Meniscus Injuries

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Pathology

The menisci are pads of fibrocartilage located between the femoral condyles and tibial plateaus. One of the roles of the menisci is to absorb shock and distribute stress across the knee to protect the cartilage of the knee joint. The menisci also play important roles in knee stability and proprioception. The medial meniscus is described as "C-shaped" and covers about 50–60% of the medial tibial plateau. Medial meniscus tears are more common than lateral meniscus tears. The lateral meniscus is described as "O-shaped," covers about 70–80% of the lateral tibial plateau, and has more excursion than the medial meniscus. The discoid meniscus variant is a thickened, ovoid variant of the lateral meniscus for which the posterior horn attachment is absent, resulting in increased motion and risk of injury [1].

The menisci are composed primarily of water (72%) along with collagen (22%), glycosaminoglycans (17%), DNA (2%), adhesion glycoproteins (<15%), and elastin (<1%). This composition gives the menisci their properties of absorption and joint lubrication.

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Though primarily avascular structures, the menisci receive their blood supply from the peripheral branches of the popliteal arteries including the medial, lateral inferior, and middle geniculate arteries. Only about 10–25% of the periphery of the lateral meniscus and 10–30% of the medial meniscus are vascularized [2]. Meniscal tears may be classified as red zone or white zone tears depending on their location in relation to vascular supply. The outer 1/3 of the meniscus contains good vascular supply, thus tears located in this area are said to be in the red zone. On the other hand, the inner 2/3 of the meniscus contains poor vascular supply, thus tears located in this area are said to be in the red-white and white zone [1].

Meniscal tears are responsible for about 11% of acute knee disorders and 31% of chronic knee disorders [3]. They are caused by a combination of rotational forces with axial loading leading to shearing of the meniscus [2]. Meniscal tears are typically classified as acute or chronic depending on time course and mechanism of injury. They are also classified by pattern of tear (Table 3.1, Fig. 3.1). Horizontal tears, also known as "cleavage" or "fish mouth" tears, run parallel to the tibial plateau and divide the meniscus into superior and inferior halves. They are typically chronic and occur in the setting of degeneration. Vertical or longitudinal tears run perpendicular to the coronal plane and divide the meniscus into central and peripheral halves. They typically occur following

Table 3.1 Meniscal tear patterns

Tear pattern	Description
Horizontal	Runs parallel to tibial plateau and divides the meniscus into superior and inferior halves, typically chronic
Vertical/ longitudinal	Runs perpendicular to coronal plane and divides meniscus into central and peripheral halves, typically occurs following trauma
Bucket handle	Full-thickness vertical/longitudinal tears involving a displaced meniscal fragment entering intercondylar notch, limits full extension of knee
Radial/ transverse	Runs perpendicular to tibial plateau and long axis of meniscus
Oblique	Occurs at the junction of the posterior and middle body of the meniscus and are unstable
Complex	Involves combination of horizontal, vertical, radial elements

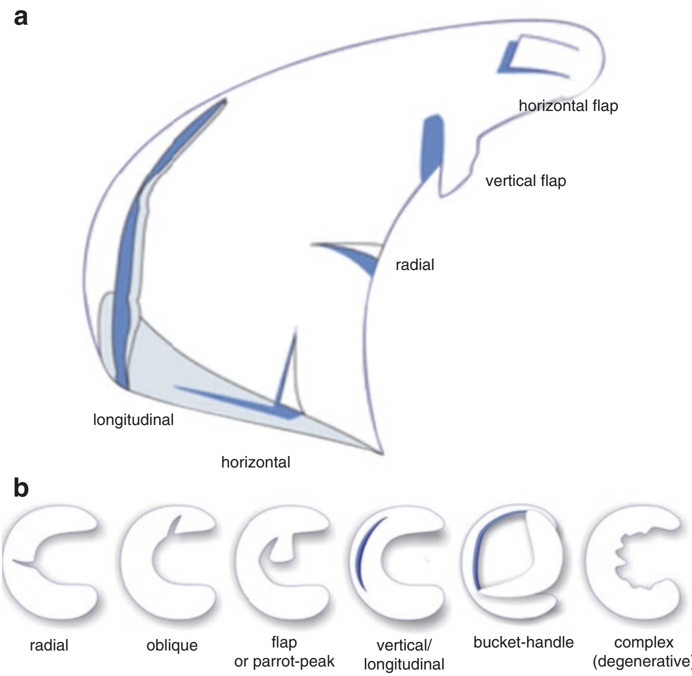

Fig. 3.1 (**a**) ISAKOS (International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine) classification of meniscal tears. (Image reprinted [6]) (**b**) Meniscus tear patterns. (Image reprinted [6])

