7 Peripheral Meniscal Tears: How to Diagnose and Repair

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7.1 Introduction

Peripheral meniscal tears are located in the most vascular portion of the menisci and comprise 39–72 % [2, 3, 56, 69, 82] of all meniscal tears. The younger population, particularly males with knee instability, is most commonly affected by this type of tear [56]. The vascularity of the peripheral menisci is primarily derived from the superior and inferior medial and lateral geniculate arteries [7]. A synovial fringe that extends approximately 3 mm over the surface of each meniscus adds further to the peripheral vascularity. This intricate blood supply results in the outer rim of the meniscus being vascularized up to 30 % of its width on the medial side and 25 % on the lateral side [7]. There is discrepancy in the vascularity of the menisci, with the peripheral parts being more vascular than the central zones. The vascularity of the menisci has also been shown to decrease and become more peripheral with age [59]. Thus, the healing potential of the meniscus depends on the location of the lesion and the age of the patient [7, 41, 44]. Because of the high vascularity, peripheral meniscal tears (red-red and part of the red-white zone) have the greatest potential for healing [44] (Fig. 7.1).

Due to their anatomic position and attachments, the menisci are vulnerable to injury when particular forces are placed on the knee joint, with specific maneuvers placing certain meniscal areas at highest risk for injury. In this regard,

R.F. LaPrade et al. (eds.), *The Menisci*, DOI 10.1007/978-3-662-53792-3_7

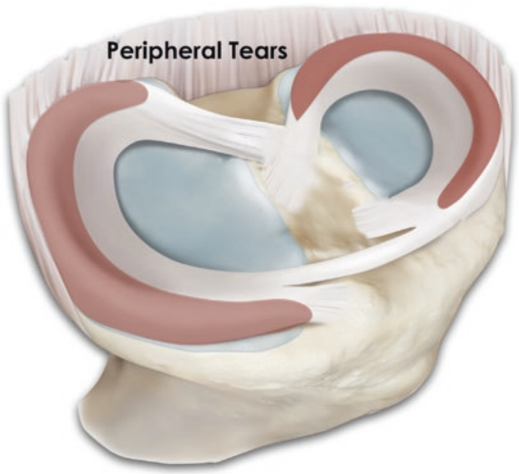

Fig. 7.1 Schematic diagram of a left knee (disarticulated from the femur) demonstrating the location of the peripheral zones of both menisci (demarcated in *red*)

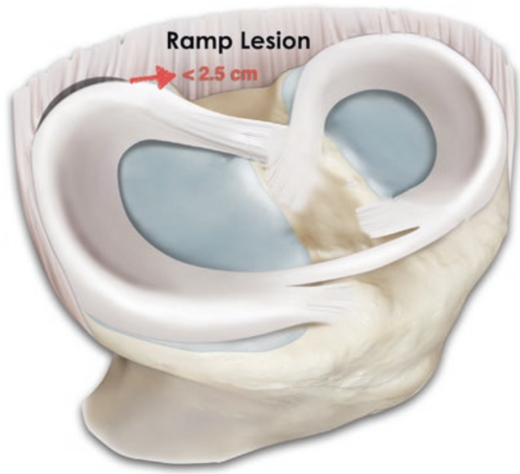

Fig. 7.2 Schematic diagram of a left knee (disarticulated from the femur) demonstrating the location of a ramp lesion in the posteromedial meniscocapsular junction of the medial meniscus. As per definition, ramp lesions are located in the meniscocapsular region and are less than 2.5 cm in length

when the knee is in flexion and the tibia in internal rotation, the posterior horn of the medial meniscus is stretched and pulled anteriorly [70]. This action may lead to a peripheral tear near its posterior attachment via the coronary ligaments [21], which is one of the most common locations for meniscal tears [47, 69, 79]. These tears, known as ramp lesions (Fig. 7.2), often occur in conjunction with ACL tears [13, 44, 79] and are commonly under-recognized when using standard anterolateral and anteromedial arthroscopic portals due to their location within the posteromedial "blind spot" [75]. Ramp lesions have been reported to be present in 9–17 % of all ACL tears [10, 53]. Conversely, the anterior horn of the medial meniscus is less commonly injured and, therefore, not well described in the literature. Chen et al. [15] demonstrated in porcine knees that the anterior horn of the medial meniscus restrains external rotational torque of the tibia. Thus, providing a possible mechanism of injury for humans in which the knee is in full extension and external rotational torque is placed on the tibia [15].

