CURRENT CONCEPTS REVIEW

Beyond the ACL: The Hidden Impact of Ramp Tears on Knee Stability

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Abstract

Medial meniscus ramp lesions have emerged as a critical but frequently overlooked contributor to knee instability, particularly in the context of anterior cruciate ligament (ACL) injuries. Recent advances in imaging and arthroscopic techniques have improved their detection and classification, enhancing our understanding of their anatomical and functional significance. Evidence indicates that untreated ramp lesions may perpetuate instability and alter knee biomechanics, underscoring the need for structured, individualized treatment. Although multiple arthroscopic repair strategies have been proposed, the optimal technique remains debated. The posterior portals approach offers superior visualization and reliable repair, and has gained increasing adoption. This review synthesizes current insights into ramp lesion pathophysiology, classification, diagnostic advances, and evolving management strategies, emphasizing the importance of accurate identification and tailored intervention to optimize patient outcomes.

Level of evidence: IV

Keywords: Anterior cruciate ligament (ACL) injury, Arthroscopic repair techniques, Knee instability, Medial meniscus ramp lesion, Meniscal biomechanics, Posteromedial portal approach

Introduction

The knee is one of the most complex and biomechanically vulnerable joints in the body, relying on multiple interdependent structures to maintain stability and function.[1] The meniscus and the anterior cruciate ligament (ACL) are particularly important, as they reduce articular stress and preserve long-term joint integrity.[2] The meniscus depends on the ACL for stability, while the ACL prevents excessive anterior translation of the tibia, controls rotational forces during dynamic movement, and contributes proprioceptive feedback essential for joint stabilization.[3] Injury to the ACL disrupts this delicate balance, significantly increasing the risk of meniscal and cartilage damage, which may accelerate degenerative changes. Consequently, surgical reconstruction is often recommended to restore stability and reduce the likelihood of long-term joint degeneration.[4]

Despite advancements in anterior cruciate ligament reconstruction (ACLR) techniques, failure rates remain notable, ranging from 3.2% to 11.1% in the general population and reaching 6.5% to 34% in high-risk groups such as young athletes.[5,6] Because isolated ACL injuries are uncommon, overlooked concomitant injuries—particularly ligamentous, meniscal, or chondral lesions—represent a major cause of graft failure.[3] Recent evidence highlights injuries to the posterolateral corner (PLC) as among the most frequently missed in the context of ACLR. Among associated meniscal pathologies, medial meniscus ramp tears (MMRTs) are especially challenging to diagnose and are often underestimated in their clinical significance. This review focuses on the role of MMRTs in ACL reconstruction outcomes, emphasizing the importance of accurate detection and management.[7]

MMRTs represent a distinct subtype of meniscal injuries involving the posterior horn of the medial meniscus at the

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meniscocapsular junction or within 3 mm of the peripheral rim.[8] These lesions are clinically important due to their strong association with ACL injuries, as both structures are subjected to similar biomechanical stresses.[9] The ramp attachment, formed by the meniscocapsular and meniscotibial ligaments (MTL), plays a critical role in resisting anterior tibial translation and maintaining knee stability.[7] Overlooked ramp lesions during primary ACL reconstruction have been implicated in the development of secondary bucket-handle medial meniscus tears [Figure 1].[10] Their frequent coexistence with ACL tears underscores the need for precise identification and management to preserve joint function and long-term stability.[2,8]

The reported prevalence of MMRTs in ACL-injured patients varies widely, ranging from 9.3% to 78%, thereby underscoring the diagnostic challenges associated with these lesions.[11-16] Although advances in imaging modalities such as magnetic resonance imaging (MRI) and improvements in arthroscopic visualization have increased recognition, both techniques remain limited in sensitivity and specificity for detecting ramp lesions.[17,18] Anatomically, the posterior meniscocapsular region—often referred to as the "hidden zone"—is poorly visualized on MRI when the knee is in full extension, predisposing these tears to underdiagnosis.[18] Preoperative assessment of ramp attachment integrity is essential for surgical planning; however, current imaging protocols frequently fail to provide a reliable evaluation, resulting in many lesions being identified only during intraoperative exploration.[19-21]

Given the complex anatomy of the medial meniscus ramp attachment and its critical biomechanical role in knee stability, timely diagnosis, monitoring of healing, and appropriate repair are essential.[1,22,23] Despite advances in our understanding of ramp tear anatomy and biomechanics, significant gaps persist in establishing reliable diagnostic methods, standardized treatment strategies, and evidence-based rehabilitation protocols.[11,24,25] The objective of this review is to consolidate current knowledge on medial meniscus ramp tears and provide clinicians with practical insights to optimize diagnosis, management, and patient outcomes in this challenging pathology.

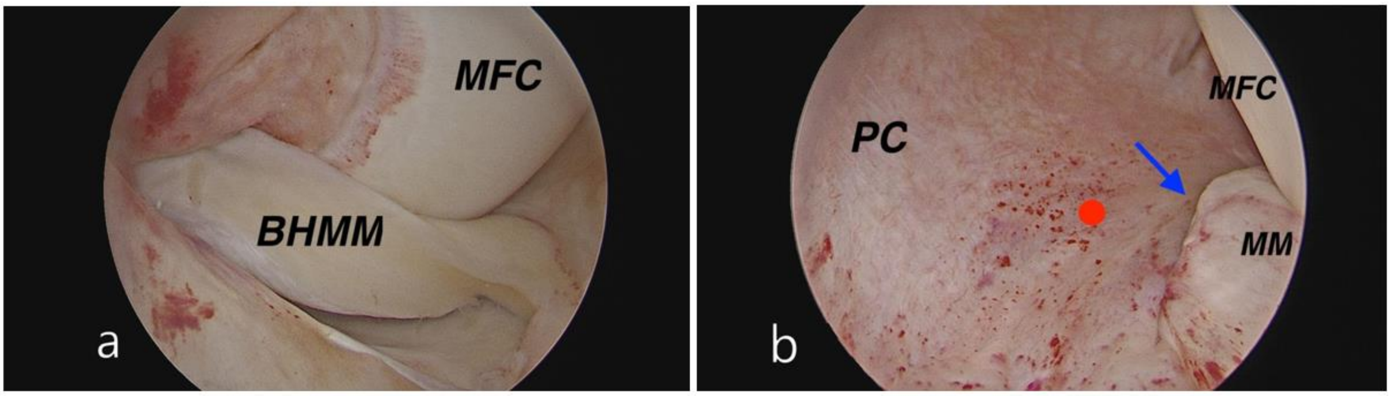

Figure 1. (a) Right knee, anterolateral portal view. (b) Post-reduction, posterolateral trans-septal view. Arrow: Ramp meniscosynovial tear; red circle: meniscofemoral ligament. BHMM: Bucket-handle medial meniscus tear; MM: Medial meniscus; PC: Posterior capsule; MFC: Medial femoral condyle

Main body

Anatomy of the Medial Meniscus and Supporting Structures

A comprehensive understanding of the quantitative anatomy of the medial meniscus (MM) and its stabilizing structures is essential for characterizing ramp lesions.[8] The MM contributes to joint stability, shock absorption, and load distribution within the knee, functions that are reinforced by several ligamentous attachments.[26] The posterior horn of the medial meniscus (PHMM) is a principal load-bearing structure, measuring approximately 20.2 mm in length. Its width varies, measuring 11–12.6 mm posteriorly and tapering to about 7.6 mm at the anterior horn. The PHMM is firmly anchored to the posterior capsule through the meniscocapsular ligament (MTL) and to the tibial plateau via the MTL, providing stability and limiting excessive displacement.[27-29]

Among the key stabilizing structures of the ramp region is the ramp ligament, also referred to as the meniscocapsular ligament. This ligament is composed of two distinct portions: (1) a superior portion, which anchors the posterior horn of the medial meniscus (PHMM) to the posterior capsule on the femoral side, and (2) an inferior portion, which connects the PHMM to the tibial plateau, thereby restricting excessive posterior horn mobility [Figure 2].[8]

The meniscotibial ligament (MTL) originates from the inferior margin of the posterior horn of the medial meniscus (PHMM) and inserts approximately 6 mm below the articular cartilage of the tibial plateau, with its attachment located 7–10 mm distal to the articular surface. The meniscofemoral ligament (MFL), regarded as a secondary stabilizer, also contributes to posterior meniscal stability, although its precise anatomical relationships remain a subject of debate.[7] Some investigators describe the meniscocapsular ligament as attaching the posterior medial capsule to the superior edge of the PHMM,[30] whereas others report an absence of direct connections in this region.[31] Despite these anatomical variations, the MTL, MFL, and related capsular structures act synergistically to reinforce medial meniscus stability and limit excessive tibial translation.

