International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Scholarly Publisher
RS Global Sp. z O.O.
ISNI: 0000 0004 8495 2390

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ARTICLE TITLE	RESTORING KNEE MOBILITY AFTER MENISCUS INJURIES: THE ROLE OF SURGICAL AND REHABILITATION TECHNIQUES
DOI	https://doi.org/10.31435/ijitss.3(47).2025.3942
RECEIVED	28 July 2025
ACCEPTED	20 September 2025
PUBLISHED	30 September 2025
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RESTORING KNEE MOBILITY AFTER MENISCUS INJURIES: THE ROLE OF SURGICAL AND REHABILITATION TECHNIQUES

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ABSTRACT

Meniscal injuries are common knee joint conditions affecting both young, active individuals and older adults. The meniscus plays a key role in load distribution, shock absorption, proprioception, and joint lubrication. Modern treatment trends prioritize preserving the meniscus rather than removing damaged tissue. Clinical decisions depend on tear type, location, vascularity, patient age, activity level, and comorbidities such as osteoarthritis.

This review, based on literature from PubMed, Web of Science, and Google Scholar, compares surgical and non-surgical strategies, focusing on outcomes, indications, and patient-specific factors. Arthroscopic meniscal repair (AMR) is favored for traumatic tears in younger, active patients, particularly those in vascular zones (red-red or red-white). Such injuries, often associated with anterior cruciate ligament (ACL) tears, yield better functional outcomes, reduced pain, and lower osteoarthritis risk with AMR compared to arthroscopic partial meniscectomy (APM). Results improve further when AMR is performed alongside ACL reconstruction due to enhanced healing conditions.

In contrast, degenerative meniscal lesions (DMLs) - prevalent in middle-aged and elderly populations-respond poorly to surgery. Major trials (FIDELITY, ESCAPE) have shown no significant benefit of APM over structured physiotherapy or even placebo surgery. Moreover, APM may accelerate osteoarthritis progression and carries surgical risks. Consequently, guidelines recommend conservative management, including physiotherapy, exercise, and potentially intra-articular injections, as first-line treatment for degenerative tears.

In summary, meniscal treatment should be individualized: surgical repair for young patients with repairable traumatic tears, and non-operative management for degenerative cases. Advances in biologics and imaging may further refine treatment approaches.

KEYWORDS

Meniscus Injury, Arthroscopic Meniscal Repair (AMR), Arthroscopic Partial Meniscectomy (APM), Conservative Treatment, Physical Therapy, Osteoarthritis

CITATION

Mateusz Myśliwiec, Tytus Tyralik, Maciej Karwat, Julia Kular, Oliwia Malec, Justyna Niebylecka, Izabella Michalska, Natalia Glanc, Dominik Sendecki, Grzegorz Zalewski. (2025). Restoring Knee Mobility After Meniscus Injuries: The Role of Surgical and Rehabilitation Techniques. *International Journal of Innovative Technologies in Social Science*, 3(47). doi: 10.31435/ijitss.3(47).2025.3942

Introduction

The meniscus is a crescent-shaped fibrocartilaginous structure situated between the femur and tibia. It plays a vital role in shock absorption, load distribution, proprioception, and joint lubrication (Fox et al., 2015) *(Makris et al., 2011)***.** The circumferential collagen fibers generate hoop stress, which stabilizes the joint during axial loading. Damage to these structures-especially the posterior root-can result in biomechanical consequences similar to total meniscectomy (Ozeki et al., 2022)

Meniscal tears are among the most frequent knee pathologies, with an incidence of 60–66 per 100,000 annually, and are especially common in athletes and the elderly (Luvsannyam et al., 2022)**,** *(Mordecai et al., 2014)*. Initially thought to be functionless, menisci were often excised through total meniscectomy. However, long-term studies revealed that removal leads to joint degeneration, altering modern treatment approaches toward preservation (Jeong et al., 2012) *(Mordecai et al., 2014)*

Meniscal tears are categorized into traumatic and degenerative. Traumatic tears usually affect younger individuals and are often associated with ligament injuries. Degenerative meniscal lesions (DMLs) are more prevalent in older adults and can be asymptomatic, though meniscal extrusion and complex tear patterns may accelerate osteoarthritis (Ozeki et al., 2022)