trauma in young patients. Bucket handle tears are caused by full-thickness vertical/longitudinal tears and involve a displaced meniscal fragment entering the intercondylar notch, thus limiting full extension of the knee joint. These account for 10% of meniscal tears and are more commonly associated with the medial meniscus. Radial or transverse tears run perpendicular to the tibial plateau and long axis of the meniscus [4]. Oblique tears, including "parrot beak" or "flap" tears, typically occur at the junction of the posterior and middle body of the meniscus and are unstable [5]. Complex tears involve a combination of horizontal, vertical, and radial elements [4]. Lastly, meniscal root tears occur in the anterior or posterior root of the medial or lateral meniscus. They often occur concomitantly with ligamentous injuries, particularly ACL tears [5].

Clinical Presentation

Acute presentations of meniscal injuries are typically traumatic and usually occur in young adults. Patients commonly report immediate onset of pain at the joint line with associated effusion. Chronic presentations of meniscal injuries are usually degenerative in nature and occur in adults greater than 45 years of age. Patients are often unable to recall a specific inciting event, may report pain with activities of daily living, and may report intermittent effusions. It can be difficult to differentiate meniscal injuries from degenerative joint disease in this population, however, those with meniscal injuries may report more localized pain, faster progression of symptoms, and are more likely to report mechanical symptoms.

Mechanical symptoms are common in meniscal injuries and include painful clicking, popping, and catching. If patients report locking with associated decreased range of motion of the knee, consider bucket handle tears. However, locking may also occur with other pathologies such as loose bodies, patella maltracking, and articular cartilage defects [4].

Patients suffering from medial meniscus injuries typically have a history of tibial rotation with knee flexion while weight-bearing. This motion is typically seen in sports such as soccer and football [1]. Pain is localized to the medial joint line, and patients may report pain when crossing their legs. Medial meniscus injuries are also associated with chronic acute cruciate ligament (ACL) deficiencies [7].

The lateral meniscus is commonly injured by squatting in full flexion with rotation. This is seen in sports such as wrestling. In traumatic presentations associated with large effusions, consider a concomitant ACL rupture. Acute ACL ruptures are present in up to 73% meniscus injuries and typically involve the lateral meniscus [8].

Physical Exam

The basic components of a knee exam including inspection, range of motion, palpation, strength testing, and provocative maneuvers should be utilized when evaluating for meniscal injuries. It is important to evaluate the entire extremity including the hip, as well as the back and compare the affected side to the unaffected side.

Inspection

Evaluate for any bony abnormalities, bruising, erythema, and effusions. It is also important to check extremity alignment as varus malalignment increases stress and the chance of injury to the medial meniscus. Valgus malalignment increases stress and the likelihood of injury to the lateral meniscus. Atrophy or asymmetry of muscles can help determine chronicity [7].

Range of Motion

This can often be limited in acute meniscal tears, but may be normal in chronic, degenerative tears [4]. The normal range of motion with knee extension is 0°–10°, and the normal range of motion with knee flexion is 130°–150° [7].

Palpation

Palpate along the joint lines and posterior knee for tenderness. Feel for warmth, effusion, and crepitus.

Strength Testing

Evaluate strength of both lower extremities.

Provocative Maneuvers

Ligamentous Injuries

Evaluate for possible ligamentous injuries by testing the integrity of the cruciate and collateral ligaments with Lachman test, anterior/posterior drawer tests, and varus and valgus instability at 0° and 30° knee flexion [4]. Please see the Ligament Injuries chapter for further information.

