

Meniscal tear

Overview

- Meniscal tear is the most common injury to the knee that necessitates surgery [1, 2].
- The medial meniscus is torn approximately three times more often than the lateral meniscus [1, 2].
- Lateral meniscus tears occur more commonly with acute ACL tears [1, 2].
- There is an increased rate of osteoarthritis in knees after meniscal tears and meniscectomy, particularly on the lateral side [1, 2].
- Traumatic meniscal tears are common in young patients with sports-related injuries [1, 2].
- Degenerative tears usually occur in older patients and can have an insidious onset [1, 2].
- Meniscal tears can be classified according to location in relation to the vascular supply [1, 2].
- Meniscal tears can be classified according to position (anterior, middle, posterior third, root) [1, 2].
- Meniscal tears can be classified according to appearance and orientation [1, 2].
- A meniscal root tear is defined as a radial tear or avulsion of the meniscal root from the tibial plateau [1, 2].
- A meniscal root tear completely disrupts the circumferential fibers of the meniscus [1, 2].
- Biomechanically, a meniscal root tear results in a loss of hoop stresses and an increase in contact forces [1, 2].
- A meniscal root tear is functionally equivalent to a total meniscectomy [1, 2].
- Lateral root tears are associated with ACL tears [1, 2].
- Medial root tears are associated with chondral injuries [1, 2].
- Acute meniscal root tears should be repaired whenever possible [1, 2].
- The vascular supply of the meniscus is a primary determinant of healing potential [1, 2].
- Tears in the peripheral third of the meniscus have the highest potential for healing [1, 2].
- In the absence of intermittent swelling, catching, and locking, meniscal tears—particularly degenerative tears—may be treated conservatively [1, 2].
- Younger patients with acute tears may benefit from operative treatment [1, 2].
- Patients with tears causing mechanical symptoms may benefit from operative treatment [1, 2].

- Patients with symptoms that fail to improve with conservative measures may benefit from operative treatment [1, 2].
- Acute meniscal root tears should be repaired early [1, 2].
- The treatment of chronic meniscal root tears is more controversial [1, 2].
- Tears that are not amenable to repair are best treated with partial meniscectomy [1, 2].
- Partial-thickness tears do not necessitate treatment [1, 2].
- Tears less than 5 to 10 mm in length do not necessitate treatment [1, 2].
- Tears that cannot be displaced more than 1 to 2 mm do not necessitate treatment [1, 2].
- Complex, degenerative, and central/radial tears are treated with resection of a minimal amount of normal meniscus [1, 2].
- Partial meniscectomy increases peak stresses in the affected compartment [1, 2].
- General indications for meniscal repair include a tear between 1 and 4 cm [1, 2].
- General indications for meniscal repair include a vertical tear [1, 2].
- General indications for meniscal repair include a red-red tear [1, 2].
- General indications for meniscal repair include a meniscal root tear [1, 2].
- General indications for meniscal repair include a patient younger than 40 years [1, 2].
- Concomitant ACL reconstruction may extend the indications for meniscal repair because results are typically better [1, 2].
- Augmentation techniques may extend the indications for meniscal repair [1, 2].
- Four techniques are commonly used for meniscal repair: open, “outside-in,” “inside-out,” and “all-inside” [1, 2].
- Newer techniques for all-inside repairs are popular because of their ease of use [1, 2].
- The latest generation of “all-inside” devices allows tensioning of the construct [1, 2].
- The gold standard for meniscal repair remains the inside-out technique with vertical mattress sutures [1, 2].
- Saphenous nerve branches must be protected during medial repairs [1, 2].
- The peroneal nerve must be protected during lateral repairs [1, 2].
- Rehabilitation following meniscus repair should involve avoidance of knee flexion beyond 90 degrees [1, 2].
- The level of allowed weight bearing following meniscus repair is controversial [1, 2].
- Success rates of 80% to 90% have been reported for meniscal repairs [1, 2].
- Success of meniscal repair depends on location, type of tear, and chronicity [1, 2].
- Results of meniscal repair are best with acute peripheral tears in young patients undergoing concurrent ACL reconstruction [1, 2].
- The success rate of meniscal repair is 90% when performed in conjunction with an ACL reconstruction [1, 2].
- The success rate of meniscal repair is 60% when performed in a knee with an intact ACL [1, 2].

- The success rate of meniscal repair is 30% when performed in a knee with a deficient ACL [1, 2].
- Nonsurgical management is a consideration for stable peripheral tears shorter than 5 to 10 mm in length [3].
- Nonsurgical management is a consideration for some degenerative tears that do not cause mechanical symptoms [3].
- Nonsurgical management is a consideration for tears in the setting of substantial osteoarthritis (Kellgren-Lawrence grade 3 or 4) [3].
- Irreparable unstable tears causing mechanical symptoms (locked knee) can be treated with partial meniscectomy [3].
- Tears in the avascular zone, such as radial or flap tears, can be treated with partial meniscectomy [3].
- Degenerative tears without substantial osteoarthritis can be treated with partial meniscectomy [3].
- Caution should be taken when considering surgical management of meniscal tears in patients with advanced radiographic osteoarthritis [3].
- Patients with advanced radiographic osteoarthritis may be better candidates for initial nonsurgical management [3].
- If nonsurgical management fails in patients with advanced radiographic osteoarthritis, knee arthroplasty can be considered [3].
- During partial meniscectomy, the unstable portion of the meniscus is identified and excised [3].
- During partial meniscectomy, the adjacent tissue is shaped into a smooth and stable contour leading into the excised segment [3].
- It is critical to preserve as much meniscal tissue as possible during partial meniscectomy [3].
- It is critical to avoid creating a defect traversing the entire width of the meniscus during partial meniscectomy [3].
- Clinical studies with long-term follow-up of partial meniscectomy found an increase in osteoarthritic changes within the affected compartment [3].
- Preservation of as much meniscal tissue as possible likely minimizes future joint degeneration [3].
- Partial meniscectomy for the management of radial tears that were within 1 cm of the posterior horn insertion led to progression of osteoarthritis in 35% of patients at a mean 77-month follow-up [3].
- At 5- to 7-year follow-up of 46 patients, one-third had progression of Kellgren-Lawrence grade 0 to 2 osteoarthritis to grade 3 or 4 osteoarthritis [3].
- Although the modified Lysholm Knee Questionnaire score often significantly improved after partial meniscectomy, only 56% of patients reported pain improvement [3].
- In a systematic review of management for traumatic meniscal tears, short-term revision surgery rates were higher after meniscal repair than after meniscectomy (16.5% versus 1.4%) [3].
- In a systematic review of management for traumatic meniscal tears, long-term revision surgery rates were higher after meniscal repair than after meniscectomy (20.7% versus 3.9%) [3].
- There were no plain radiographic degenerative changes in 78% of knees after meniscal repair [3].

