Treatment of Meniscal Injuries in Young Athletes

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ABSTRACT

The young, active patient with a meniscal tear poses a significant challenge for the surgeon. Multiple factors influence the treatment of meniscal pathology and the ultimate goal of meniscal surgery should be to remove only torn and nonfunctional tissue by limited meniscectomy or to repair amenable tears. The chondroprotective significance of the meniscus has influenced the current treatment of meniscal injuries in young athletes with the emphasis on repairing meniscus tears to include complex tears and tears in the avascular zone. Partial meniscectomy and meniscal repair techniques have provided good long-term clinical success and return to activity. The decision to debride versus repair a meniscus depends on tear pattern, location, and the patient's willingness to comply with post-operative restrictions. In patients with symptomatic meniscus deficiency, meniscal allograft transplant is an option that may provide pain relief but may not allow return to sports. The purpose of this article is to provide a succinct review of the diagnostic and management principles for the young, active patient with a meniscal tear.

KEYWORDS: Meniscus, meniscal, meniscectomy, repair, allograft

The menisci are fibrocartilaginous structures of the knee whose functions include load transmission, shock absorption, increasing joint congruity, reducing joint contact stresses, and provide joint lubrication and nutrition.[1–10] The medial meniscus, also, serves as a secondary stabilizer to anterior tibial translation in an anterior cruciate ligament (ACL) deficient knee.[6] In 1948, Fairbank et al described the classic radiographic changes of osteoarthritis after complete meniscectomy, which was the common treatment for meniscal tears until the early 1980s.[11] Patient subjective outcomes following complete meniscectomy proved to be fair to poor at long-term follow-up.[12,13] Several studies have demonstrated the correlation of clinical and radiographic osteoarthritis in patients with a history of previous meniscectomy.[14–16] The mechanical properties and chondroprotective significance of the meniscus has influenced the current treatment of meniscal injuries in young athletes with the primary goal to maintain maximal meniscal integrity possible.

The success of meniscus repair depends on tear pattern recognition and location for the capacity to heal. There have been multiple studies that have demonstrated the clinical success of meniscal repair ranging from 75 to 92% with various tear patterns and repair techniques, but the literature is inconclusive on the ability of meniscal repair to halt the progression of degenerative changes and clinical symptoms.

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Additionally, despite clinical success, evaluation of meniscal repairs in young patients by arthrography, magnetic resonance imaging (MRI), and second look arthroscopy have proven that a high number of the tears have incomplete healing.[17,18] Bach et al analyzed failures of 300 meniscal repairs and found that younger patients fail earlier than older patients.[19] While there is literature to suggest age has no effect on success of repair,[20,21] repair should be considered for all young patients and active older patients.

The young, athletic patient with a meniscal tear poses a significant challenge for the surgeon. Although multiple factors influence the treatment of meniscal pathology, the ultimate goal of meniscal surgery should be to remove only torn and nonfunctional tissue by limited meniscectomy or implement meniscal repair strategies for amenable tear patterns. In this specific patient population the current trend and first-line treatment is to attempt to repair the meniscus, at the risk of potential nonhealing and need for subsequent partial meniscectomy. In a small subpopulation of young, active patients with a complete or near complete meniscectomy and pain localized to the affected compartment meniscal allograft transplantation may be considered, although the long-term clinical outcomes are poorly understood. The purpose of this article is to review the approach to meniscal injuries in the young patient and discuss treatment considerations.

EPIDEMIOLOGY

It has been estimated that there are over 850,000 meniscal procedures performed annually in the United States.[3,22–24] A recent study of acute meniscal tears in active duty military personnel showed an incidence rate of 8.27 per 1000 person-years—more than 10 times the rates reported in civilian populations.[25] Males tend to be affected 2 to 4 times as often as females and typically sustain injuries in the third decade of life.[3,22] The medial meniscus is more commonly torn in all age groups.[22,26,27] Patients younger than 30 years of age often sustain traumatic tears of the meniscus resulting in peripheral vertical tears or bucket-handle tears of the meniscus, whereas older patients typically develop chronic, degenerative tears to the posterior horn of the medial meniscus.[22] In the chronic ACL-deficient knee the posterior horn of the medial meniscus tends to tear as a result of its function as a secondary stabilizer to anterior tibial translation.