Thessaly Test

The maneuver is described in Fig. 3.2. The test is positive if the patient experiences pain at the joint lines or a catching/locking sensation. This test has the highest sensitivity and specificity for meniscal tears with a sensitivity of 98% for medial meniscus and 92% for lateral meniscus, and a specificity of 97% for medial meniscus and 96% for lateral meniscus [9].

McMurray Test

The exam is described in Fig. 3.3. The test is positive if the maneuver reproduces the pain or the examiner feels or hears a click. This test has a low sensitivity but high specificity for meniscal injury [3].

Fig. 3.2 Thessaly test: patient stands on affected lower extremity while lifting the unaffected lower extremity off the ground while the examiner holds patient's outstretched hands (**a**). Patient then rotates the knee and body internally (**b**) and externally (**c**) at 5° and 20° of knee flexion

Fig. 3.3 McMurray test: patient lies supine while flexing the affected knee at 20°–30° and hip to 90° (**a**). The examiner places a hand over the knee joint and uses the other hand to hold the lower extremity to extend while internally (assessing lateral meniscus) (**b**) and externally (assessing medical meniscus) (**c**) rotating the tibia

Apley Grind Test

Patient lies prone with affected knee flexed at 90° and hip extended. The examiner then provides axial pressure on the foot and rotates the tibia internally and externally (Fig. 3.4). The test is positive if pain is reproduced at the joint lines [4].

Bounce Home Test

Patient lies supine with knee and hip in full flexion. The patient's heel is placed in the examiner's hand, and the patient is then asked to passively extend. The knee should extend completely (Fig. 3.5). The test is positive if the knee is unable to extend completely or has a rubbery end feel [2].

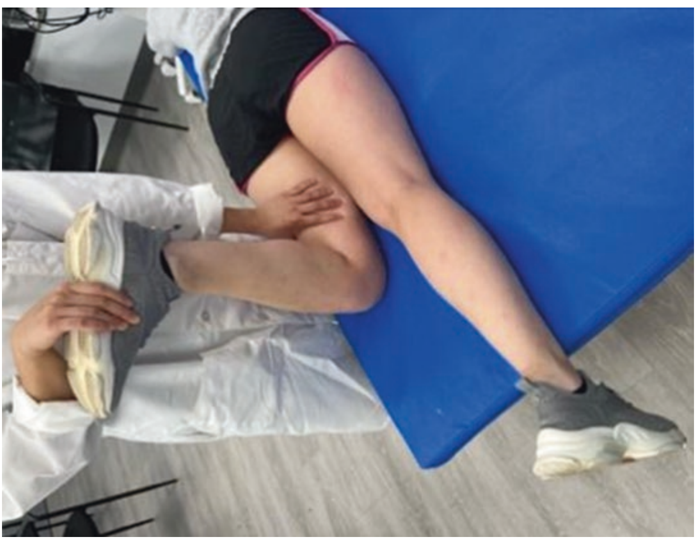

Fig. 3.4 Apley test: patient lies prone with hip extended and knee flexed at 90°. The examiner provides axial force to the foot while rotating the tibia internally and externally

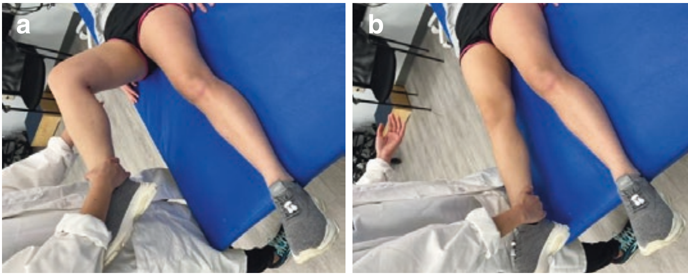

Fig. 3.5 Bounce home test: patient lies supine with lower extremity fully flexed (**a**). Examiner's hand is placed under the patient's heel and the patient passively extends the lower extremity (**b**)

Fig. 3.6 Steinmann part 1 test: patient lies supine with affected knee flexed at 90°. The examiner holds the affected knee with one hand and tibia (**a**) with the other and internally (**b**) and externally (**c**) rotates the lower leg

Steinmann Part 1 Test

The exam is described in Fig. 3.6. The test is positive if pain is reproduced at the joint lines [4]. Of note, Steinmann part 2 test is used to distinguish meniscal pathology from injury secondary to ligaments or osteophytes rather than diagnosis of meniscal pathology.

