

## Posterior medial meniscal root lesions and its different patterns: an imaging approach

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## Learning objectives

- Review relevant meniscal anatomy based on Magnetic Resonance Imaging (MRI).
- Identify and demonstrate the main imaging findings of a posterior medial meniscal root tear (PMMRT) with illustrative cases.
- Discuss PMMRT association with several pathologies and clarify possible pitfalls.
- Elaborate a diagnostic work-up protocol for the radiologist

## Background

Identification of meniscal root tears at MRI is crucial because new arthroscopic surgical techniques have been developed to repair meniscal root tears and preserve the tibiofemoral cartilage of the knee. If left untreated, the consequences may include an early degenerative joint disease, with features like progressive cartilage loss, osteoarthritis, and subchondral edema, with the potential for development of a subchondral insufficiency fracture.

MRI consists in a fundamental tool in the anatomic assessment, detection and management of PMMRT. We will review this condition, focusing on the aspects and specific protocols that can be most helpful to evaluate this condition and its associations.

## Findings and procedure details

The meniscal roots are ligament-like structures that anchor the meniscal body and horns to the tibial plateau and provide added mechanical stability for femorotibial gliding [1,3]

The semicircular medial meniscus has a wide posterior horn, narrows anteriorly, and has a more open C-shaped configuration than the more circular lateral meniscus. The attachment of the

posterior horn of the medial meniscus is located at the posterior intercondylar fossa of the tibia. It can be identified between the attachment of the posterior horn of the lateral meniscus and the PCL. [1] (Figs. 1,2)

The menisci are important structures for the knee, sharing the force load by increasing the contact surface area and providing uniform distribution of weight bearing across the articular surfaces. [11]

The meniscus increases the contact surface and resists radial extrusion from axial loading. In addition, the meniscal roots provide secondary stability to the knee; the posterior root of the medial meniscus provides support against tibial external rotation and lateral translation leading to varus deformity of the articular cartilage. [3]

The medial meniscus is less mobile than the lateral meniscus and is firmly fixed to the joint capsule. The relatively limited mobility of the medial meniscal attachment to the deep layer of the MCL and capsule render the medial meniscus susceptible to injury. [1,3]

Meniscal body and horn tears occur in numerous tear types, including radial, longitudinal, bucket-handle, and degenerative tears with each tear pattern requiring specialized treatment approaches. [10](Fig.3)

Root tears had been defined as "an avulsion of the tibial insertion of the meniscus or a radial tear close to the meniscal insertion". Various numbers of authors have defined meniscal root tears as tears within 9 to 10 mm of the root attachment. In addition, biomechanical studies have described that complete radial tears up to 9 mm from the root attachment significantly alter the native biomechanics of the posterior meniscal roots. [10, 11]

Laprade et al. were able to classify meniscal root tears into 5 tear types: partial stable root tears (type 1), complete radial tears within 9 mm from the bony root attachment (type 2), bucket-handle tears with complete root detachment (type 3), complex oblique or longitudinal meniscal tears with a complete root detachment (type 4), and avulsion fractures of the meniscal root attachment (type 5) [10] (Figs. 4)

Posterior meniscus root tears typically result in loss of meniscal circumferential hoop stress. Equivalent peak tibiofemoral contact pressure has been shown between a complete posterior medial meniscal root tear and a total medial meniscectomy. [3, 11]

PMMRT is the most common lesion, with a prevalence of 10 to 21% of meniscal surgeries. More frequently these are chronic injuries associated with meniscal extrusion, reduced shock absorption, joint degeneration and ultimately osteoarthritis. [6]

In clinical practice, the incidence of these lesions is often underestimated. The clinical diagnosis is often limited by unspecific symptoms. Presenting symptoms are posterior knee pain; Joint pain (at the joint line); Clicking; Effusions; essential-but not always present-clinical diagnostic tool is the presence of a popping sound during light activities such as doing housework, going upstairs/downstairs, rising from a chair, and squatting. [1,5]

The gold standard for diagnosis of a meniscal root lesion is under direct visualization during arthroscopy. In most cases, however, the diagnosis of meniscal root tears should occur prior to proceeding to the operating room

MRI has profoundly changed our ability to image the meniscal root, thereby allowing us to more accurately define both normal and pathologic anatomy.