The medial meniscus, covering 50–60% of the medial tibial plateau, is more prone to injury due to its reduced mobility and stronger capsular attachments. This makes surgical precision essential for maintaining joint function (Śmigielski et al., 2015)

Treatment decisions depend on multiple factors, including tear type, vascularization, and patient profile. Surgical options include arthroscopic partial meniscectomy (APM) and meniscal repair, with the latter favored for peripheral, repairable tears in younger patients (Doral et al., 2018)**;** *(Mordecai et al., 2014)* However, poor vascularization in the inner zones limits healing success (Makris et al., 2011)

Non-operative treatment-such as structured physiotherapy, injections, and unloading-has proven effective in many cases, particularly for degenerative tears. Randomized trials have demonstrated comparable outcomes between conservative and surgical interventions in select groups (Ozeki et al., 2022)

Aim of the Work:

The aim of this study is to review current approaches to the treatment of meniscus injuries, with a particular focus on comparing surgical and non-surgical strategies. The study also evaluates the effectiveness, benefits, and limitations of each treatment option and discusses the factors influencing the choice of therapy. Additionally, it highlights current challenges in clinical decision-making and patient outcomes related to meniscus injury management.

Methods

This paper presents a literature review focused on the treatment of meniscal injuries with particular emphasis on comparing surgical and conservative (non-surgical) approaches. The analysis included scientific publications in English, sourced from databases such as Web of Science, PubMed, and Google Scholar, as well as from relevant websites and medical textbooks.

Only studies that met the following inclusion criteria were considered:

Addressed the treatment of meniscal injuries using surgical and/or non-surgical methods;

Evaluated the effectiveness, indications, and outcomes of various treatment options;

Compared clinical outcomes, recovery times, and long-term prognoses of both approaches;

Considered patient-specific factors influencing treatment decisions, such as age, activity level, and injury type.

The reviewed materials consisted of both original research articles and literature reviews, selected based on their methodological rigor and clinical relevance.

Literature review results

The current body of literature highlights significant differences in the treatment efficacy and indications for surgical and non-surgical strategies depending on the type of meniscal injury-traumatic versus degenerative. Arthroscopic meniscal repair (AMR) has emerged as a preferred option in treating traumatic meniscal tears, particularly in younger and physically active patients. Biomechanically, meniscal repair is superior to meniscectomy, as it preserves the meniscus' load-distributing function, which reduces the risk of early-onset osteoarthritis. Several studies confirm that, compared to arthroscopic partial meniscectomy (APM), AMR results in better long-term outcomes, including reduced pain and lower incidence of osteoarthritis when the procedure is well-indicated and performed in the vascular zone of the meniscus. Notably, vertical longitudinal tears in the red-red or red-white zones are associated with the highest rates of successful healing following AMR (Vaquero-Picado & Rodríguez-Merchán, 2018).

However, despite these advantages, AMR is also associated with a higher reoperation rate, which makes proper patient selection critical. Failures are more common in chronic tears, avascular zones, and in older patients with degenerative changes (Vaquero-Picado & Rodríguez-Merchán, 2018). The literature also emphasizes that AMR yields better outcomes when combined with anterior cruciate ligament (ACL) reconstruction, likely due to the biological environment created by bone marrow stimulation during the procedure (Vaquero-Picado & Rodríguez-Merchán, 2018).

In contrast, degenerative meniscal tears-more commonly seen in middle-aged and elderly populations-are predominantly managed conservatively. Systematic reviews consistently report that in this group, APM does not offer meaningful clinical benefits in terms of pain or function over structured physical therapy (Thorlund et al., 2015). Most included reviews agreed that conservative treatment, particularly exercise therapy, should be the first-line management. In addition, MRI studies have shown a high prevalence of asymptomatic degenerative meniscal lesions in the general population, further questioning the rationale for surgical intervention (Thorlund et al., 2015) This raises broader concerns regarding overtreatment and the ethical implications of performing unnecessary surgery, particularly when conservative treatment options have not been exhausted or properly trialed.