HISTORY AND PHYSICAL EXAMINATION

When interviewing a patient with a suspected meniscal tear, a detailed history and physical examination should be obtained. Diagnosis of a meniscal tear can commonly be made with history and physical examination alone. Acute meniscal pathology presents with a history of a twisting injury, mild joint effusion, and pain localized to the affected joint line. The patient may present with complaints of popping, clicking or locking, and a block to full knee range of motion due to a displaced meniscal fragment or bucket-handle tear. Mechanical symptoms may be absent in a stable meniscal tear. The history should include patient age, activity level, description of injury, onset of symptoms, type of symptoms (pain, mechanical, instability), previous injuries to the knee, and previous surgeries. Additionally, the clinician should elicit whether there are provocative maneuvers or inciting activities that reproduce the symptoms. In the setting of a chronic meniscal tear, patients tend to be slightly older and complain of insidious onset of joint line pain, recurrent effusions, and mechanical symptoms. This is an important distinction because a delay in diagnosis and treatment of the young patient with an acute meniscal tear may allow for further meniscal and chondral injury rendering a tear that was initially repairable as irreparable.

The examination should begin with observing the patient's gait and standing mechanical alignment. Inspection of the knee should look for joint effusion—which is usually present with an acute meniscal tear. Knee range of motion should be compared with the contralateral extremity looking for a mechanical block of motion due to a displaced bucket-handle meniscal tear, which would warrant acute surgical intervention. Joint line tenderness has been shown to be the most accurate and sensitive examination for meniscal pathology although this examination finding is less reliable for a meniscal tear in acute ACL tears and may represent bone bruising.[28–31] Multiple provocative examinations such as McMurray's, Apley's, Squat, and Thessaly tests have been described for meniscal pathology and, although not as sensitive as the presence of joint line tenderness, can be helpful in making the diagnosis.[28,30–33] All these tests attempt to recreate symptoms of a meniscal tear by applying an axial load to the affected compartment attempting to catch the torn meniscus between the femur and tibia. A full ligamentous examination of the knee should be performed to rule out concomitant pathology with particular attention to the ACL examination, which is commonly associated with acute meniscal tears.

IMAGING

Standard radiographs should be obtained in any patient with knee pain and effusion to rule out fracture or concomitant pathology. Radiographs should include weight-bearing anteroposterior (AP), lateral, and Merchant view. Posteroanterior 45-degree flexed view (Rosenberg view) should be obtained to assess the extent of osteoarthritis. If there is concern for possible mechanical malalignment on clinical examination, a weight-bearing long leg alignment film should be included.

Alignment films should also be obtained routinely on patients with recurrent tears or with a deficient meniscus.

MRI is a helpful adjunct in diagnosing meniscal tears with good accuracy.[34] MRI should not be used alone in making the decision for surgical intervention due to its high false-positive rate for meniscal tears. One study showed a false-positive rate in asymptomatic patients younger than 45 to be 13% and in patients older than 45 to be 36%.[35] A radiographic grading system for meniscal tears was developed to help diagnose meniscal tears that extend to the joint surface and may be amenable to surgery. Grade III signaling (linear signal extending to joint surface) on two consecutive images has a sensitivity over 90% for diagnosing a meniscal tear.[36] Therefore, MRI should be utilized when the clinical history and examination are inconclusive for a meniscal tear, but not as a primary diagnostic tool. MRI can also help in the diagnosis of displaced bucket-handle tears of the meniscus, concomitant ligamentous injury, or chondral pathology. The classic double posterior cruciate ligament (PCL) sign is the pathognomonic MRI finding for a displaced bucket-handle tear of the medial meniscus into the notch (see Fig. 1A, B). A flipped bucket-handle tear of the lateral meniscus can result in a flipped meniscus sign (see Fig. 2A, B). Finally, arthroscopy remains the gold standard for diagnosis and treatment of all meniscus tears.