Diagnostic Studies

Plain Radiographs

Though plain radiographs are not diagnostic of meniscal injury, they are important in ruling out other causes of knee pain such as degenerative changes, loose bodies, chondrocalcinosis, etc. Weight-bearing anterior–posterior, lateral, and patellofemoral views should be obtained. Full-length lower extremity standing views may also be useful to assess alignment and osteoarthritis changes [4].

Magnetic Resonance Imaging

This has high sensitivity and specificity in diagnosing meniscal injuries. MRI sequences used for meniscal pathology evaluation include fat-suppressed and diffusion-weighted fast spin-echo (cartilage) sensitive in axial, coronal, and sagittal views. Normal meniscal structure is signified by uniform low signal intensity on fast spin-echo and fat-suppressed images [5]. Areas of hyperintensity within the meniscal area may demonstrate degeneration.

The following two criteria must be met to diagnose a meniscus tear: abnormal signal in the meniscus suggesting a tear seen on at least two consecutive images and visualization of a meniscal tear in two planes (sagittal and coronal). When both of these criteria are met, the diagnostic accuracy is greater than 90% [4, 10]. MRI classification for meniscal tears is based on meniscus signal intensity [1] and is outlined in Table 3.2 and demonstrated in Fig. 3.7.

Table 3.2 MRI classification for meniscal tears

	Findings
Grade 1	Small focal area of hyperintensity without extension to articular surface
Grade 2	Linear area of hyperintensity without extension to articular surface
Grade 3	Hyperintensity extends to at least one articular surface, referred to as a definite meniscal tear

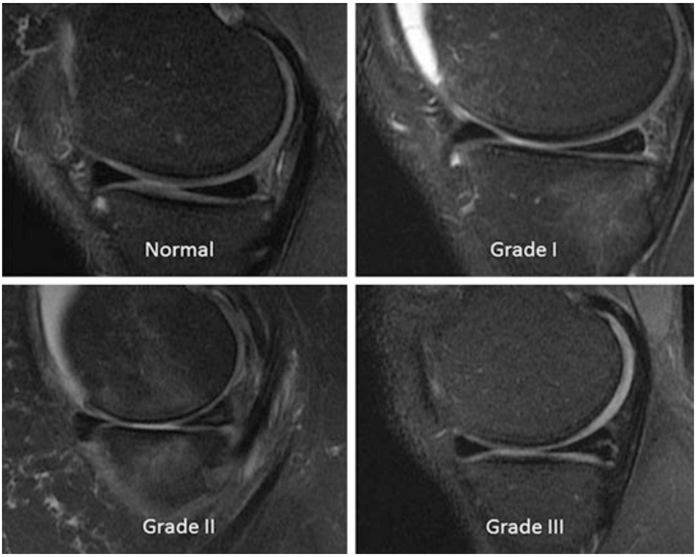

Fig. 3.7 MRI classification for meniscal tears. (Image reprinted [6])

It is important to note that incidental findings of meniscal pathology on MRI are common and increase with age. In patients with radiographic evidence of knee osteoarthritis (Kellgren–Lawrence grade ≥2), the prevalence of a meniscal tear is 63% in symptomatic patients (knee pain, aching, stiffness on most days) and 60% in asymptomatic patients [11].

A discoid meniscus is a congenital variant that describes an enlarged meniscus with further central extension onto the tibial plateau and more commonly occurs in the lateral compared to medial meniscus. The three types of discoid menisci are incomplete, complete, and Wrisberg (lacks normal posterior ligament and capsular attachments) [4]. The Wrisberg type can result in instability and is often referred to as "snapping-knee syndrome" [5]. A diagnosis of discoid meniscus is made on MRI when the

