Review of Meniscal Root Tears: Diagnosis, Classification and Treatment

Miten Rajendra Sheth¹, Sachin Ramchandra Tapasvi², Shantanu Sudhakar Patil²

Abstract:
Meniscal root tears include direct avulsions off the tibial plateau or radial tears adjacent to the root itself. These injuries eventually behave as meniscectomised knee and predispose to accelerated degeneration. The present review accounts for the current development in diagnosis and management of these injuries and also gives details of authors preferred method of treatment of these injuries.

Keywords: Meniscal root tear, classification, management

Introduction
The menisci are integral to overall function of the knee and play a key role in shock absorption, joint stabilization, and possibly proprioception [1,2]. More importantly, each individual meniscus dissipates around 70-90% of the axial load transmitted through its respective compartment, and hence protects the articular cartilage [3]. In addition to menisco-capsular attachments, there are four meniscal roots that firmly anchor the medial and lateral menisci to the anterior and posterior tibial inter-condylar region [4]. For the menisci to function properly, the bio-mechanical integrity of both anterior and posterior roots on the tibial plateau must be maintained [5,6].

Occurring on either the medial or lateral meniscus, root tears by definition include direct avulsions off the tibial plateau or radial tears adjacent to the root itself [7]. These tears left untreated result in loss of hoop tension and altered tibio-femoral contact forces. These injuries eventually will behave similar to a meniscectomized knee and predispose to accelerated degeneration [3,4,6]. Improved ability to detect them, and an increased understanding of their bio-mechanical consequences, has prompted a lot of research in the field of root tears and their management. This review summarizes the literature regarding assessment of meniscal root tears, their classification and treatment.

Diagnosis
Meniscal root tears can occur in both acute and chronic settings. Acute tears of the posterior root of the lateral meniscus have been associated with contact anterior cruciate ligament (ACL) injuries, where as those of the posterior root of the medial meniscus are either seen in younger patients with multi-ligament injuries or in older patients with subtle trauma due to hyper-flexion or squatting [8,9,10]. More frequently, posterior root tears are chronic injuries associated with meniscal extrusion, observed in older patients, as an expression of osteoarthritis [2,9,11]. Of the possible four sites for a root tear, a posterior root tear of the medial meniscus is most common. This may be because of the fact that it is the least mobile of all meniscus roots [2,12]. In general, posterior horns of the menisci bear more load than anterior horns, especially at 900 of flexion, and are more likely to be injured [13]. Posterior root tears of the medial meniscus have a reported higher prevalence in Asian countries, where a floor-based lifestyle is habitual, especially in the older population (over 50 years of age) [14,15]. Individuals with a higher body weight index, lower activity level, varus mal alignment and females are at an increased risk [16].

Anterior root tears are very infrequent, and may occur as a consequence of tibial tunnel drilling during ACL reconstruction, or intra-medullary nailing for a tibial shaft fracture [17,18].

Diagnosis of a meniscal root injury is difficult and challenging because the clinical presentation is unlike that of a meniscal body tear. Mechanical symptoms classic of a meniscal injury may not be present [19]. Further, posterior root tears of the medial meniscus may be diagnosed in patients with knee pain without any recollected traumatic event [20]. A popping sensation in the knee at onset followed by severe pain may indicate an acute posterior root tear. Symptoms resolve eventually and patients are able to walk, but residual posterior knee pain may persist [16,21,22]. In our practice an interesting finding noted by some patients is sudden onset of pain on getting up from a chair or while trying to climb stairs. These patients also report inability to sit cross-legged on the floor, after the onset of pain. The natural history of untreated root tears follows a protracted course with premature and extensive degeneration the rule rather than the exception [6,7,23].
2. Physical examination
The most common signs are posterior knee pain with deep flexion and joint line tenderness [21]. In our practice Payr’s test (Fig 1) has proved to be a useful adjunct to medial joint line tenderness and McMurray test to diagnose acute posterior tears of the medial meniscus in patients with early to moderate arthritis. Additionally, the extruded meniscus may be palpated over the anteromedial joint line, when the knee is given a varus stress in full extension [24].

3. Radiographic Evaluation
Plain radiographs must ideally include anteroposterior, true lateral, patellar skyline and Rosenberg views of the knee as well as a standing, coronal, weight-bearing scanogram of both lower limbs [7]. These radiographs are

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Figure 1: A,B,C,D- Payr’s test. Payr test is used to evaluate for medial meniscus tears by applying a varus force to compress the medial meniscus with the knee held in 90° of flexion.

Figure 2: - Images - 3 Tesla MRI with knee coil. 2A - Ghost sign- sagittal plane. 2B - Radial linear defect in axial plane. 2C- Vertical linear defect in coronal plane.
used to judge overall limb alignment and joint space
narrowing. Traumatic root tears, mostly identified in
younger patients, have unremarkable radiographs except
in cases with bony root avulsions [25]. Degenerative root
tears, common in older patients, are more often than not
accompanied by varus alignment and arthritic changes on
radiographs [11, 1. The presence of arthritis and the degree
of arthritis has an influence on the treatment offered to
patients with a degenerative root tear.