NONOPERATIVE MANAGEMENT

The decision to pursue nonsurgical management of a meniscal tear depends on the location of the tear and whether or not it is stable. Stable vertical tears measuring <5 mm in length in the peripheral one-third of the meniscus are generally stable. The location of the tear and its potential to heal spontaneously is related to the vascular supply of the meniscus. Arnoczky and Warren demonstrated that the peripheral 30% of the medial meniscus and 25% of the lateral meniscus had the best blood supply in the adult meniscus; otherwise known as the red/red zone.[37] Nonoperative management should consist of 3 months of rest, ice, anti-inflammatories, and physical therapy.

Unstable tears can be described as bucket-handle tears, radial, parrot-beak, oblique, degenerative, and complex tears or tears that extend into the avascular portion of the meniscus. These tears, in association with mechanical symptoms or a mechanical block to motion, are unlikely to heal with nonoperative management and should be treated surgically. Additionally, treating tears conservatively can potentially convert stable, repairable tears to irreparable tears if the tear propagates.

Meniscectomy

The goal of arthroscopic partial meniscectomy is to remove the torn portion of the meniscus, while maintaining as much meniscus as possible. The torn edge of the meniscus can be a mechanical irritant and cause significant pain in patients. This torn portion does not perform mechanically as healthy meniscus and should be removed. However, significant debridement of the meniscus can cause disruption of the circumferential fibers, which can subsequently lead to the inability of the remaining meniscus to effectively dissipate hoop stresses. The extent of meniscal debridement can directly increase contact stresses and decrease contact area, which has been shown to contribute to the development of osteoarthritis.[1,2,5] Clinical studies have confirmed earlier development of osteoarthritis in patients after meniscectomy when compared with nonoperative patients.[2,16] Factors that determine the amount of meniscus to debride in an unstable irreparable tear is the location and pattern of the tear, and arthroscopic examination.

The outcomes following partial meniscectomy have demonstrated good clinical and radiographic results. Shelbourne et al demonstrated that 12 years after

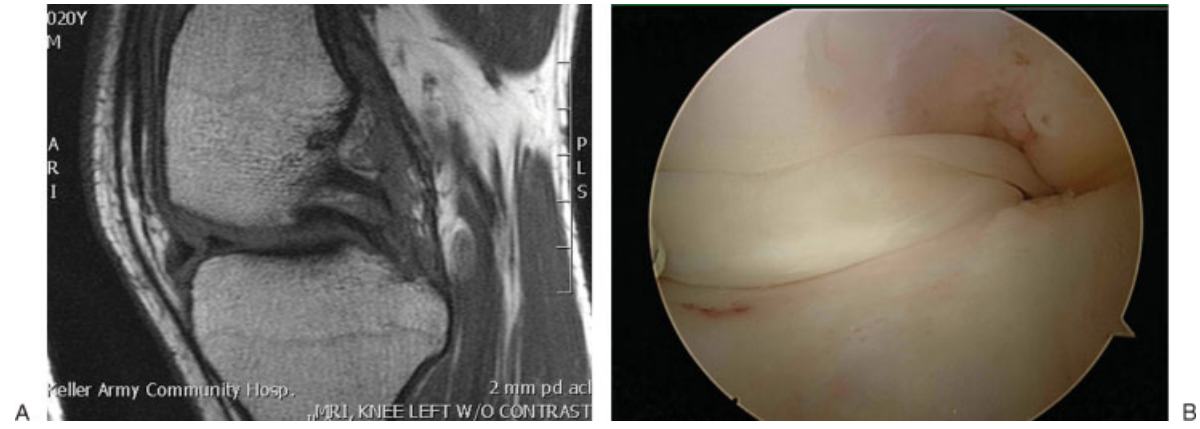

Figure 1 A 20-year-old collegiate wrestler presented with a locket knee and effusion. The appearance of a double posterior cruciate ligament (PCL) sign is noted on magnetic resonance imaging (MRI) (A) and the flipped bucket-handle tear of the medial meniscus is confirmed at arthroscopy (B).

