line drawn at the most lateral margin of the femur should not have more than 5 mm of tibial plateau beyond it. The degree of displacement and comminution of the fragments should be noted.

Haemorrhage from the fracture may lead to a lipohaemarthrosis around the joint. This is visible as a fat–blood layer on the HBL projection (*Figure 4*). CT is often required for surgical planning to accurately assess the extent of articular depression (*Figure 5*). MRI demonstrates meniscal and ligamentous ruptures and sprains, as well as post-traumatic bone oedema.

Figure 3. A frontal knee radiograph showing a comminuted fracture of the lateral tibial plateau extending into the tibial spines. The head of the fibula is also fractured.



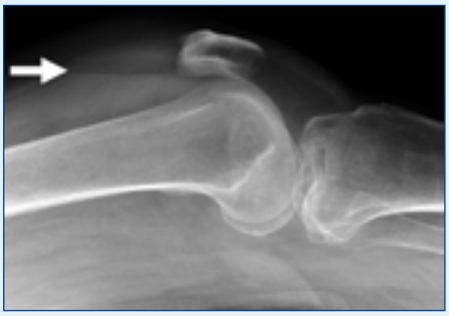
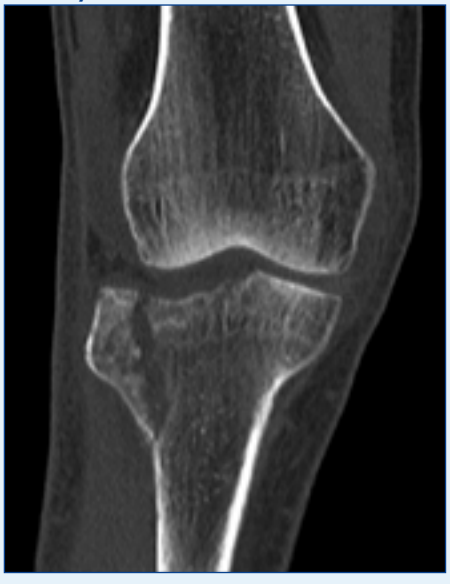


Figure 4. A horizontal beam lateral radiograph of a knee showing the fat–blood fluid level of a lipohaemarthrosis (arrow). This indicates an intra-articular fracture.

Segond fracture

The Segond injury is a small avulsion fracture of the lateral tibia just distal to the plateau (*Figure 6*). This results from an injury with internal rotation which puts excessive stress on the lateral capsular ligament. Although the fracture appears minor it is commonly associated with rupture of the anterior cruciate and injury to the collateral ligaments.

Figure 5. A coronal reformat of a knee computed tomogram. This allows the extent of articular depression in a tibial plateau fracture to be accurately assessed.



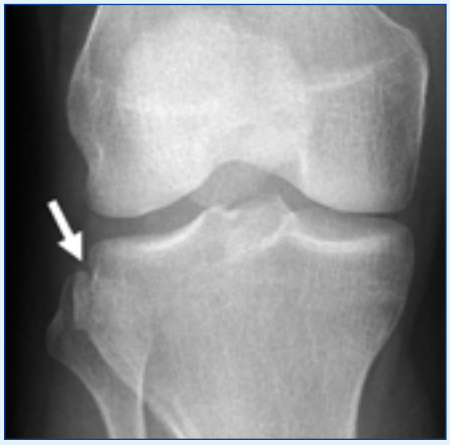


Figure 6. A frontal knee radiograph showing a Segond avulsion fracture (arrow). This is frequently associated with an anterior cruciate ligament rupture.

Tibial spine

Fractures of the tibial spine (or intercondylar eminence) are relatively rare. They nearly always involve the anterior spine and most commonly occur in children falling from a bicycle. They are associated with injuries to the anterior cruciate ligament.

Tibial tubercle

These often occur in adolescence before growth plate fusion. The mechanism is typically related to jumping during forceful quadriceps contraction. The fracture plane involves the proximal tibial epiphysis and may extend to the articular surface of the knee. The fractures are usually apparent on the standard lateral radiograph and the fracture fragment is often displaced superiorly. In Osgood–Schlatter disease chronic microtrauma to the tibial tuberosity may produce a partial avulsion fracture and new bone formation.

It is important to be familiar with the normal appearance of the unfused tibial tubercle to avoid mistaking this for a fracture.

Knee dislocation

The mechanism of injury may be a high velocity impact, such as a road accident, or low velocity during a sporting injury. The dislocation is described by the position of the tibia relative to the femur and may be anterior, posterior, medial, lateral or rotatory. Further classification of the injury is made by the associated ligamentous damage sustained. Generally one or both of the cruciate ligaments are torn, but rarely they may remain intact. Avulsion fractures are also frequently seen. Vascular injury to the popliteal vessels may occur and prompt reduction is required.

Proximal tibiofibular joint dislocation

Sudden plantar flexion with an inverted foot and a flexed knee may result in anterolateral dislocation of the proximal tibiofibular joint. On the anteroposterior radiograph the fibular head is displaced laterally and there is widening of the interosseous gap. On the lateral view the fibular head appears displaced anteriorly. Posteromedial and superior dislocations occur less commonly.

Conclusions

Knee injuries are common but most do not require X-rays. Conversely, some significant injuries may appear as quite subtle findings on radiographs and be associated with ligamentous damage. BJHM

Conflict of interest: none.

Jenny JY, Boeri C, El Amrani H et al (2005) Should plain X-rays be routinely performed after blunt knee trauma? A prospective analysis. *J Trauma* **58:** 1179–82

Stiell IG, Wells GA, Hoag RH et al (1997) Implementation of the Ottawa Knee Rule for the use of radiography in acute knee injuries. *JAMA* **278:** 2075–9

KEY POINTS

- Use a protocol to decide who needs an X-ray.
- Look for a lipohaemarthrosis on the lateral view.
- Review areas are the femoral condyles, tibial plateau and around the proximal fibula.
- Ligamentous injury may occur despite the absence of a fracture.
- Normal variants and unfused epiphyses may be mistaken for fractures.