Two additional stabilizing components related to the posterior horn of the medial meniscus (PHMM) are the semimembranosus (SM) tendon and the posterior oblique ligament (POL). The SM tendon provides dynamic stabilization, particularly during knee flexion and rotational movements. Approximately 34% of the PHMM length from the root is connected to the SM tendon, a region referred to as the "corner point" by Keyhani et al. The SM tendon attaches through two distinct portions: the anterior arm and the direct arm [Figure 3]. The anterior arm, present in 86% of individuals, forms a fascial connection to the posterior inferior margin of the PHMM, with an average length of 9.2 mm. In addition, the capsular branch of the semimembranosus (CBSM) inserts into the PHMM, further enhancing its stability. Recent anatomical studies have also described an intermediary adipose tissue layer positioned posterior to the PHMM, anterior to the CBSM, inferior to the meniscocapsular ligament, and superior to the meniscotibial ligament (MTL). This layer may play a role in the structural reinforcement and injury mechanisms of ramp lesions. Furthermore, histological analyses have demonstrated that the meniscocapsular and meniscotibial attachments are well vascularized, which supports their healing potential when ramp lesions are adequately treated. From a clinical perspective, some authors suggest that in carefully selected patients, stable, non-displaced ramp lesions associated with ACL rupture may not always require surgical repair, given their intrinsic vascularity and healing capacity. [7,8,28,32,33]

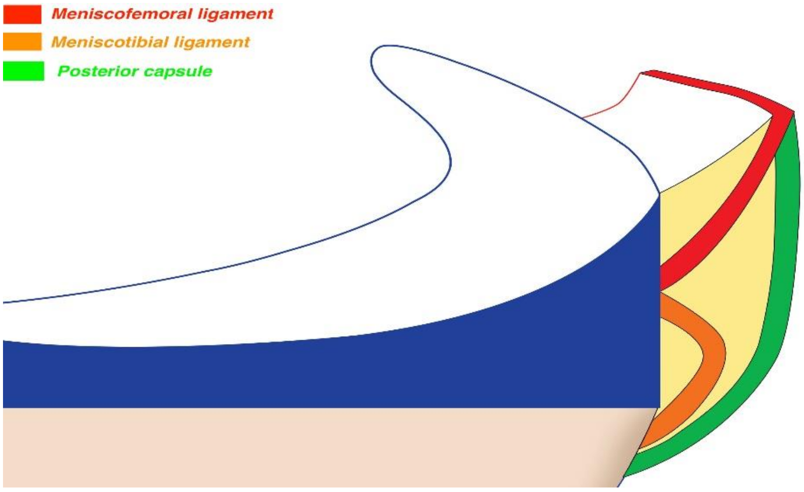

Figure 2. Anatomy of the posterior horn of the medial meniscus (PHMM). (Reproduced with permission from Keyhani et al., Journal of Experimental Orthopaedics).[68]

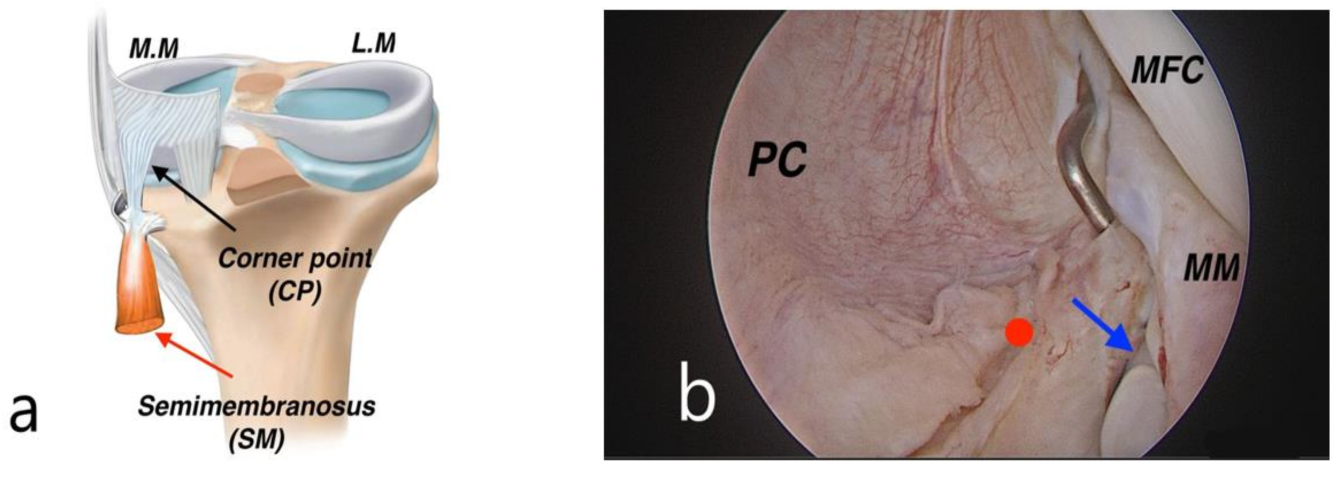

Figure 3. (a) Corner point anatomy (reproduced with permission from Keyhani et al., Journal of Experimental Orthopaedics[68]); (b) Right knee, posterolateral trans-septal view. The probe indicates the corner point. Red circle:Meniscofemoral ligament-Blue arrow:Medial tibial plateau. PC: Posterior capsule; MM: Medial meniscus; MFC: Medial femoral condyle

Studies have shown that the outer 10–20% of the medial meniscus (MM), known as the red-red zone, is well vascularized, whereas the inner 80% (white-white zone) is avascular, limiting its intrinsic healing capacity.[34,35] A recent descriptive laboratory study by Smigielski et al. provided new insights into the vascular anatomy of the MM, particularly the role of the medial meniscal artery (MMA). This artery has been identified as a distinct vascular structure supplying direct blood flow to the MM. Branches of the MMA nourish the posterior horn and extend into the semimembranosus (SM) tendon, thereby enhancing vascularization in this region. These findings suggest that the peripheral posterior horn of the medial meniscus (PHMM) benefits from a well-vascularized meniscosynovial junction and surrounding adipose tissue, which may facilitate healing when ramp lesions are accurately diagnosed and appropriately managed.[36]

Biomechanics

The posterior horn of the medial meniscus (PHMM) plays a synergistic role in supporting the anterior cruciate ligament (ACL) by acting as a secondary stabilizer against excessive anterior tibial translation (ATT) and rotational forces.[37,38] Owing to its bulk and firm anchorage, the PHMM provides a "door-stop effect" that mechanically limits anterior tibial displacement, particularly during deep knee flexion.[39] This stabilizing effect is further reinforced by its associated attachments, including the ramp ligament and the posterior medial capsule (PMC), which help resist ATT and distribute loads across the joint. Collectively, these structures act as passive restraints, working in concert with the ACL to preserve knee stability under rotational and shear stresses.[12]