The typical parameters used in menisci MRI include a field of view of 16 cm or less, a matrix size of at least 192 × 256 (phase-encoding × frequency-encoding directions), and a section thickness of 3-4 mm [7]. The accuracy of MR imaging for tear detection is comparable at field strengths ranging from 0.1-7.0 T; however, higher field strengths often improve spatial resolution and reader confidence and reduce image acquisition time. For detection of medial meniscal root tears, coronal T2-weighted images show higher accuracy (96%, compared with 85% for PD-weighted images). More recently, three-dimensional (3D) sequences with isotropic resolution have been developed that provide thinner sections and reduce partial volume averaging. [4]

If an PMMRT is identified, one must determine whether there is associated medial compartment degenerative cartilage wear, to identify the subset of patients who might benefit from root repair. [10]

MR imaging criteria for meniscal tears include abnormal morphologic structure or abnormal fluid-sensitive signal intensity extending to the articular or osseous surface [3,5]

The addition of the "two-slice-touch" rule of seeing the tear on two or more MR images increases the positive predictive value for a medial meniscal tear to 94% from 91% and increases the positive predictive value for a lateral meniscal tear to 96% from 83% . Meniscal tears isolated to the posterior root of the medial meniscus can be detected with a high sensitivity of 86%-90% and a high specificity of 94%-95% [3,4]

Direct signs for radial meniscal root tear include a radial linear defect on axial MR images perpendicular to the long axis of the meniscus, a "cleft" sign on coronal MR images, and a "truncated triangle" or "ghost meniscus" on sagittal MR images. The ghost sign consists in the absence of an identifiable meniscus in the sagittal plane, or an increased signal replacing the normally dark meniscal tissue signal in more than 3 contiguous MRI cuts. [5] (Figs. 5, 6)

Secondary or indirect signs of a meniscal tear are MR imaging findings that can accompany meniscal tears. In technically limited or equivocal cases, these signs can increase the reader's diagnostic confidence. Although these indirect signs have low sensitivity, they have high specificity and high PPVs for an underlying tear. [4] (Fig. 7,9)

Meniscal extrusion is an indirect and concerning sign that may be observed on MRI. Medial meniscal extrusion, which is defined as a partial or total displacement of the meniscus from the tibial articular cartilage, is a finding highly correlated to the presence of a root tear. If greater than 3 mm of displacement of the medial meniscal body in the midcoronal plane is considered pathologic extrusion, often associated with radial tear of the medial meniscus and, specifically, MRT. Other indirect signs that can be found are parameniscal cysts, joint effusion and subchondral marrow edema. [5,7,10] (Fig. 7)

In addition, a higher risk of spontaneous osteonecrosis of the knee (SONK) has been described in association with PMMRT, compared with *simple* radial tears of the meniscus. PMMRT is associated with SPONK in 80% of patients, while medial meniscal tears in. [6] (Fig. 8)

At our institution, we describe the grade of the tear-degeneration, partial tear, or complete tear; the orientation of the tear-radial or longitudinal or complex; and the distance of the tear from the root attachment and possible extension into the posterior horn. These factors have implications in the preoperative planning for root repairs. Similar kind of description is also viewed in another institutions. [3]

