Review Article

Meniscal Repair

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Abstract

Historically, treatment of meniscus tears consisted of complete meniscectomy. Over the past few decades, however, the long-term morbidities of meniscal removal, namely the early development of knee osteoarthritis, have become apparent. Thus, management of meniscal tears has trended toward meniscal preservation. Recent technological advances have made repairs of the meniscus easier and stronger. In addition, adjunctive therapies used to enhance the healing process have advanced greatly in the past few years. Today, with increased understanding of the impact of meniscal loss and the principles of meniscal repair and healing, meniscal preservation is viewed as an increasingly realistic and important goal in the management of meniscus tears.

Knee arthroscopy is the most common type of orthopaedic surgery performed in the United States, accounting for >900,000 procedures in 2006.[1] Of these, more than half involved a meniscal tear. Traditionally, meniscal tears were managed with meniscectomy. However, since the long-term morbidities of meniscus removal became apparent (eg, early development of knee osteoarthritis), management has been increasingly focused on meniscal preservation.

Anatomy

The medial and lateral menisci are each approximately 3 cm wide.[2] The medial meniscus is approximately 4 to 5 cm in length, and the lateral meniscus is approximately 3 to 4 cm in length. The normal meniscus is composed of approximately 70% water and 30% organic matter. The organic matter is made up of approximately 75% collagen (types I, II, III, IV, V, VI, and XVIII) and 25% other organic matter, including proteoglycans (15%), DNA (2%), adhesion proteoglycans (<1%), and elastin (<1%).

Arnoczky and Warren[3] first described the blood supply for each meniscus. They illustrated a microvascular perimeniscal plexus supplied by the vascularized synovial tissue on the periphery of the menisci. This plexus is formed from the medial and lateral geniculate arteries, which are branches of the popliteal artery. The vascular supply terminates in short capillaries that extend from the periphery inwards, constituting approximately 10% to 30% of the width of the medial meniscus and 10% to 25% of the width of the lateral meniscus (Figure 1).

Meniscal Biomechanics

The medial and lateral menisci have important biomechanical functions within the knee joint. These include load bearing, shock absorption, joint stability, joint lubrication, and proprioception.

In 1948, Fairbank[4] examined post-meniscectomy knees and noted that over time they developed joint-space

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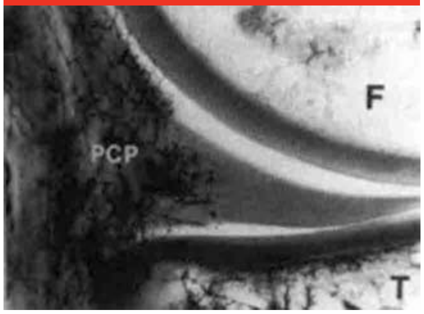
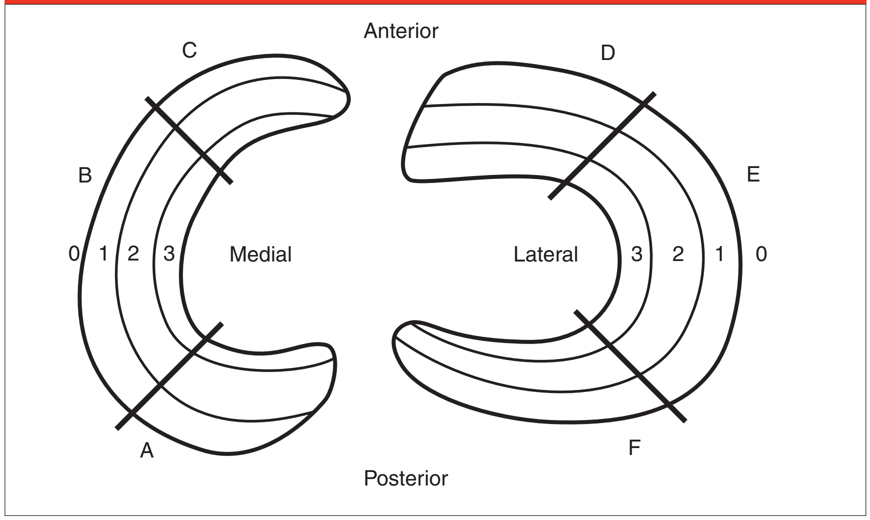
Figure 1



Cross-section of the medial compartment of the knee, highlighting the meniscal vasculature. F = femur, PCP = perimeniscal capillary plexus, T = tibia. (Reproduced with permission from Arnoczky SP, Warren RF: Microvasculature of the human meniscus. *Am J Sports Med* 1982;10[2]:90-95.)