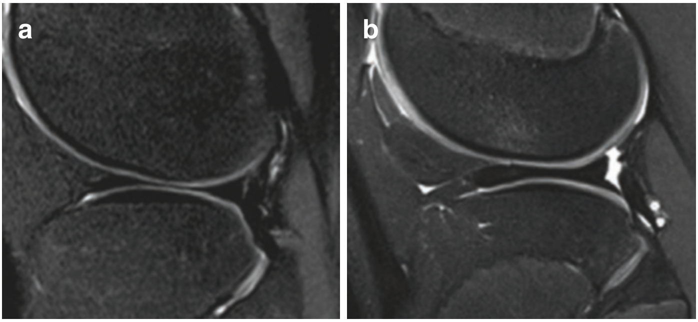

Fig. 3.8 MRI discoid meniscus. (Image adapted [4]). T2-weighted MR images of lateral meniscus (**a**) normal (**b**) discoid

meniscus body measures 15 mm or more on a midline coronal image or when three or more bowtie shapes are seen on continuous sagittal images. The sensitivity and specificity of MRI detection of a discoid tear are highly variable [4] (Fig. 3.8).

CT Arthrography

This may be used in patients with contraindications to MRI. Disadvantages to this modality include the use of intravenous and intra-articular contrast and radiation exposure [4].

Ultrasound

This is not typically used for the diagnosis of meniscal pathology as its accuracy is user dependent. However, studies have shown some promise in the use of diagnostic ultrasound in identifying meniscal injuries. A meta-analysis evaluating seven prospective studies demonstrated summary estimates of sensitivity, specificity, positive likelihood ratio, negative likelihood ratio, and diagnostic odds ratio of ultrasonography in the diagnosis of meniscal injury to be 0.88 (95% CI 0.84–0.91), 0.90 (95% CI 0.86–0.93), 7.07 (95% CI 4.34–11.52), 0.17 (95% CI 0.10–0.26), and 58.13 (95% CI 24.38–138.62), respectively [12].

Arthroscopy

The gold standard for the diagnosis of meniscal pathology is a complete diagnostic arthroscopy with examination of all intra-articular structures. It is used for both the confirmation of diagnosis and surgical treatment of meniscal injury when nonoperative management is not indicated or has failed [5].

Treatment

Nonoperative management is recommended for patients with minor tears and/or those without significant limitations in function. The types of tears that may be treated nonsurgically include partial-thickness longitudinal (vertical) tears, small (<5 mm) full-thickness peripheral tears, and minor inner rim or degenerative tears [13]. The nonoperative approach aims to manage symptoms rather than heal the meniscal tear as most unrepaired meniscal tears will not heal. Conservative management includes rest, ice, nonsteroidal anti-inflammatory drugs, and activity modification for 6–12 weeks [5]. Other recommendations include cryotherapy, bracing, weight loss, aspiration if there is a large effusion present, and physical therapy. The goals of therapy are to decrease pain and swelling and increase range of motion, muscle strength, and endurance. Static strengthening along with electrical stimulation are used to combat quadriceps atrophy. With time, the addition of aerobic conditioning and open/closed kinetic chain exercises in all three planes with stretching of the lower limb may be utilized. Gradual resolution of symptoms within a period of 6 weeks and normal function by 3 months has been seen with some meniscal injuries [13].

The use of intra-articular injections of corticosteroids, analgesic medications such as lidocaine or bupivacaine, and viscosupplementation may be considered if there is associated underlying osteoarthrosis. It is important to note that corticosteroids may hinder meniscal healing [13].

Orthobiologics are continuing to be studied in the treatment of meniscal injuries. These include platelet rich plasma (PRP), mesenchymal stem cells (MSCs), or micro-fragmented adipose tissue (MFAT) [14]. PRP, which is derived from autologous whole blood, is made up of numerous growth factors and cytokines that has been shown to promote healing [2]. Intraoperative PRP injections given to patients that underwent open meniscal repair has been shown to significantly improve pain and function [15]. Intraoperative PRP injections administered to patients that underwent index arthroscopy were also shown to significantly improve meniscus healing and functional outcome [16]. Studies examining the role of intrameniscal PRP injections without surgery have also demonstrated improvement in pain [17].