Following an anterior cruciate ligament (ACL) injury, the mechanical load borne by the posterior horn of the medial meniscus (PHMM) increases substantially. Experimental studies have demonstrated that anterior tibial loading can elevate forces on the PHMM by up to 200%.[39] When ramp tears are present, they further exacerbate instability, particularly by increasing internal and external rotational laxity.[40] This additional instability places excessive strain on the reconstructed ACL and compromises knee stability, especially at flexion angles of 30° and 90°. Clinically, this is often manifested as a high-grade pivot shift preoperatively or as residual pivot shift postoperatively, reflecting combined anteroposterior and rotational instability. The resulting biomechanical imbalance also imposes greater stress on secondary stabilizers, including the semimembranosus (SM) and the posterior oblique ligament (POL).[9]

Ramp tears disrupt the synergy of stabilizing structures in the posteromedial knee, amplifying stress on anterior cruciate ligament (ACL) grafts by 33–50% and thereby increasing the risk of graft failure. Biomechanical and cadaveric studies have demonstrated that untreated ramp tears result in persistent anterior tibial translation (ATT) and rotational laxity even after ACL reconstruction (ACLR).[8,41] In contrast, successful repair of the meniscocapsular and meniscotibial attachments restores the stabilizing function of the posterior horn, reduces graft overload, and enhances overall joint stability and functional outcomes.[42,43]

Prevalence

Ramp tears are a common yet frequently overlooked injury in the setting of anterior cruciate ligament (ACL) tears.[44] Reported prevalence varies widely, from 9.3% to 78%, reflecting differences in diagnostic methods, surgical techniques, and patient populations.[11] Early work by Bollen et al. (2010) documented a 9.3% prevalence among 183 ACL reconstruction patients,[45] while Thaunat et al. later reported 15.5% in a cohort of 2,156 patients, with nearly half classified as Type 1 tears.[16] With improvements in detection techniques, subsequent studies by Liu et al. and Sonnery-Cottet et al. demonstrated higher rates of 16.6% and 24%, respectively.[17,18] More recently, Cristiani et al. (2023) found a prevalence of 39.5% in 253 ACL-injured patients, underscoring the growing recognition of this lesion.[15] Population-specific research has further highlighted variability; for example, Aberu et al. observed a prevalence of 78.2% in soccer players compared with 10.6% in the general population.[13] Collectively, these findings suggest that the true prevalence of ramp tears has long been underestimated, and that advanced posterior arthroscopic approaches are increasingly revealing the full extent of this injury.[19,44,46,47] Moreover, some evidence indicates that prevalence may increase with time following ACL injury, emphasizing the importance of early detection and management.[48]

The variability in reported prevalence rates is largely attributable to diagnostic limitations. Magnetic resonance imaging (MRI) frequently fails to detect ramp tears, with some studies reporting sensitivity as low as 50%.[11,49,50] This limitation is partly due to the posterior meniscocapsular region, or "hidden zone," being poorly visualized when the knee is in extension. Advanced arthroscopic approaches—such as transnotch visualization, posteromedial portal exploration, and the posterior trans-septal arthroscopy (PTSA) technique—have markedly improved detection rates.[51,52] Chronic ACL injuries are associated with higher prevalence of ramp tears, likely due to prolonged abnormal loading and increased stress on the posterior horn of the medial meniscus, further elevating the risk of tear formation in high-risk populations.[53,54] Recent developments in posterior arthroscopy now enable more precise evaluation and tailored diagnostic strategies, underscoring the importance of thorough intraoperative assessment in ACL-injured patients.

Mechanism of Injury

Rotational trauma is considered the primary mechanism linking anterior cruciate ligament (ACL) injuries and ramp tears.[8] Both lesions commonly occur during abrupt directional changes, such as pivoting or twisting, which generate anterior tibial translation (ATT), shear forces, and excessive knee hyperextension or flexion.[28,30] These stresses place considerable strain on the stabilizing structures of the knee. In particular, rotational forces contribute not only to ACL rupture but also to the development of ramp tears in the posterior horn of the medial meniscus (PHMM). Two principal hypotheses have been proposed to explain the formation of ramp tears in association with ACL injuries.[12]

Two main hypotheses have been proposed to explain the formation of ramp lesions. The first, termed the "contrecoup mechanism," suggests that during the pivot-shift motion of an ACL injury, a combination of varus stress and internal femoral rotation produces a bone contusion of the medial tibial plateau. Simultaneously, traction from the semimembranosus tendon applies tensile stress to the posterior horn of the medial meniscus, resulting in ramp tear formation. The second hypothesis, known as the "crushing mechanism," proposes that valgus stress or internal tibial rotation during ACL injury, combined with anterior subluxation of the medial tibial plateau (MTP), compresses the posterior horn between the medial femoral condyle and the MTP. This compressive force damages the meniscus and ultimately produces a ramp lesion.[7,12,41]

Ramp tears demonstrate a strong correlation with posteromedial tibial plateau bone bruising, with studies reporting a 6.1-fold greater likelihood of these lesions when such bruising is present.[11] This finding supports the contrecoup mechanism of ramp tear formation. In addition, contraction of the semimembranosus (SM) muscle during ACL injury may further increase stress at the meniscocapsular junction, thereby predisposing this region to tearing.[39,55]

The posteromedial corner (PMC) of the knee, where the posterior horn of the medial meniscus (PHMM) attaches to the joint capsule and the meniscotibial ligament (MTL), represents a technically challenging area in arthroscopy. Visualization with standard anterior portals is often restricted by the narrow medial compartment and the overhanging medial femoral condyle. In contrast, the use of posteromedial portals provides direct access and enables complete visualization of the posterior medial compartment. Such access to the "corner point" is essential for reliable identification and successful repair of ramp lesions [Figure 4].[52,56,57]

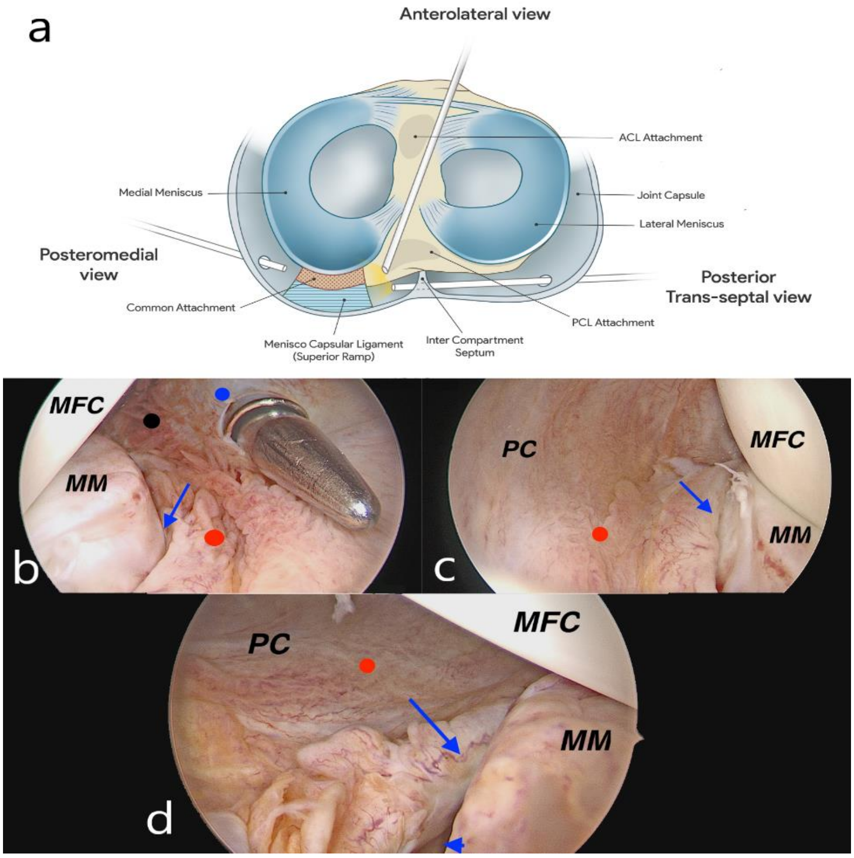

Figure 4. (a) Schematic overview of a ramp lesion in comparative views; (b) Posteromedial view; (c) Posterolateral trans-septal view (black circle: PCL; blue circle: septum); (d) Trans-notch view (red circle: meniscofemoral ligament; arrowhead: meniscotibial ligament; arrow: ramp meniscosynovial tear). PCL: Posterior cruciate ligament; PC: Posterior capsule; MFC: Medial femoral condyle; MM: Medial meniscus