Peripheral tears, in general, are believed to partially preserve the load distribution function of the meniscus, whereas other tears, such as radial tears or more central, complex tears, do not preserve the load distribution function due to the disruption of the large circumferential fiber bundles [31, 55]. However, it has been reported that peripheral tears with meniscal rim involvement have a significant association with the development of radiographic osteoarthritis (OA) [63], likely resulting from altered biomechanics. The role of the meniscus as a secondary stabilizer of the knee joint should not be overlooked. The posterior horn has demonstrated importance in anterior tibial translation [9, 67]. In the setting of ACL deficiency, peripheral meniscal tears have been reported to drastically alter knee biomechanics, similar to that of a total meniscectomy [1]. Allen et al. [5] reported that a resultant force in the medial meniscus of an ACL-deficient knee increased by over 50 % in full extension and nearly 200 % at 60° of flexion. In contrast, in a knee with otherwise intact ligamentous structures, Goyal et al. [37] reported that there was no alteration in tibiofemoral kinematics or joint contact pressures when simulating a peripheral lateral meniscal tear. Additionally, a recent cadaveric study demonstrated that anterior tibial translation and external rotation laxities were significantly increased after inducing a ramp lesion in an ACL-deficient knee [74]. Therefore, the menisci play an important role of the biomechanics of the knee joint, particularly in the setting of ACL-deficient knees when additional force and stress is placed on the menisci. This increase in mechanical force likely leads to meniscal tears following ACL injury with delayed or inadequate repair. When taking into account the various biomechanical properties and roles of the menisci, it is clear that injury to the menisci can have detrimental effects on the knee joint. By reaching an appropriate, timely diagnosis with subsequent repair, surgeons can minimize future complications such as increased graft forces or OA [20, 56].

The diagnosis of peripheral meniscal tears often includes a detailed history, physical examination, and diagnostic imaging. Despite these diagnostic techniques, a peripheral meniscal injury can be misdiagnosed. Once identified, a surgeon must consider the characteristics of the tear, such as the location, size, appearance, chronicity, and presence of secondary tears, prior to intervention [44]. Furthermore, patient factors such as age, activity level, compliance, and concomitant ACL injury must be taken into account as well [44] due to their influence on patient outcomes.

Better comprehension of the function (shock absorption, stability, force transmission) and vascularity of the menisci, as well as the knowledge of degenerative articular changes after meniscectomy, has led to the development of numerous surgical meniscal repair procedures used to preserve the meniscus. Described surgical techniques include open, outside-in, inside-out, and all-inside, in addition to nonoperative treatment in certain circumstances [4, 11, 14, 28]. Outcomes with these techniques have been favorable overall [3, 4, 20, 24, 28, 38, 40, 43, 46, 58, 69], with arthroscopic techniques becoming the mainstay for surgical intervention. Improved outcomes are often associated with the type of tear, location, knee stability, surgery less than 8 weeks from injury, and age [2, 4, 24].

The following chapter includes diagnostic techniques and imaging studies used in the diagnosis of peripheral meniscal tears, followed by in-depth descriptions of surgical techniques, patient outcomes, and postoperative rehabilitation.

7.2 Diagnosis

Meniscal tears can be challenging to diagnose at times, even for an experienced surgeon, but an effective history and physical examination can direct the working diagnosis toward a meniscus problem. In this chapter, we will not cover history taking in the setting of suspected meniscal pathology but focus on physical examination maneuvers and diagnostic imaging involved in the diagnosis of peripheral meniscal tears. After a pertinent patient history is obtained, physical examination follows and is one of the major contributors to reach a diagnosis of a meniscal tear. When interpreting the findings from the various tests and examinations, it is important to understand the sensitivity, specificity, and limitations of each examination. As previously stated, a timely diagnosis of peripheral meniscal tears is important in limiting degenerative changes in the cartilage and the menisci that results from the changed joint loading and biomechanics.

7.2.1 Physical Examination

Many clinical tests have been described to assist in diagnosing meniscal tears, including joint line palpation, McMurray and Apley tests, as well as the figure-4 test [6, 25, 26, 33, 44, 48–50, 56, 60, 70, 85]. Tibiofemoral joint line palpation is among the most basic diagnostic physical exam test for meniscal pathology. During this exam, manipulation of the knee joint allows for the palpation of specific meniscal regions. For example, flexion of the knee allows for the palpation of the anterior half of each meniscus, valgus force on knee joint exposes the medial edge of the medial meniscus, and varus force on the knee enhances palpation of the lateral meniscus (Fig. 7.3) [54]. The literature reports the sensitivity and specificity of joint line tenderness to be 55–85 % and 29.4–67 %, respectively [6, 33, 49, 85].

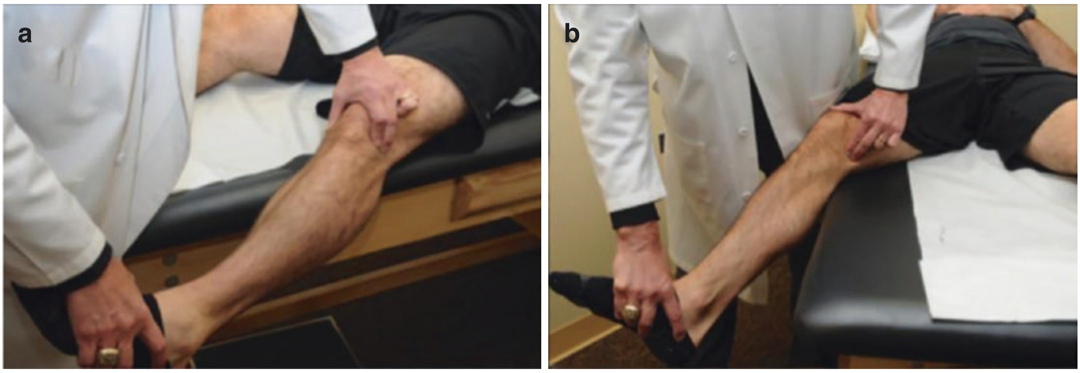

Fig. 7.3 Image demonstrating joint line tenderness test on a (**a**) lateral meniscus of a left knee while extruding the meniscus with a varus force and (**b**) medial meniscus of a right knee while extruding the meniscus with a valgus force

