The menisci of the human knee are fibrocartilaginous, crescent-shaped structures that lie on the articular surface of the tibia (Figure 1). They are integral components of knee biomechanics. Injuries to the knee menisci are common, especially among athletes. Short-term sequelae of meniscal injury include knee pain and deficits in knee range of motion. Long-term sequelae of meniscal injury include degenerative changes in the knee joint with associated knee pain and stiffness.

Conservative treatments involving nonsteroidal anti-inflammatory drugs (NSAIDs) and physical therapy are often sufficient for the treatment of meniscal tears. A patient who presents with either mechanical symptoms of catching and locking, or range-of-motion deficits will often benefit from surgery. Surgical treatment options include partial meniscectomy or meniscal repair.

**Meniscal Anatomy and Function**

The knee menisci are wedge-shaped in cross section, thicker near the periphery of the joint space. The menisci are composed largely of type 1 collagen fibers arranged primarily in a circumferential orientation (resisting stress along the length
of the meniscus) with some radially oriented fibers (resisting stresses across the cross section of the meniscus).\textsuperscript{1}

The menisci derive their blood supply from a perimeniscal capillary plexus formed by branches of the superior and inferior geniculate arteries. This capillary plexus penetrates only the outer 10% to 30% of the meniscal tissue.\textsuperscript{2} The remainder of the inner meniscus is avascular, and its nutritional needs are supplied mainly by diffusion.\textsuperscript{1} The clinical significance of this perfusion scheme is that the inner 70% of the meniscus is much less likely to heal from injury than the periphery and may need to be debrided rather than repaired.\textsuperscript{4}

**MEDIAL MENISCUS**

The medial meniscus is C-shaped and wraps around the periphery of the medial joint space. The anterior horn of the medial meniscus attaches to the tibia anteromedial to the anterior cruciate ligament (ACL) insertion. The posterior horn of the medial meniscus attaches directly posterior to the ACL insertion.\textsuperscript{5} The medial meniscus also is anchored to the tibia throughout its periphery to a portion of the joint capsule referred to as the coronary ligament. The midportion of the medial meniscus attaches to the deep fibers of the medial collateral ligament. The medial meniscus is widest at its posterior horn and gradually tapers in width as it courses anteriorly.

**LATERAL MENISCU**

The lateral meniscus is more semicircular in shape, covers a larger area, and is less firmly attached at its periphery than the medial meniscus. The anterior and posterior horns of the lateral meniscus attach close to each other and lateral to the tibial insertion of the ACL. The periphery of the lateral meniscus is only loosely attached to the joint capsule.\textsuperscript{6} Two meniscofemoral ligaments, the ligaments of Humphries and Wrisberg, course from the posterior horn of the lateral meniscus to the medial femoral condyle adjacent the posterior cruciate ligament.

**MENISCAL FUNCTION**

The knee menisci play a key role in protecting the articular cartilage from high contact stresses. The menisci accommodate the shape mismatch between the round femoral condyles and the relatively flat tibial articular surface, increasing the contact surface area of the tibial plateau and thereby decreasing the contact stress at any 1 point. A tear or meniscectomy involving 15% to 34% of the meniscus causes an increase in contact pressures in the knee joint of up to 350%.\textsuperscript{7}

The viscoelastic menisci also play a role in shock absorption, with total meniscus removal decreasing the shock absorption capacity of the knee by 20%.\textsuperscript{8}

The conforming natures of the menisci are thought to aid in joint proprioception and lubrication as well as to enhance joint stability. In fact, in an ACL-deficient knee, the medial meniscus is the key restraint against an anterior load applied to the tibia.\textsuperscript{9,10}

**MENISCAL INJURY**

**Epidemiology**

The overall incidence of meniscal tears that lead to surgery is 60 to 70 incidents per 100 000 people per year.\textsuperscript{11-13} One third of meniscal tears are associated with...
Sports injuries. Sports in which cutting and pivoting moves predominate, such as football, soccer, and basketball, lead to the highest incidence of meniscal tears. Men are 3 times more likely than women to sustain a meniscus tear, probably due to greater numbers of the former participating in high-risk activities. Acute, Degenerative, Chronic Tears

Meniscal tears can be considered acute when associated with a specific traumatic event or degenerative when associated with recurrent microtrauma. Acute meniscal tears are more common among younger patients and in this population are associated with acute ACL injury 33% of the time. In patients with an intact ACL, medial meniscal tears are more common than lateral meniscal tears by a ratio of 5:1. This is thought to be due to the decreased mobility of the medial meniscus, which is tethered to the joint capsule peripherally. In industrial workers who squat a great deal, the ratio of medial to lateral tears is closer to 20:1. However, in patients with an acute ACL injury, the lateral meniscus is more likely to be torn due to shifting of the lateral condyle on the lateral plateau, which occurs at the time of injury.