Figure 2



Schematic diagram of the medial and lateral meniscus demonstrating the 12 Cooper zones. The radial thirds are labeled with letters A through F, and the numbers zero through 3 represent the subdivisions into circumferential thirds. (Adapted with permission from Cooper DE, Arnoczky SP, Warren RF: Meniscal repair. *Clin Sports Med* 1991;10[3]:529-548.)

narrowing and femoral condylar flattening. He was the first to describe the load-bearing function of the meniscus. When an axial load is applied across the knee joint, the menisci experience tensile, compressive, and shear stresses.[5] Studies measuring contact pressures on the tibial plateau have shown that the menisci transmit at least 50% of the load placed across the knee joint in the first 90° of flexion, with higher transmission at full extension.[6]

The crescentic wedge shape of the meniscus assists in the translation of compressive forces from the articular cartilage into concentric forces on the meniscus. These hoop stresses are then transmitted to the bony anchors of the meniscal horns by the circumferential fibers of the meniscus.[7] This distribution of force helps protect the articular cartilage and prevent degeneration.

Loss of meniscal volume has a dramatic impact on the contact mechanics of the knee joint. Biomechanical studies have shown that complete medial meniscectomy decreases the tibiofemoral contact area by 50% to 70% and results in an increase in peak pressures and an increase in the area under high pressure.[6] More recent studies have shown that even small decreases in meniscus volume, such as following a partial lateral meniscectomy, can significantly alter knee mechanics, resulting in increased peak pressures and mean contact pressure.[8]

Joint stability is enhanced by the shape of the meniscus and the attaching ligaments. The concavity of the superior aspect of the meniscus and the flat surface of the inferior aspect of the meniscus enhance the congruity of the tibiofemoral joint. The meniscotibial and meniscofemoral ligaments also add to the stability of an otherwise incongruous joint.

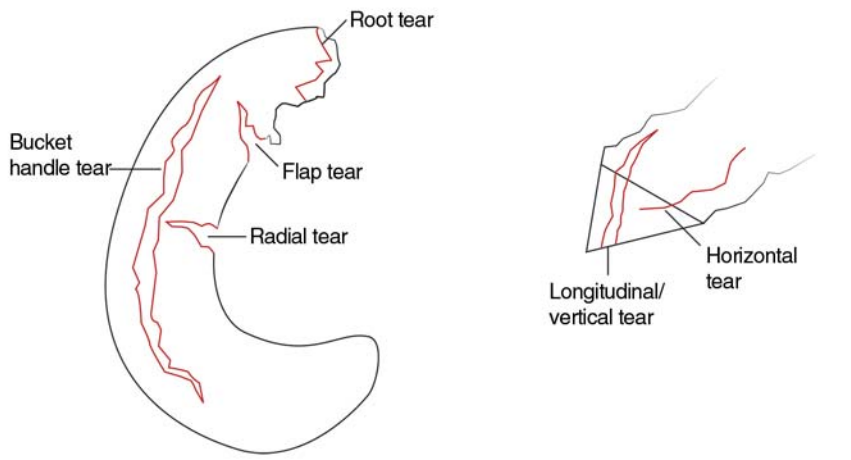
Although it has been suggested that the meniscus has a role in joint lubrication, no studies to date have proved a direct contribution. It has been proposed that the conformity of shape between the meniscus and the femoral condyles allows for a thin film of fluid to remain over the articular surface, thereby assisting lubrication.[5]

Meniscal Tears

Meniscal tears are described by location and shape. The meniscus can be divided into vascular and avascular zones (eg, red, red-white, white). Cooper et al[9] further categorized these into 12 zones, with each meniscus divided into thirds both longitudinally and radially (Figure 2).

Tears of the meniscus can be classified as acute or degenerative. A degenerative tear occurs in a meniscus that has been worn down by age, chronic knee instability, or malalignment. Tear types include horizontal; bucket handle; longitudinal (ie, vertical); oblique (ie, flap); radial; complex, which consists of a combination of different tear morphologies; and meniscal root (Figure 3). The shape, configuration, and location of a tear are important factors in determining whether it will heal following repair.

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]

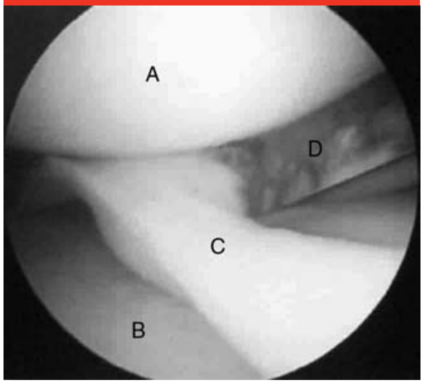
Repair Indications

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.