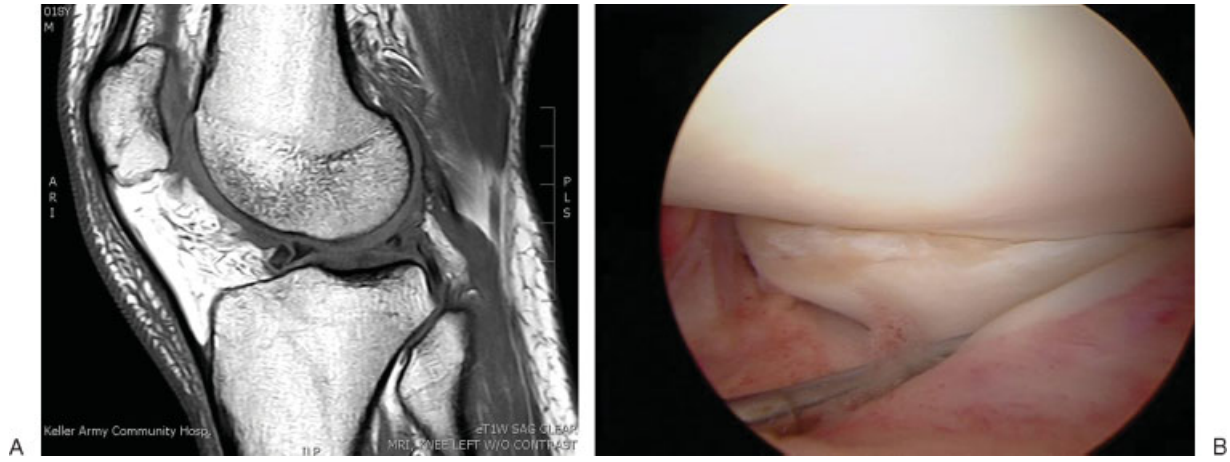

Figure 2 An 18-year-old collegiate boxer presented with a locked knee and effusion. The appearance of a flipped meniscus sign (A) is noted on magnetic resonance imaging (MRI) and a flipped bucket-handle tear of the lateral meniscus is confirmed at arthroscopy (B).

partial meniscectomy patients had minimal radiographic evidence of osteoarthritis.[38] Additionally, it has been shown that 88% of patients after partial meniscectomy have favorable subjective outcomes when there is no concomitant ligamentous injury or chondral damage and better long-term clinical outcome when compared with complete meniscectomy.[39,40] A recent systematic review looking at the clinical and radiographic outcomes in patients undergoing meniscectomy described the preoperative and intraoperative predictors of poor outcomes to be total meniscectomy, removal of the peripheral rim of the meniscus, lateral meniscectomy, degenerative meniscal tears, presence of chondral damage, and increased body mass index (BMI).[41]

Biomechanical studies investigating the effects of partial meniscectomy have emphasized the importance of maintaining meniscal integrity. Several important points should be emphasized when performing partial meniscectomy in different portions of the menisci. First, the lateral meniscus is an integral structure in the lateral joint space. The lateral meniscus helps improve articular conformity of the concave lateral femoral condyle to the relatively convex lateral tibial plateau. Meniscectomy of the lateral meniscus has been shown to increase peak joint contact pressures when compared with medial meniscectomy and increase the incidence of osteoarthritis.[42] Therefore, every effort should be made to retain the maximal amount of lateral meniscus. Second, radial tears in the central portion of the meniscus may not be amenable to repair and may be best treated with debridement. Excessive debridement or debridement that extends to the peripheral meniscus completely disrupts the circumferential fibers which have been shown to be biomechanically equivalent to a complete meniscectomy.[5] Consequently, repair of large radial tears in the young, active patient may initially be warranted (see Fig. 3A–D). Short-term outcome studies have shown success with repair of radial tears of the meniscus.[43,44] Finally, resection of 75% or more of the posterior horns of the menisci biomechanically functions as a complete meniscectomy.[1,5]

