Magnetic Resonance Imaging of the Meniscus

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KEYWORDS

• Meniscus • Knee • Tear • Magnetic resonance imaging • MRI
• ISAKOS (International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine)

KEY POINTS

- The magnetic resonance (MR) criteria for diagnosing a meniscal tear include either increased signal unequivocally contacting the articular surface or abnormal meniscal morphology in the absence of previous surgery.
- Accurate description of tear patterns is vital in guiding treatment options. The ISAKOS (International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine) arthroscopic tear classification system includes longitudinal-vertical, horizontal, radial, vertical flap, horizontal flap, and complex.
- Displaced tears may be overlooked on MR imaging and should be sought in the recesses, the posterior intercondylar notch, and popliteal hiatus in the setting of a blunted meniscus.
- Secondary signs may accompany meniscal tears and increase diagnostic confidence. The indirect signs with the highest positive predictive value include parameniscal cysts, linear subchondral edema, and meniscal extrusion.

INTRODUCTION

Arthroscopic partial meniscectomy is the most common orthopedic surgery performed in the United States.[1] Perspectives on the function of the menisci, biomechanical effects after meniscectomy, and treatment algorithms continue to evolve, placing a greater emphasis on meniscal preservation and outcome measures. The potential deleterious effects of surgery have been known for some time: the landmark study in 1948 by Fairbank[2] recognized that "meniscectomy is not wholly innocuous…" in the sentinel article recognizing the chronic maladaptive changes after a meniscectomy. More recently, studies[1] have shown no difference in long-term improvement between patients undergoing partial meniscectomies and a sham procedure in the treatment of degenerative meniscal tears. In addition, symptomatic patients with meniscal tears and underlying chondrosis showed no difference in functional status when comparing surgery versus physical therapy alone.[3]

Since its inception into clinical practice in the 1980s, magnetic resonance (MR) has become the preferred imaging method for evaluating the meniscus, with reported accuracies, sensitivities, and specificities ranging between 85% and 95% in detecting meniscal tears.[4] Given the evolving treatment strategies, one must not only identify a tear but describe the location, extent, tear pattern, and any associated chondrosis to guide treatment options. The International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine (ISAKOS) Knee Committee formed a Meniscal Documentation Subcommittee in 2006, with the objective of developing a reliable classification system in the evaluation of the meniscus to

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facilitate outcome assessment. The tear patterns in this classification system include longitudinal-vertical, horizontal, radial, vertical flap, horizontal flap, and complex.[5]

Therefore, the role of MR imaging has expanded to be not only a simple diagnostic study but a critical decision-making tool providing information that may not only alter the surgical technique but also provide information that would obviate surgery. This review focuses on normal anatomy, technical factors involved when imaging the meniscus, the imaging criteria for diagnosing meniscal tears, the imaging appearance of the various patterns of meniscal tears, secondary signs of meniscal injury, and common diagnostic pitfalls.

ANATOMY

The shape and composition of the menisci confer an ability to absorb shock, distribute axial load, assist in joint lubrication, and maintain joint congruity in extremes of flexion and extension.[6] The semilunar, triangular, fibrocartilaginous menisci are C-shaped, with a concave surface tapered centrally, conforming to the morphology of the femoral condyle, and a flat base attached to the condylar surface of the tibia via the anterior and posterior root ligaments (**Fig. 1**). The intimate anatomic relationship and contiguous fibers between the anterior root ligament of the lateral meniscus and anterior cruciate ligament (ACL) insertion site result in a striated or comblike appearance, which can be mistaken for a meniscal tear (**Fig. 2**).[7] Although rarely identified on MR, a similar connection between the ACL and medial meniscus through the meniscocruciate ligament has been noted in several anatomic studies.[8] A common variant of the anterior root of the medial meniscus is an insertion along the far anterior margin of the tibia, giving the false impression of extrusion or pathologic subluxation (**Fig. 3**).[9] The typical meniscal tibial attachment sites and their relationship with the cruciate ligaments are shown in **Figs. 1** and **2**.

The configuration of 3 distinct layers of collagen within the meniscus and formation of collagen bundles oriented along both the long and short axes of the menisci allow for efficient load transmission and shock absorption. The longitudinal fibers are circumferentially oriented, resulting in the ability of the meniscus to distribute axial loads and provide what is commonly referred to as hoop strength. The more loosely organized radial fibers help form a lattice and act to tie the longitudinal bundles together and resist forces that would lead to longitudinal splitting of the meniscus (**Fig. 4**).[10]

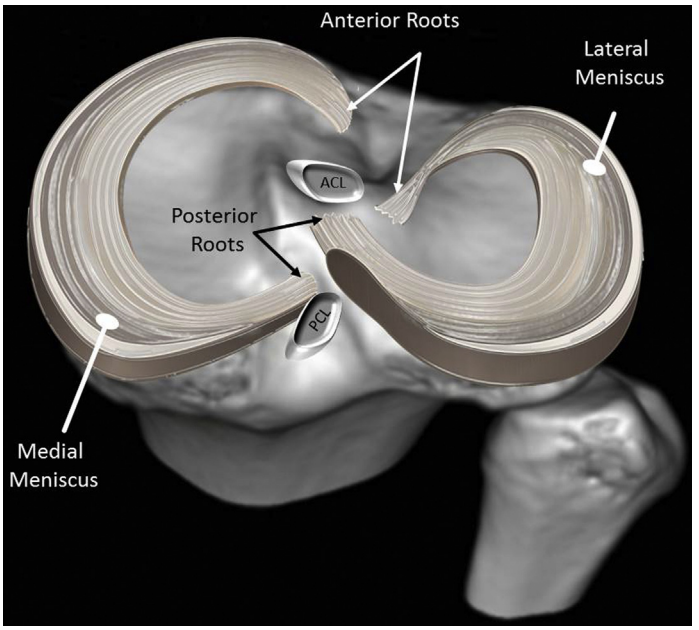

Fig. 1. Three-dimensional illustration of normal meniscal anatomy, viewed from above. The concave superior surface conforms to the morphology of the femoral condyles and results in increased contact area. The root ligaments attach centrally close to the cruciate ligaments. Although larger, the medial meniscus covers a smaller percentage of the articular surface of the tibia (50% compared with 70% for the lateral meniscus). ACL, anterior cruciate ligament; PCL, posterior cruciate ligament.