- There were no plain radiographic degenerative changes in 64% of knees after meniscectomy [3].
- Nearly 80% of patients with arthroscopic meniscal repair had no osteoarthritis progression at 8- to 10-year follow-up [3].
- Only 40% of patients with meniscectomy had no osteoarthritis progression at 8- to 10-year follow-up [3].
- Approximately 96% of the patients who underwent arthroscopic meniscal repair returned to their preinjury level of sports activity [3].
- Only half of the patients who underwent a partial meniscectomy returned to their preinjury level of sports activity [3].
- At 4-year follow-up, patients who underwent repair of a medial meniscal root tear had less progression of osteoarthritis than those who underwent partial medial meniscectomy [3].
- At 4-year follow-up, patients who underwent repair of a medial meniscal root tear had better clinical scores than those who underwent partial medial meniscectomy [3].
- The risk for symptomatic osteoarthritis progression following meniscal repair is 25% to 50% lower than that following arthroscopic partial meniscectomy [3].
- The risk for symptomatic osteoarthritis progression following meniscal repair remains approximately twice as high as the general population [3].
- Preservation of the integrity of the articular cartilage on quantitative MRI has been associated with healed meniscal repairs [3].
- There has been a shift toward meniscal repair as the treatment of choice for meniscal tears when possible [3].
- The goal of meniscal repair is to provide the meniscus with structural support and the ability to heal [3].
- The goal of meniscal repair is to preserve meniscus integrity and restore its function [3].
- Traumatic longitudinal tears occurring in the red/red (vascular) zone in patients younger than 30 years are believed to be most amenable to a successful repair [3].
- Good results have been demonstrated in red/white zone repairs in young patients [3].
- Tears in the red/red zone are most likely to heal [3].
- Tears in the red/white zone are less likely to heal than tears in the red/red zone [3].
- White/white zone tears are avascular and thus have limited potential for healing [3].
- The failure and revision surgery rate was found to be higher for medial than lateral meniscal repairs at short-term and medium-term follow-up [3].
- Concomitant ACL reconstruction positively correlated with healing [3].
- Age younger than 30 years trended toward a positive correlation with healing [3].
- Tears longer than 2 cm are negatively associated with healing rates [3].
- Smoking is negatively associated with healing rates [3].
- Management of meniscal tears is predicated on symptoms [4].
- Not all meniscal tears cause symptoms [4].

- Many symptomatic tears become asymptomatic [4].
- Stable longitudinal tears less than 10 mm in length with less than 3 to 5 mm of displacement are commonly managed nonsurgically [4].
- Degenerative tears associated with significant osteoarthritis are commonly managed nonsurgically [4].
- Short radial tears less than 3 mm in length are commonly managed nonsurgically [4].
- Stable partial tears are commonly managed nonsurgically [4].
- Nonsurgical management can include ice, NSAIDs, or physical therapy for range of motion and general strengthening of the lower extremities [4].
- Arthroscopic partial meniscectomy is indicated for radial, oblique, flap, horizontal cleavage, and complex tears [4].
- Arthroscopic partial meniscectomy is indicated for tears located in the white-white avascular zone [4].
- Arthroscopic meniscectomy has been demonstrated to reduce surgical morbidity over open meniscectomy [4].
- Arthroscopic meniscectomy has been demonstrated to improve function over open meniscectomy [4].
- The goal of arthroscopic partial meniscectomy is to débride degenerative or torn meniscal tissue, leaving a stable contoured rim and preserving as much tissue as possible [4].
- Peak contact articular cartilage stresses increase proportionally to the amount of meniscus removed [4].
- Studies have demonstrated greater than 80% satisfactory function at minimum 5-year follow-up after arthroscopic partial meniscectomy [4].
- A 50% finding of Fairbank's changes on radiographs was observed in studies of arthroscopic partial meniscectomy [4].
- Degenerative changes and a decrease in function occur more quickly in patients who have undergone arthroscopic lateral meniscectomy [4].
- Factors that predict better long-term function following arthroscopic partial meniscectomy include age younger than 40 years [4].
- Factors that predict better long-term function following arthroscopic partial meniscectomy include normal lower extremity alignment [4].
- Factors that predict better long-term function following arthroscopic partial meniscectomy include minimal arthritic changes noted at the time of arthroscopy [4].
- Factors that predict better long-term function following arthroscopic partial meniscectomy include a single fragment tear [4].
- Tear types appropriate for repair include vertical longitudinal tears in the vascular zone of the meniscus [4].
- Tear types appropriate for repair include displaced bucket-handle tears that remain in good condition once they are reduced [4].
- Relative contraindications for meniscal repair include advanced degenerative articular cartilage damage [4].
- Relative contraindications for meniscal repair include complex tears [4].
- Relative contraindications for meniscal repair include poor meniscal tissue quality [4].