Although some patients with degenerative lesions may not improve with physical therapy and might experience symptom relief after surgery, these represent a minority. Even then, current evidence suggests careful evaluation, as the benefits of APM are often marginal in the long term (Thorlund et al., 2015). Shared decision-making, which involves thorough patient education and consideration of patient preferences, plays a crucial role in determining whether surgery should be considered, especially when symptoms persist despite high-quality conservative care.

This aligns with recent meta-analytic protocols designed to identify potential subgroups of patients who might truly benefit from APM. A large-scale individual participant data meta-analysis (IPDMA) is underway to determine whether certain clinical profiles-such as patients with persistent mechanical symptoms, limited response to conservative care, or specific MRI findings-respond better to surgical intervention. The rationale for this analysis stems from the fact that previous randomized controlled trials (RCTs), while rigorous, were likely underpowered to detect meaningful subgroup differences (Wijn et al., 2020) Such nuanced analysis could allow for more personalized treatment algorithms and minimize unnecessary surgical interventions.

Nevertheless, the overall trend in the literature is toward limiting surgical intervention in degenerative meniscal disease, unless clearly indicated by persistent disabling symptoms. Even then, the potential for adverse events and the risk of accelerating osteoarthritic progression must be carefully considered (Wijn et al., 2020). This evolving paradigm emphasizes a shift from surgical default to evidence-informed, function-focused treatment planning, underscoring the need for multidisciplinary collaboration among orthopedic surgeons, physiotherapists, and radiologists.

A systematic review and meta-analysis conducted by Thorlund et al. demonstrated that arthroscopic procedures, including partial meniscectomy and debridement, yield only minor pain relief that is statistically significant but clinically negligible. The observed improvement- 2.4 mm on a 0–100 mm visual analogue scale-was most pronounced at 3 and 6 months post-surgery but faded entirely by 12 to 24 months (Thorlund et al., 2015) Additionally, the procedure showed no measurable improvement in physical function at any point during the follow-up period (Thorlund et al., 2015) These procedures are not without risks. The same meta-analysis reported complications such as deep vein thrombosis (4.13 per 1000 procedures), pulmonary embolism, infection, and even death, raising concerns about the cost-benefit balance of arthroscopy in this population (Thorlund et al., 2015).

Long-term results support these findings. In a 10-year RCT by Sonesson et al., patients who underwent knee arthroscopy in addition to an exercise program had no better outcomes than those treated with exercise therapy alone. Both groups showed an equal prevalence of radiographic osteoarthritis (67%), and no significant difference in symptomatic osteoarthritis was found (47% in the non-surgical group vs. 57% in the surgical group; p =.301) (Sonesson et al., 2024). Patient-reported outcomes, including KOOS subscales for pain, symptoms, and function, were statistically indistinguishable across all follow-up points (Sonesson et al., 2024). The lack of sustained benefit from surgery, as revealed in long-term follow-ups, reinforces the argument for prioritizing rehabilitation and muscle conditioning over invasive interventions.

Biomechanical and histological insights offer further explanation for these clinical outcomes. The meniscus is a crucial load-bearing and shock-absorbing structure, especially in knee flexion, where it can transmit up to 90% of joint load. Removal of even a small portion of the meniscus results in a disproportionate increase in contact pressure-by over 65% - which accelerates cartilage wear and joint degeneration (Kawamura et al., 2003). Partial meniscectomy also disrupts the circumferential collagen fiber network responsible for load transmission (hoop stress), compromising the meniscus's mechanical integrity (Kawamura et al., 2003).

Moreover, the meniscus's limited blood supply-confined mostly to the peripheral "red-red" zone-makes healing difficult in central tears, particularly those in the avascular "white-white" zone. As a result, surgical resection often removes tissue that might otherwise be salvaged or left asymptomatic (Kawamura et al., 2003). Emerging biological therapies, including gene therapy and engineered scaffolds, aim to improve healing potential in these regions, offering promising non-surgical alternatives for the future (Kawamura et al., 2003). Further exploration of these modalities may provide a viable path forward in treating complex or avascular meniscal injuries without resorting to resection.