Chronic tears of the meniscus most commonly occur in middle-aged and older patients and are often not associated with a specific traumatic event. As the function of the meniscus gradually decreases over time, concomitant arthritic changes in the articular cartilage of the knee often accompany this presentation.

Types of Meniscal Tears

Meniscal pathology can be described based on the tear pattern, length, depth (either partial thickness or complete), and stability (ability of the torn segment to move relative to the body of the meniscus). Five types of pathologic meniscal tears seen via arthroscopy are shown in Figure 2. This classification system is different from the grading scale used by radiologists (please see “Radiographic Evaluation” below). In practice, most tears of the meniscus are either oblique or vertical longitudinal. Vertical longitudinal tears are more common in younger patients and can be unstable (the torn inner segment can move with knee motion). A bucket-handle tear is a complete vertical tear, which is by nature unstable and can displace toward the center of the joint. This will cause the clinical symptoms of catching and locking, as well as deficits in knee extension and flexion. Oblique tears can catch between the femoral condyle and tibia and cause traction on the meniscocapsular junction, producing pain. Complex tears are multilobar, usually degenerative and chronic, and often associated with arthritic changes in the articular cartilage in the medial and lateral joint spaces. Horizontal tears are more common in older patients and more likely to be associated with meniscal cysts, which are often palpable at the joint line. Horizontal tears are also the tears most likely to be asymptomatic. Radial tears begin at the inner edge of the meniscus but can traverse the entire cross section, disrupting the weight-bearing function of the meniscus. All tears have free edges that may catch between articulating surfaces and cause propagation of the tear further into the body of the meniscus. One goal of meniscal surgery is to limit tear propagation.

Clinical Evaluation

The clinical evaluation should focus on determining whether the patient has a meniscal tear and, if so, whether this tear is causing mechanical symptoms that would necessitate surgery. Unfortunately, no one symptom or clinical test is diagnostic of a meniscal tear; rather, the diagnosis is made based on a composite of symptoms and clinical examination findings.

Patients should be questioned about traumatic events, knee swelling, and the presence of mechanical symptoms including painful knee joint catching and locking. A subjective feeling of catching during knee motion could indicate an unstable torn meniscal fragment sandwiched between the articular surfaces at a particular knee position that then reduces back to its original position, relieving the catch. A torn meniscal fragment that displaces toward the center of the joint could cause the knee to lock, or prevent further flexion or extension. Classically, locking occurs with a bucket-handle meniscus tear that displaces and prevents full extension of the knee. Patients also should be questioned concerning the location of the pain, as meniscal pain is typically felt along the medial or lateral joint line. Patients with meniscal tears also may experience pain with activities that involve weight bearing in maximum knee flexion, such as squatting.

Patients with patellofemoral pain, with or without arthrosis, may describe symptoms similar to those of a meniscus tear. A sensation of catching or locking may occur in the articulation between the patella and the distal femur, particularly during activities that load this articulation, such as deep squats or stair climbing. Sometimes, patients are able to localize this pain to the patellofemoral joint, but often they confuse the symptoms with those arising from the tibiofemoral articulation.

Clinical Examination

The clinical examination should begin with an inspection of the knee for effusion and palpation for tenderness followed by assessments of knee range of motion, knee ligament stability, and associated
patellofemoral disorders. Finally, provocative maneuvers should be done to evaluate for meniscal tears.

**Joint Line Tenderness.** In patients with intact ACLs and a meniscal tear, 60% to 80% will have tenderness along the joint line. The tenderness should be localized as medial or lateral and correlated with the site of pain experienced with everyday activities. A meniscal cyst also may be present along the joint line. Meniscal cysts are joint capsule outpouchings filled with a gelatinous substance resembling synovial fluid. Most often seen at the lateral joint line, these cysts decrease in size with knee flexion and are highly suggestive of an underlying meniscal tear. They are different from Baker’s cysts, which are larger and often occur posteriorly in the popliteal fossa. Joint line tenderness is not always pathognomonic of a meniscal tear; it also may be associated with chondral lesions of either the femoral or tibial articular surfaces or with knee ligament injury. In the presence of an acute injury, such as an ACL tear, joint line tenderness is much less reliable for predicting the presence of a meniscal injury.