- Relative contraindications for meniscal repair include ACL deficiency [4].
- The four potential meniscal repair techniques are open, arthroscopic inside-out, arthroscopic outside-in, and arthroscopic all-inside [4].
- Open repair usually is reserved for peripheral tears in the posterior horn approached through a capsular incision [4].
- Arthroscopic inside-out repairs are performed using absorbable or nonabsorbable sutures placed using zone-appropriate cannulas [4].
- In arthroscopic inside-out repairs, sutures are retrieved and tied through a small capsular incision [4].
- The arthroscopic outside-in technique usually is reserved for anterior horn tears [4].
- The arthroscopic outside-in technique involves placing a suture through a needle placed across the tear [4].
- In the arthroscopic outside-in technique, the suture is retrieved and tied outside the knee through an arthroscopic portal [4].
- In the arthroscopic outside-in technique, the knot is pulled into the knee to reduce the tear when tied over the capsule [4].
- Arthroscopic all-inside repairs involve absorbable stents or sutures tied to stents placed through arthroscopic portals [4].
- All-inside repairs may offer reduced neurovascular risk [4].
- Mechanical studies have demonstrated reasonable loads to failure for all-inside meniscal repair devices [4].
- No all-inside meniscal repair device improves on the load to failure of vertically placed inside-out sutures [4].
- Clinical success rates for all meniscal repair techniques in stable knees range from 70% to 95% [4].
- Second-look arthroscopy has shown lower rates of success for meniscal repair, ranging from 45% to 91% [4].
- Ligamentously unstable knees decrease the success rate of meniscal repair to 30% to 70% [4].
- Several studies have demonstrated meniscal repair success greater than 90% when performed in conjunction with an ACL reconstruction [4].
- Complications of meniscal repair include failure to heal the tear [4].
- Complications of meniscal repair include knee stiffness [4].
- Complications of meniscal repair include potential damage to the articular surface from mechanical devices used to repair the tear [4].
- Meniscal allograft transplantation has been reserved for the patient who remains symptomatic in activities of daily living after partial or total meniscectomy [4].
- Meniscal allograft transplantation has been reserved for the patient who develops recurrent pain after partial or total meniscectomy [4].
- Meniscal allograft transplantation is usually reserved for patients who are skeletally mature but younger than 50 years [4].

- Contraindications for meniscal allograft transplantation include uncorrected lower extremity malalignment [4].
- Contraindications for meniscal allograft transplantation include uncorrected ligamentous instability [4].
- Contraindications for meniscal allograft transplantation include inflammatory arthritis [4].
- Contraindications for meniscal allograft transplantation include significant chondral changes in the treated compartment [4].
- Return to strenuous sports generally is not recommended after meniscal allograft transplantation [4].
- Meniscal allograft transplantation has been performed for more than 10 years with varying degrees of reported success [4].
- Subjective improvement in tibiofemoral pain is seen after meniscal transplant [4].
- Increased activity levels are seen after meniscal transplant [4].
- A long-term benefit for preventing the progression of osteoarthritis has not been established for meniscal allograft transplantation [4].
- Grafts have performed better when placed with a bone block or plug [4].
- Preservation of at least some peripheral rim is important to prevent peripheral extrusion after meniscal allograft transplantation [4].
- A variety of meniscal scaffold options continue to be investigated but have not yet undergone widespread human clinical use or investigation [4].
- The menisci are 65% to 75% water [4].

Anatomy & Pathophysiology

MENISCAL STRUCTURE AND COMPOSITION

- The menisci are wedge-shaped fibrocartilaginous structures situated between the femoral condyles and tibial plateaus [21].
- The menisci have a triangular cross section [23].
- The extracellular matrix of the meniscus is composed predominantly of type I collagen [4, 21, 23].
- Types II, III, V, and VI collagen are also present in the meniscal extracellular matrix [21, 23].
- Proteoglycans such as aggrecan are components of the meniscal extracellular matrix [21].
- Proteoglycans make up 1% of the dry weight of the meniscus [23].
- Water comprises 65% to 75% of the meniscal volume [4, 21, 23].
- Fibrochondrocytes are the predominant meniscal cell type and produce the extracellular matrix [21].
- Type I collagen is most abundant in the superficial zones of the menisci to provide tensile strength [21].
- Larger concentrations of proteoglycans and water are found in the deeper zones of the meniscus and provide compressive strength [21].

COLLAGEN FIBER ORIENTATION

- Collagen fibers are randomly oriented on the superficial aspects of the menisci [21].
- In the deeper zones of the meniscus, collagen fibers are oriented in a circumferential pattern [21, 23].
- Intermittent radially oriented tie fibers anchor the circumferential fibers in the deeper zones of the meniscus [21].
- The circumferential orientation of fibers allows for the absorption and dissipation of hoop stresses from axial loading during weight bearing [21].

GROSS ANATOMY: MEDIAL MENISCUS

- The medial meniscus is semicircular, or C-shaped [21].
- The medial meniscus covers 50% to 60% of the medial tibial plateau surface [21].
- The medial meniscus covers 64% of the condyle surface [23].
- The posterior horn of the medial meniscus is approximately 11 mm wide [21].
- The anterior horn of the medial meniscus is slightly smaller than the posterior horn [21].
- The medial meniscus is 10 mm wide [23].
- The medial meniscus is 3 to 5 mm thick [23].
- The medial meniscus is attached to the deep medial collateral ligament fibers and joint capsule [21, 23].
- The inferior aspect of the posterior horn of the medial meniscus is attached to the tibia by the meniscotibial or coronary ligament [21].
- The medial meniscus is less mobile than the lateral meniscus due to its attachment to the deep medial collateral ligament [21, 23].

GROSS ANATOMY: LATERAL MENISCUS

- The lateral meniscus is more circular in shape than the medial meniscus [21, 23].
- The lateral meniscus has equally sized anterior and posterior horns [21].
- The lateral meniscus covers 84% of the condylar surface [23].
- The lateral meniscus is 12 to 13 mm wide [23].
- The lateral meniscus is 3 to 5 mm thick [23].
- At the posterior lateral meniscal attachment, popliteomeniscal fascicles extend from the meniscus to the posterior capsule [21].
- The popliteal hiatus is created as the popliteus tendon becomes intra-articular at the posterior lateral meniscal attachment [21].
- The menisiofemoral ligaments connect the posterior horn of the lateral meniscus to the medial femoral condyle [21].
- The anterior menisiofemoral ligament of Humphrey courses anterior to the posterior cruciate ligament [21].

- The posterior meniscomfemoral ligament of Wrisberg courses posterior to the posterior cruciate ligament [21].
- The lateral meniscus has more mobility than the medial meniscus because it has less continuous attachment to the capsule [21].