A systematic review of systematic reviews by Rotini et al. supports this conservative-first approach by highlighting a consistent lack of clinically meaningful benefit from APM over structured physical therapy in degenerative meniscal lesions. Across multiple high-level reviews, physical therapy remained the recommended first-line treatment, with APM reserved only for those who fail to improve after rehabilitation. Notably, crossover rates from conservative to surgical management varied between 16.2% and 27.3%,

indicating that although some patients eventually choose surgery, most achieve adequate relief without it (Rotini et al., 2022).

The findings of the FIDELITY trial by Sihvonen et al. further strengthen this conclusion. This double-blind, placebo-controlled RCT compared APM with sham surgery in patients with degenerative medial meniscus tears. After 24 months, there were no statistically or clinically relevant differences between groups in pain, function (WOMET, Lysholm), or post-exercise outcomes. Moreover, subgroup analyses-including those with mechanical symptoms or unstable meniscal tears-showed no additional benefit of surgery, thereby challenging traditional justifications for APM in these cases (Sihvonen et al., 2018).

The Finnish FIDELITY trial assessed 146 patients in a placebo-controlled RCT and found no significant clinical advantage of APM over sham surgery in terms of pain, function, or patient satisfaction two years postoperatively (Sihvonen et al., 2013). Extending the follow-up to five years, the same study group confirmed these findings and additionally reported that APM was associated with a greater risk of radiographic progression of osteoarthritis, without any measurable improvement in knee symptoms or function compared to placebo (Sihvonen et al., 2020). Interestingly, mechanical symptoms-often cited as surgical indications-were actually more frequently reported in the APM group after surgery, suggesting possible harm or overtreatment (Sihvonen et al., 2020).

Placebo-controlled trials like FIDELITY are difficult to conduct. Hare et al. describe the difficulties in recruiting patients for such trials, with only 40 out of 476 screened participants enrolled, due to patients' reluctance to risk receiving placebo (Hare et al., 2014). Still, when oral information was provided, 90% of participants cited scientific contribution as their primary motivation (Hare et al., 2014). Moreover, these trials revealed a substantial rate of misdiagnosis, with 33% of suspected meniscal lesions not confirmed on MRI, highlighting a critical need for accurate diagnostic protocols (Hare et al., 2014).

The ESCAPE trial-another RCT-demonstrated that both APM and physical therapy led to similar functional improvements over 24 months, with no clinically meaningful difference in outcomes (Noorduyn et al., 2020). Many patients overestimated surgical benefits; 59% held unrealistic expectations regarding postoperative recovery, which may explain the continued use of APM despite equivalent outcomes with physical therapy (Noorduyn et al., 2020).

These findings are in line with the pivotal study by Katz et al., which compared surgery and physical therapy in patients with meniscal tear and concomitant osteoarthritis. The randomized trial found no significant difference in functional outcomes between the two groups at 6 and 12 months, reinforcing the notion that structured physical therapy can be as effective as surgical intervention in this population (Katz et al., 2013). Importantly, a substantial proportion of patients initially assigned to physical therapy did not require surgery, indicating that conservative care may suffice for many individuals (Katz et al., 2013).

This is further supported by a narrative review by Akkawi et al., which concluded that APM should not be first-line treatment for degenerative meniscal lesions (DML), especially in patients with signs of osteoarthritis (Akkawi et al., 2021) The authors also noted promising results for intra-articular hyaluronic acid (HA) and platelet-rich plasma (PRP) injections, both of which demonstrated improved outcomes compared to conservative therapy alone (Akkawi et al., 2021) Zorzi et al. found HA reduced lesion size and depth on MRI (Akkawi et al., 2021)While more high-quality trials are needed to establish optimal treatment protocols, these findings signal potential for biological adjuncts in future non-surgical regimens.

MRI-based cohort studies confirm the high prevalence of degenerative meniscus tears, particularly among individuals aged 31–40, with medial meniscus injuries being most common. Effusion and early signs of OA were often seen alongside these tears, reinforcing the close link between meniscus damage and joint degeneration. In clinical practice, these imaging patterns may assist in differentiating between incidental findings and clinically relevant lesions.