Meniscal Repair

The treatment of choice for unstable tears in the vascular zone of the meniscus is meniscal repair. Meniscal repair has been shown to have good clinical success rates. The success of meniscal repair depends on patient age, activity level, type and location of tear, ligamentous stability, mechanical alignment, and type of repair. In the setting of an ACL reconstruction the success of meniscal repair rates has been shown to drastically improve.[45]

In the young, active patient, an attempt at meniscal repair should be made, even for tears that extend to the avascular zone of the meniscus or complex tears that may have been historically treated with meniscectomy. Noyes et al published the results of meniscal repairs in the avascular zone of the meniscus in patients younger than 20 and in another series of patients older than 40, and found a clinical success rate of 75% and 87%, respectively.[46] Clinical success of meniscal repair for tears in the avascular zone can be independent of actual healing of the tear on second-look arthroscopy with a high rate of partial or nonhealing.[47] Therefore, there are few contraindications for meniscal repair in the young patient. There have been many different meniscal repair techniques and implants described in the literature with varying success rates. The available repair techniques include inside-out, all inside, outside-in, and open; however, the discussion of the various implants is beyond the scope of this manuscript.

The gold standard for meniscal repair still remains the inside-out meniscal repair first described by Scott

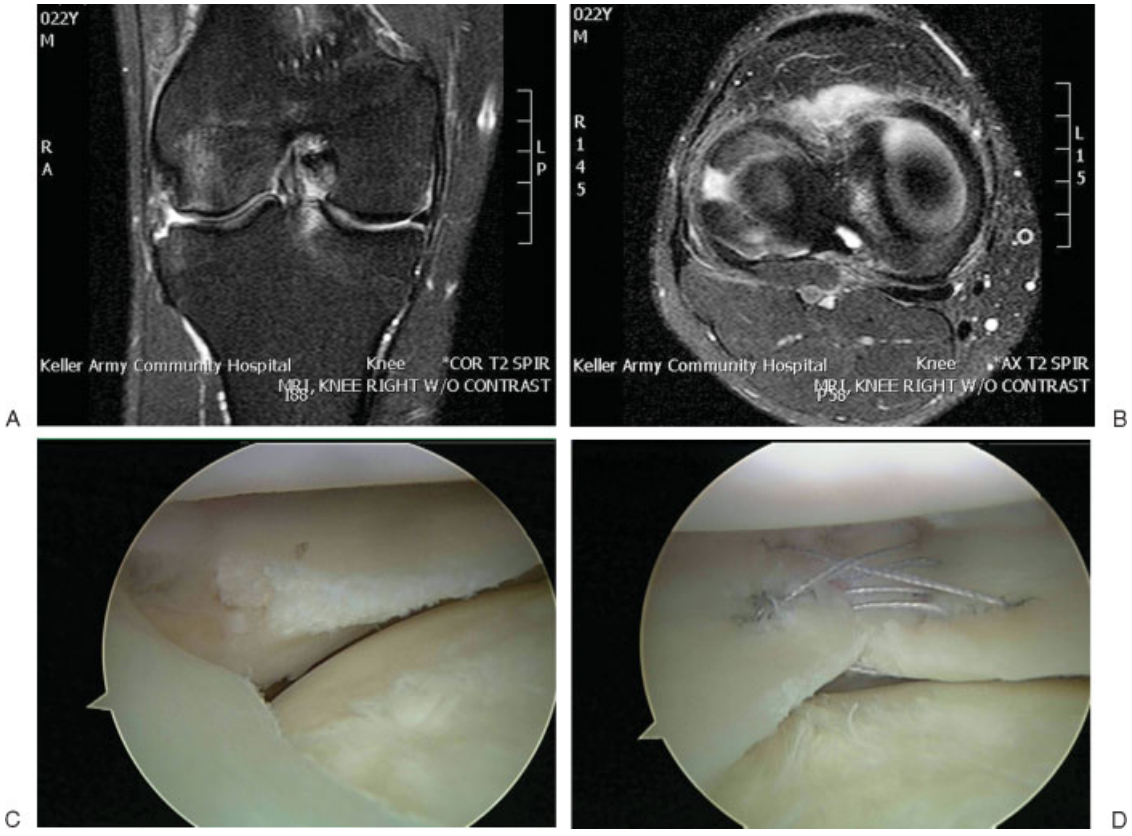

Figure 3 A 22-year-old collegiate football player presented at the end of the season with knee pain and an effusion. The magnetic resonance imaging (MRI) suggested a radial tear of the lateral meniscus on both coronal (A) and axial cuts (B). This tear was confirmed at arthroscopy (C) and an inside-out repair was performed using a combination of horizontal mattress, vertical mattress, and cruciate sutures (D).

et al in the 1980s.[48] This technique utilizes placement of long, double-limbed needles with nonabsorbable suture intra-articularly with zone-specific cannulas or delivery devices, and retrieved through a small open incision and tied over the joint capsule under direct visualization. The sutures are preferably placed in a vertical mattress fashion through the meniscus. Vertical mattress sutures have increased biomechanical strength when compared with other suture configurations.[49] Care must be taken to avoid injury to the neurovascular structures with this surgical approach. The risk for medial meniscal repair is the saphenous nerve and more specifically the infrapatellar branch of the nerve. Lateral meniscal repairs place the peroneal nerve at risk. Results of inside-out repair have been successful in several clinical follow-up studies.[18,50,51] Clinical success rates range from 62 to 96% with a 80% return to previous level of activity. Additionally, radiographic follow-up for meniscal repair has demonstrated minimal osteoarthritic changes when compared with the contralateral extremity.[50]