INTERMENISCAL CONNECTIONS

- The most common connection between the medial and lateral menisci is the transverse intermeniscal ligament [21].
- The transverse intermeniscal ligament is present in 60% to 94% of knees [21].
- A posterior and medial or lateral oblique intermeniscal ligament can also be present [21].

VASCULAR SUPPLY AND ZONES

- The vascular supply of the menisci comes from the superior, middle, and inferior geniculate arteries [21, 23].
- The peripheral 10% to 30% of the meniscus is well vascularized by synovial and capsular branches [21].
- The anterior and posterior root attachments of the meniscus are well vascularized by synovial branches [21].
- The outer third of the meniscus is called the red/red zone and is well vascularized [21, 23, 25].
- The middle third of the meniscus is called the red/white zone and is at the border of the vascularized and avascular zones [21, 23, 25].
- The inner third of the meniscus is called the white/white zone and is devoid of a vascular supply [21, 23, 25].
- Approximately 50% of the meniscus is vascularized at birth [23].
- Only 10% to 25% of the meniscus is vascularized in the adult [23].
- The vascularity of the meniscus decreases with advancing age [4].
- The poorly vascularized portions of the menisci receive nutrition through diffusion [21].

NEURAL SUPPLY

- Neural elements are found mostly in the periphery of the anterior and posterior horns of the meniscus [21].
- The menisci are believed to have a role in proprioception because of their peripheral neural configuration [21].

BIOMECHANICS AND LOAD DISTRIBUTION

- The menisci function in proprioceptive feedback, load distribution during physiologic loading, joint lubrication during motion, and maintenance of tibiofemoral joint stability and congruity [21].
- In knee extension, as much as 50% of the load is absorbed by the meniscus [4, 21, 23].
- The percentage of load-sharing by the meniscus increases to 90% at 90° of knee flexion [4, 23].

CQ HAND + UPPER LIMB

- In flexion, the menisci transmit as much as 85% of joint loads [21].
- Beyond 90° of knee flexion, most of the force is transmitted to the posterior horns of the menisci [23].
- The lateral meniscus provides more biomechanical protection to the joint than the medial meniscus [23].
- When the meniscus is removed completely, articular cartilage contact stress increases by two to three times that experienced when the meniscus is intact [23].
- Removal of the inner third of the meniscus results in a 10% reduction in contact area and a 65% increase in contact stress on the articular cartilage [23].
- A vertical tear of the medial meniscus causes increased contact area and maximum contact pressure in both the lateral and medial compartments of the knee [23].
- A radial tear of the medial meniscus that extends from the inner rim to the peripheral third but preserves the peripheral third has not been found to change maximum contact pressure and contact area in the knee [23].
- A radial tear involving 90% of the medial meniscus results in a posterocentral shift in peak-pressure location [23].
- Medial meniscus root tears result in peak articular cartilage contact pressure similar to that seen after a complete meniscectomy [23].
- Disruption of circumferential meniscal fibers leads to a loss of ability to transmit hoop stresses, with biomechanical effects approaching total meniscectomy [18].
- Tears of the posterior medial meniscal root can increase contact pressure, external rotation, and lateral tibial translation [18].
- A lateral root tear substantially decreases the contact area and increases contact pressure in the lateral compartment [18].

DISCOID MENISCUS

- The discoid meniscus is an uncommon meniscal variant that may present with symptomatic tearing and/or instability during childhood or adolescence [17].
- Discoid menisci are almost always lateral and extremely rare to find medially [17].
- The etiology of the discoid meniscus is not completely understood but is considered a congenital anomaly with a possible genetic component [17].
- Estimates of discoid meniscus incidence vary, with a lower incidence (0.4% to 5.2%) in those of Western European descent and a much higher incidence (up to 17%) reported in Asian countries [17].
- The central area of a discoid meniscus is partially or completely filled in and may lack normal attachments to the surrounding capsule, distal femur, and proximal tibia [17].
- The thickness of the discoid meniscus may be abnormally increased, resulting in a block of abnormal tissue [17].
- Investigation into the histopathology of the discoid meniscus shows a disorganization of the circumferential collagen network at a molecular level [17].

- Structural abnormalities in the discoid meniscus compromise its ability to withstand normal stresses across the knee and predispose it to tears [17].
- The traditional Watanabe classification system consists of three types of discoid meniscus variants: type I (complete discoid shape), type II (incomplete discoid shape), and type III (Wrisberg variant) [17].
- The Wrisberg variant is described as a more normally shaped meniscus that lacks normal peripheral attachments except for the ligament of Wrisberg [17].
- Discoid menisci are classified into three subtypes: type I (incomplete), type II (complete), and type III (Wrisberg variant) [30].
- Type III discoid menisci lack posterior attachment to the tibia [25, 30].
- Discoid meniscus more commonly affects the lateral meniscus (1.4% to 15%) than the medial meniscus (<1%) [30].

TEAR CLASSIFICATION AND PATHOPHYSIOLOGY

- Meniscal tears can be classified according to location in relation to the vascular supply, position (anterior, middle, posterior third, root), and appearance and orientation [1, 2].
- Longitudinal tears most commonly occur as a result of trauma to a reasonably normal meniscus [6].
- Longitudinal tears are usually vertically oriented and may extend completely or partially through the thickness of the meniscus [6].
- A longitudinal tear oriented parallel to the edge of the meniscus that is complete may produce a displaceable inner fragment [6].
- When the inner fragment of a longitudinal tear displaces over into the intercondylar notch, it is referred to as a bucket-handle tear [6].
- A peripheral vertical tear in zone I is referred to as a red-red tear, and a tear between zone I and II is referred to as a red-white tear [6].
- Horizontal tears tend to be more common in older patients [6].
- Horizontal cleavage planes occur from shear, dividing the superior and inferior surfaces of the meniscus [6].
- Horizontal tears are more commonly seen in the posterior half of the medial meniscus or the midsegment of the lateral meniscus [6].
- Oblique tears are full-thickness tears running obliquely from the inner edge of the meniscus out into the body of the meniscus [6].
- Radial tears are vertically oriented, extending from the inner edge of the meniscus toward its periphery [6].
- Radial tears can be complete or incomplete depending on the extent of involvement [6].
- Flap tears are similar to oblique tears but usually have a horizontal cleavage element rather than being purely vertical in orientation [6].
- Complex tears may contain elements of all tear types and are more common in chronic meniscal lesions or older degenerative menisci [6].