Risk Factors

Several demographic, anatomical, and injury-related factors have been associated with an increased risk of medial meniscus ramp tears (MMRT). Demographically, younger males under 30 years of age, individuals with higher body mass index (BMI), and smokers are at elevated risk. Anatomical predispositions include varus knee alignment greater than 3°, a medial tibial slope exceeding 7.1°, and a medial meniscal slope greater than 3.2°.[26,34,58,59] Injury-related factors also play a significant role. Concomitant lateral meniscus tears, contact injuries, and marked anterior cruciate ligament (ACL) laxity are strong predictors of MMRT. Other studies have identified male sex, revision ACL reconstruction, and side-to-side laxity differences exceeding 6 mm as significant risk factors.[14,18] Finally, delayed ACL reconstruction further increases the likelihood of ramp tears, with risk peaking between 6 and 24 months after injury before plateauing.[53,60,61]

Collectively, these findings highlight the importance of early diagnosis and timely intervention in addressing ramp lesions and chronic meniscal instability, as such strategies are crucial for optimizing anterior cruciate ligament (ACL) reconstruction outcomes and improving long-term joint stability.[62]

Classification of Medial Meniscus Ramp Tears

The classification of medial meniscus ramp tears (MMRT) has advanced considerably with improvements in diagnostic and surgical techniques.[63] One of the earliest frameworks, proposed by Thaunat et al., categorized ramp tears into five types based on anatomical location and severity.[64] These ranged from partial tears at the meniscocapsular junction (Type I) to complex double tears (Type V). This system emphasized the close association between ramp tears and anterior cruciate ligament (ACL) injuries, providing a foundational guide for arthroscopic evaluation and surgical decision-making. By offering a structured understanding of tear patterns in ACL-deficient knees, Thaunat's classification laid the groundwork for subsequent refinements in ramp lesion assessment.[27]

Building on Thaunat's foundational system, Greif et al. refined the classification of ramp tears by incorporating stability as a central parameter and introducing enhanced probing techniques during arthroscopy. This updated framework expanded the system to seven types, with greater emphasis on tear location—such as the peripheral posterior horn and meniscocapsular ligament—and their stability under probing [Figure 5].[65] These refinements improved interobserver reliability and offered surgeons a practical tool for identifying unstable lesions that are more likely to progress. By highlighting the importance of probing in evaluating ramp tear stability, Greif's classification provided a more tailored approach to surgical decision-making and contributed to more effective repair strategies in the setting of ACL reconstruction.[66]

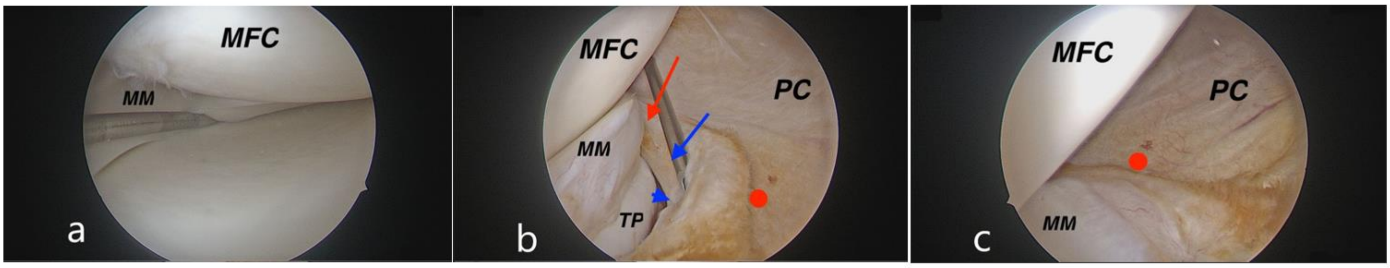

Figure 5. Stability testing. (a) Left knee: abnormal anterior motion demonstrated by probe testing from anterior portals; (b) Posterolateral trans-septal view (red arrow: corner point; blue arrow: ramp lesion; arrowhead: meniscotibial ligament; red circle: meniscofemoral ligament; TP: Tibial plateau); (c) Trans-notch view (red circle: meniscofemoral ligament). MM: Medial meniscus; MFC: Medial femoral condyle; PC: Posterior capsule

Recent advances have expanded ramp tear classification systems, particularly through MRI-based and posterior arthroscopy-based approaches. MRI-based classifications differentiate between tears at the meniscocapsular junction (Type A) and those involving the meniscotibial junction and peripheral meniscus (Type B).[67] While these schemes promote preoperative detection, they remain limited in defining the precise extent of lesions, underscoring the importance of radiologist input for surgical planning.[46] Arthroscopy-based classifications have introduced greater depth by incorporating biomechanical behavior and activity-related considerations. One such system describes five major types with 14 subcategories, leveraging posterior portals to improve visualization of hidden or complex tears, and recommending techniques such as meniscal edge debridement and abrasion to optimize repair outcomes.[68] Similarly, Pimprikar et al. proposed a descriptive classification that distinguishes ramp lesions—defined as peel-off injuries of the posteromedial structures—from isolated meniscal injuries, grouping them into five categories for greater clarity.[69] Together, these modern classification systems enhance diagnostic accuracy, facilitate surgical decision-making, and provide a framework for comprehensive protocols that integrate lesion type with tailored treatment strategies [Table 1].[63]

Diagnosis

Clinical Examination

Accurate preoperative prediction of ramp tears offers significant advantages, enabling surgeons to anticipate operative time, anesthesia requirements, and the need for specialized instruments.[62] The diagnostic process begins with a detailed clinical evaluation, with particular attention to signs suggestive of posteromedial meniscal involvement. A grade 3 Lachman test, reflecting marked anterior tibial translation (ATT), and a grade 3 or greater pivot-shift test, indicative of substantial internal rotational instability, are strongly associated with ramp tears.[16,40,70] Familiari et al. reported a 34.4% incidence of ramp lesions in patients with primary ACL injuries, demonstrating a significant correlation between severe Lachman test results and ramp tear prevalence.[71] However, standard physical examination maneuvers commonly used for meniscal pathology lack the sensitivity and specificity required to reliably diagnose ramp lesions. This limitation underscores the need for complementary imaging and arthroscopic evaluation in high-risk cases.[72]

Radiological Assessment

Magnetic resonance imaging (MRI) remains the primary modality for preoperative identification of medial meniscus ramp tears (MMRT). On T2-weighted sequences, suggestive findings include a thin fluid line between the posterior horn of the medial meniscus (PHMM) and the posterior capsule, or a vertical hyperintense signal within the posterior meniscus.[65,71,73] Posteromedial tibial plateau (PMTP) bone bruising, even in the absence of visible meniscal injury, also raises suspicion for a ramp lesion. Despite these advantages, MRI has important limitations. Reported sensitivity for detecting ramp tears ranges from 48% to 86%, while specificity varies between 79% and 99%.[74] Diagnostic precision can be improved by optimizing imaging protocols. Nonaka et al. demonstrated that imaging with the knee flexed at 120° increased sensitivity and specificity to 91.9% and 94.6%, respectively.[75] Similarly, Kumar et al. highlighted the predictive value of PMTP edema, with a sensitivity of 66.3% and a 2.1-fold increased likelihood of detecting ramp tears when edema was present.[76] Although these refinements enhance MRI utility, current techniques still lack sufficient sensitivity to serve as a definitive diagnostic tool. Consequently, MRI should be regarded as a valuable adjunct that informs but does not replace intraoperative arthroscopic evaluation.[11,50]