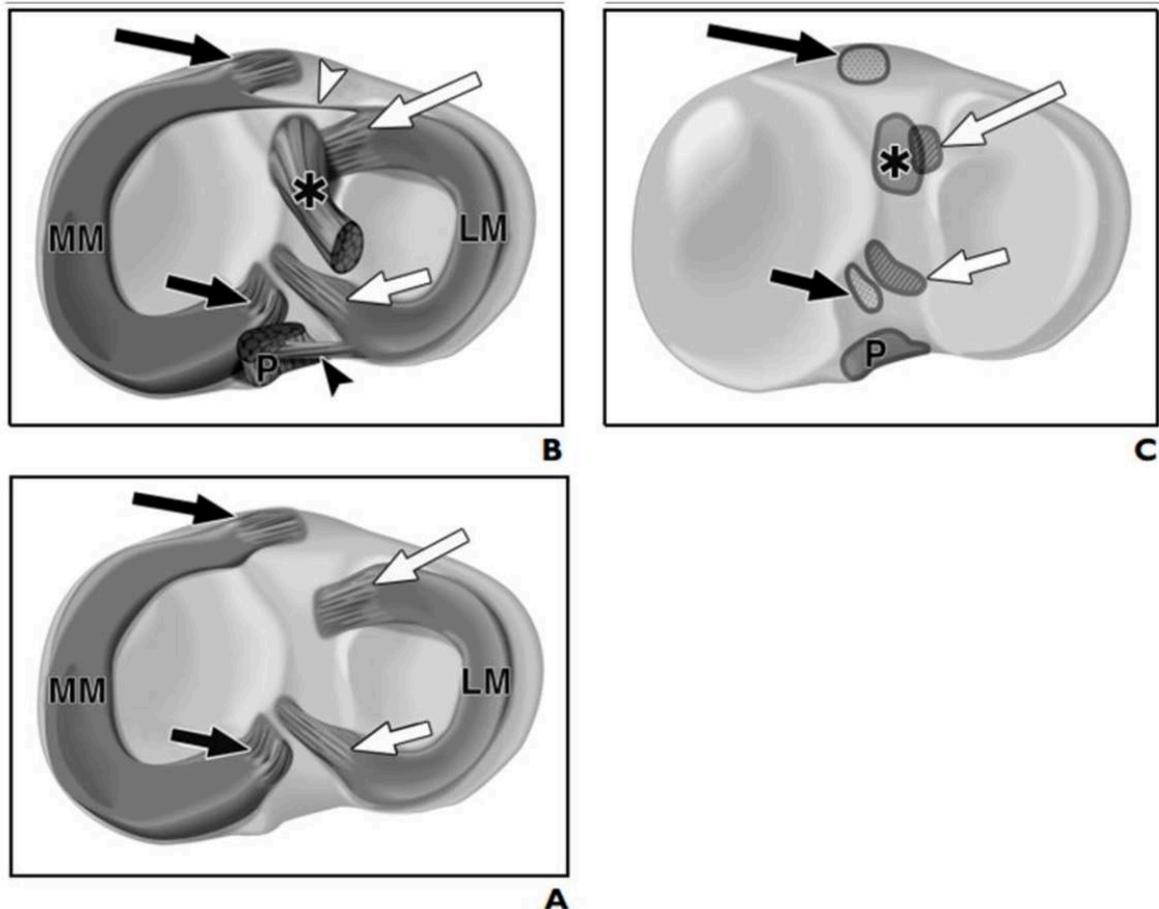
Over the last few years, there has been an increasing interest in surgical repair of tears or avulsions at the meniscal root. All of the described techniques are done arthroscopically or in an arthroscopically assisted manner to avoid posterior dissections of the knee. [8]

Repair is usually indicated for patients with acute tears, with or without associated soft tissue injury to the knee, and those with chronic or acute on chronic tears with minimal arthritis within the knee. Depending on the tear pattern, repair techniques include pull-out (transosseous), suture anchors, and side to side repair. Additional posteromedial and posterolateral portals can be established to facilitate the procedure. [3,6, 8]