**Range of Motion.** The range of motion of the involved knee should be carefully assessed and compared to that of the contralateral knee. Deficits in knee extension or flexion should alert the examiner to possible displaced meniscal tears prohibiting full range of motion.

**Evaluation of the Patellofemoral Joint.** The patella should be examined for smooth tracking throughout knee flexion without excessive medial or lateral deviation from the femoral trochlea. Symptoms of catching or grinding should be localized to either the patellofemoral joint or the articulation between the femur and tibia (menisci), if possible. In addition, the patient should be examined for pain with patellar loading. To perform this test, the examiner presses the patella against the femoral condyle while asking the patient to slowly contract the quadriceps. The patient should be asked whether he or she experiences pain during this maneuver and more specifically whether this maneuver reproduces the original pain. A positive response to these questions suggests a patellofemoral rather than meniscal etiology.

**Specific Maneuvers to Diagnose Meniscal Tears.** Several maneuvers have been developed to test specifically for the presence of a meniscal tear. McMurray’s test, described by Smith in a previous issue of this Journal, involves passively flexing the knee from an extended position while internally rotating the foot and then repeating the movement with the foot externally rotated. During this maneuver, 1 of the examiner’s hands palpates the joint line; the other hand manipulates the leg. A positive McMurray test is revealed by a palpable “thud” that occurs when a fragment of meniscus catches between the femur and the tibia at some point during the flexion arc. Classically, a posterior medial meniscus tear will produce a positive result with the leg externally rotated (heel rotated medially), whereas a posterior lateral meniscus tear will produce a positive result with the leg internally rotated (heel rotated laterally). McMurray’s test is specific (0.98) but not sensitive (0.16) for diagnosing medial meniscus tears. It is not as accurate at diagnosing lateral meniscal tears, with a positive predictive value of only 0.29. Even if a thud is absent when performing the test, pain that reproduces the patient’s symptoms strongly suggests a meniscal pathology.

Apley’s test, also discussed by Smith, was developed to differentiate between meniscal pathology and other sources of intra-articular derangement. The test involves having the patient lie prone with the hip extended and knee flexed 90 degrees. Then the physician presses down on the foot while rotating the leg internally and externally (grind maneuver). Pain with this compressive, shearing, grind maneuver indicates a meniscal tear. The test is then repeated with distraction rather than compression applied to the leg, unloading the menisci. Pain with distraction and rotation indicates some source of pathology other than a torn meniscus.

**IMAGING STUDIES**

**Radiographic Evaluation.**

Patients suspected of having a meniscal tear should have radiographs taken of the involved knee. Though radiographs will not show the meniscal tear, they will delineate alternative and concurrent pathologies, such as a fracture in a patient with an acute knee injury or arthritic changes in a patient with chronic symptoms. Two views of the knee, usually anteroposterior and lateral views, can reveal gross pathology such as medial- or lateral-compartment degenerative arthritis or fractures. Standard views obtained by an orthopedic surgeon include a posterior-anterior (P-A) weight-bearing view in 45 degrees of flexion, lateral views in 30 degrees of flexion, and an axial “sunrise” view or a Merchant view of the patella. Arthritic changes in the medial and lateral tibiofemoral compartments are best evaluated on the P-A weight-bearing 45-degree view, whereas patellofemoral arthritis and malalignment problems are best evaluated on the axial patella view.

**Magnetic Resonance Imaging.**

Magnetic resonance imaging (MRI) is commonly used to evaluate a meniscal tear. MRI allows evaluation of soft tissue structures in the knee, including the cruciate and collateral ligaments, menisci, and patellar tendon. Osteochondral lesions, patellofemoral disorders, and intra-articular loose bodies often can be seen with MRI. Meniscal cysts also are easily detected with
MRI. Normally, the menisci appear as uniformly dark structures devoid of high-signal areas.

Tears are seen as high-signal areas within the substance of the meniscus. Radiologists use a grading system to delineate these signal changes, with grade 0 being a normal meniscus; grades I and II, high-signal intrameniscal areas that do not abut a free meniscal edge; and grade III a high-signal area that tracks to the edge of the meniscus. Grade III changes are the only changes consistent with a clinically significant meniscal tear and, for this reason, care must be used when interpreting MRI images and reports. Care must also be used when interpreting signal changes in a patient who has had previous meniscal surgery, as MRI is often unreliable in these cases.