- Degenerative tears often refer to complex tears and present with marked irregularity and complex tearing within the meniscus [6].
- The most common type of tear is the longitudinal tear, usually involving the posterior segment of either the medial or lateral meniscus [7].
- Before the extensive use of arthroscopy, tears of the medial meniscus were approximately five to seven times more common than those of the lateral meniscus [7].
- With increased use of arthroscopy, medial and lateral meniscal tears are believed to occur with almost equal frequency [7].
- Most meniscal tears involve the inferior rather than the superior surface of the meniscus [7].
- Small tears limited to the posterior horn are not capable of producing locking but will cause pain, recurrent swelling, and a feeling of instability in the joint [7].
- Extensive longitudinal tears can cause mechanical locking if the central portion of the meniscus is displaced into the intercondylar notch [7].
- Transverse, radial, or oblique tears more commonly involve the lateral meniscus [7].
- Radial tears usually are located at the junction of the anterior and middle thirds [7].
- The lateral meniscus is more of a circle and has a shorter radius, making the inner free edge more easily torn radially than its medial counterpart [7].
- Cysts of the menisci are frequently associated with tears and are nine times more common on the lateral than on the medial side [7].
- The most common cause of meniscal cysts is trauma that produces degeneration and secondary mucinous and cystic changes in the periphery of the meniscus [7].
- Discoid menisci are vulnerable to compression and rotary stresses due to hypermobility and the bulk of tissue between the articular surfaces [7].
- Meniscal root tears are defined as a radial tear or avulsion of the meniscal root from the tibial plateau [1, 2].
- Meniscal root tears completely disrupt the circumferential fibers of the meniscus [1, 2].
- Biomechanically, meniscal root tears result in a loss of hoop stresses and an increase in contact forces [1, 2].
- Meniscal root tears are functionally equivalent to a total meniscectomy [1, 2].
- Root tears much more commonly occur at the posterior horn attachment [18].
- Posterior medial meniscus root tears occur with a higher incidence in middle-aged and obese patients and are typically degenerative tears [18].
- A traumatic posterior medial meniscus root tear is often associated with multiligamentous knee injury or injury occurring during deep knee flexion [18].
- The medial posterior root is less mobile than the lateral root and is therefore more susceptible to isolated injury [18].
- A lateral root tear is most common in association with ligamentous injury [18].
- Both posterior root tears and ramp lesions are thought to lead to increased anterior instability in ACL-deficient knees [7].

- Posterior root tears are associated with increased contact forces and early arthritis [7].

Classification

TEAR MORPHOLOGY AND PATTERNS

- O'Connor's classification of meniscal tears includes longitudinal, horizontal, oblique, radial, and variations such as flap, complex, and degenerative tears [6].
- Longitudinal tears are vertically oriented, parallel to the meniscal edge, and may be complete or incomplete [6].
- A complete longitudinal tear with a displaceable inner fragment that moves into the intercondylar notch is termed a bucket-handle tear [6].
- Longitudinal tears near the meniscocapsular attachment are termed peripheral tears [6].
- Horizontal tears result from shear forces dividing the superior and inferior surfaces of the meniscus [6].
- Horizontal tears are more common in older patients and frequently occur in the posterior half of the medial meniscus or midsegment of the lateral meniscus [6].
- Oblique tears are full-thickness tears running obliquely from the inner edge into the body of the meniscus [6].
- Radial tears are vertically oriented, extending from the inner edge toward the periphery, and can be complete or incomplete [6].
- Flap tears contain a horizontal cleavage element and are classified as superior or inferior based on the surface where the flap is based [6].
- Complex tears contain elements of multiple tear types and are common in chronic lesions or older degenerative menisci [6].
- Degenerative tears present with marked irregularity and complex tearing, most often seen in older patients [6].
- The most common type of meniscal tear is the longitudinal tear, usually involving the posterior segment of either the medial or lateral meniscus [7].
- Transverse, radial, or oblique tears more commonly involve the lateral meniscus than the medial meniscus [7].
- Radial tears are almost unique to the lateral meniscus and occur rarely in the medial meniscus [15].
- Tears within the meniscus can be complete or incomplete, with most involving the inferior rather than the superior surface [7].
- Small tears limited to the posterior horn cause pain, recurrent swelling, and instability but are not capable of producing locking [7].

ANATOMICAL ZONES AND VASCULARITY

- A peripheral vertical tear in zone I is referred to as a red-red tear [6].

- A tear between zone I and II is referred to as a red-white tear [6].
- Red-red and red-white tears are located in the vascularized portion of the meniscus [6].
- Zone I is the outer third, Zone II is the middle third, and Zone III is the inner third of each meniscus [15].
- Tears in the red/red zone are most likely to heal, followed by tears in the red/white zone [3].
- White/white zone tears are avascular and have limited potential for healing [3].

SPECIAL TEAR TYPES AND ASSOCIATIONS

- The posterior root tear is a type of radial tear at the posterior root attachment of the meniscus [7].
- The ramp lesion is a form of longitudinal tear at the meniscocapsular junction or meniscotibial attachment [7].
- Cysts of the menisci are nine times more common on the lateral side than on the medial side [7].
- Discoid menisci are vulnerable to compression and rotary stresses due to hypermobility and tissue bulk [7].
- The diagnosis of discoid meniscus is often made incidentally on MRI or at arthroscopy, as it may not produce significant symptoms until derangement occurs [7].

