The case:

A 28-year-old man presented with left knee pain after a fall. An anteroposterior radiograph of the knees was obtained.

Figure: Anteroposterior radiograph showing both knees.

Your diagnosis?

For answer see page 558
Diagnosis: Bipartite Patella

Kathryn Niemeyer, MD; Albert Song, MD; Laurie M. Lomasney, MD; Terrence C. Demos, MD; Harold Rees, MD

A 28-year-old healthy man presented with left anterior knee pain after a direct fall onto his knee playing basketball 1 month previously. On physical examination, mild tenderness existed at the patellofemoral joint, particularly at the lateral aspect. The patella tracked normally. No tenderness existed over the medial or lateral joint line. Ligamentous examination was intact without instability.

The anteroposterior radiograph of the patient’s knees showed well corticated ossicles contiguous with the lateral borders of the patellae of both knees (Figure 1A). Magnetic resonance imaging (MRI) was done for evaluation of internal derangement or occult injury. An axial gradient echo image showed smooth, hyaline cartilage covering the articular surfaces of both the patella and the ossicle (Figure 1B). The signal characteristics of the cartilage at the synchondrosis between the ossicle and patella are similar to articular cartilage. A coronal T2-weighted fat-saturated MRI showed no adjacent bone marrow edema or fluid within the synchondrosis (Figure 1C), findings that would suggest disruption or abnormal motion. In an otherwise asymptomatic patient, this is diagnostic of a lateral bipartite patella.

A bipartite or multipartite patella (a normal patellar variant) is found in 2% to 6% of the population and results from developmental union failure of 1 or more accessory ossification centers. A bipartite patella is bilateral in 30% to 40% of patients and is more common in men than women, with a ratio as high as 9:1. Although multiple ossification centers are evident...
in young children, a diagnosis of bipartite patella can be made definitively near age 12 years when the accessory ossification centers normally coalesce.\(^2,3\)

**Normal Anatomy and Development of the Patella**

The patella is the largest sesamoid bone in the human body. It develops initially as an expanding vascularized mass of cartilage. Patellar ossification begins between ages 3 and 5 years as multiple small foci of ossification (Figure 2) coalesce to form a central nidus.\(^6\) Ossification continues until between ages 9 and 10 years. Thereafter, ossification slows and the centers unite, forming a continuous subchondral plate. The superolateral patella remains irregular.\(^6\) Two or 3 ossification centers are seen in 23% of children, which typically unite by age 12 years.\(^2,7\) A single center of ossification is present in 77% of older children.\(^2,7\)

It is not until adolescence that the superolateral margin loses its irregularity, the trabeculae mature, Sharpey fibers develop, and patellar ossification increases until the upper margins of the patella become confluent with the quadriceps tendon.\(^6\)

The development of the patella occurs within the confines of the surrounding anatomy. The patella is the central element for several extensor muscles about the knee. These include the insertion of the vastus medialis into the medial aspect of the quadriceps tendon and the medial border of the patella, the vastus intermedius that inserts into the posteriuperior patella, the vastus lateralis that inserts into the superolateral patella, and the rectus femoris that combines with the vastus muscles to form the quadriceps tendon, which then inserts into the base of the patella. With anterior aponeurotic condensation, the quadriceps tendon-patella complex continues over the superficial patellar cortex to become the patellar tendon and inserts into the tibial tuberosity.\(^8\)

The rich vascular supply to the patella comes from 6 arteries (Figure 3). However, Scapinelli\(^8\) described dominant anterior and posterior-inferior supplies. This dual supply offers a protective effect for the inferior patella with trauma.\(^10\) In addition, Scapinelli\(^8\) reported minimal vascular supply to the margins of the patella.

The etiology of bipartite patellae is not well understood. Several theories have been suggested, including a model proposing that apophyseal ossification is similar to epiphyseal ossification in terms of vascular supply and biomechanical forces.\(^6,11\) This model posits that the biomechanical pull of the vastus lateralis and the relatively poor blood supply of the superolateral patella lead to growth inhibition of the secondary ossification center, resulting in a synchondrosis rather than bony union.\(^6,9,11\)

Bipartite patella is classified based on the location of the persistent accessory ossification center, originally described by Erich Saupe.\(^1,7\) The classically described bipartite patella (occurring in 75% of cases) is type III (Figure 4), with the accessory ossicle in the superolateral location.\(^1,7,12,13\) In type I bipartite patellae (Figure 5), the accessory ossicle is located at the inferior pole of the patella (occurring in 5% of cases).\(^1,7,12,13\) This type can be associated with Sinding-Larsen-Johansson syndrome (patellar tendinosis and osteochondrosis, or jumper’s knee),...
A 39-year-old man presented with diffuse right knee pain after a motor vehicle collision. Anteroposterior (A) and lateral (B) radiographs of the right knee showing a well-marginated inferior patellar ossicle (asterisk) with irregular but sclerotic margins. Pain could not be localized to the inferior patella. A type I bipartite patella can be indistinguishable from and is probably associated with Sinding-Larsen-Johansen syndrome.

not infrequently with multiple ossicles. In type II bipartite patellae (Figures 1, 6), the accessory fragment is located along the lateral patellar border (occurring in 20% of cases).\cite{1,7,12,13}

**Clinical Presentation**

Bipartite patella is usually an asymptomatic variant that is encountered incidentally. Only 2% of patients have symptoms, which include superolateral patellar tenderness on palpation or pain with knee extension. Pain onset is gradual and often seen in athletes and soldiers participating in repetitive strenuous exercise, likely caused by overuse and microtrauma to the synchondrosis.\cite{13,14} Acute pain is rare and caused by fracture or traumatic separation of the accessory fragment through the synchondrosis.\cite{13,15}

**IMAGING**

**Radiography**

The bipartite or multipartite patella is usually an incidental finding shown on anteroposterior or skyline views. The lateral view seldom helps characterize the ossicle and may not show it at all. When multipartite, 1 or more secondary ossicles are contiguous with the margin of the parent patella. Accessory ossicles are normally well corticated and rounded with smooth margins. However, the margins may be irregular, especially in younger patients, and this irregularity can be mistaken for a fracture on radiographs.\cite{6} The combined ossicles approximate the size of a normal patella.