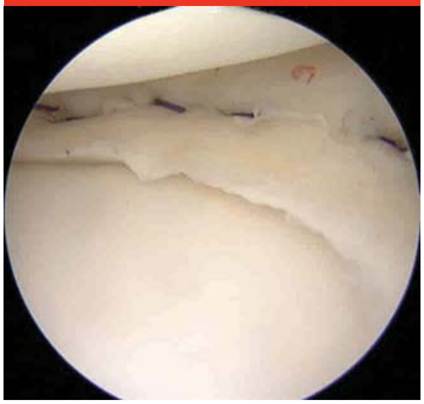
Controversy persists regarding whether the timing of repair affects success. Tengrootenhuysen et al[17] found a significantly higher success rate in tears repaired <6 weeks after the injury ($P < 0.001$). In contrast, other studies have indicated either an insignificant difference or no difference in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

Figure 7

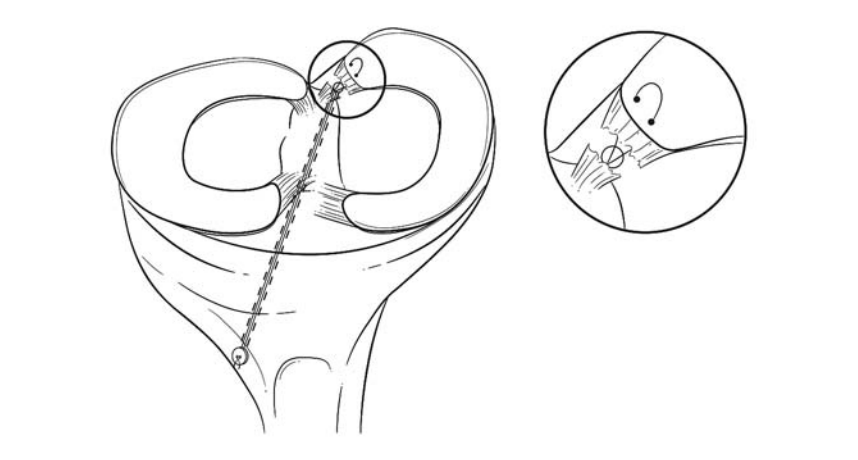


Illustration of meniscal root tear repair using the tibial tunnel technique. A 2.4-mm tunnel was drilled from the anterolateral aspect of the tibia to the root insertion site, using an anterior cruciate ligament tunnel guide, and a horizontal mattress suture was passed through the meniscal root. Using a suture passer, the free ends of the suture were passed through the tunnel, then tied over a button under manual tension. (Adapted with permission from Allaire R, Muriuki M, Gilbertson L, Harner CD: Biomechanical consequences of a tear of the posterior root of the medial meniscus: Similar to total meniscectomy. *J Bone Joint Surg Am* 2008;90[9]:1922-1931.)

study, Gunes et al[34] found that these repair devices created fixations that were as strong as outside-in sutures and significantly stronger than other all-inside fixation devices.

Meniscal root tears are repaired differently from other meniscal tears because the meniscal root must be reaffixed to bone to prevent meniscal extrusion. The torn meniscal root is fixed to the tibial plateau either using sutures attached to suture anchors in the bone or using an intraosseous suturing technique, then passing the meniscal sutures through a tunnel drilled with an ACL tibial tunnel drilling guide and anchoring them at the anteromedial tibia (Figure 7). Both techniques have been shown to be clinically effective. However, in some cases, the repair does not completely heal, leading to some persistent meniscal extrusion and subsequent articular cartilage degeneration.[35]

Review of the literature suggests that inside-out, outside-in, and the three most recent generations of all-inside meniscal repair are all effective options for tear fixation and that they can be used with equal clinical effectiveness. However, the surgeon must be mindful of the risk of device breakage with first- and second-generation all-inside repairs and the risk of neurovascular complications with inside-out and outside-in suture techniques.

Complications

Meniscus repair is a relatively fast and noninvasive procedure, and complications are rare. However, given the proximity of the menisci to neurovascular structures, the surgeon must be aware of the risk of damaging those structures during surgery.