Additionally, joint line tenderness has potential discrepancies with laterality, showing increased sensitivity, specificity, and accuracy in lateral pathology compared to the medial side [25, 48, 60]. Positive predictive value (PPV) and negative predictive value (NPV) for the medial meniscus are reported to be 59 % and 90 %, respectively. Alternatively, the lateral side displayed a PPV of 92 % and NPV of 97 % [25]. Thus, the absence of joint line tenderness is suggestive of an intact, healthy meniscus, while joint line tenderness is by no means pathognomonic of meniscal injury.

Tests that assess meniscal integrity, such as the McMurray and Apley grind tests, may not be conclusive but can aid in diagnosis [44, 56, 70]. The McMurray test, first described in 1940 [26], is widely known as a primary clinical exam to evaluate for meniscal tears. A positive sign is indicated by a "popping" and sensation of pain symptoms along the joint line [70]. This test is examiner dependent, with the success and failure often being driven by the clinician. The sensitivity of the McMurray test ranges from 16 to 75.8 % [6, 26, 33, 49, 85] and a specificity of 77–98 % [26, 33, 49, 85]. In the clinical setting, a negative McMurray testing should be interpreted with caution given the wide range of reported sensitivity. In contrast, its utility in diagnosis of a meniscal tear is maximized with a positive test. The Apley grind test has reported sensitivity and specificity of 13–16 % and 80–90 % [33, 49], respectively, with an accuracy of 28 % [49]. The Apley test requires the patient to be in the prone position, which may be difficult in patients with limited mobility. A positive test produces increased pain on compression. With reported PPV of 95 % and NPV of 35 % [85], a positive result indicates a likely meniscal tear whereas the absence of pain during the maneuver does not necessarily eliminate meniscal pathology.

The figure-4 test, first described in 2005, places the affected knee in flexion, varus, and external rotation [50]. This maneuver produces tension on the posterolateral structures of the knee, as the popliteus complex and popliteomeniscal fascicles prevent medial displacement of the lateral meniscus [45, 68, 72, 77]. When this test is performed on a patient with an injury to the popliteomeniscal fascicles, the lateral meniscus can displace medially into the joint causing increased pain along the joint line [72, 77]. The figure-4 test was first used by LaPrade and Kowalchuk in a case series with six patients who had isolated unstable tears of the popliteomeniscal fascicles of the lateral meniscus. All patients were noted to have lateral joint line pain that was exacerbated by the figure-4 test, despite the absence of locking, catching, or difficulty squatting [50]. Therefore, this test of the knee is likely to be clinically useful in the setting of unstable popliteomeniscal fascicle tears, with the need for additional evidence in a larger cohort.

In addition to physical exam maneuvers aimed at diagnosing meniscal tears, the collateral and cruciate ligaments should also be assessed to determine the presence of an additional injury.

This is particularly important in the setting of ACL injury or deficiency, because a peripheral meniscal tear increases knee joint instability in a similar fashion to a total meniscectomy [1], and failure rates of meniscal repair dramatically increase with residual knee laxity [4, 23, 65]. Thus, knee laxity and meniscal tears should be addressed concurrently. These maneuvers will not be covered in this chapter but should be included for a thorough exam of the knee.

As noted before, when all physical exam maneuvers and observations are used in combination, the resulting diagnosis is more accurate than any test alone. Tenderness to palpation along the joint line is among the most common signs of meniscal tear, but joint effusion, crepitus, quadriceps atrophy, or lack of full knee range of motion (i.e., loss of extension more than 5°) may also be noted on examination [44, 56]. In studies using multiple clinical exam tests (joint line tenderness, McMurray, Steinmann, and modified Apley) for the diagnosis of meniscal tears, clinical diagnosis from an experienced surgeon was similar to that of a diagnosis obtained via MRI [48, 60]. Within these studies, lateral meniscal tear diagnostic specificity and sensitivity of clinical examination ranged from 90 to 95% and 67 to 75%, respectively. Alternatively, medial meniscal tear specificity was 60–68 % and sensitivity was 87–92 % [48, 60]. Moreover, when using five separate criteria on physical examination—crepitus, effusion, joint line tenderness, McMurray examination, and loss of motion—91 % of medial or lateral and 96 % of combined medial and lateral tears were associated with one or more of the five criteria [56]. When comparing these results from previously stated individual sensitivities and specificities for each examination, it is clear that multiple physical examination tests have increased diagnostic value than any individual test. Thus, physical examination maneuvers cannot and should not be used individually to accurately diagnose meniscal pathology, but in combination with one another [48, 60, 70]. This notion must be understood and applied within clinical practice in order to appropriately diagnose and subsequently manage peripheral meniscal tears.