Table 1. Posterior arthroscopy Classification of Medial Meniscal Ramp Lesions with Proposed Treatment Approaches

<table>
<tr><th colspan="2">Classification</th><th colspan="2">Definition</th><th>Proposed treatment approach</th></tr>
<tr><td rowspan="4">**Type 1**</td><td>*A*</td><td colspan="2">Meniscofemoral tear</td><td>Posterior approach</td></tr>
<tr><td>*B1*</td><td colspan="2">Meniscotibial tear from the meniscus</td><td>Posterior approach</td></tr>
<tr><td>*B2*</td><td colspan="2">Meniscotibial tear from tibial (Tibial avulsion)</td><td>Posterior approach, fixation with the anchor</td></tr>
<tr><td>*C*</td><td colspan="2">Both meniscofemoral and Meniscotibial tears from the meniscus.</td><td>Posterior approach</td></tr>
<tr><td rowspan="2">**Type 2**</td><td>*A*</td><td colspan="2">An incomplete tear in the inferior portion of the meniscus</td><td>**Stable lesion**: Abrasion of meniscus edges from Anterior with or without MCL trephination</td></tr>
<tr><td>*B*</td><td colspan="2">Incomplete tear in the inferior portion of the meniscus with posterior extension</td><td>**Unstable lesion:** Complete the tear by posterior approach and repair via the anterior or posterior approach</td></tr>
<tr><td rowspan="2">**Type 3**</td><td>*A*</td><td colspan="2">An incomplete tear in the superior portion of the meniscus within the red zone</td><td>**Stable lesion:** Abrasion from the posterior
Unstable lesion: Abrasion of the meniscus edges from the posterior and repair by the anterior or posterior approach</td></tr>
<tr><td>*B*</td><td colspan="2">An incomplete tear in the superior portion of the meniscus within the red-white zone</td><td>**Stable lesion:** Abrasion of meniscus edges from anterior, with or without MCL trephination
Unstable lesion: Abrasion of the meniscus edges and repair by the anterior approach</td></tr>
<tr><td rowspan="6">**Type 4**</td><td rowspan="3">*A*</td><td colspan="3">***Complete single tear in the meniscus***</td></tr>
<tr><td>A1</td><td>Red zone</td><td>Abrasion of meniscus edges and repair by posterior approach</td></tr>
<tr><td>A2</td><td>Red-white zone</td><td>Abrasion of the meniscus edges and repair by the anterior approach</td></tr>
<tr><td rowspan="3">*B*</td><td colspan="3">***Complete single tear in the meniscus with posterior extension***</td></tr>
<tr><td>B1</td><td>Red zone</td><td>Abrasion of meniscus edges and repair by posterior approach</td></tr>
<tr><td>B2</td><td>Red-white zone</td><td>Abrasion of the meniscus edges and repair by the anterior approach</td></tr>
<tr><td rowspan="2">**Type 5**</td><td>*A*</td><td colspan="2">Double incomplete tear in the meniscus</td><td>Abrasion of meniscus edges and repair by posterior approach</td></tr>
<tr><td>*B*</td><td colspan="2">Double complete tear in the meniscus</td><td>Abrasion, resection of the avascular segmental meniscus fragment, and repair via a posterior approach. [Figure 7]</td></tr>
</table>

Reproduced with permission from Keyhani et al., Journal of Experimental Orthopaedics.[68]

Arthroscopic Diagnosis

Arthroscopy is widely regarded as the gold standard for diagnosing medial meniscus ramp tears (MMRT).[7,16] However, evaluations performed solely through anterior portals may fail to detect up to 40% of these lesions.[57] One major challenge is the anterolateral subluxation that occurs in ACL-deficient knees, which restricts visualization of the meniscotibial junction. Thaunat and Di Vico both documented frequent missed diagnoses of hidden ramp tears, underscoring the importance of improved arthroscopic techniques to reliably identify these injuries.[51,56]

Several advanced arthroscopic techniques have been developed to overcome visualization challenges and improve diagnostic accuracy.[18] The anterior portal with trans-notch view allows direct visualization of the posterior meniscocapsular attachment using a 30° or 70° arthroscope.[69] The creation of a posteromedial portal provides even closer and more precise access to the posterior horn and meniscocapsular junction, significantly enhancing diagnostic reliability.[68] When the medial collateral ligament (MCL) restricts access to the posterior compartment, medial collateral ligament trephination (MCLT), also known as pie-crusting, can be performed.[77] This technique not only improves visualization but also enhances vascularization and reduces the risk of iatrogenic cartilage damage, thereby promoting safer and more effective management of ramp tears.[78] Posterior arthroscopic techniques—whether through the trans-notch approach or posterior trans-septal arthroscopy (PTSA)—enable direct identification of ramp lesions without the risks associated with cartilage injury or the need for MCLT [Figure 4].

Posterior arthroscopy is particularly indicated in high-risk scenarios associated with ramp lesions. These include chronic ACL deficiency, high-grade knee instability, and young, active patients engaged in high-demand sports. It is also valuable in cases of excessive medial meniscus displacement—suggestive of instability—or unexplained medial compartment laxity despite an intact-appearing meniscus. Furthermore, posterior arthroscopy is recommended for patients undergoing ACL reconstruction (ACLR) who present with persistent medial pain or instability, ensuring a more comprehensive evaluation of associated injuries.[10,52,79,80] The posterior trans-septal approach (PTSA) offers a direct and unobstructed view of the entire posterior medial meniscus, from the root region to the "corner point" between the posterior and middle thirds where the semimembranosus inserts. In contrast, visualization of this area using trans-notch or posteromedial portals is either highly limited or not feasible. PTSA also facilitates effective shaving and debridement of tear borders by posteromedial portal, thereby optimizing surgical preparation and repair [Figure 6].[57,68,81,82]

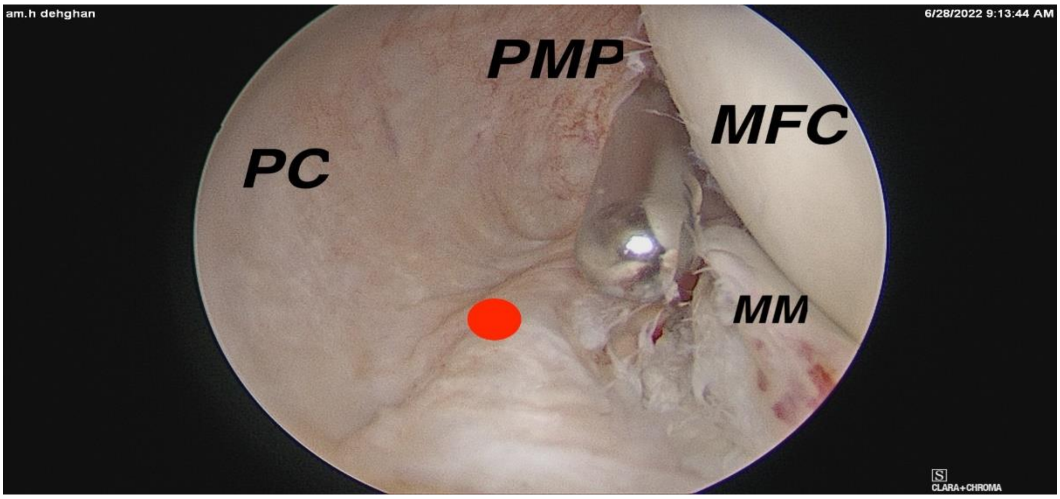

Figure 6. Right knee, posterolateral trans-notch view: arthroscopic shaving of a ramp lesion (meniscal border abrasion) ;Red circle: meniscofemoral ligament. PMP: Posteromedial portal; MM: Medial meniscus; PC: Posterior capsule; MFC: Medial femoral condyle