Clinical Presentation

HISTORY AND MECHANISM

- Meniscal tears are unusual in patients younger than 10 years [9].
- Most meniscal tears in adolescents and young adults occur with a twisting injury or with a change in direction [9].
- Middle-aged and older adults can sustain meniscal tears from squatting or falling [9].
- Patients with a traumatic tear may report pain onset during a twisting mechanism or during deep knee flexion [20].
- Occasionally, an audible or palpable popping is reported with traumatic meniscal tears [20].
- Up to 40% of patients experience a spontaneous onset of symptoms without a known inciting event [29].
- With an acute meniscal tear, an effusion often develops several hours after injury [9].
- Swelling in acute meniscal tears develops more slowly than in anterior cruciate ligament (ACL) injuries, where swelling develops rapidly within the first few hours [9].
- Approximately one-half to two-thirds of patients with meniscal tears report knee swelling [20].
- Patients with meniscal injuries localize pain to the joint line or posterior knee [9].
- Patients may describe mechanical symptoms of locking or catching [9].
- Mechanical symptoms such as catching or frank locking have been reported in 12% to 69% of patients in two studies [20].
- Chronic meniscal tears demonstrate intermittent effusions, often with mechanical symptoms [9].

- Pain may diminish after injury but return and be associated with a knee effusion with activity [29].
- Other symptoms include locking, giving way, and clicking sensations [29].
- King reported pain in 82% of patients, giving way in 63%, locking in 43%, a sensation of clicking in the knee in 45%, but recurrent effusions in only 34% [29].

PHYSICAL EXAMINATION

- Small joint effusions and joint line tenderness with palpation are common findings with meniscal tears [9].
- Palpation of the joint line may elicit tenderness at the location of a meniscal tear [20].
- Posterior horn tears are most prevalent, and the posterior joint line is a common location for tenderness [20].
- In a patient with an isolated meniscal tear, joint line tenderness was found to be an accurate test in 81% to 90% of patients [20].
- Manipulative maneuvers, including the McMurray and Apley tests, may produce a palpable or audible click with localized tenderness [9].
- The McMurray and Apley tests are not specific for meniscal pathology [9].
- In a patient with an isolated meniscal tear, the McMurray test was accurate in 57% to 77% of patients [20].
- In the Thessaly test, the patient flexes the knee to 20° while standing on the affected extremity and twists in internal and external rotation [9].
- The Thessaly test often reproduces pain in patients with a meniscal tear [9].
- In a patient with an isolated meniscal tear, the Thessaly test was accurate in 61% to 80% of patients [20].
- Range of motion is typically normal in meniscal tears [9].
- Longitudinal bucket-handle tears may block full extension of the knee joint [9].
- Patients may report tightness in flexion if an effusion is present [9].
- The accuracy of the clinical diagnosis of meniscal tears has been demonstrated to be 70% to 75% in several large studies [9].
- In patients with associated ligamentous or chondral injury, meniscus-specific physical examination tests lose specificity for meniscal pathology [20].

IMAGING

- MRI remains the noninvasive diagnostic procedure of choice for confirming meniscal pathology [9].
- MRI has demonstrated a high negative predictive value for meniscal tears [9].
- A well-performed MRI of a knee with no meniscal pathology will rarely demonstrate a tear [9].
- The sensitivity and specificity of 1.5-Tesla (T) and 3.0-T MRI diagnosis of medial meniscal tears, as confirmed with arthroscopy, were found to be 93% to 96% and 88% to 90%, respectively [20].
- MRI was less sensitive (77% to 82%) but more specific (98% to 99%) for lateral meniscal tears [20].

- A study of 3.0-T MRI for detecting posterior meniscal root tears found sensitivity of 77% and specificity of 73% [20].
- The decreased accuracy of MRI for diagnosing root tears may be attributable in part to the radial orientation of many posterior root tears, making them more difficult to visualize on MRI [20].
- To be considered a relevant finding, a tear seen on MRI should correspond to the patient's history and clinical examination findings [20].
- Meniscal injury is identified on MRI in 31% of asymptomatic athletes [5].
- Meniscal injury is identified on MRI in 91% of patients with knee osteoarthritis [5].
- In nonarthritic knees, focal joint line tenderness, effusion, and positive meniscal signs on physical examination may indicate meniscal pathology as a symptomatic source worthy of surgical intervention [5].
- In the presence of osteoarthritis, mechanical symptoms such as locking or catching in combination with unstable meniscal tears on MRI warrant intervention [5].
- Débridement of stable meniscal tears in the presence of osteoarthritis is unlikely to provide lasting relief [5].

Investigations

HISTORY AND CLINICAL PRESENTATION

- Swelling from an acute meniscal tear differs from an anterior cruciate ligament (ACL) injury, in which swelling develops rapidly within the first few hours [9].
- Patients with meniscal injuries may describe mechanical symptoms of locking or catching [9].

PHYSICAL EXAMINATION

- Range of motion is typically normal in patients with meniscal tears [9].

IMAGING

- Standard knee radiographs should be obtained to evaluate for bone injuries or abnormalities [9].
- A weight-bearing radiograph is necessary to evaluate for osteoarthritis [9].
- Weight-bearing radiographs for osteoarthritis evaluation may include a weight-bearing AP or 45° PA flexion view [9].
- A right-to-left difference of at least 2 mm on weight-bearing radiographs represents a significant difference that will be verified by articular cartilage chondrosis at the time of arthroscopy [9].
- In grade III MRI classification of meniscal tears, increased signal intensity reaches the articular surface of the meniscus [9].

DIAGNOSTIC ACCURACY AND DIFFERENTIAL DIAGNOSIS

- Several large studies have demonstrated the accuracy of the clinical diagnosis of meniscal tears to be 70% to 75% [9].
- Possible intra-articular diagnoses in the differential for meniscal tears include osteochondritis dissecans, medial patella plica, patellofemoral pain syndromes, loose bodies, pigmented villonodular synovitis, inflammatory arthropathies, and osteonecrosis [9].
- Possible extra-articular diagnoses in the differential for meniscal tears include collateral ligament injuries, slipped capital femoral epiphysis, bone or soft-tissue tumors, osteomyelitis, synovial cyst, pes or medial collateral ligament bursitis, injury, complex regional pain syndrome, lumbar radiculopathy, iliotibial band friction, and stress fracture [9].