If a root tear is suspected on the basis of clinical findings,
an MRI must be obtained. MRI scan is the gold standard in
diagnosing these lesions [2]. A high index of suspicion is
necessary to pick up these tears on MRI scans. Recent
studies have proposed that MRI could have a 100% detection rate if images in all three planes are reviewed
along with clinical symptoms. ‘Ghost sign’-absence of an
identifiable meniscus on sagittal plane; radial linear defect
at the root insertion on axial plane; and a vertical linear
defect at the root insertion on coronal plane, are the best
indicators of a root tear [26,27] (Fig. 2). Absolute meniscal
extrusion >3mm or a relative extrusion >10% are
significantly associated with articular cartilage
degeneration and highly correlate with the presence of a
root tear [28,29]. Sub-chondral bone marrow edema
usually precedes a root tear and subsides when the tear
occurs but insufficiency fractures may be seen as well
[8,30]. Recently, fat-suppressed volume isotropic turbo
spin echo acquisition (FS 3D VISTA) with reader defined

![Figure 3- Classification of root tears](image)

![Figure 4- 4A- Two UHWMPE sutures threaded through the root. 4B- Diagrammatic representation of post-fixation. 4C- Root repaired](image)
axial reconstruction has been described as a powerful diagnostic tool for visualization of root tears [31].

Classification

With the hope of ensuring uniform and improved reporting, meniscal root tear patterns have been categorized by several authors on the basis of MRI as well as arthroscopy.

MRI:

Posterior medial meniscus root lesions can be classified as: degeneration and tear, the latter being categorized into partial or complete with delineation of the point of failure as enthesis, mid-substance, or meniscal junction [32].

Arthroscopy:

LaPrade et al, on the basis of tear morphology, classified all root tears as: partial stable root tears (type 1), complete radial tears within 9 mm from the bony root attachment (type 2), bucket-handle tears with root detachment (type3), complex oblique or longitudinal tears extending into the root attachment (type 4), and avulsion fractures of the root attachment (type 5). Radial root tears are subclassified into types 2A, 2B and 2C (0 to <3 mm, 3 to <6 mm, and 6-9 mm respectively). In addition, complete posterior lateral meniscal root tears with intact menisco-femoral ligament(s) can be considered a variant tear pattern [33].

Degenerative medial meniscus root tears can be classified as: non-displaced and widely displaced, the latter group being associated with greater meniscal extrusion, and more severe chondral wear and arthritis [34]. Posterior lateral meniscus root tears can be classified as: avulsion of the root (type 1), radial tear of the posterior horn close to the root with an intact menisco-femoral ligament (type 2), and complete detachment of the posterior horn (type 3) [35].

Treatment.

The treatment options for meniscal root tears include conservative management, partial meniscectomy and repair. Factors confounding the decision-making process include: age of the patient, symptoms, cartilage status, presence or absence of meniscal extrusion, type, location and chronicity of the root lesion.

Conservative treatment:

Although non-operative management of root tears fails to restore native bio-mechanics and may induce arthritic changes over time, certain patients may best be treated non-surgically [36]. Symptomatic treatment with rest, cryotherapy, anti-inflammatory medications, activity modification, and/or unloader bracing may alleviate joint pain. Patients with multiple co-morbidities, advanced age, and severe osteoarthritis must attempt a period of non-operative treatment before undergoing surgical intervention [1,3,7].

Partial Meniscectomy

Partial meniscectomy is the preferred treatment option in patients with chronic root tears and symptomatic grade III or IV chondral lesions (pre-existing arthritis) who fail non-operative treatment, and patients with partial root tears with a major portion of the footprint intact. Advantages of partial meniscectomy over repair include reduced operative time, easier post-operative rehabilitation, and faster return to activities and sports. These gains and improved short-term subjective scores must be read cautiously, knowing that patients undergoing root repair have better improvement in scores and less progression of arthritic changes over time [1,15,16,38].

Repair

Since root tears bio-mechanically simulate a total meniscectomized state, there has been a recent trend towards repair and reattachment over meniscectomy [6,8]. Surgical repair is best reserved for patients with good cartilage status and relatively acute root tears. Indications for meniscal root repair include: (i) acute symptomatic root tears with minimal arthritis, (ii) chronic symptomatic root tears, having failed conservative treatment, without significant pre-existing arthritis or varus mal-alignment, (iii) lateral meniscus root tears concomitant with ACL injuries [1,5,7,9,10,20,39].

Several techniques and fixation methods have been described to repair either medial or lateral root tears. The surgical techniques fall into two broad categories: pull-out suture repairs and suture anchor repairs. Recent description of surgical landmarks has facilitated accurate identification of the roots and the key is anatomic repair irrespective of the technique used [40,41].