Characteristically, the articular surfaces of each fragment have normal hyaline cartilage. The articular cartilage surface is continuous despite the radiolucent line seen on radiographs, and minimal evidence is seen of underlying bony discontinuity on gross inspection of the articular surface.\cite{5}

When a symptomatic bipartite patella is suspected, a nonweight-bearing tangential patella view can be compared with a stress view with the patient in a squatting position. Separation on the squatting view indicates isolation of the accessory fragment from the body of the patella.\cite{13,15}

**Nuclear Scintigraphy**

Imaging findings on bone scan are variable. Increased tracer uptake has been frequently noted in asymptomatic and symptomatic patients, so this imaging modality is generally not used for evaluation.\cite{5,13}

**Magnetic Resonance Imaging**

In an asymptomatic patient, MRI is not required. However, a bipartite patella may be encountered incidentally on MRIs done for other purposes. The synchondrosis between the body of the patella and the bipartite accessory ossicle typically appears the same as hyaline cartilage, with intermediate signal on proton density and intermediate to high signal on T2-weighted sequences (Figure 7). Less commonly, imaging characteristics of fibrous tissue that is hypointense can be seen on proton-density and T1- and T2-weighted sequences.\cite{5}

Bone marrow edema at the bony interface (Figure 8), characterized by hyperintensity on T2-weighted fat-saturated images and hypointensity on T1-weighted images, is likely reactive and suggests abnormal motion between the patella and the ossicle.\cite{5} This may be associated with pain. Pain is also associated with a disrupted synchondrosis, which contains fluid and is therefore hyperintense on fluid-sensitive MRI sequences such as T2-weighted and inversion recovery sequences.\cite{5}

Although the ossification variation does not increase the probability of jointline degeneration, the cartilage overlying the bipartite fragment may still develop chondromalacia. The appearance of chondromalacia on MRI ranges from heterogeneous increased signal to thinning, fibrillation, and focal fluid-filled defects. Additional foci of chondromalacia may be seen in other parts of the patellofemoral compartment.

**DIFFERENTIAL DIAGNOSIS**

It is important to separate the normal variant bipartite patella from pathologies involving the patella. Other diagnostic considerations for patellar discontinuity on
the radiograph include acute fracture of a normal patella, stress fracture, sleeve fracture, and patellar tendinosis with osteochondrosis. The diagnosis of fracture is suggested by a history of trauma, most commonly a direct blow or patellar dislocation. Secondary findings supporting fracture include hemarthrosis, sharply angled edges, and lack of cortication (Figure 9). Orientation is also helpful because acute fracture planes are typically transverse, in contrast to the vertical or rounded orientation of the bipartite variant. A stress fracture may be vertical and may have sclerotic edges but generally retains the acutely angled margins and lacks true cortication. A patellar sleeve fracture results in a significantly smaller bone fragment than the bipartite variant located at the superior or inferior pole of the patella (perhaps even a thin crescent) and may be accompanied by patella alta. These findings represent an avulsion fracture at the osseous-cartilaginous interface with delamination of the adjacent cartilage. The osteochondrosis associated with patellar tendinosis (Sinding-Larsen-Johanssen disease) may be indistinguishable from a bipartite patella in a skeletally immature child. Similar to Osgood-Schlatter disease of the tibial tuberosity, chronic overactivity causing traction on the chondro-osseous junction at the inferior patella leads to injury of the cartilage and tendon. In addition, later imaging of these patients may show a type I bipartite patella, suggesting an etiologic association.

**Treatment of Painful Bipartite Patella**

The majority of patients with symptomatic bipartite patella are treated with immobilization for 3 to 4 weeks, as well as anti-inflammatory agents, physical therapy, and bracing. Conservative therapy should be followed for 6 months before considering operative treatment, unless a history of trauma exists or symptoms are severe. Open excision of the accessory fragment is a widely performed surgical treatment for painful bipartite patella after trauma or lack of response to conservative therapy. Patient selection is important. In cases in which the bipartite fragment is large or involves a significant portion of the articular surface, other options should be considered, including lateral retinacular release or release of the vastus lateralis either subperiosteally or directly from the ossicle. The goal of these releases is to reduce traction on the accessory fragment and allow healing of microfractures. Bony union has even been reported following these procedures. Abnormal patellofemoral tracking because of unbalanced pull of the vastus medialis is a complication of both release procedures, along with weakness of knee extension.

Internal fixation, with or without a bone graft, has been performed in an attempt to preserve function and articular integrity. However, this option requires longer rehabilitation and immobilization than the soft tissue procedures, which can lead to stiffness. Therefore, this approach is reserved for patients with large fragments covering a significant portion of the articular surface.

**Conclusion**

Bipartite patella is usually recognized as a normal variant, generally found incidentally on imaging. However, in patients with pain and injury in the setting of a bipartite patella, imaging can be a useful tool to delineate the underlying cause of knee pain, including injury to the synchondrosis or articular cartilage of the bipartite patella. Conservative therapy of symptomatic bipartite patella is effective in most patients. Although rarely indicated, several surgical options are available for the treatment of symptomatic bipartite patella, including new procedures that may limit complications.
REFERENCES