All-inside meniscal repair has recently gained in popularity due to success rates of 85% good or excellent outcomes and return to activity.[52,53] The advantages of the all-inside technique include direct access to posterior horn tears, no counterincisions, decreased risk to neurovascular structures, decreased surgical time, and avoiding the need for a skilled assistant. The initial generation of arthroscopic implants was rigid, bioabsorbable devices that were associated with a high failure rate and complications from direct chondral abrasion.[54–56] The current generation of implants avoid the risk of chondral damage by having only suture contacting the articular cartilage. Additionally, the delivery devices come in straight and curved configurations which makes suture placement easier and more versatile for different tear patterns and locations. Biomechanical studies have demonstrated one of these current generation implants has equivalent strength to vertical mattress suture techniques and has superior strength in comparison to other all-inside devices.[52,57,58] However, a recent systematic review of the various all-inside implants showed no difference in failure rates between the various implants.[59] The limitations of the all-inside technique include the potential impact of multiple plastic anchors in the meniscus or capsule as well as implant cost. This technique is preferred when a small number of implants are necessary to complete the needed repair.

Outside-in meniscal repair was developed to decrease injury to neurovascular structures which is a

known risk of inside-out techniques. A spinal needle is placed percutaneously and visualized arthroscopically as it penetrates the meniscus at the proposed repair site. A suture is then introduced through the needle and shuttled back through the meniscus with a separate spinal needle and tied together with multiple sutures to the outside of the capsule. A common indication for this technique would be for anterior horn meniscal tears which can be challenging with other repair techniques. Additionally, the outside-in technique improves versatility and can be used in more complex tear patterns. Additionally, this technique has demonstrated reproducibly good success rates of 74 to 98.6% but is biomechanically weaker than other repair techniques.[51]

Open repairs are performed in conjunction with other procedures for the knee where open incisions provide good visualization of the meniscus. Open repairs are ideal in the setting of reconstruction for multiligamentous knee injury or tibial plateau fractures. Outcomes following open repair are similar to other repair techniques with success rates ranging from 79 to 91%.[60,61]

Adjunctive procedures such as trephination, synovial abrasion, or fibrin clot suturing can be used alone or in conjunction with meniscal repair and have been shown to have good results for healing.[62,63] These processes theoretically work by delivering blood to the repair site to facilitate healing and may be considered in cases without concomitant ACL reconstruction.