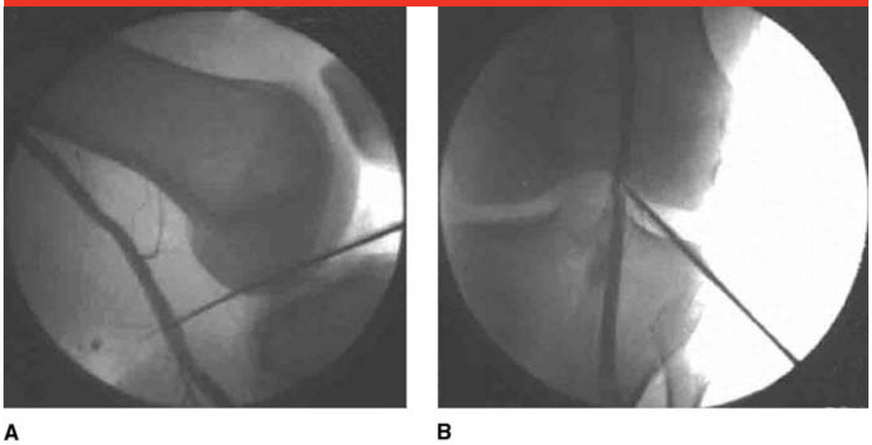
The popliteal artery closely borders the posterior knee and injury to it is, perhaps, the most dreaded complication in the repair of posterior horn meniscus tears. Hematoma, aneurysm, and pseudoaneurysm of the popliteal artery have been described in the literature. Symptoms often present within the first 2 to 3 weeks postoperatively, but can rarely present later, up to 10 weeks postoperatively.[36] In a cadaver study, Cohen et al[37] found that the needles used in third-generation all-inside repairs of the posterior horn of the lateral meniscus come within a few millimeters of the popliteal artery (Figure 8). Some manufacturers include penetration limiters to minimize vascular risk, but even with these, surgeons must take care when performing posterior repairs.

Complications involving the common peroneal nerve have been reported in lateral meniscus repair. Jurist et al[38] published a case report in which complete motor neuropathy was caused by sutures placed in an inside-out repair. The lateral geniculate artery is also at risk during inside-out lateral meniscal repair. Lateral geniculate pseudoaneurysm has been reported, and the proximity of this vessel has been well demonstrated in simulated meniscal repairs in the laboratory.[39]

The proximity of the saphenous nerve to the medial meniscus can also lead to complications ranging from transient paresthesia[40] to complete neuropathy. Because of variations in anatomy, neurovascular complications can occur separate from the location of the repair.

First- and second-generation all-inside rigid meniscal repair devices are also associated with specific complications. These devices can break, forming loose fragments that can damage articular cartilage and cause aseptic reactive synovitis. A case report has been published of a broken device exiting the joint capsule, necessitating surgical removal.[30] Although the design of rigid implants has improved in third- and fourth-

Figure 8



Lateral (**A**) and AP (**B**) fluoroscopic views demonstrating an all-inside meniscal repair device shown in close proximity to the popliteal artery as demonstrated on angiography. No depth penetration limiter was used in this case. (Reproduced with permission from Cohen SB, Boyd L, Miller MD: Vascular risk associated with meniscal repair using Rapidloc versus Fas T-Fix: Comparison of two all-inside meniscal devices. *J Knee Surg* 2007;20[3]:235-240.)

Figure 9

Arthroscopic image demonstrating use of a rasp to access the meniscus-synovial junction in preparation for repair of a tear and to introduce hematogenous healing factors into the joint space.

generation devices, even headless screws and arrows may become exposed and cause damage to the surrounding cartilage.[31]

Repair Enhancement

Multiple augmentation techniques are available to optimize the healing potential of meniscal repair. Peripheral tears are known to have a closer proximity to the perimeniscal blood supply and, therefore, to heal more predictably. Most augmentation techniques are performed with the intent to enhance the healing of more central meniscal tears.

Fibrin clots are created by spinning autologous blood in a glass tube until a clot is formed. Henning et al[41] showed that incorporation of a fibrin clot into an isolated meniscal repair resulted in a failure rate of 8%, compared with 41% without the clot.

Meniscal abrasion using a meniscal rasp (Figure 9) or arthroscopic shaver has been shown to promote the healing response through the expression of cytokines.[42] In 2003, Uchio et al[43] published a retrospective study that demonstrated complete healing in 71% of treated menisci following meniscal rasping at second-look arthroscopy. However, 44 of 48 tears were associated with an ACL tear. Trephination is a controversial technique that involves the creation of vascular channels to connect the avascular meniscus to the peripheral perimeniscal blood supply. A spinal needle is used to puncture the meniscus through the area of the repair; the needle is directed toward the periphery. In a goat model, such channels were shown to result in the stimulation of fibrochondrocytes, leading to a reparative process involving fibrovascular tissue.[44] However, it has been suggested that these channels can disrupt the circumferential collagen fibers of the meniscus.