7.3 Imaging

Imaging is an important part of the diagnostic work-up. Preoperative imaging is necessary to help the treating surgeon verify/confirm the diagnosis, evaluate the type of meniscal injury, and diagnose concomitant injuries in order to inform the patient and develop a treatment plan. Several imaging modalities exist, but MRI is the most sensitive and regarded as the gold standard for imaging the knee soft tissues including the meniscus. Even though diagnostic arthroscopy can provide both the diagnosis and opportunity to treat meniscal lesions, it is not considered the first option because of its invasiveness, costs, and risk associated with surgery. The different imaging modalities will be discussed below.

7.3.1 Standard Radiographs

Menisci and noncalcified soft tissue are not normally visualized on standard radiographs, limiting the value of this imaging modality in the setting of meniscal damage. Plain standard radiographs are most valuable when assessing for differential diagnoses such as in cases of recent trauma and for the evaluation of elderly patients (>50 years) where the risk of concomitant osteoarthritis is high. This is particularly important when evaluating menisci pathology, because degenerative menisci are associated with osteoarthritis and, therefore, the indication for repairs of meniscal tears in older patients depends on the amount of underlying arthritis and their physiologic age. When osteoarthritis is suspected, standing AP, lateral, and flexion view radiographs should be taken to evaluate the joint space. Loose bodies and signs of osteochondral lesions can be visualized on standard radiographs, which can be signs of chronic meniscal lesions which led to the development of osteoarthritis. Furthermore, a relative widening of the lateral joint space can be a sign of discoid meniscus. Finally, chondrocalcinosis can be usually detected in patients with calcium pyrophosphate dihydrate (CPPD) crystal deposition disease [73]. Fisseler-Eckhoff and Muller [30] reported on 3228 patients undergoing knee arthroscopy, where a radiographic diagnosis of chondrocalcinosis was confirmed in 39.2 % of patients with pathologically proved CPPD crystal deposition. The authors concluded that chondrocalcinosis is an important factor in posttraumatic or degenerative meniscal pathology.

7.3.2 Ultrasound

Ultrasound is not routinely used for the diagnosis of meniscal lesions because it lacks adequate visualization of deeper structures and requires an experienced, well-trained operator. Although the reliability of ultrasound in the diagnosis of meniscal pathology varies in the literature [12, 18, 35], ultrasound can be a valuable tool for visualizing meniscal cysts and joint effusion, as well as tendon and collateral ligament injuries. Dynamic ultrasound has a reported sensitivity of 82 % for the detection of meniscal degeneration based on certain criteria such as cystic lesions, calcifications, and meniscal irregularities [17]. Using ultrasound for detecting meniscal cysts has a reported sensitivity of 97 %, a specificity of 86 %, and an accuracy of 94 % [62].

7.3.3 Magnetic Resonance Imaging

Magnetic resonance imaging is the "gold standard" for evaluating meniscal lesions. It is less invasive when compared to arthroscopy and, thus, can be used on the majority of patients. The quality of the MRI has improved significantly and has eliminated the use of diagnostic arthroscopies in meniscal lesion diagnoses. The advantages of utilizing MRI are the ability to see in different planes, high resolution, and ability to evaluate using different sequences (T1, T2, diffusion, STIR) depending on the structure of interest. Both the location and extent of the meniscal injury, as well as associated chondral and ligament lesions, can be evaluated on MRI. Meniscal root lesions, which can otherwise be difficult to diagnose, can be effectively diagnosed on MRI [52]. MRI has a sensitivity of 86–96 % and a specificity of 84–94 % for medial meniscal lesions. The sensitivity for lateral meniscal lesions is lower compared to that for medial meniscal lesions. The sensitivity is 68–86 % and the specificity is 92–98 % [19, 57, 64]. The variability of reported specificity and sensitivity can largely be explained by interobserver variations, low study populations, and the quality of the images.

There remain few limitations to the use of MRI, such as obese patients and patients with orthopedic metal implants. The use of non-ferromagnetic metals, such as titanium, minimizes artifacts on MRI [76] (Fig. 7.4).

7.3.4 CT Arthrography

CT arthrography can be valuable in patients who are unable to obtain an MRI because of weight, battery-powered cardiac or other implants, or claustrophobia. High-quality multi-planar reconstructions can be acquired for better visualization. Contrast enhancement can aid in detecting some of the lesions that may not be visible on MRI, such as lesions between the meniscus and the capsule. A sensitivity of 84–100 % is reported for CT arthrography in detecting meniscal and

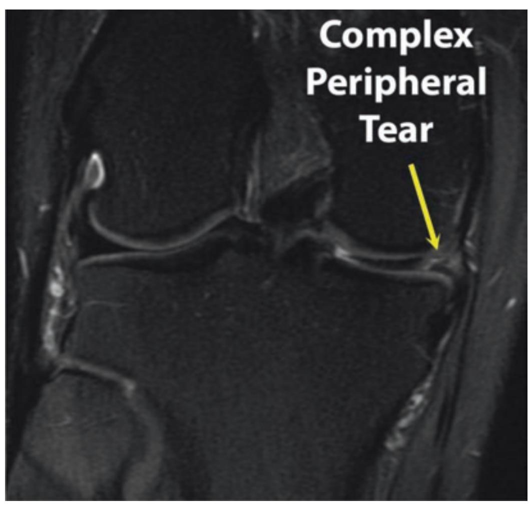

Fig. 7.4 Magnetic resonance image (T2 sequence) demonstrating a complex peripheral tear of a medial meniscus in a right knee

cartilage lesion [16]. It is a relatively safe procedure. However, ionizing radiation exposure and the risk of adverse reaction from the contrast are a concern.