There have been limited clinical studies following MRTs and repairs. Complete healing has been defined as continuity of the repaired root in all three planes (axial, coronal, and sagittal), partial healing as the loss of continuity in one plane, and a repeat tear as the loss of continuity in all three planes. In general, an intact repair is characterized by root

continuity and no T2 hyperintensity extending to the articular surface a partial repeat tear is characterized by partial discontinuity and T2 hyperintensity extending to the articular surface, and a complete repeat tear is characterized by complete discontinuity and T2 signal void. [3]

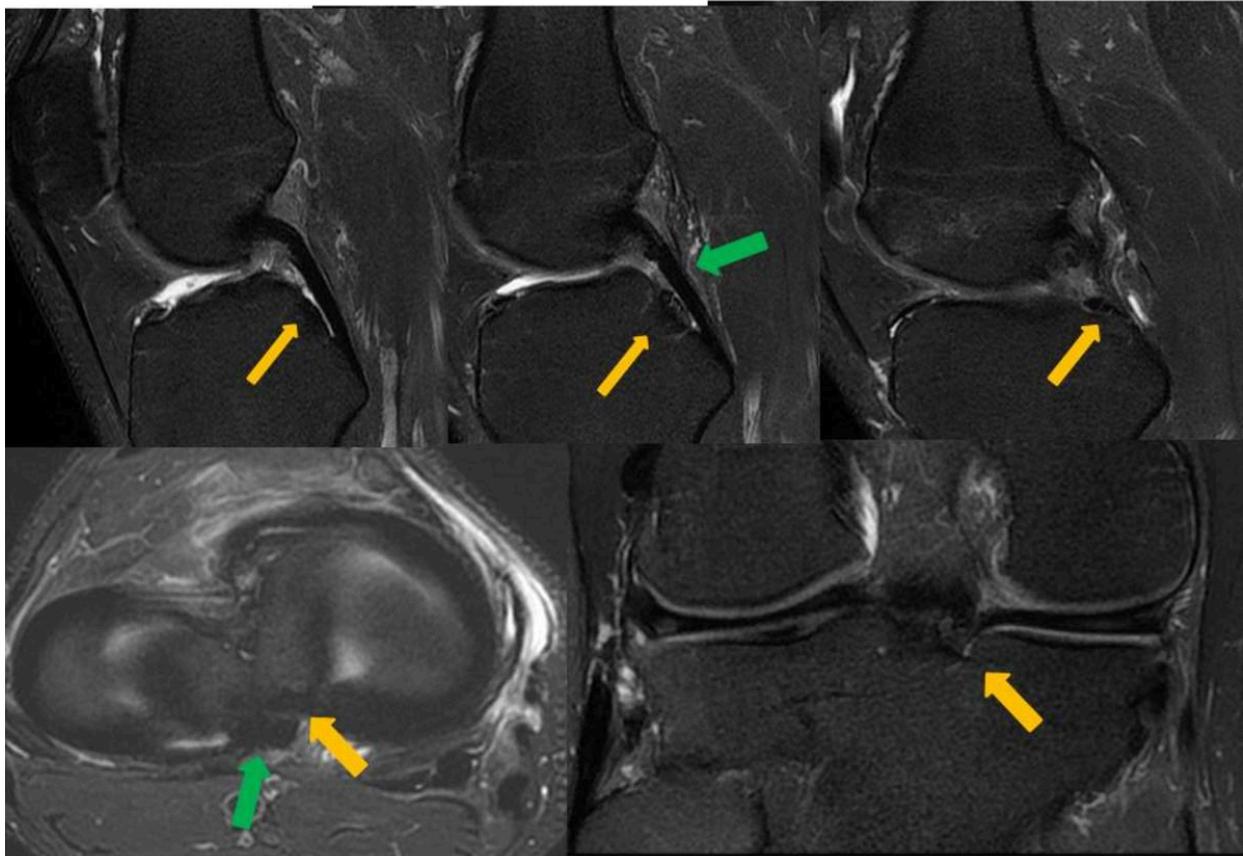
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**Fig. 1:** A, Superior-view drawing shows relative insertion site positions on right tibial articular surface. B, Superior-view drawing shows relations to anterior cruciate ligament (asterisk), posterior cruciate ligament (P), posterior menisiofemoral Wrisberg's ligament (black arrowhead), and transverse genual ligament (white arrowhead). C, Superior-view drawing shows relative locations of tibial insertion sites with soft-tissue structures removed. Asterisk indicates anterior cruciate ligament. P = posterior cruciate ligament. D, Photograph corresponds to C. MP = medial tibial plateau, MT = medial tibial tubercle, LT = lateral tibial tubercle, LP = lateral tibial plateau. P = Posterior cruciate ligament. A B C Fig. 2-Cadaver of 59-year-old man. Photographs show anatomic relations of anterior meniscal roots, transverse genual ligament, and tibial insertion of anterior cruciate ligament (ACL). A, Anterior view of knee with menisci and ligaments removed shows outlined insertional footplate of anterior root of medial meniscus (black arrow) on anterior intercondylar crest (arrowheads), anterior root of lateral meniscus (white arrow), and tibial insertion site of ACL (asterisk). LP = lateral tibial plateau, LT = lateral tibial tubercle, MP = medial tibial plateau, MT = medial tibial tubercle. B, Anterior view of knee with meniscus and ligaments in place shows relations of anterior root of medial meniscus (black arrow), anterior root of lateral meniscus (white arrow), ACL (asterisk), and transverse genual ligament (hook). C, Anterior view of knee with ACL removed (asterisk) shows shared insertion of anterior