Other techniques

Ultrasound (US) is emerging as a promising adjunct for the preoperative assessment of medial meniscus ramp tears (MMRT). Nakase et al. developed an innovative US protocol that uses the semimembranosus (SM) tendon as a key anatomical landmark. In this technique, the patient is positioned prone with the knee flexed to 70°, while an assistant facilitates isometric contractions of the knee. With the probe placed above the SM tendon, clinicians can visualize the posteromedial meniscocapsular junction and identify ramp lesions with improved accuracy. This method enhances preoperative diagnostic precision and may be particularly valuable in settings where MRI is limited or inconclusive.[83-86]

In a separate study, Falkowski et al. evaluated medial meniscal extrusion using ultrasound in both supine and upright positions.[87] They observed that a normal meniscus demonstrates minimal displacement compared with a pathological meniscus, which exhibits greater mobility when transitioning between positions. This dynamic approach suggests a potential role for ultrasound in detecting subtle meniscal instability, including ramp lesions. Other researchers have explored single-photon emission computed tomography combined with computed tomography (SPECT/CT). Increased bone tracer uptake (BTU) has been observed in damaged menisci and may provide indirect insights into associated ligamentous and soft tissue injuries, such as ramp tears.[88] However, the role of BTU in evaluating these lesions remains investigational and has yet to be validated for routine clinical use.

For accurate diagnosis and effective management of ramp lesions, a multimodal strategy that integrates clinical examination, MRI assessment, and advanced arthroscopic visualization is essential. Each modality contributes complementary information, collectively reducing the risk of missed lesions and laying the foundation for appropriate surgical planning and repair.[89,90]

Treatment of Medial Meniscus Ramp Tears

The management of ramp lesions requires careful consideration to determine whether all such tears should be repaired or only selected cases.[8] Repair decisions are typically based on factors such as tear size, lesion location, and joint stability.[28] Given the reported ramp lengths of 17 mm and 24 mm, tears greater than 10 mm—representing approximately half the length of the meniscocapsular or meniscotibial attachments—or those found to be unstable on probing are considered candidates for repair.[63,91] Several studies have suggested that debridement may be sufficient for small, stable ramp lesions; however, when the tear involves the meniscocapsular junction and compromises medial meniscus stability, repair is generally recommended.[8,24,28,64] Although clinical outcomes reported in the literature remain inconsistent, repair in uncertain cases is often advised due to the high risk of progression to more severe injuries, such as bucket-handle tears [Figure 1, 7].[10,19,92] While some studies, including that of Xin Liu et al., have reported no significant difference in healing outcomes between stable ramp lesions managed with abrasion and trephination alone versus surgical repair, the decision to repair may ultimately depend on patient-specific factors and surgeon preference.[32,93] A recent systematic review similarly found no significant differences in functional outcome scores, healing rates, knee stability, or return-to-sport rates between patients with repaired and non-repaired stable ramp tears. However, the presence of a ramp lesion was associated with delayed return to sports, potentially prolonging the overall rehabilitation period.[94]

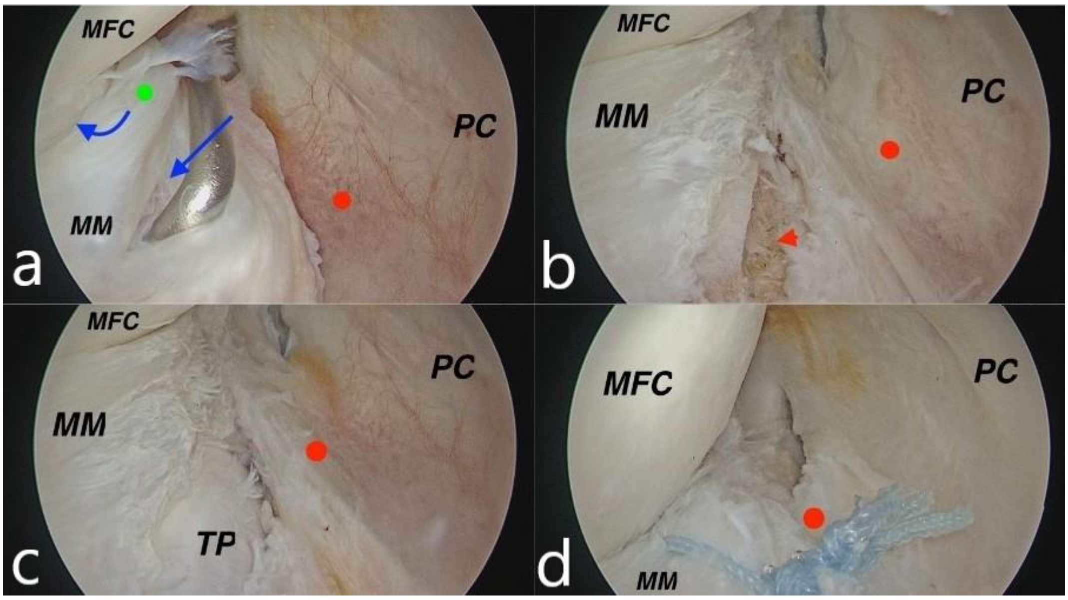

Figure 7. (a) Left knee, posterior trans-septal view (blue arrows: RAMP type V with double tears; green circle: avascular middle fragment; red circle: meniscofemoral ligament); (b) Red arrowhead: after removal of the middle fragment; (c) After abrasion of the posteromedial tibia to promote in situ blood clot formation; (d) After repair using a suture hook from the posteromedial portal. MFC: Medial femoral condyle; PC: Posterior capsule; MM: Medial meniscus; TP: Tibial plateau

In ACL-deficient knees, or in cases where ACL reconstruction (ACLR) does not fully restore stability, untreated ramp tears may progress, resulting in poorer functional outcomes and potentially necessitating more invasive interventions at a later stage.[33,71] Keyhani et al. and others have reported that standard probe assessments during arthroscopy may underestimate instability, as even “stable” ramp tears can contribute to subtle knee laxity.[48] Repairing ramp lesions, irrespective of their apparent stability, has been associated with improved clinical and functional outcomes.[62] Consequently, many authors recommend identifying and repairing all ramp lesions associated with ACL injuries—whether acute or chronic (ranging from 6 to 24 months)—during arthroscopy, in order to optimize outcomes and reduce the risk of long-term complications.[19,40]

Surgical Techniques

The surgical management of medial meniscus ramp tears requires selecting the most appropriate repair technique according to the tear’s location, size, and complexity.[95] Several techniques are available, including the all-inside repair using an all-inside device, the all-inside suture hook repair performed via posterior arthroscopy—which can be further subdivided into the single posteromedial portal, double posteromedial portals, and trans-septal portal techniques—and the inside-out repair method, each offering distinct advantages.[24]

The all-inside repair technique using an all-inside device is a minimally invasive approach particularly suitable for undersurface meniscal tears near the peripheral rim or meniscotibial attachment, especially for unstable tears > 10 mm. This method eliminates the need for a medial incision, thereby reducing surgical trauma and lowering the risk of associated complications. The device is introduced through an anteromedial or anterolateral portal, allowing precise suture placement while minimizing the risk to neurovascular structures.[96,97] In this technique, the meniscus is anchored to the joint capsule, although visualization can be limited in the narrow medial compartment. To improve access, medial collateral ligament (MCL) pie-crusting may be performed; however, this maneuver carries risks such as MCL rupture or nerve injury. Long-term studies have demonstrated favorable healing rates and functional improvements,[24] yet some reports have raised concerns about potential alterations in knee biomechanics and higher secondary meniscectomy rates compared with posterior arthroscopic techniques.[57,98]