Treatment

NON-OPERATIVE MANAGEMENT

- Short radial tears (<3 mm in length) are commonly managed nonsurgically [4].
- Partial-thickness split tears that arise from the femoral or tibial surfaces and are stable to probing may be observed [8].
- Short (<10 mm) vertical peripheral tears may be observed as they often heal sufficiently to resolve symptoms [8].
- In pediatric patients, partial thickness tears comprising less than 50% of the total meniscal thickness may be suitable for nonsurgical management [13].
- In pediatric patients, small (<1 cm), stable, longitudinal tears in the peripheral red-red zone may be treated nonsurgically [13].

PARTIAL MENISCECTOMY

- Caution should be taken when considering surgical management of meniscal tears in patients with advanced radiographic osteoarthritis, even in those with frank mechanical symptoms [3].
- Patients with advanced radiographic osteoarthritis may be better candidates for initial nonsurgical management and, if this fails, knee arthroplasty [3].
- In general, complex, degenerative, and central/radial tears are treated with resection of a minimal amount of normal meniscus [1].
- It is critical to preserve as much meniscal tissue as possible and avoid creating a defect traversing the entire width of the meniscus [3].
- Preservation of as much meniscal tissue as possible minimizes future joint degeneration [3].
- Despite satisfactory function, a 50% finding of Fairbank's changes on radiographs was observed in studies of arthroscopic partial meniscectomy [4].

MENISCAL REPAIR

- Augmentation techniques (fibrin clot, platelet-rich plasma clot, vascular access channels, synovial rasping) may extend the indications for repair [1].
- No all-inside device improves on the load to failure of vertically placed inside-out sutures [4].
- It is essential that the saphenous nerve branches be protected during medial repairs [1].
- It is essential that the peroneal nerve be protected during lateral repairs [1].
- In several studies, 80% to 90% success rates with meniscal repairs have been reported [1].
- The results of meniscal repair are best with acute peripheral tears in young patients undergoing concurrent ACL reconstruction [1].
- The success rate is 90% when meniscal repair is performed in conjunction with an ACL reconstruction [1].
- The success rate is 60% when meniscal repair is performed in a knee with an intact ACL [1].
- The success rate is 30% when meniscal repair is performed in a knee with a deficient ACL [1].
- Second-look arthroscopy has shown lower rates of success, ranging from 45% to 91% [4].
- Good results have also been demonstrated in red/white zone repairs in young patients [3].
- Only half of those who underwent a partial meniscectomy returned to their preinjury level of sports activity [3].
- In pediatric patients, an attempt should be made to repair meniscal tears whenever possible [13].
- Tear patterns generally considered amenable to repair in children include longitudinal, vertical, and bucket-handle tear morphologies [13].
- Attempts are typically made to repair radial tears in children, especially if the tear extends to the periphery of the meniscus [13].
- Oblique and horizontal tear configurations are less amenable to repair in children [13].
- Meniscal tears that are complex in nature, with extensive tissue maceration or degeneration, may be irreparable in children [13].
- Tears in the peripheral red-red zone in children are considered most likely to heal because of the robust blood supply [13].
- Surgical repair of tears in the more central zones of the meniscus may be attempted in younger children due to perceived potential for healing [13].
- In pediatric patients, a surgeon may push the limits of a meniscus repair as a tear in the avascular zone, time from injury to surgery, or tear size may not be contraindication to a repair [8].
- Indications for meniscal repair in pediatric patients include long (>10 mm) tears in the periphery without irreparable damage to the body of the meniscus [8].
- The best results of meniscal repair in adults are achieved in tears within 3 mm of the periphery [8].
- In children, it is likely that tears extending more than 3 mm from the periphery will have a good intermediate outcome [8].
- 3- to 5-year outcomes for meniscal repair in children are generally good [8].

- Biologic enhancement increases the likelihood of healing in pediatric meniscal repairs [8].
- Inside-to-out vertical mattress suture techniques remain the gold standard for pediatric meniscal repair [8].
- Newer generation all-inside devices have demonstrated similar strength and excellent early outcomes in pediatric meniscal repair [8].
- It is generally recommended to avoid an all-inside repair technique in younger children because the smaller distances from the meniscal anchors placed through the joint capsule and the popliteus neurovascular bundle may put the bundle at increased risk for direct injury [13].
- Preparation of the meniscus and capsule by mechanically abrading the tissue on either side of the planned repair with a rasp or shaver is considered to be an important step in all meniscal repair procedures [13].
- Young patients with isolated meniscal tears that are chronic in nature may benefit from techniques intended to optimize the vascularity of the repair [13].
- Trephination, injection of autologous blood clots, and microfracture of the notch at the level of the posterior cruciate ligament have been described to optimize vascularity in pediatric meniscal repairs [13].
- For open medial meniscal repair, the knee is positioned in 60 degrees of flexion [14].
- For open medial meniscal repair, a vertical posteromedial arthrotomy incision is made from the medial epicondylar area of the femur distally toward the semimembranosus tendon [14].
- For open medial meniscal repair, interrupted sutures of Mersilene or other nonabsorbable surgical suture material are placed every 3 to 4 mm [14].
- For open medial meniscal repair, sutures are passed vertically from inferior to superior through the meniscus [14].
- For open medial meniscal repair, the edges of the tear are debrided with a small curet or scalpel [14].
- For open medial meniscal repair, the debrided edges of the tear and parameniscal synovial tissue are abraded with a small rasp to evoke an increased inflammatory healing response [14].
- For open lateral meniscal repair, the posterior horn of the lateral meniscus is exposed through a posterolateral capsular incision above the popliteal tendon [14].
- Lateral meniscal tears are more difficult to repair than medial meniscal tears [14].
- If the repair is not combined with another procedure and the tear is small and stable, immediate range of motion from 0 to 90 degrees is permitted [14].
- If the repair is not combined with another procedure and the tear is small and stable, touch-down weight bearing is permitted immediately [14].
- If the repair is not combined with another procedure and the tear is small and stable, full weight bearing is permitted at 6 weeks [14].
- If the repair is not combined with another procedure and the tear is small and stable, no sports are allowed for 3 months [14].
- If the repair is not combined with other procedures but the tear is sufficiently large to allow displacement into the joint, the knee is placed in a hinged brace locked in full extension for 3 to 4 weeks [14].

