Arthroscopic Transtibial Pullout Suture Repair Versus Suture Anchor Repair in Posterior Root Tear of the Medial Meniscus, open-label blinded endpoint randomized controlled trial.

NCT Number: Not yet registered

Study Date: August 2025

Introduction

The menisci play a fundamental role in maintaining normal knee biomechanics by distributing load, absorbing shock, providing stability, and facilitating joint lubrication. Damage to the meniscus, particularly root tears, disrupts hoop tension and leads to altered joint loading patterns. This condition accelerates cartilage degeneration and predisposes patients to early-onset osteoarthritis, especially when untreated or inadequately managed. (Kim et al., 2025)

Posterior root medial meniscus tears (PRMMTs) have gained increasing clinical attention in the past two decades. These injuries are biomechanically equivalent to a total meniscectomy because they cause extrusion of the meniscus and loss of its load- sharing capacity. PRMMTs typically affect middle-aged and older patients, often associated with degenerative changes, but can also occur in younger populations following trauma or high-impact activities. (Kumar et al., 2024)

The clinical presentation of PRMMTs is often subtle, with patients experiencing posterior knee pain, mechanical symptoms, and joint line tenderness. Magnetic resonance imaging (MRI) remains the gold standard for diagnosis, with characteristic findings such as the "ghost sign" and meniscal extrusion beyond 3 mm. However, diagnosis is frequently delayed, contributing to the progression of cartilage degeneration by the time of surgical intervention. (Monson et al., 2025)

Several risk factors have been identified, including female gender, obesity, varus malalignment, and increased posterior tibial slope. These factors not only predispose patients to PRMMTs but also influence the prognosis following surgical repair. Given the high prevalence of these risk factors, especially in populations with rising obesity and osteoarthritis incidence, effective treatment strategies have become essential. (Furumatsu et al., 2023)

Surgical repair techniques have evolved significantly to restore hoop stresses and improve long-term outcomes. Two widely practiced arthroscopic methods are the transtibial pullout suture repair and the suture anchor repair. Both aim to reattach the meniscal root to its anatomical footprint, thereby restoring biomechanics and delaying degenerative progression. (Furumatsu et al., 2022)

The transtibial pullout technique involves creating a tibial tunnel through which sutures are passed and tied over a bone bridge or fixation device. This method is technically reproducible, cost-effective, and provides strong fixation. However, concerns have been raised regarding potential tunnel widening, loss of fixation strength over time, and non-anatomic placement in some cases.(Briese et al., 2025)

On the other hand, the suture anchor technique employs specialized anchors inserted into the tibial plateau, securing sutures directly to the meniscal root. This method provides anatomic fixation and avoids tibial tunnels but is technically demanding and may carry a higher cost. Additionally, anchor placement near the root attachment site poses a risk of cartilage damage if improperly executed.(Cuéllar et al., 2017)

Recent comparative studies have reported conflicting outcomes regarding healing rates, functional recovery, and complication profiles between these two techniques. Some trials suggest that transtibial pullout repairs provide comparable clinical outcomes to anchor-based repairs, whereas others highlight superior biomechanical stability and healing with suture anchors. These inconsistencies underscore the need for further evaluation of both methods in comparable patient populations.(Kumar et al., 2024)

The goal of surgical intervention is to preserve meniscal function, alleviate symptoms, and prevent osteoarthritis progression. Therefore, selecting the optimal repair technique for PRMMTs is critical in orthopedic practice. Evaluating and comparing these approaches may help establish evidence-based recommendations and improve patient outcomes. (Moon et al., 2023)

This study aims to evaluate the results of arthroscopic transtibial pullout suture versus anchor repair in patients with a tear of the posterior root of the medial meniscus using Lysholm and International Knee Documentation Committee [IKDC] scores.

Methodology

This study will be designed as a prospective, open-label, blinded-endpoint, randomized, single-center clinical trial conducted at Al-Zahraa University Hospital, Faculty of Medicine for Girls, Al-Azhar University (Cairo, Egypt). The study period extended from August 2023 to February 2026, during which patients will be consecutively recruited and followed up for at least 12 months postoperatively. The study was approved via the Institutional Review Board of Al-Zahraa University Faculty of Medicine, and it was given the following code: **1971/4-7-2023** The study followed the CONSORT guidelines for reporting the results(Hopewell et al., 2025).

Randomization

Randomization will be performed using a computer-generated random sequence, and allocation will be concealed in sealed opaque envelopes. The operations will be performed by the same senior orthopedic surgical team to minimize inter-surgeon variability. Neither the patients nor the surgeons will be blinded to the procedure; however, the outcome assessors will be blinded to the intervention type to reduce bias.