The all-inside suture hook repair technique is specifically indicated for superior surface tears of the medial meniscus or tears involving the meniscocapsular attachment within the red zone. This method is particularly effective for unstable tears greater than 10 mm.[99] Using an accessory posteromedial portal, the surgeon positions the leg in maximum internal rotation to optimize access to the lesion. An alternative approach, the suture hook passer technique described extensively by Sonnery-Cottet et al., follows a systematic four-step sequence: trans-notch visualization, posteromedial portal creation, lesion debridement, and repair with a curved suture hook loaded with absorbable or nonabsorbable monofilament sutures. To minimize the risk of iatrogenic cartilage damage, internal tibial rotation is applied, and the suture is secured with a self-locking sliding knot placed away from the articular cartilage.[57] Thaunat et al. analyzed 132 cases of meniscal ramp lesions associated with ACL ruptures using this method, reporting significant improvements in IKDC scores and a 9% failure rate, thereby supporting its clinical effectiveness.[64] Furthermore, Hatayama et al. demonstrated superior healing and reduced anterior laxity compared with untreated lesions.[100]

The all-inside suture technique using two posteromedial portals, introduced by Ahn et al., improves visualization and repair accuracy by employing a dual-portal system. In this approach, an arthroscope is first inserted through the anterolateral portal into the intercondylar notch, allowing direct visualization of the lesion. A standard posteromedial portal is then created, followed by a second, larger posteromedial portal established 1 cm superior to the first, using an 18-gauge needle for guidance. This second portal accommodates a cannula for stabilization, while a suture hook device inserted through the standard portal is used to complete the repair.[79] Although this technique provides anatomically precise suturing and enhanced stabilization, it also presents notable disadvantages, including the need for two additional incisions, a higher risk of saphenous nerve injury, and increased operative time.[24] Clinical studies, such as that by Gülenç et al., reported significant patient improvements at 8-month follow-up; however, other investigations found no clear advantage over simpler methods, such as abrasion and trephination during ACL reconstruction, suggesting that the added complexity may not consistently yield superior clinical outcomes.[101,102]

The trans-septal portal technique, first introduced by Ahn, enhances visualization and facilitates arthroscopic access to both the medial and lateral posterior compartments for meniscal ramp lesion repair.[103] After establishing the posterolateral portal by identifying the lateral collateral ligament and the long head of the biceps femoris—while ensuring anterior placement to avoid peroneal nerve injury—a blunt arthroscopic sheath is used to carefully open the posterior septum, thereby connecting the posteromedial and posterolateral compartments. To minimize the risk of arterial or popliteal vessel injury, the septal aperture is created just posterior to the posterior cruciate ligament (PCL) at its midpoint. Once access is established, the arthroscope is advanced to the posteromedial portal, providing complete visualization of the ramp lesion. Following posteromedial portal creation under transillumination, suturing is performed using a suture hook device introduced through the posteromedial portal.[104] Keyhani et al. proposed managing ramp lesions in a manner analogous to bone non-union, suggesting a three-step augmentation strategy to improve repair efficiency. This involves debriding fibrotic tissue, abrading the borders of the synovial and meniscal tears, and using an arthroscopic burr to expose cancellous bone in the non-cartilaginous portion of the posteromedial tibial plateau, facilitating in situ clot formation [Figure 8].[82] This approach enables comprehensive evaluation of the posterior horn of the medial meniscus (PHMM), repositioning the inferior peripheral fragment to its anatomical site for maximum contact, and allowing precise vertical mattress suture placement without the need for rotational maneuvers. It provides complete access to the posterior meniscus, extending from the root attachment to the corner point. Despite these advantages, the technique is technically demanding, with the complexity of posterolateral portal creation, a steep learning curve, and prolonged operative time representing significant limitations.[43] Nevertheless, favorable clinical outcomes have been reported in 128 ACL reconstruction cases, with significant improvements in Lysholm and IKDC scores at two-year follow-up and no procedure-related complications.[48] Moreover, posterior arthroscopy offers unique benefits for posterior debridement, enabling direct visualization of partial inferior ramp tears (Thaunat type 3) as well as effective removal of the intermediate segment in double ramp tears (Thaunat type 5).

Figure 8. Red arrowhead: After abrasion of the posteromedial tibia to promote in situ blood clot formation; red circle: meniscofemoral ligament. PC: Posterior capsule; MM: Medial meniscus; MFC: Medial femoral condyle

The inside-out technique is a widely accepted approach for repairing larger and more complex meniscal ramp tears, including full-thickness tears, complete meniscocapsular separations, and double ramp lesions. This method provides strong fixation by enabling the placement of multiple sutures with fine needles, offering greater precision compared with all-inside devices or suture hooks. The procedure begins with arthroscopic visualization through the anterolateral portal, followed by a medial incision posterior to the medial collateral ligament (MCL) to facilitate suture passage. Medial collateral ligament trephination (MCLT) may be performed to improve visualization of the superior meniscal surface. Sutures are typically placed in a vertical mattress configuration to capture both the meniscus and capsule, thereby ensuring optimal stabilization. A retraction device positioned proximal to the semimembranosus tendon and anterior to the medial head of the gastrocnemius helps protect neurovascular structures and guide needle passage. After every three to four sutures, knots are tied externally and assessed arthroscopically to confirm appropriate meniscal reduction.[105] Although this method requires an open approach—which increases the risk of iatrogenic injury to the saphenous nerve and surrounding vessels—it remains an effective and reliable option for unstable and extensive ramp tears, particularly when a medial incision is already necessary for concomitant procedures such as MCL repair. Nevertheless, multiple penetrations from the anterior can predispose to iatrogenic meniscal damage, and achieving precise anatomical reduction of the peripheral sagged fragment can be technically challenging.[106,107]

Arthroscopic repair remains the gold-standard treatment for meniscal ramp lesions. To maximize the success of repair, several key surgical principles should be observed. First, the tear edges should be rasped and debrided to remove fibrotic tissue and stimulate healing. Second, abrasion of the submeniscal bone with an awl or burr is performed to induce bleeding and facilitate in situ clot formation, thereby enhancing the biological environment for healing. Third, anatomic reduction with maximum contact surface should be achieved to promote meniscal healing and provide rigid fixation, which is best accomplished using advanced visualization techniques such as medial collateral ligament trephination (MCLT), the trans-notch view, or the posteromedial trans-septal approach (PTSA). Finally, proper suture spacing—maintaining intervals of at least 5 mm—helps preserve meniscal integrity and optimize repair outcomes. [43,62,101,108]

The advantages and disadvantages associated with the anterior versus posterior approach in ramp tear repair were also presented [Table 2].