- If the repair is not combined with other procedures but the tear is sufficiently large to allow displacement into the joint, only touch-down weight bearing with crutches is permitted [14].
- If the repair is not combined with other procedures but the tear is sufficiently large to allow displacement into the joint, motion from 0 to 90 degrees is begun at 4 weeks [14].
- If the repair is not combined with other procedures but the tear is sufficiently large to allow displacement into the joint, weight bearing to 50% is reached at 6 weeks [14].

Complications

MENISCAL REPAIR

- The failure and revision surgery rate for meniscal repair is higher for medial than lateral meniscal repairs at short-term and medium-term follow-up [3].
- Tears longer than 2 cm and smoking are negatively associated with meniscal healing rates [3].
- Concomitant ACL reconstruction positively correlates with meniscal healing [3].
- Age younger than 30 years trends toward a positive correlation with meniscal healing [3].
- Complications of meniscal repair include failure to heal the tear, knee stiffness, and potential damage to the articular surface from mechanical devices used to repair the tear [4].
- The benefit of meniscal repair is balanced with an increased risk of revision surgery after meniscal repair (20.7%) as compared with partial meniscectomy (3.9%) [5].
- There were no plain radiographic degenerative changes in 78% of knees after meniscal repair, compared with 64% of knees after meniscectomy [3].
- At 8- to 10-year follow-up, nearly 80% of patients with arthroscopic meniscal repair had no osteoarthritis progression compared with only 40% of patients with meniscectomy [3].
- Approximately 96% of the patients who underwent arthroscopic meniscal repair returned to their preinjury level of sports activity compared with only half of those who underwent a partial meniscectomy [3].

PARTIAL MENISCECTOMY

- Clinical studies with long-term follow-up of partial meniscectomy for the treatment of meniscal tears found an increase in osteoarthritic changes within the affected compartment [3].
- Studies have demonstrated greater than 80% satisfactory function at minimum 5-year follow-up, despite a 50% finding of Fairbank's changes on radiographs [4].
- The relative risk of osteoarthritis after undergoing total meniscectomy is 14.0 [5].
- The relative risk of osteoarthritis after undergoing total meniscectomy is associated with 4% cartilage loss per year [5].

MENISCAL ALLOGRAFT TRANSPLANTATION

- Overall failure rate (conversion to total knee arthroplasty) for meniscal allograft transplantation ranges from 10% to 29% in long-term follow-up [5].
- Meniscal allograft transplantation is contraindicated in knees with diffuse arthritic changes, morbid obesity, age over 50 years, or unaddressed ligamentous instability, limb malalignment, or chondral defects [5].
- Preservation of at least some peripheral rim is important to prevent peripheral extrusion in meniscal allograft transplantation [4].

References

- [1] Miller S Review Of Orthopaedics. MENISCAL INJURIES.
- [2] Miller S Review Of Orthopaedics. SECTION 16 PATELLAR TRACKING IN TOTAL KNEE ARTHROPLASTY > MENISCAL INJURIES.
- [3] Orthopaedic Knowledge Update Sports Medicine 6. Meniscal Injuries > Management.
- [4] Aaos Comprehensive Orthopaedic Review 3. Meniscal Injuries > V. Treatment.
- [5] Orthopaedic Knowledge Update 13 Ebook Without Multimedia. Knee Arthroscopy and Preservation, Knee Reconstruction > Knee Preservation > Meniscal Preservation.
- [6] Campbell S Operative Orthopaedics 4 Volume Set. ARTHROSCOPIC EXAMINATION AND DEBRIDEMENT OF THE ANKLE JOINT > ARTHROSCOPIC SURGERY OF THE MENISCUS > CLASSIFICATION OF MENISCAL TEARS.
- [7] Campbell S Operative Orthopaedics 4 Volume Set. CLASSIFICATION OF MENISCAL TEARS.
- [8] Tachdjian S Pediatric Orthopaedics From The Texas Scottish Rite Hospital For Children E Book. Plate 35.2 Scapulocostal Stabilization for Scapular Winging (Ketenjian Technique) > Meniscal Injuries > Treatment.
- [9] Aaos Comprehensive Orthopaedic Review 3. Meniscal Injuries > III. Evaluation.
- [13] Orthopaedic Knowledge Update. Meniscal Tears in Children and Adolescents > Traumatic Meniscal Tears > Management.
- [14] Campbell S Operative Orthopaedics 4 Volume Set. OPEN MENISCAL REPAIR > TECHNIQUE 45.1.
- [15] Campbell S Operative Orthopaedics 4 Volume Set. ARTHROSCOPIC EXAMINATION AND DEBRIDEMENT OF THE ANKLE JOINT > ARTHROSCOPIC SURGERY OF THE MENISCUS > TYPES OF MENISCAL EXCISIONS.
- [17] Orthopaedic Knowledge Update. Meniscal Tears in Children and Adolescents > Discoid Meniscus.
- [18] Orthopaedic Knowledge Update Sports Medicine 6. Meniscal Injuries > Management > Root Tears.
- [20] Orthopaedic Knowledge Update Sports Medicine 6. Meniscal Injuries > Diagnosis.

- [21] Orthopaedic Knowledge Update Sports Medicine 6. Meniscal Injuries > Anatomy.
- [23] Aaos Comprehensive Orthopaedic Review 3. Meniscal Injuries > II. Pathoanatomy.
- [25] Aaos Comprehensive Orthopaedic Review 3. Musculoskeletal Conditions and Injuries in the Young Athlete > VIII. Meniscal Injuries and Discoid Meniscus.
- [29] Tachdjian S Pediatric Orthopaedics From The Texas Scottish Rite Hospital For Children E Book. Plate 35.2 Scapulocostal Stabilization for Scapular Winging (Ketenjian Technique) > Meniscal Injuries > Clinical Features.
- [30] Aaos Comprehensive Orthopaedic Review 3. Meniscal Injuries > IV. Classification.