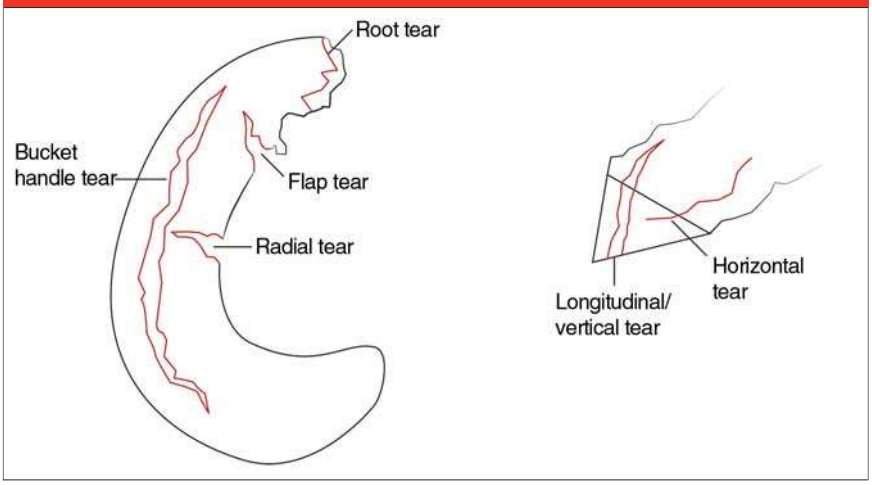
Figure 3



Schematic illustration of the types of meniscal tears. Note that the bucket-handle tear has a morphology similar to that of the longitudinal or vertical tear but involves more displacement of the tear edges.

Table 1

Indications for Meniscal Repair

Tear >1 cm and <4 cm in length
Red-red zone tears
Vertical tears
Patient age <40 y
No mechanical axis malalignment
Acute tears (ie, <6 wk)
Concurrent anterior cruciate ligament reconstruction

Diagnosis

The diagnosis of a meniscal tear is typically clinical. Symptoms include joint line tenderness, mechanical symptoms of catching or a locking sensation, clicking on moving the knee, and intra-articular effusion.

The clinical evaluation should include assessing for joint line tenderness, range of motion testing, the Apley grind test, the McMurray test, and the Thessaly test. Joint line tenderness has a reported sensitivity of 71% and 78% and specificity of 87% and 90% for medial and lateral meniscal tears, respectively.[10] For the Apley grind test, the patient lies prone with the knee flexed to 90°. The examiner assesses for pain by performing internal and external rotation of the leg while applying axial load. This test has a sensitivity of 41% for both medial and lateral tears and a specificity of 93% and 86% for medial and lateral meniscal tears, respectively.

In the McMurray test, the patient lies supine and the knee is flexed to 90°. Next, the examiner applies a varus or valgus stress to the knee while internally or externally rotating the leg. The test is positive when a pop or a click is palpated at the joint line as the knee is slowly extended. The sensitivity for this test is 48% and 65% and the specificity is 94% and 86% for the medial and lateral menisci, respectively.

The Thessaly test was described by Karachalios et al[10] in 2005. The patient stands on the affected knee and flexes it to 20°, then internally and externally rotates the knee and body. A positive test produces either pain at the joint line or a locking or catching sensation. The Thessaly test was found to have sensitivity of 89% and 92% and specificity of 97% and 96% for the medial and lateral menisci, respectively.[10]

MRI is typically used to confirm a clinical diagnosis. However, its added value in diagnosis has been disputed; its usefulness is largely based on the quality of the MRI. A prospective study showed accuracy of 73.7% with MRI diagnosis and accuracy of 80.7% on clinical examination.[11] MRI is not sufficiently accurate to show whether a tear is repairable.[12]

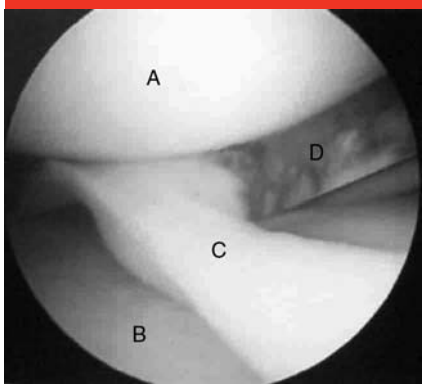
Repair Indications

Although meniscal preservation is important, only certain types of tears are amenable to repair. Factors that contribute to good healing potential and low failure rates have been well studied. The relative indications of meniscal repair are summarized in Table 1.