Rehabilitation

Following combined ACL reconstruction (ACLR) and medial meniscus (MM) ramp repair, adherence to an appropriate rehabilitation protocol is essential for achieving optimal recovery and restoring joint stability.[8,33] Early active knee flexion after ramp repair may compromise repair integrity due to mechanical interactions between these structures.[30,109] Therefore, postoperative rehabilitation protocols should account for the influence of semimembranosus (SM) activation on posterior horn of the medial meniscus (PHMM) stability, to prevent surgical failure and ensure long-term meniscal function.[63,110]

The rehabilitation protocol emphasizes a controlled progression with gradual advancement in weight-bearing, mobility, and strength restoration. Active knee flexion should be strictly avoided for the first six weeks postoperatively. Patients are generally allowed weight-bearing as tolerated, with crutches discontinued once they can ambulate without a limp. During the first two weeks, knee flexion should be restricted to a maximum of 90 degrees to protect the repair.[43]

The rehabilitation program begins with controlled motion, proprioceptive training, and low-impact strengthening during the first six weeks, emphasizing exercises such as leg presses and step-ups. Between weeks 6 and 12, the focus shifts to moderate strengthening, neuromuscular training, and restoration of the full range of motion. After three months, sport-specific activities—including running, jumping, and pivoting—are gradually introduced according to individual tolerance. Return-to-sport decisions are guided by functional performance tests and the surgeon's ACL reconstruction (ACLR) protocol. These criteria typically include achieving strength and flexibility symmetry, performing pain-free functional drills, and completing tasks such as single-leg hop and agility tests. Adherence to a structured, individualized rehabilitation plan enables a safe return to athletic activity while minimizing the risk of reinjury.[110,111]

Table 2. Comparison Of Anterior Vs. Posterior Arthroscopy

	Criteria	Anterior Arthroscopy	Posterior Arthroscopy
1	Portals Used	AM and AL portals (PM portal optional)	PM portal(s), optional PL trans-septal portal
2	Devices Used	All-inside suture device, curved suture device	Suture hook pass device, spinal needle
3	Visualization	Limited, indirect visualization	Direct, complete visualization from root to corner point
4,5	Suture Techniques	Vertical mattress, versatile configurations	Vertical mattress sutures
6	Risk of Nerve/Vascular Injury	Lower risk but possible iatrogenic damage with pie-crusting	Higher risk of CPN (peroneal and saphenous) injuries
7	Learning Curve	Shorter (requires expertise in all-inside sutures)	Longer due to PM or PL portals establishment and suture handling
8	Operative Time	Shorter, generally faster	Longer, increased operative time, but decreases significantly after passing the learning curve.
9	Biomechanical Strength	Horizontal mattress suture, though it may be difficult to put strong vertical mattress fixation	Strong with biologic augmentation options
10	Cost	More expensive (all-inside devices)	Lower cost (suture hook devices)
11	Risk of Cartilage Damage	Higher risk if using a curved device	Lower risk with proper assistance
12	Applicability	Less accurate for assessing the full tear extent	Better access for small or hidden tears

Clinical Outcomes

Impact on Stability and Tear Progression

The clinical outcomes of medial meniscus ramp tear (MMRT) repair are closely associated with tear stability and the risk of progression.[22,101] Studies suggest that small (≤10 mm) stable ramp tears may heal spontaneously due to sufficient vascularization along the meniscocapsular border. However, augmentation techniques such as rasping, trephination, and marrow venting are often recommended to enhance healing potential.[112] Nevertheless, untreated stable ramp tears still demonstrate a 21.4% risk of progression to more severe injuries, including bucket-handle tears, during long-term follow-up.[10] In contrast, unstable ramp tears (>10 mm or mobile on probing) show a markedly reduced risk of progression when surgically repaired, thereby lowering the likelihood of secondary meniscal surgery. These findings underscore the importance of accurately assessing tear stability and selecting the appropriate treatment strategy to prevent further knee damage.[34,43]

Comparing Surgical Techniques and Their Success Rates

The effectiveness of different surgical techniques varies considerably depending on factors such as the size of the tear, patient demographics, postoperative care, surgeon expertise, and lesion complexity.[24,62,101] The inside-out repair technique is widely regarded for its strong fixation and low failure rates, particularly in large or complex tears. In contrast, all-inside repairs—commonly applied to meniscotibial or undersurface tears—have demonstrated higher failure rates compared with suture hook repairs in some studies.[24] For instance, one investigation reported a 31.2% failure rate for all-inside repairs versus 15.5% for suture hook techniques, highlighting the importance of appropriate technique selection. Suture hook repairs, primarily when performed through posteromedial portals, have shown lower failure rates in high-risk populations when combined with anterolateral ligament reconstruction (ALLR).[62,98] Collectively, these findings emphasize that repair techniques should be tailored to the specific tear pattern and patient profile to optimize clinical outcomes.[24]

Patient-Reported Outcomes and Long-Term Prognosis

Studies evaluating patient-reported outcomes after medial meniscus ramp tear (MMRT) repair generally demonstrate favorable results.[24,62,92] However, some investigations have found no significant differences in pain levels or knee function between patients who underwent isolated ACL reconstruction (ACLR) and those who had combined ACLR with ramp repair, suggesting that the necessity of ramp repair may depend on individual tear characteristics and patient-specific factors.[93] In one study, 88% of patients returned to their pre-injury or higher levels of sports participation, with a low secondary meniscectomy rate of 2%.[33] Reported secondary meniscectomy rates across studies, however, range from 2% to 18.26%, primarily influenced by surgical technique and risk factors such as anterior tibial translation (ATT).[32] Furthermore, patients who underwent ACLR without ramp repair had a 7.85-fold higher risk of recurrent ACL tears compared with those who underwent combined ACLR and anterolateral ligament reconstruction (ALLR).[33] Collectively, these findings underscore the importance of timely surgical intervention in preserving long-term knee function and reducing the risk of reinjury.[110]

The long-term effectiveness of medial meniscus ramp tear (MMRT) repair remains a subject of debate, with studies reporting variable outcomes depending on surgical technique and the necessity of repair.[100] A recent survey by Tanel et al. critically evaluated the posteromedial portal technique in 81 patients over 10 years, reporting a 21.9% failure rate of meniscal repair and subsequent need for reoperation.[113] Another study analyzing type 3 medial meniscus (MM) ramp lesions in patients undergoing ACL reconstruction (ACLR) found that 46.0% of patients underwent all-inside repair, 20.4% underwent suture hook repair, and 33.6% were left in situ without intervention. The overall rate of secondary procedures due to ACL graft failure or meniscal repair failure was 15%. Isolated ACLR was identified as the only significant risk factor for reoperation, irrespective of the repair technique employed.[112] In a larger series of 1,037 ACLR patients, the rate of secondary meniscectomy was 7.7% at a mean follow-up of 72.4 months. Notably, patients who did not undergo ramp repair at the time of ACLR were more than twice as likely to require secondary meniscectomy, underscoring the benefits of concurrent ramp lesion repair during ACLR.[114]

Accurate identification and repair of ramp tears—often requiring posterior visualization and posteromedial probing—are essential for optimizing ACL reconstruction (ACLR) outcomes, restoring normal knee biomechanics, and preventing long-term complications.[115]

Conclusion

Medial meniscus ramp tears (MMRTs) play a critical role in overall knee stability, particularly in the context of ACL reconstruction (ACLR), necessitating thorough evaluation and a tailored surgical approach. Given the limitations of MRI in detecting these lesions, comprehensive arthroscopic assessment—including trans-notch views and the posteromedial trans-septal approach (PTSA)—is essential, especially in patients presenting with high-grade Lachman or pivot shift tests under anesthesia. The decision to repair a torn ramp should be guided by tear size, location, stability, and timing after injury. Inferior-based tears are most effectively managed with all-inside devices, superior-based tears are best addressed with suture hook techniques, and complex or full-thickness unstable tears typically require inside-out repair to achieve optimal fixation.

Key surgical strategies—such as rasping the tear edges to stimulate healing, improving visualization through medial collateral ligament trephination (MCLT), and utilizing posterior-view arthroscopy—are critical for enhancing repair success. Clinical evidence demonstrates that repairing unstable ramp tears significantly reduces the risk of secondary meniscectomy and ACL re-injury. However, the absence of a standardized classification system for ramp lesions and variability in reported success rates make it difficult to establish a universal treatment algorithm. Comparative studies have confirmed the effectiveness of multiple repair techniques. Given the high failure rates associated with untreated unstable ramp tears, surgical repair of all unstable lesions is generally recommended to prevent progression, preserve long-term knee function, and minimize the risk of secondary procedures.

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