The main disadvantages of MRI are the costs associated with the test and the large number of incidental meniscal findings in asymptomatic patients.28 A study comparing the sensitivity and specificity of a clinical examination with an MRI for diagnosing meniscal tears found them to be similar.57 The study highlighted 2 important concepts. First, the clinical examination findings were not the result of a specific maneuver but rather a composite of (1) the patient’s history as elicited by an experienced orthopedic surgeon and (2) the findings of several examinations. Second, the MRI scans had a high negative predictive value for excluding a meniscal tear as the cause of knee pain.53,17,33

It is imperative that findings on MRI be correlated with a careful history and physical examination before attributing the patient’s knee pain to the specific MRI finding. Also, before ordering an MRI, thought should be given to whether the results of the MRI will change the treatment. For instance, a patient with an acute injury and a knee effusion should be referred to a specialist without delay. A patient with a suspected meniscus lesion and mechanical symptoms and signs also should be referred, as partial meniscectomy or meniscal repair may substantially benefit such a patient. A patient with a suspected or documented meniscal lesion but no mechanical symptoms may not need to see a specialist initially. Particularly in the case of degenerative knee osteoarthritis, an extended course of conservative treatment may be indicated. Failure of conservative treatment and interference with activities of daily living would be indications for referral.

REFERRAL TO A SPECIALIST

A question often arises regarding when to refer a patient to an orthopedic surgeon or a primary care sports medicine specialist. Certainly an athlete with an acute injury and a knee effusion should be referred to a specialist without delay. A patient with a suspected meniscus lesion and mechanical symptoms and signs also should be referred, as partial meniscectomy or meniscal repair may substantially benefit such a patient. A patient with a suspected or documented meniscal lesion but no mechanical symptoms may not need to see a specialist initially. Particularly in the case of degenerative knee osteoarthritis, an extended course of conservative treatment may be indicated. Failure of conservative treatment and interference with activities of daily living would be indications for referral.

SURGICAL TREATMENT

Prior to the 1980s, total meniscectomy was a popular treatment for patients with meniscal injuries. King was the first to notice the degenerative articular cartilage changes in the knees of patients who had undergone total meniscectomy.35,36 Fairbank described the degenerative changes that one can visualize on radiographs following total meniscectomy (and presumably following meniscal tears): squaring of the femoral condyle, osteophyte formation, and joint space narrowing.37 As these findings came to light, the orthopedic community began to appreciate the relationship between meniscal function and prevention of articular cartilage damage, and gradually moved from total meniscectomy to procedures that preserve as much meniscal tissue as possible, such as partial meniscectomy and meniscal repair.

Current surgical treatment of meniscal tears has 2 goals: to relieve pain and to limit further degenerative
changes in the surrounding articular cartilage. Degenerative changes in the articular cartilage are likely to start soon after the meniscal tear occurs. The changes are due to the inability of the affected segment to participate in load transmission and shield the underlying articular cartilage from increased contact stresses. Pain and mechanical symptoms produced by a torn flap of meniscal tissue intermittently interposed and tethered between the articulating surfaces of the knee often respond to simple debridement of the torn meniscal tissue. However, the well-known association between total meniscectomy and degenerative changes in the articular cartilage compels the surgeon to preserve as much functional meniscus tissue as possible. During surgery, steps also are taken to halt tear propagation into normal meniscal tissue.

A patient with joint line tenderness, mechanical knee symptoms, and positive results on specific examinations for a meniscal tear, who is adversely affected by symptoms and has no other explanation for the knee pain, is a candidate for knee arthroscopy and surgical management of the meniscal lesion. At this point surgical management most often consists of (1) partial meniscectomy with removal of only the torn fragment and contouring of the remaining meniscus to prevent tear propagation or (2) meniscal repair involving direct suturing of the torn fragment to the meniscal body. Other techniques of surgical management include replacement of the entire meniscus with an allograft meniscal implant or bioengineered meniscal implant. Neither of the latter techniques is in widespread use at this time except in specialized circumstances.

The decision between performing a meniscal repair vs a partial meniscectomy is made based on the pattern of the tear, the distance from the rim, concomitant joint pathology, and the age of the tear. The patient's age, activity level, involvement in sports, and ability to be compliant with the postoperative rehabilitation schedule are also taken into account. As will be discussed, meniscal repair generally involves a longer postoperative rehabilitation schedule and may not be considered desirable by high-performance athletes who wish to return to participating in sports as quickly as is possible.