Based on what is known about these imaging modalities, it can be concluded that MRI is the imaging modality of choice for evaluating meniscal lesions. Tear morphology, extent of tear, and concomitant pathologies can be evaluated on MRI. For patients who cannot take MRI because of claustrophobia or weight problems, CT arthrography is a good alternative with good sensitivities reported for meniscal and cartilage lesions while taking into account radiation and contrast exposure.

7.4 Surgical Techniques

Meniscal repair techniques can be divided into inside-out, outside-in, and all-inside technique [36]. Among these, the inside-out technique allows for versatility of placing sutures, lower implant cost, and the use of low-profile needles that allow for multiple sutures without compromising the structural integrity of the meniscus [38]. Disadvantages of this technique include additional incisions (posteromedial and posterolateral), the risk for neurovascular injury, the need for an assistant, and theoretical increased procedure time [14]. The outside-in repair technique was described in an attempt to eliminate the need for a posterior incision and dissection. An outside-in repair technique allows for adequate access to the anterior horn of the meniscus, provides a stable fixation construct, and avoids leaving prominent intra-articular material. However, it has a limited access to tears in the posterior third of both menisci and has lower precision when compared to the inside-out technique. Lastly, the all-inside technique can be performed without additional approaches, allows access to the middle and posterior thirds, and does not require an assistant. Nonetheless, the larger sizes of the all-inside implants when compared to inside-out sutures can compromise the meniscal tissue when trying to place multiple sutures due to the larger holes these devices make in the meniscal tissue. All-inside devices are not exempt from intra-articular deployment of the device and neurovascular damage. A recent systematic review [38] analyzing 19 studies comparing inside-out and all-inside meniscal repair techniques showed no differences in clinical failure rate (17 % vs. 19 %) or subjective outcome. Complications are associated with both techniques. Nerve symptoms are more commonly associated with the inside-out repair, while implant-related complications (soft tissue irritation, swelling, implant migration, or breakage) are more common with the all-inside technique. Stärke et al. [71] reported that regardless of the repair technique employed, there is a general trend of increasing failure rates with time (75–94 % of success in the first year of surgery to 59–76 % beyond the fourth year). Of note, criteria for success and failure were heterogeneous among studies.

7.4.1 Inside-Out Repair

The posteromedial and posterolateral approaches will be described in detail in Chap. 10 (step-by-step surgical approaches for meniscal repairs). Before performing a peripheral meniscal repair, a complete evaluation of the lesion should be performed including size, stability, state of the meniscus, type, and zone of the lesion. Typically, lesions between 1 and 4 cm, located peripherally, have been reported to yield good results; however, every meniscal repair should be attempted. The tear should be anatomically reduced by placing sutures perpendicularly to the lesion to restore its position (Fig. 7.5).

For an inside-out repair, a self-delivery gun fitted with a cannula (SharpShooter) is used to pass double-loaded nonabsorbable sutures (No. 2 FiberWire) into the meniscus. Prior to placing the sutures, the knee is positioned in 20°–30° of flexion, and the meniscal needle is advanced through the superior or inferior aspect of the meniscus. Then the corresponding portion of the capsule (superior or inferior) is penetrated with the second needle of the suture (Fig. 7.6).

In order to help the assistant, retrieve the needle through the previously made posterolateral or posteromedial approach the knee can be flexed to 70°–90,° while the needle is advanced through the meniscus or capsule. The needles are cut from the sutures, and the suture ends are clamped while maintaining slight tension. The same process is repeated adjacent to the previous suture, with sutures in the superior and inferior borders of the meniscus placed between 3 and 5 mm apart. An average of eight sutures are used in order to create a strong construct. When possible, a vertical suture pattern is preferred because it allows for greater capture of the strong circumferential fibers of the meniscus; however, oblique and horizontal patterns can also be used if necessary to reduce the meniscal tear. Lastly, with the knee at 90° of flexion, all sutures are tied, being careful not to overtighten the tissue (Fig. 7.7).

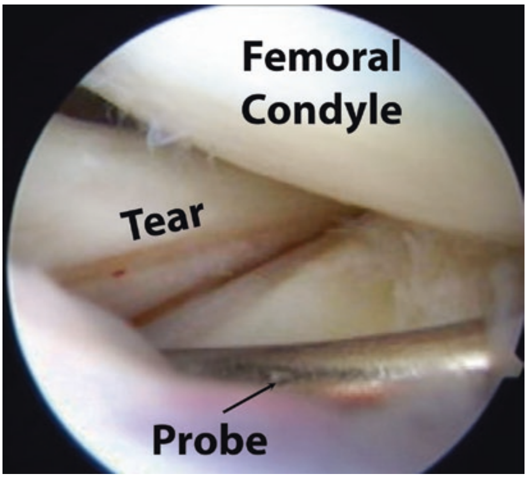

Fig. 7.5 Arthroscopic image of a peripheral tear in a right knee of a medial meniscus assessed with the probe viewed through the anteromedial portal