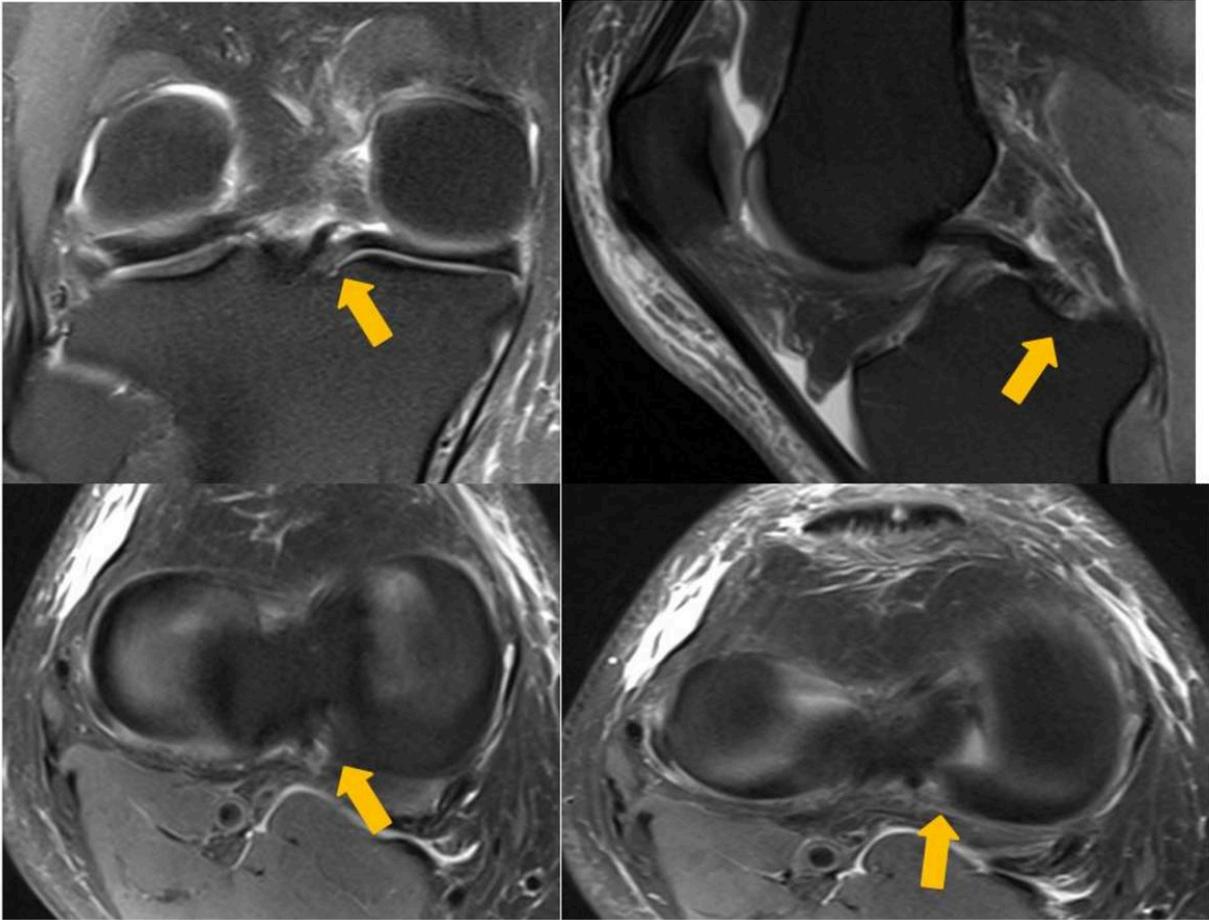
root of lateral meniscus (white arrow) and fibers of anterior root of medial meniscus (black arrow) in foreground.