**Partial Meniscectomy**

Partial meniscectomy is indicated in patients who have tears in the inner 70% of the meniscus, where the tear fragment is mobile and can cause mechanical symptoms or might propagate further into the body of the meniscus. The procedure is usually performed on an outpatient basis using arthroscopic instruments. Surgery usually takes 15 to 45 minutes and is performed using regional or general anesthesia. Three to 5 small (5 mm) portal incisions are made in various locations overlying the knee joint for the introduction of arthroscopic instruments. With fluid infused through the joint to distend the joint capsule and allow visualization, an arthroscopic camera is introduced into 1 portal and a systematic inspection of the entire knee joint is performed. Other portals are used for introducing various probes, manual cutting instruments, and motorized shavers. After identifying a meniscal tear that is not a candidate for a repair procedure, a partial meniscectomy is performed under camera visualization. The mobile fragments of torn meniscus are debrided back to a stable rim using the cutting instruments and motorized shaver. The resultant rim is then smoothed to prevent propagation of the tear (Figure 3). The instruments are removed and the arthroscopic portals are usually closed using 1 suture per portal. Almost all patients are allowed to bear weight as tolerable immediately after the procedure. Most patients use crutches for 1 to 2 days postsurgery. Patients involved in administrative or similarly sedentary professions often return to work after 1 week of recovery. Laborers typically require 2 to 4 weeks before returning to full duties. Athletes generally can return to their sport 2 to 6 weeks following surgery. Long-term follow-up of patients with partial meniscectomy has shown that 88% of patients have an excellent clinical outcome at 15 years.

**Meniscal Repair**

Meniscal repair is indicated only for certain patterns of meniscal tear. The tear pattern most amenable to repair is the vertical longitudinal tear. To obtain the necessary blood supply for healing, the tear must be in the outer 30% of the meniscus and should be longer than 1 cm; shorter tears in the periphery may heal on their own.

Several techniques are used to repair meniscal tears. Using small incisions to expose the joint capsule, an "inside-out" repair uses suture needles passed through the torn meniscus under arthroscopic vision and retrieved on the outside of the knee. Vertical mattress
sutures are used to reapproximate the torn surfaces. The suture knots are tied down over the external joint capsule surface (Figures 4 and 5). This technique is more useful for tears in the posterior aspects of the medial and lateral menisci.

The “outside-in” technique is more useful for tears in the anterior aspects of the menisci and involves spinal needles placed across the meniscal tear from outside the knee. The needles are visualized arthroscopically as they cross the torn surfaces. Sutures are then passed through the needles to repair the tear using a vertical mattress configuration. “All-inside” techniques involve specially developed instrumentation and biodegradable meniscal “arrows” that provide fixation across meniscal tears, much like threaded carpentry tacks. Ease of use and the fact that no additional incisions are necessary for placement make these devices attractive. However, the fixation they provide is not as secure as that provided by sutures, making them less appropriate for higher-demand tears.

Following repair of a meniscal tear, patients usually have restricted weight bearing on the operative leg for 2 weeks and must wear a brace. Administrative workers may return to work after 1 week, but laborers may be on restricted duty for 6 to 12 weeks. Athletes may usually return to their sport within 12 to 16 weeks.

The long-term results of meniscal repair have been evaluated in patients with at least 10-year follow-up. Johnson et al found that 76% of patients who receive a meniscal repair have excellent symptomatic results at 10 years.

CONCLUSION

Meniscal injuries are common, especially among athletes. A careful history and physical examination focusing on mechanical signs and symptoms are important to distinguishing meniscal pathology from other knee complaints, such as patellofemoral pain. A typical patient presenting with an effusion, joint line tenderness, and mechanical signs and symptoms should be referred to a specialist, such as an orthopedic surgeon or primary care physician specializing in sports medicine. A patient with a meniscal tear who has failed conservative treatment also should be referred to a specialist. MRI has excellent sensitivity for diagnosing meniscal tears but should not replace a careful history and physical examination. In addition, MRI has a high negative predictive value for excluding a meniscal tear; a negative MRI should therefore prompt a search for other causes of knee pain.

Conservative treatment is indicated for stable meniscal tears in patients with low activity requirements. Patients failing conservative treatment may require surgical management of their meniscal lesion. Partial meniscectomy is often successful at eliminating a patient’s short-term pain. Meniscal repair is not only effective for relieving short-term pain but also has the added benefit of limiting further articular cartilage damage.

Figure 4. The Inside-Out Meniscal Repair

Figure 5. Meniscal Repair
REFERENCES