Historically, total meniscectomy was standard, until Fairbank and others showed it accelerated joint degeneration (Simonetta et al., 2023) Simonetta et al. classified meniscal tears as "good," "bad," or "ugly" based on healing potential. "Good" peripheral tears may heal conservatively or with repair; "ugly" root or radial tears require surgical intervention to prevent joint deterioration (Simonetta et al., 2023) Anatomical and biomechanical factors-such as vascularity and tear pattern-play a decisive role in outcomes (Simonetta et al., 2023)

A recent study by Bottomley et al. showed that patients undergoing meniscal repair reported better PROMs (e.g., KOOS, Lysholm, IKDC) than those who had meniscectomy (Bottomley & Al-Dadah, 2023). While meniscectomy offers short-term relief, it accelerates long-term degeneration, especially in younger patients. Meniscal repair better preserves joint integrity (Bottomley & Al-Dadah, 2023). Furthermore, repair

procedures, when feasible, align with the current emphasis on joint preservation strategies and tissue-sparing surgical principles.

Exercise therapy consistently provides outcomes equivalent to APM. In Kise et al.'s RCT of 140 patients, no significant difference was found between surgery and supervised exercise therapy over two years, though the latter improved quadriceps strength more significantly (Kise et al., 2016). Notably, 19% crossed over to surgery, yet experienced no superior outcomes (Kise et al., 2016).

Herrlin et al. similarly found no difference between APM plus rehab and rehab alone in patients with degenerative medial tears (Herrlin et al., 2007). Improvements in sport and quality of life were comparable (Herrlin et al., 2007). Aneesullah et al. echoed these results: in 80 patients, pain relief, functional outcomes, and satisfaction did not significantly differ between APM and exercise groups (Aneesullah et al., 2024)

In summary, the literature supports surgical repair primarily for traumatic meniscal injuries in younger patients, particularly when performed early and in conjunction with ACL reconstruction. In contrast, non-surgical strategies-mainly exercise therapy-remain the standard of care for degenerative lesions, with APM reserved for select refractory cases. Current evidence overwhelmingly favors conservative management in middle-aged and older adults with degenerative tears, highlighting the importance of individualized treatment based on tear morphology, vascularity, symptoms, and patient expectations. The evolution of treatment standards, guided by increasingly robust trial data and emerging biological therapies, continues to shape a more nuanced, patient-centered approach to meniscus injury management.

Conclusions

The current evidence base supports a stratified approach to the treatment of meniscal injuries, distinguishing clearly between traumatic and degenerative tear patterns. For traumatic meniscal injuries, particularly in younger and active individuals, arthroscopic meniscal repair (AMR) remains the preferred strategy. This approach offers superior long-term outcomes in terms of joint preservation, pain reduction, and decreased risk of osteoarthritis when compared to meniscectomy. Success, however, is highly contingent on proper patient selection, tear location within the vascular zone, and timely intervention-often in conjunction with procedures such as ACL reconstruction.

In contrast, degenerative meniscal tears, predominantly affecting older adults, do not benefit meaningfully from surgical intervention in most cases. Multiple high-quality studies, including placebo-controlled and long-term randomized trials, demonstrate that arthroscopic partial meniscectomy (APM) offers no significant advantage over structured physical therapy in terms of pain relief, function, or long-term joint health. Moreover, APM carries inherent procedural risks and may even accelerate joint degeneration in some populations.

Conservative management-especially exercise-based therapy-has emerged as the first-line treatment for degenerative lesions, with surgery reserved only for well-defined subgroups unresponsive to non-surgical care. Even in these cases, the expected benefits of APM appear modest and must be weighed against the potential for harm. The literature increasingly advocates for shared decision-making, grounded in accurate diagnosis, patient education, and realistic expectations.

Finally, advances in biological therapies and imaging techniques offer promising future directions for managing meniscal pathology without tissue resection. As the treatment paradigm shifts toward joint preservation and individualized care, interdisciplinary collaboration becomes essential in aligning clinical decision-making with evolving evidence. This shift marks a critical departure from the historic surgical default and supports a more nuanced, patient-centered framework for treating meniscal injuries.

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