© Brody JM et al. The meniscal roots: gross anatomic correlation with 3-T MRI findings. AJR 188: W446-W450, 2007.



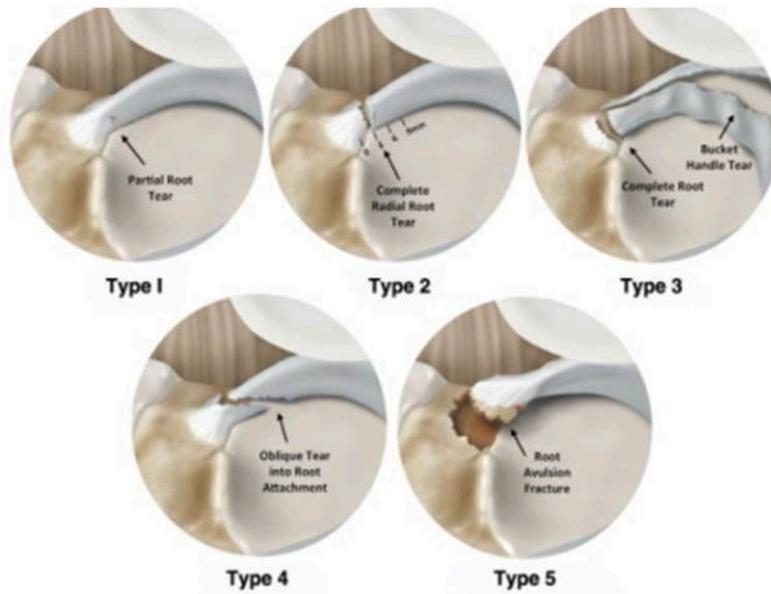
**Fig. 2:** Fat-suppressed proton-density-weighted MR image shows a normal medial meniscus root (yellow arrow) and its important relation with posterior cruciate ligament (PCL)(green arrow) in three planes.

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**Fig. 3:** Fat-suppressed proton-density-weighted images shows a subtle high intensity foci on the posterior medial meniscal root (yellow arrow) indicating degenerative changes and partial tear (Laprade type 1).