Other techniques to enhance meniscal repairs are being studied and are being used by some surgeons. However, there is currently no medical literature that formally evaluates them.

Platelet-rich plasma (PRP) is autologous blood that has been spun in a centrifuge until the concentration of platelets is above baseline levels. The two PRP injection systems that are currently approved by the US Food and Drug Administration yield platelet concentrations four to five times greater than normal. PRP is theorized to have a beneficial effect on healing because of the high levels of growth factors, including platelet-derived growth factor, transforming growth factor β, fibroblast growth factor, insulin-like growth factors (IGFs [ie, IGF-1, IGF-2]), vascular endothelial growth factor, and interleukin-8. Combining the PRP with an activating agent, such as thrombin or calcium chloride, results in the release of growth factors. When injected near or sutured into a meniscal repair, the proximity of these growth factors may stimulate collagen synthesis and promote angiogenesis and neovascularization. No randomized, controlled trials investigating the use of PRP in meniscal repairs are underway.

Newer biologic enhancement techniques have been discussed recently. Hyaluronic acid injections following meniscal repair have been shown in animal models to result in faster healing and better defect fill.[45] Cell-based therapy involving the growth of autologous chondrocytes on an implanted scaffold as well as the injection of specific growth factors to stimulate meniscal cells and augment meniscal repair are being tested in animal studies. No formal studies have been published to date regarding outcomes of these techniques.

Rehabilitation

The postoperative limitations of meniscal repair are markedly greater than those of partial meniscectomy. Because it is impossible to know for certain before surgery whether a meniscal tear is repairable, it is important that patients be well-informed and prepared for a potentially extensive rehabilitation protocol.

In the first 4 to 6 weeks following repair, the patient should avoid knee flexion during weight bearing. The surgeon may choose to allow the patient to bear weight with the knee immobilized in extension or to allow knee flexion with restricted weight bearing. The exact time period and specific restrictions vary based on repair location and type.[46] Pressure on the menisci is significantly increased during flexion while weight bearing,[47] and the femoral condyles translate posteriorly relative to the tibia during this motion.[48] Both of those actions can put undue stress on the repair in the early stages of healing. After this initial period, the patient should begin a physical therapy program that is tailored to the location and type of repair performed.[46]

Because of the increased strain on the meniscus in tibial rotation and deep flexion, deep squats and excessive internal and external rotation of the tibia should be avoided until at least 4 months postoperatively.[48,49] The duration varies depending on repair location and type.[46] During this period, the patient also must refrain from participating in sports that involve running or cutting.

Some studies have shown that an accelerated rehabilitation program, including unrestricted weight bearing and a return to sports activity as soon as it is tolerated, is no less effective than standard, more conservative, meniscal repair rehabilitation programs in preventing repair failures.[50] However, currently, there is insufficient corroborated evidence to support the use of accelerated rehabilitation following meniscal repair.

Summary

Arthroscopic management of meniscal injury is the most commonly performed orthopaedic procedure in the United States annually. Many studies have demonstrated the long-term sequelae of partial and complete meniscectomy, and as a result, the use of meniscus repair has increased.

Factors shown to be predictive of a successful meniscus repair include an acute, unstable, longitudinal, peripheral tear in a young patient with a concomitant ACL reconstruction. For tears that do not fit into this category but are deemed appropriate for surgical repair, multiple augmentation techniques are available to optimize healing potential.

The inside-out technique remains the standard of care for meniscus repair; however, the outside-in and the three most recent generations of all-inside repairs all have been shown in the literature to be effective options for tear fixation. Knowledge of the surrounding neurovascular structures as well as the complications associated with each specific meniscal repair device is essential. Following meniscus repair, a strict rehabilitation protocol is required, and the patient must understand preoperatively the importance of adhering to the rehabilitation protocol postoperatively.

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. In this article, reference 33 is a level I study. Reference 35 is a level II study. References 11, 14, 18, 28, 29, 37, 40, 43, and 48 are level III studies. References 4, 10, 12, 15-17, 20-27, 32, 34, 42, 44, 47, and 49 are level IV studies. References 1-3, 5-9, 13, 30, 31, 36, 38, 39, 41, 45, 46, and 50 are level V expert opinion.

References printed in **bold type** are those published within the past 5 years.

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