Pull-out suture repair:

The pull-out suture method involves drilling of one or two tibial tunnels, with an ACL guide, at the root insertion. Standard anteromedial and anterolateral portals are sufficient to complete the repair using a suture passing device or shuttle, and non-absorbable ultra-high molecular weight poly-ethylene (UHMWPE) sutures [1]. A posterior trans-septal portal and high posteromedial or posterolateral portals have been useful to improve visualization and suturing of the roots [5,42,43]. Several single or double suture configurations have been described and can be used, though it seems that two stitches are better than one, and the modified Mason-Allen technique provides the best bio-mechanical strength [20,44] The sutures can be retrieved through the
proximal tibial bone tunnels, made employing an ACL guide, and they can then be fixed using a bone bridge, button or screw and washer [5,20,25,44].

**Suture anchor repair:**
In the setting of multi-ligament or revision surgery, suture anchor repair seems to be the better option as it avoids the need for tibial bone tunnels. Most suture anchor techniques involve creation of an accessory posteromedial or posterolateral portal [45,46]. An arthroscopic knot is placed directly on the meniscal root with a knot pusher and more precise tensioning of the repair is theoretically possible.

**Our preferred method**
The senior author's current preferred technique for medial meniscus posterior root fixation involves a trans-osseous pull-out suture repair. Besides two standard portals, a 2-cm oblique incision is made over the anteromedial tibia for drilling trans tibial tunnels. Whilst performing the root repair with a concomitant ACL reconstruction, care should be taken to avoid coalition of tunnels. A commercial suture passing device is used to thread two UHMWPE sutures through the root. A bone tunnel is created with an ACL tibial guide, using a 4.5mm reamer over the guide pin. The two sutures are retrieved from these tunnels, the knee is cycled and then these sutures are tied over a fixation post; one with the knee in extension and other with the knee in 900 of flexion. This ensures uniform tension across the repair in this range, and allows range-of-motion exercises post-operatively.

**Rehabilitation:**
As of today, there is no real consensus regarding post-operative rehabilitation after root repair.

Isometric quadriceps strengthening exercises can be started immediately on the first post-operative day itself. Both immobilization for a variable period of time, and immediate passive motion have been suggested in the early post-operative period [1, 20]. Slow, progressive increase in range of motion, individualized to each patient, is advised over ensuing weeks. The general consensus is to restrict weight-bearing for first six weeks, followed by a progressive increase to full weight bearing by two months [1, 39]. Return to full activity and sports can be expected by four-six months post-operatively, depending on other concomitant injuries [1, 7].

**Treatment Outcomes:**
Several authors have reported outcomes comparing the three existing modalities of treatment.

Both non-operative treatment and partial meniscectomy may provide short-term symptomatic relief but they do not halt progressive degeneration of the affected knee [2, 36]. These findings parallel bio-mechanical evidence equating untreated root tears with knees having undergone total meniscectomy [3, 6,8]. An anatomic medial meniscal root repair heals well, restores hoop tension, and improves clinical and radiographic scores [1, 3,20,44]. There is no evidence to prove that root repairs retard the progression of arthritis, though it has been reported that repairs do better than partial meniscectomy in this regard [47]. Both methods of root repair (pull-out suture and suture anchor) result in improved functional scores [22,44,46].

The optimal technique is yet to be determined, though it seems that that suture anchors provide superior biomechanical properties compared with pull-out sutures [48]. Complete healing of the repaired root and reduction of meniscal extrusion are less predictable [44]. Posterior root tears of lateral meniscus have been treated conservatively and with root repair, with low level evidence justifying either line of management [5,36].

**Complications:**
Most intra-operative complications are related to surgical technique and include iatrogenic damage to ACL or cartilage of the ipsilateral compartment, and injury to posterior neuro-vascular structure [7]. Potential complications unique to the pull-out suture technique include tunnel coalition during multi-ligament surgery, suture abrasion or stretching within tunnels, and displacement of the repaired root with knee movements post-operatively [1,49]. Suture anchor repairs may fail due to inadequate knot tensioning during surgery or loosening of anchors post-surgery [21]. Meniscal root repair is a technically demanding surgery. Insufficient tension on the repair, inadequate tissue-bite or quality, and non-anatomic fixation may not restore joint biomechanics [21,50].

There is insufficient evidence to elucidate prevalence of re-tears and evidence regarding anterior root tears is yet lacking because of low incidence of these injuries.

**Conclusion**
Posterior root tears of either meniscus alter tibio-femoral mechanics and may lead to progressive degeneration of the knee. Clinical diagnosis is challenging and surgeons must be watchful to not miss these tears. Most root tears can be identified with improved MRI imaging and experienced reporting. Recent clinical studies suggest a clear benefit of repairing acute root tears especially in patients with minimal arthritic changes. An anatomic root repair, irrespective of the technique used, affords the best chance for healing, restoring original biomechanics and possibly retarding progression of arthritis. Further studies are needed to elucidate efficacy of different surgical techniques and long-term consequences of root repairs.
References