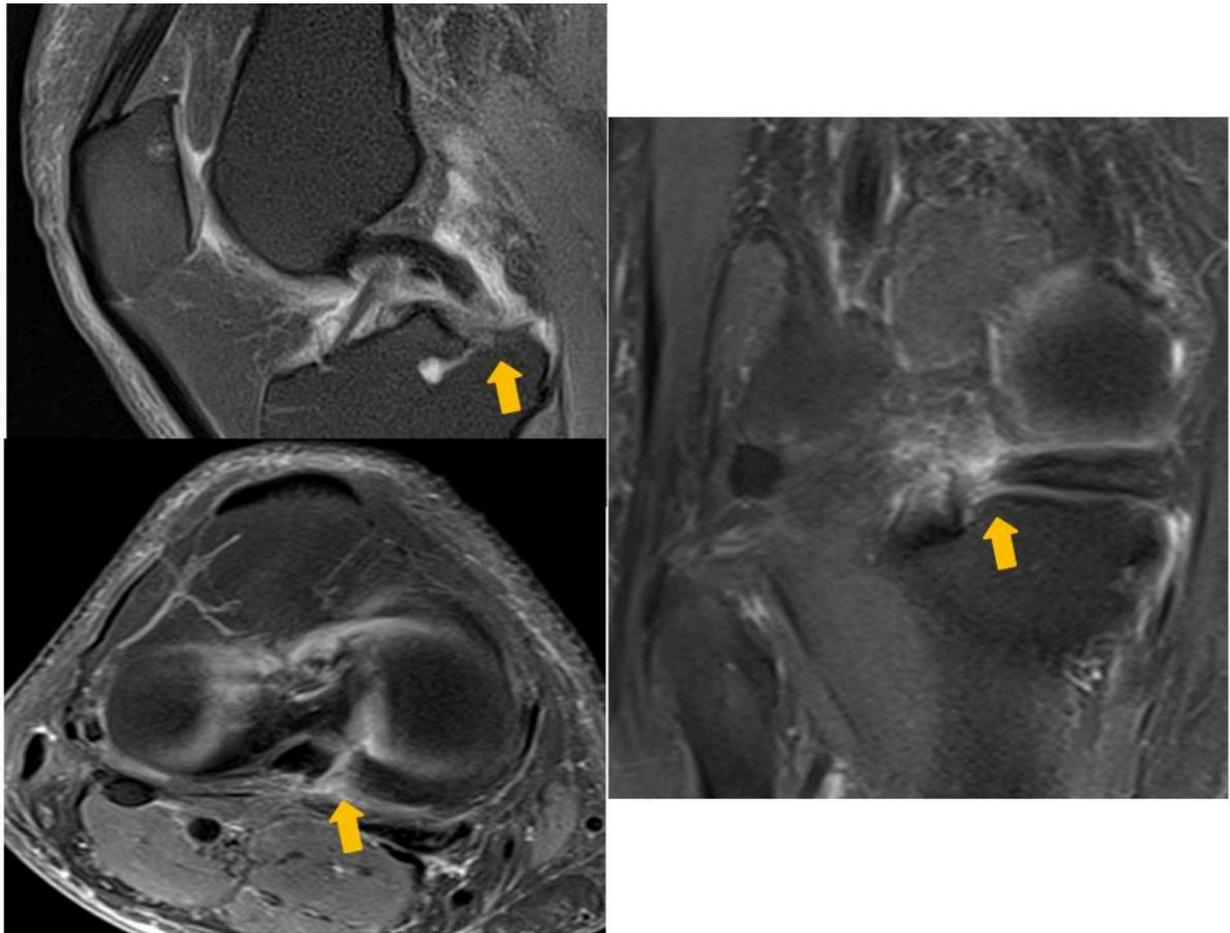
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**Figure 1.** Illustrations of the meniscal root tear classification system in 5 different groups based on tear morphology. All meniscal tears are shown as medial meniscal posterior root tears for consistency in this illustration. The 5 tear patterns were classified based on morphology: partial stable root tear (type 1), complete radial tear within 9 mm from the bony root attachment (type 2), bucket-handle tear with complete root detachment (type 3), complex oblique or longitudinal tear with complete root detachment (type 4), and bony avulsion fracture of the root attachment (type 5).