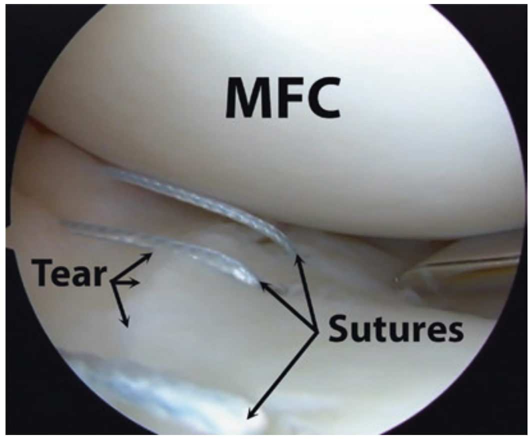

Fig. 7.7 Arthroscopic image showing medial meniscal repair after passing the sutures with an inside-out repair technique. A peripheral tear and the superior sutures (*black arrows*) are shown through the anteromedial portal. The sutures are then tied to stabilize the repair construct

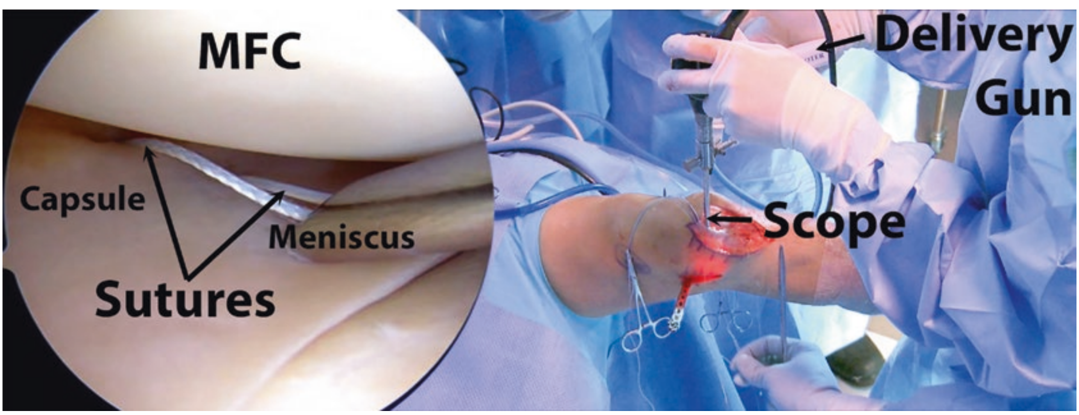

Fig. 7.6 Arthroscopic image (*left*) of a medial meniscal tear being repaired with an inside-out technique (viewed through the anteromedial portal). Of note, one suture is penetrating the superior border of the capsule and the other the corresponding side of the meniscus. On the *right*, an intraoperative image demonstrating the setup for this technique

7.4.2 Outside-In Repair

Following a standard diagnostic arthroscopy, the scope is placed through the contralateral portal in the compartment of the involved meniscus to visualize the extent of the tear. Initially, no skin approach is needed for this procedure. The surgeon uses a spinal needle from an outside-in repair kit to pierce the overlying capsule. Transillumination of the skin can sometimes be useful to locate the tear and joint line when introducing the needle. The spinal needle is then advanced through the superior or inferior side of the meniscus traversing the area of the tear. The inner cannula of the needle is removed, and a #1 PDS suture is placed through the needle into the joint. An arthroscopic grasper is used to secure the free end of the suture, while the needle is subsequently removed, leaving the suture in the joint. A second pass is made with the spinal needle through the corresponding side of the capsule in a similar manner as before. The inner cannula is again removed, and a looped suture retriever is passed through the second needle into the joint. The free end of the previously passed PDS suture is then placed through the looped retriever using a grasper, and the suture is pulled back out of the knee creating a mattress suture construct to secure the meniscal tear. Depending on the nature of the tear and surgeon preference, either a horizontal or vertical mattress suture configuration can be utilized. Once the outside-in repair is complete, a minimal incision can be made with the knee flexed to 90° where the exit of the suture is to be able to tie them in the surface of the capsule (Fig. 7.8).

7.4.3 All-Inside Technique

Once the meniscal tear has been carefully assessed, the penetrating points of the meniscus are decided strategically. The meniscal depth probe is utilized at this point to determine the