Sample Size

The sample size will be calculated using the Kelsey method with data derived from previous literature that reported differences in Lysholm and IKDC scores between the two techniques. Assuming an effect size of 0.8, a significance level (α) of 0.05, and a power ($1-\beta$) of 0.8, a minimum of 18 patients per group will be required. To account for potential dropouts, the sample will be increased to 20 patients per group (40 total).

Eligibility criteria

Inclusion Criteria

Patients aged between 20 and 50 years, who had an acute or degenerative posterior root tear of the medial meniscus, confirmed by MRI, will be included. Patients should have an isolated medial meniscus root tear or a tear associated with anterior cruciate ligament (ACL) injury.

Exclusion Criteria

On the other hand, we will exclude patients who refused to participate or had Knee joint malalignment (varus/valgus) confirmed clinically and radiologically. Also, patients with Osteoarthritis grade III or IV according to Kellgren–Lawrence classification, inoperable or severely degenerated, crushed meniscus. We excluded patients with prior ipsilateral knee fracture, infection, or tumor, and patients were deemed unfit for surgery or anesthesia.

Preoperative Evaluation

All patients underwent:

- Detailed history taking with emphasis on trauma, mechanical symptoms, and functional limitations.

- Clinical examination, including general examination and specific knee tests (McMurray test, Apley grinding test, joint line tenderness, and Akmese sign test).
- Radiological imaging:
  - ✓ Weight-bearing X-ray of the affected knee in anteroposterior (AP) and lateral (LAT) views.
  - ✓ The degree of pre-existing osteoarthritic changes was classified using the Kellgren–Lawrence grading system, and results were presented as Kellgren–Lawrence Grade, n (%).
  - ✓ Long-leg alignment views were performed if malalignment was suspected.
  - ✓ Magnetic resonance imaging (MRI) of the knee (sagittal, coronal, axial views) was considered the gold standard for diagnosing meniscal root pathology.

Operative Technique

All procedures were performed under spinal anesthesia with the patient in the supine position and a tourniquet applied to the proximal thigh. The operative field was prepared and draped in a standard sterile fashion.

A diagnostic arthroscopy was carried out through anterolateral and anteromedial portals. The tear pattern, tissue quality, and concomitant intra- articular pathology were evaluated

Transtibial Pullout Suture Repair

Arthroscopic Examination

Standard diagnostic arthroscopy was performed using anterolateral (viewing) and anteromedial (working) portals.

The posterior horn of the medial meniscus was carefully probed to confirm the presence, type, and extent of the posterior root tear.

The articular cartilage of the medial femoral condyle and tibial plateau was inspected to assess the degree of chondral damage, and associated pathologies were recorded

Preparation of the Root Footprint

The anatomic footprint of the posterior medial meniscus root was identified just anterior to the posterior cruciate ligament (PCL) insertion.

Fibrotic tissue and remnants were debrided using a curette and motorized shaver until bleeding cancellous bone was exposed, creating a biological bed for tendon-to-bone healing

Suture Passage Through Meniscal Root

Using a suture-passing device (Arthrex Knee Scorpion™ or Suture Lasso™), No. 2 FiberWire sutures were passed through the substance of the torn meniscal root

Two separate sutures were placed, usually in a Mason–Allen or luggage-tag configuration, to enhance fixation strength and tissue capture

Each pass was confirmed arthroscopically to ensure adequate tissue bite and avoidance of suture cutout or tissue cut through.

A low-profile ACL C- guide was introduced through the anteromedial portal and its tip positioned at the center of the root footprint.

Under direct arthroscopic visualization, a passing pin was advanced from the anteromedial tibial cortex to the root attachment site

A 4.5-mm cannulated drill bit was used over the passing pin to create a tibial tunnel directed toward the root footprint.

Care was taken to avoid tunnel convergence in cases of concomitant cruciate ligament reconstruction

Suture Retrieval Through Tibial Tunnel

The suture limbs were retrieved through the tibial tunnel using a suture- shuttling technique with a passing wire using a nonabsorbable suture (PDS, FiberWire, or Prolene No. 2) as a loop.

All suture ends were exteriorized from the tibial cortex exit point to allow extracortical fixation

Fixation on Tibial Cortex

The sutures were tensioned under direct arthroscopic visualization to reduce the meniscus to its anatomic footprint.

Fixation was performed over the proximal tibial cortex using one of the following devices:

Adjustable Button System (ABS) (extracortical suspensory fixation), EndoButton (extracortical fixation device), Screw and washer construct (for cost-effective secure fixation).

Small plate and screw and tie sutures o it through plate holes.

The fixation method was chosen according to surgeon preference and intraoperative availability.

Final Arthroscopic Assessment

The repair site was probed to confirm anatomic reduction, firm fixation, and absence of gapping. The knee was taken through full cycles of flexion and extension to ensure that the repair remained stable under physiological motion

Postoperative Radiography

Standard anteroposterior and lateral radiographs of the knee were obtained to confirm the position of the tibial tunnel and fixation device.