The vascular supply of a meniscal tear is the most important intrinsic factor in healing. Most meniscal repairs are attempted on tears that are close to the vasculature supply, that is, in the red-red or red-white zone. Prospective studies evaluating clinical and arthroscopic assessments of healing have found that tears within 2 mm of the meniscal vascular rim have the highest rates of healing following repair.[13,14] Conversely, those that lie >4 mm from the rim have high rates of failure following repair.[13,14] However, some studies have reported successful repair of tears that extend into the avascular zone of the meniscus, especially in younger patients.[15,16]

The length of a tear affects its stability. Tears measuring <1 cm in length are generally considered stable, and repair is usually unnecessary.[13,15,17] Tears measuring >4 cm in length are unstable to the point that attempted repairs often fail; thus, tears of this size are rarely repaired, either.[13,14]

Figure 4



Arthroscopic image of a meniscus tear that is a good candidate for repair because it is located in the red-white zone, is nondegenerative, and is of the bucket-handle type. A = femoral condyle, B = tibial plateau, C = white zone portion of bucket-handle tear, D = red zone portion of bucket-handle tear

Figure 5

Arthroscopic image of a meniscus tear that is a poor candidate for repair because it is degenerative and is located in the peripheral avascular zone. Such tears should be managed with arthroscopic débridement.

Tear shape is another factor in whether repair is possible. Radial tears are often located in the avascular zone, and as a result, they are typically managed with partial meniscectomy. More substantial radial tears that extend the entire width of the meniscus may be an indication for repair.[18] Horizontal tears often are not repaired, in part because it is difficult to reduce the edges with sutures in these tears, which are oriented parallel to the plane of the knee joint. Additionally, horizontal tears are frequently degenerative tears.[13,15] Conversely, longitudinal tears are commonly repaired because they are amenable to suture fixation (Figure 4).

Tears that appear to be degenerative tend to be associated with chronic damage to the meniscus; typically, these tears are débrided[14] (Figure 5). In a biomechanical study published in 2008, Allaire et al[19] demonstrated that medial meniscal posterior root tears have an impact on tibiofemoral contact mechanics almost identical to the impact of complete medial meniscectomy because those tears allow the meniscus to extrude from the knee. Moreover, the study shows that normal contact mechanics are restored with tear repair, which highlights the importance of repairing meniscal root tears to preserve normal knee mechanics.

Controversy persists regarding whether the timing of repair affects success. Tengrootenhuysen et al[17] found a significantly higher success rate in tears repaired <6 weeks after the injury ($P < 0.001$). In contrast, other studies have indicated either an insignificant difference or no difference in healing rates.[13-16,20]

Traditionally, it has been presumed that the menisci of younger patients have a more effective healing response and, thus, that meniscal repair should be favored in these patients. Outcome studies evaluating repair failure rates have questioned this presumption, with some studies showing significantly better success in young patients[9,12] and others showing no difference based on age.[13,16] Regardless, repair should be favored in young patients because arthritic progression following meniscectomy takes years to develop. Elderly patients are unlikely to live long enough to develop symptoms following meniscectomy; however, persons who undergo meniscectomy early in life will experience symptoms and will suffer a longer duration of associated morbidities.[15]

Anterior cruciate ligament (ACL) tear is the most common injury that occurs concurrently with meniscal tear. Outcome studies have demonstrated that repairs of the meniscus performed concurrently with ACL reconstruction are as successful as[20] or significantly more successful than[13,14,17] repairs performed in ACL-intact knees. This may be the result of the release of blood and other healing factors into the joint during the ACL reconstruction. There is some debate with regard to, and some evidence in support of, staged meniscus repair and ACL reconstruction.[21] However, it is generally recommended that ACL reconstruction and meniscal repair be performed concurrently.

Tears of the lateral meniscus are generally found following acute ACL rupture, and these tears are likely related to the initial injury. Lateral meniscus tears are usually found incidentally and are often stable and nondisplaced. Conversely, tears of the medial meniscus are often found in chronically ACL-deficient knees, likely resulting from the increased instability commonly found in these joints. Typically, these tears are degenerative and complex, and often they are not repairable.[22] In a meta-analysis of 10 studies, Pujol and Beaufils[23] evaluated the healing rates of meniscal tears that were neither repaired nor débrided at the time of ACL reconstruction. They found a 4.8% incidence of residual pain or repeat meniscectomy for lateral meniscus tears, compared with 14.8% in medial meniscus tears. However, other than stability of the tear, inclusion criteria varied considerably among the studies.