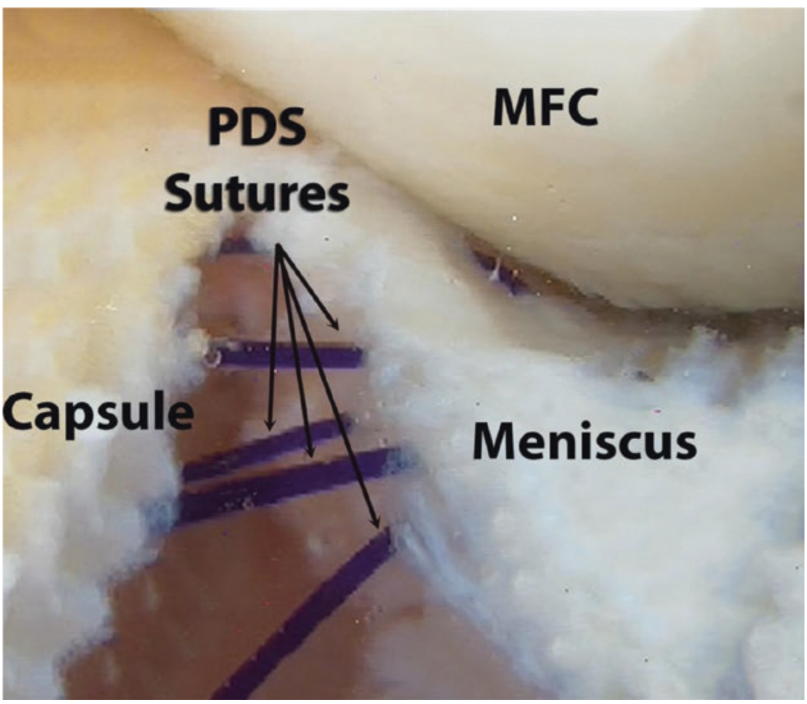

Fig. 7.8 Arthroscopic view of an anterior horn of a medial meniscus demonstrating PDS sutures penetrating the capsule and the meniscus in a horizontal mattress configuration to repair the tear

desired depth limit of the meniscus. The tip of the probe should be placed at the meniscosynovial junction and used to measure the width of the meniscus at the desired entry point for the delivery needle. Usually a depth of 14 mm is adequate. Next, the depth penetration limiter is adjusted to the desired length. After preparation and debridement of the stumps, the all-inside device is inserted into the joint through the corresponding portal. It is important to dilate the portal to allow for easier passage of the delivery needle into the joint. Lateral meniscal tears can be approached using the anterolateral portal as a viewing portal and the anteromedial portal for the delivery needle and vice versa for medial meniscal tears. An arthroscopic rasp should be used in the meniscal tear area to stimulate healing before the sutures are placed. When attempting a vertical mattress suture repair, place the first implant on the superior side of the meniscal tear. Once the needle has been inserted, the tip should be rotated away from the neurovascular structures. The device can now be deployed using the deployment slider on the handle. Complete release of the deployment slider and slowly withdrawing the needle out of the meniscus can prevent intra-articular migration of the device. Next, the entry point for the second implant is defined at least 5 mm away from the tear site. The delivery needle is again advanced until the depth penetration limiter contacts the surface of the meniscus and the second device is deployed in a similar manner. Finally, the delivery needle is removed from the knee, pulling the free end of the suture out of the joint. The free end of the suture is pulled to advance the sliding knot and reduce the meniscal tear. Slight tension should be applied to the suture until the knot is secured.

7.5 Outcomes

Meniscectomy and partial meniscectomy are associated with increased risk of osteoarthritis, likely due to joint loading changes associated with these procedures [27, 51, 80, 84]. It is inherent that preserving the meniscus restores the joint congruity and loading, thus, preventing the development of osteoarthritis. Different techniques for repair have been described (all-inside, inside-out, outside-in, and trephination) for peripheral tears that allow for preservation of the meniscus. Repair of the meniscus improves clinical outcomes of pain, catching, and knee function using Tegner and Lysholm scores. Mean Lysholm scores and Tegner scores for all-inside techniques are reported to be 90 and 6 respectively, while for the inside-out technique, they are 88 and 5 respectively. When comparing the all-inside technique with the inside-out technique, no significant differences in clinical or anatomic failure rates (clinical failure, 11 % vs. 10 %, respectively; anatomic failure, 13 % vs. 16 %, respectively) were found [29]. Complication rates are 4.6 % for all-inside vs. 5.1 % for inside-out [29]. The clinical healing rates for red-white zone repairs are reported to be 83 %. Patient age, gender, chronicity, compartment involved (medial vs. lateral), and concurrent ACL reconstruction do not influence healing rates [8].

Peripheral meniscal lesions in the red-red zone have inherently good healing rates because of the blood supply. Lateral meniscus lesions of <10 mm in length and not extending > 1 cm anterior to the popliteus can be left in situ during ACL reconstructions [22, 32, 66].

Unfortunately, most studies on healing rates, and those comparing the different techniques, are of low level of evidence. The chondroprotective effect of meniscal repairs and the role of biologics as adjuncts to meniscal repairs need to be evaluated further.

It is well established that meniscal repair in the setting of anterior cruciate ligament reconstruction results in better healing than meniscal repair alone [61, 81, 83]. Several studies have looked at the effects of augmenting meniscal healing after meniscal repair. Although some laboratory studies have been promising, clinical outcomes are still lacking. Biologic factors such as fibrin clot, platelet-rich plasma (PRP), and growth factors have been studied, and their application to meniscal repair has been evaluated. PRP has been reported to enhance meniscal tissue regeneration in vitro and in vivo, as noted in mRNA expression of extracellular matrix proteins compared with meniscal cells without PRP [42]. However, Griffin et al. [39] reported no difference in reoperation rates between patients with meniscal repair with or without PRP augmentation.