Suture Anchor Repair

Arthroscopic Examination

Arthroscopy was performed through anterolateral and anteromedial portals.

The posterior medial meniscus root tear was visualized and probed to confirm diagnosis and evaluate tissue quality

Associated intra-articular lesions were documented.

Preparation of the Root Footprint

The anatomic tibial attachment of the meniscal root was identified.

The footprint was debrided using a curette and shaver until a bleeding cancellous bone bed was created to promote tendon-to-bone healing

Anchor Tunnel Preparation

An ACL C guide was inserted through the anteromedial portal and positioned at the root footprint.

Under direct arthroscopic visualization, a tibial tunnel was created. The passing pin was advanced and retracted repeatedly to debride the tunnel walls, ensuring a smooth internal surface and achieving the desired concentric diameter. Drilling was performed carefully to avoid breaching the joint or damaging adjacent structures.

anteromedial portal, positioning its tip at the anatomic footprint of the meniscal root. B. drilling tunnel by passing pin advanced and retracted repeatedly toward the posterior tibial cortex to accommodate the suture anchor.

Anchor Insertion

Insertion of a nonabsorbable suture (PDS, FiberWire, or Prolene No. 2) into the tibial tunnel as a loop and retrieval through the anteromedial portal

A 2.9-mm all-suture anchor (ASA) was prepared. One limb of the suture was marked at 20 mm from the anchor using a sterile marker

A pulling suture was applied at the kink point of the ASA, and the anchor was pulled into the joint and guided into the drilled tunnel

reaches the drill hole at the meniscal root footprint.

By retracting on the suture, the anchor was deployed and locked beneath the tibial cortical bone, providing stable fixation

Suture Passage Through the Meniscus

The sutures of the anchor were passed through the meniscal root using a Scorpion™ or Lasso™ device. Simple or mattress sutures were performed to ensure secure fixation of the meniscal tissue

Knot Tying

Arthroscopic sliding knots were tied sequentially, with knot pushers used to advance the knots onto the meniscal root.

Adequate tension was maintained to ensure firm apposition of the root to its prepared footprint without over-constraining the meniscus

Final Arthroscopic Assessment

After knot were tied and suture ends were cutted the repair was probed to check stability, anatomic reduction, and absence of displacement under tension.

The knee joint was cycled through flexion and extension to verify repair integrity throughout the range of motion of the anchor repair.

Postoperative Radiography

Standard anteroposterior and lateral radiographs were obtained to confirm anchor placement and tunnel integrity

General Steps for Both Groups

Accessory portals: Posteromedial or posterolateral portals were created if needed for suture passage or anchor placement, ensuring safe passage by transillumination and careful blunt dissection to avoid saphenous nerve or vein injury.

Associated procedures: In cases with concomitant ACL tears, ACL reconstruction was performed in the same sitting, with tunnel planning adjusted to avoid convergence.

Closure: Hemostasis was achieved, arthroscopic fluid was drained, and portals were closed with proline sutures. Sterile dressings and compressive bandages were applied.

Postoperative Rehabilitation

- Patients will be kept non–weight-bearing on crutches for 6 weeks.
- A hinged knee brace will be applied in extension for the first 2 weeks.
- Quadriceps setting and straightleg raise exercises were initiated immediately postoperatively.
- Range of motion should be increased gradually by 30° every 2 weeks, reaching 135° by 10 weeks.
- Partial weight bearing will be started at 6 weeks, with progression to full weight bearing by 10–12 weeks.

- Deep knee flexion and squatting will be avoided until 3 months postoperatively.
- Return to full sports activities will be permitted at 6 months.

Compliance with rehabilitation was supervised by the same physiotherapy team, and adherence was documented.

Outcomes

The primary outcomes are subjective functional improvement assessed via 1/ Arabic validated form of the Lysholm score(Ahmed et al., 2019) and the Arabic validated form of the International Knee Documentation Committee (IKDC) 2000 score. (Ahmed et al., 2019) These outcomes were assessed at 3, 6, and 12 months postoperatively.

The secondary outcomes included meniscal evaluation tests, Pain relief, return to activity, and operative complications

Statistical Analysis

Data will be entered into SPSS software (version [28]). Quantitative variables will be expressed as mean ± standard deviation (SD), while categorical variables will be expressed as frequencies and percentages. An independent t-test or Mann–Whitney U test will be used to compare continuous data between groups, while the Chi-square test (or Fisher's exact test) will be used for categorical variables.

Repeated measures ANOVA will be applied to compare preoperative and postoperative scores within groups. A P-value < 0.05 was considered statistically significant. Finally, Multivariable logistic regression was performed to assess the predictors of the poor outcomes defined as Lysholm score < 80 or IKDC score $< 80\%$ at 12- month follow-up

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