Figure 6

Arthroscopic image of a meniscal repair performed with the inside-out suturing technique with horizontal mattress sutures in a left knee.

Repair Techniques

Initially, repairs of meniscal tears were approached from the periphery of the meniscus without arthroscopic instrumentation; thus, only the most peripheral tears could be accessed. The inside-out suturing technique was the first one used for arthroscopic repair of meniscal tears, and it is still considered to be the standard of care for meniscal repair.

In general, meniscal repair begins with a complete arthroscopic assessment of the knee and full evaluation of the tear. In patients who require repair, the margins of the tear are débrided, with or without rasping. At that point, the surgeon must decide on a repair technique: inside-out, outside-in, all-inside, or a combination of these.

With the inside-out technique, sutures are inserted into the meniscus using a needle cannula under arthroscopic visualization (Figure 6). The needles with suture attached are passed on either side of the tear through the meniscus, then out the knee through the capsule. An incision is made in the skin, and the sutures are tied down to the capsule.

For medial meniscus repair, the medial incision is made anterior to the medial head of the gastrocnemius muscle, thereby exposing the capsule. For lateral incisions, the dissection is made anterior to the lateral head of the gastrocnemius. Care is taken to avoid neurovascular structures. A sterile spoon or a speculum may be used to retrieve sutures and visualize the capsule. Sutures must be tied with the knee in relative extension to prevent capture of the posterior capsule of the knee as it folds on flexion, thus limiting extension.

The inside-out technique is still commonly used, although it is very difficult technically to repair tears in the posterior horns of the menisci with this technique.[24] Although it has proved to be effective, this technique has a significant learning curve and typically requires the presence of a surgical assistant.

In the outside-in technique, sutures are passed through the meniscus from the outside, thus avoiding the more extensive incisions and retractions involved in inside-out repairs. As with inside-out repairs, however, outside-in repairs are largely limited to anterior portions of the medial and lateral menisci.[25]

Prospective studies have indicated success with both techniques. In a meta-analysis of isolated meniscus repairs, Grant et al[26] found a combined 17% incidence of repair failure with the inside-out technique and an average Lysholm score of 87.8 on follow-up. In a follow-up study of 41 patients with menisci repaired using the outside-in technique, Abdelkafy et al[27] found that 5 patients (12%) required subsequent partial meniscectomy, and 36 patients had a mean Lysholm score of 87.3 at a mean of 11.7 years.

Mechanical studies have historically shown that vertical mattress sutures provide stronger fixation than do horizontal sutures.[28] However, a more recent mechanical study by Aros et al[29] found that with high-strength suture material, load to failure is the same regardless of suture orientation.

All-inside repair devices were developed to reduce surgical time, prevent complications resulting from external approaches, and allow access to tears of the posterior horn. First-generation all-inside techniques involved the insertion of rigid arrow or screw implant devices made of absorbable polymers. However, it quickly became apparent that the devices were prone to breaking[30] and to damaging articular cartilage;[31] they were abandoned for second-generation headless screws and arrows, which protruded less. These improved rigid fixation devices are still used, although recent studies have shown them to have less mechanical strength than suture repairs.[32] Järvelä et al[33] recently showed that of 42 meniscal repairs performed using meniscal screws and arrows, 11 failed clinically on follow-up, and some exhibited articular cartilage damage.

The third-generation all-inside repair devices involve the insertion of sutures and suture fixators. These devices have been shown to be clinically effective. Grant et al[26] found a pooled failure rate of 14.6% among three studies in their meta-analysis. A bovine mechanical study showed third-generation all-inside devices to have the same or slightly less load to failure than horizontal or vertical mattress sutures.[29] Third-generation all-inside suturing systems remain a viable option for meniscal repair.

Fourth-generation repair devices allow placement of sutures in the meniscus without the aid of an external incision or a suture fixator system. These new devices are self-adjusting, with the anchor located behind the capsule and with a sliding knot that can be tensioned appropriately by the surgeon. In a mechanical