Meniscal Allograft Transplantation

The first meniscal allograft transplantation was performed in 1984.[64] Since the procedure was described 25 years ago there have been no randomized controlled studies or long-term outcome studies for the procedure. The relative indications for a meniscal transplantation are the following: young and active patient, history of complete or near complete meniscectomy, pain localized to affected compartment, normal or correctable mechanical alignment, ligamentous stability, and the absence of moderate to advanced osteoarthritis. Concomitant ligamentous instability or malalignment must be addressed before or in conjunction with meniscal transplantation. Additionally, chondral injury can be addressed at the time of meniscal transplantation with osteochondral autograft/allograft transplant or autologous chondrocyte implantation. Other contraindications to allograft transplantation are obesity, infection, inflammatory arthritis, and skeletal immaturity. The ultimate goal of the surgery should be to provide pain relief for the patient during activities of daily living and moderate physical activity. While return to high-level athletic competition in activities that require jumping, twisting, and cutting may be possible, this is usually discouraged and should not be anticipated. Therefore, patient selection and expectation management are paramount to a successful surgical outcome. Further research needs to provide prospective data on the expected return to high-level sports and the long-term outcomes associated with this procedure to help guide surgeon recommendation to return to activity guidelines.

A recent systematic review identified several important factors that potentially affect the outcomes of meniscal transplantation.[65] The factors addressed in the 15 clinical studies were patient selection, method of graft preservation and sterilization, graft sizing, method of surgical fixation, and postoperative rehabilitation. The conclusions drawn from the study for improved outcomes include graft sizing by radiographic or MRI technique should be within 5% of the normal meniscus, graft fixation should be performed either open or arthroscopic but should be placed with multiple suture fixation to the capsule, and finally rigid fixation of the horns of the graft is critical to restore the normal hoop stresses of the meniscus. Short-term outcome studies have demonstrated improvement in pain, function, and suggest relative prevention of the progression of osteoarthritis.[65–68] Complications associated with this procedure are most commonly associated with graft tearing and failure. Other theoretical concerns are infection and immunologic reaction. Further prospective research needs to evaluate return to high-level sports, long-term outcomes, and the effect on osteoarthritis progression to help guide surgeon recommendations.

Rehabilitation

Rehabilitation after meniscal surgery should be dictated by location and whether or not a repair was performed. Additionally, there should be direct communication between the surgeon and the therapist for optimal outcome. Commonly, partial meniscectomy results in a self-paced return to activity with therapy-guided progression of motion and weight-bearing as tolerated. Following repairs, traditional rehabilitation protocols consist of a period of restricted weight-bearing ranging from 6 to 12 weeks. Range-of-motion restrictions are common during the healing period from 0 to 90 to protect the posterior horns with deeper knee flexion. Accelerated rehabilitation programs following repairs emphasize full, progressive range of motion, limited weight-bearing restrictions, and earlier return to activity with similar reported outcomes to traditional rehabilitation protocols.[65–68]

SUMMARY

The meniscus plays a vital role in the preservation of the chondral surfaces and the prevention of osteoarthritis. The young, active patient who presents with a

meniscal tear presents several unique challenges and considerations for the surgeon. The primary goal is to alleviate pain and mechanical symptoms while preserving as much functional meniscal tissue as possible. Therefore, to optimize outcomes in young patients, efforts should be made to perform meniscal repairs, which include complex tears and tears extending into the avascular zone. Meniscal allograft transplantation is an option for symptomatic meniscal deficiency that may provide pain relief and chondral protection. Areas of future interest include biologic adjuncts for repair and implantable scaffolds for replacement of lost meniscal tissue.

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