MSCs, a subdivision of stem cells, have been isolated from bone marrow (BM), periosteum, trabecular bone, adipose tissue, skeletal muscle, and deciduous teeth [14]. BM-derived MSCs have been shown to significantly improve knee pain after partial meniscectomy [18]. Adipose-derived stem cells (ASCs) are MSCs originating from adipose tissue with the ability to differentiate into numerous cell lines and have been shown to yield more stem cells when compared to BM-derived MSCs. In vitro studies have revealed the potential of ASCs to differentiate into chondrogenic and osteogenic cells with improved healing of articular cartilage in animal models, however, there are limited studies evaluating the use of ASCs in humans with meniscal injuries [14]. MFAT has been used in the treatment of knee osteoarthritis among other musculoskeletal conditions. A case report demonstrated the successful treatment of a degenerative meniscal tear in a triathlete with MFAT [19].

Operative management is considered when patients experience significant functional limitations without improvement following conservative management or those with large tears causing mechanical symptoms. The goal of surgery is to maximize the preservation of the meniscus. When able, a meniscal repair is preferred over a meniscectomy. As the outer 1/3 of the meniscus has good vascular supply, tears in this area can often be repaired.

However, the inner 2/3 of the meniscus is poorly vascularized, therefore meniscal tears in this area may require removal of tissue through meniscectomy [1]. Meniscal repair allows for the greatest preservation of tissue, however, it typically involves a longer rehabilitation process. In contrast, meniscectomy allows for a faster return to play, but increases the future risk of osteoarthritis. Lastly, meniscal transplant is considered when a patient continues to be symptomatic, wants to maintain an active lifestyle, and there is minimal viable meniscal tissue with high risk of progression to osteoarthritis. Ideally, the patient should have undergone total or near-total meniscectomy prior to the procedure [20].

Return to Activities

Rehabilitation for Nonoperative Patients

The goals of physical therapy include the maintenance of range of motion and improvement in strength and endurance. An athlete will advance through resistance exercises as tolerated and will subsequently slowly return to running. Nonimpact conditioning such as swimming and cycling is also recommended. Prior to returning to sports activity, athletes should exhibit at least 70–80% strength in the injured side compared to the uninjured side. The time course in which an athlete may return to sports activity is variable and depends on the patient's goals and severity of injury [21].

Rehabilitation Following Surgery

The patient advances through activities as tolerated. The athlete may return to competitive sports when he/she has achieved equal strength, full range of motion, and endurance in sports-specific activities. Accepted rehabilitation protocols are outlined in Table 3.3 [20]:

Table 3.3 Rehabilitation protocols following surgeries

	Meniscectomy	Meniscal repair	Meniscal transplant
Phase 1	*0–2 weeks:* WB and ROM exercises as tolerated. Hamstring, quadriceps, and core-strengthening exercises	*0–2 weeks:* Fully WB in extension, +/− brace, ROM 0°–90° NWB, isometric quadriceps strengthening	*0–2 weeks:* TTWB brace locked in extension, ROM 0°–90° without brace and NWB, isometric quadriceps strengthening
Phase 2	*2–4 weeks:* Sports-specific exercises, return to cardio training	*2–6 weeks:* Fully WB in extension, ROM 0°–90° NWB, closed chain exercises, terminal knee extensions	*2–8 weeks:* 50% WB at weeks 2–4, full WB at week 4, brace unlocked 0°–90° at weeks 2–6, ROM 0°–90° when NWB, closed chain exercises, terminal knee extensions, all activities with brace then discontinue brace at 6 weeks
Phase 3	*4–6 weeks:* Progress in sports-specific training, maintain strengthening program	*6–12 weeks:* Fully WB, discontinue brace, full ROM, hamstring and proprioception exercises, leg presses 0°–90°, stationary bicycle	*8–12 weeks:* Full WB w/o brace, full ROM, hamstring and proprioception exercises, leg press 0°–90°, stationary bicycle
Phase 4	N/A	*12–20 weeks:* Progress with exercises, start swim at 12 weeks, sports-specific exercises, run/jump protocol at 16 weeks	*12–20 weeks:* Progress with exercises, swim at 12 weeks, elliptical Run/jump protocol at 16 weeks
Phase 5	N/A	N/A	*More than 20 weeks:* Advance to sports-specific activities

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