Trephination is reported to improve healing in goat models and in clinical practice [34]. There are no controlled clinical studies evaluating the use of biologics in augmenting peripheral meniscal healing. Some promising results are reported for the use of fibrin clot on radial tear.

7.6 Rehabilitation

Patients with an isolated meniscal tear remain non-weightbearing for 6 weeks. A recent systematic review of different rehabilitation protocols concluded that outcomes after restricted weightbearing protocols and accelerated rehabilitation (immediate weightbearing) yielded similar good to excellent results; however, there was lack of similar objective criteria, and consistency among surgical techniques and existing studies makes direct comparison difficult [78]. Meniscal repairs benefit from early range of motion (ROM) that is limited to the initial 2 weeks postoperatively. This early mobility facilitates postsurgical joint effusion resolution, normal range of motion restoration, and reduction of the scar formation. Passive ROM is completed with the patient in the supine or seated position. Passive ROM is limited to 0–90° during the first 2 weeks and then progresses to full range of motion as tolerated by the patient. Isolated hamstring contraction is performed in the first 6 weeks post-surgery to reduce meniscal stress through posterior tibial translation. Hyperextension of the tibiofemoral joint should be avoided at least for the first 4 weeks in order to prevent stress on the meniscal repair. After this initial period of restriction, restoration of symmetrical extension is encouraged for optimal tibiofemoral biomechanics. After 6 weeks, if joint conditions and clinical examination deem appropriate, a progressive, weightbearing program is initiated. Also at this time, patients may begin the use of a stationary bike with low-resistance settings, and ¼ body weight leg presses to a maximum of 70° of knee flexion. Starting 12 weeks postoperatively, additional increases in low-impact knee exercises may be permitted as tolerated. Patients are recommended to avoid deep squatting, sitting cross-legged, or performing any heavy lifting or squatting activities for a minimum of 4 months following surgery (Fig. 7.9).

Conclusion

Meniscal tears constitute one of the most frequent pathologies in sports medicine. Due to the increasing understanding of its function and knee physiology, preservation of this tissue should be attempted in every case. A high index of suspicion is necessary at times to accurately diagnose some of these lesions, while meniscal tears are often evident in the physical exam and on imaging. Several techniques have been described with good to excellent reported outcomes. Determination of which technique to use depends on the anatomic meniscal region, the surgeon's preference, and experience on each device. A robust rehabilitation protocol is mandatory to achieve the best results.

ROM RESTICTIONS	PROM 0-90 x 2 wks.
BRACE SETTINGS	0-0 x 6 weeks
Weight Bearing status	NWB x 6 wks.
TIME LINES	Week 1 (1-7POD) Week 2 (8-14POD) Week 3 (15-21POD) Week 4 (22-28POD)

●= Do exercise for that week

Week														
Initial Exercises	1	2	3	4	5	6	7	8	9	10	12	16	20	24
Flexion/Extension - wall slides	●	●	●	●	●	●	●	●						
Flexion/Extension – seated	●	●	●	●	●	●	●	●						
Patella/Tendon mobilization	●	●	●	●	●	●	●	●						
Extension mobilization	●	●	●	●	●	●	●	●						
Quad series	●	●	●	●	●	●	●	●						
Hamstring sets							●	●	●	●				
Sit and reach for hamstrings (towel)	●	●	●	●	●	●	●	●	●	●				
Ankle pumps	●	●	●	●	●	●	●	●	●	●				
Toe and heel raises							●	●	●	●				
Balance series								●	●	●	●	●	●	●
Cardiovascular Exercises	1	2	3	4	5	6	7	8	9	10	12	16	20	24
Bike/Rowing with well leg	●	●	●	●	●	●	●	●						
Bike with both legs – no resistance							●	●	●					
Bike with both legs - resistance									●	●	●	●	●	●
Aquajogging									●	●	●	●	●	●
Treadmill – walking 7% incline									●	●	●	●	●	●
Swimming with fins										●	●	●	●	●
Elliptical trainer											●	●	●	●
Rowing											●	●	●	●
Stair stepper												●	●	●
Weight Bearing Strength	1	2	3	4	5	6	7	8	9	10	12	16	20	24
Double knee bends							●	●	●	●	●	●	●	
Double leg bridges									●	●	●			
Reverse lunge – static hold							●	●	●	●	●			
Beginning cord exercises									●	●	●			
Balance squats										●	●	●	●	●
Single leg deadlift										●	●	●	●	●
Leg press										●	●	●	●	●
Sports Test exercises											●	●	●	●
Agility Exercises	1	2	3	4	5	6	7	8	9	10	12	16	20	24
Running progression												●	●	●
Initial – single plane												●	●	●
Advance – multi directional													●	●
Functional sports test													●	●
High Level Activities	1	2	3	4	5	6	7	8	9	10	12	16	20	24
Golf												●	●	●
Outdoor biking, hiking, snowshoeing												●	●	●
Skiing, basketball, tennis, football, soccer													●	●

No deep squats or sitting cross-legged x 4 months

Fig. 7.9 Standard rehabilitation protocol sheet demonstrating suggested activities and progression during the rehabilitation phase

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