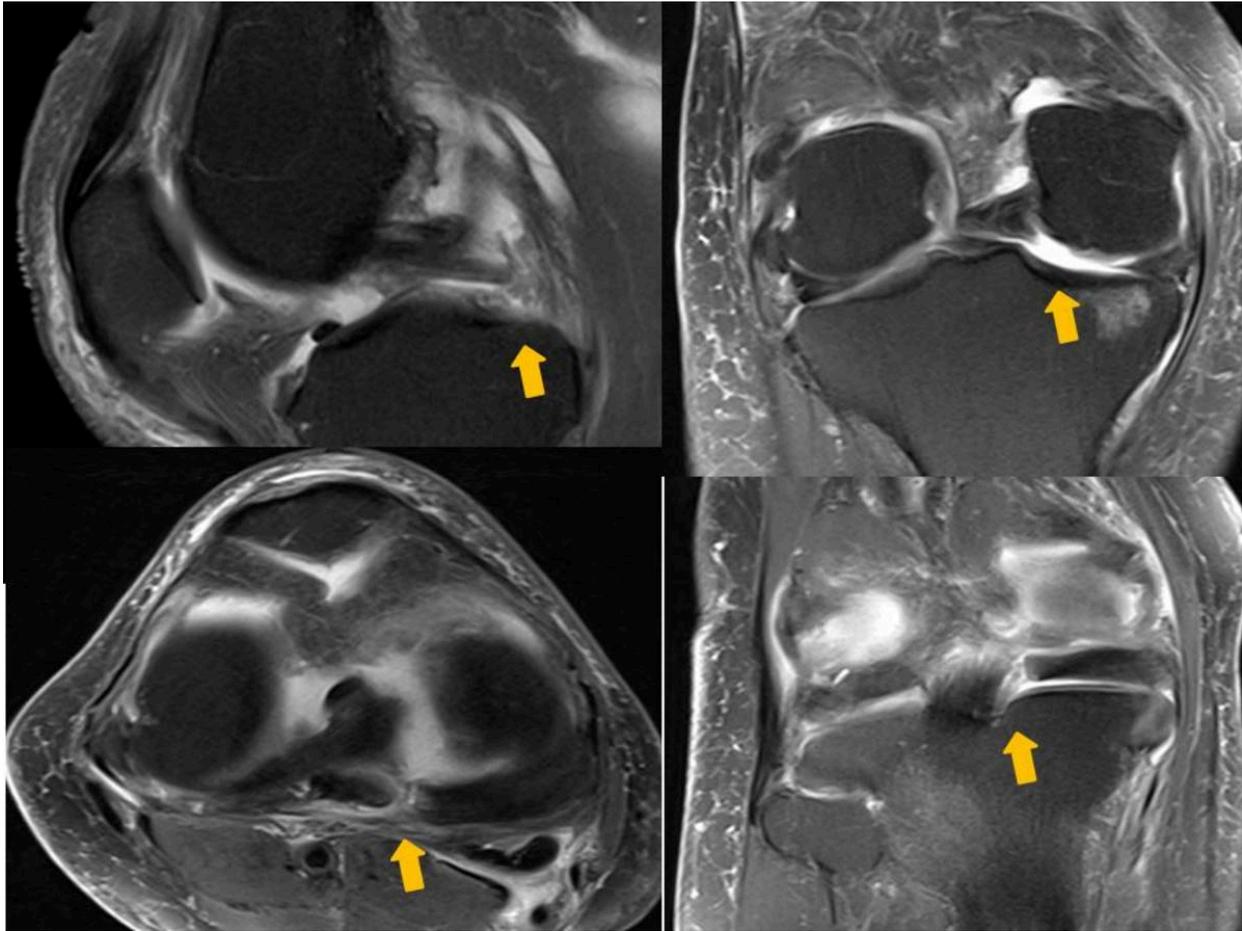
**Fig. 4:** Laprade classification of root tears.

© LaPrade et al. Meniscal root tears: a classification system based on tear morphology. Am J Sports Med 2015b;



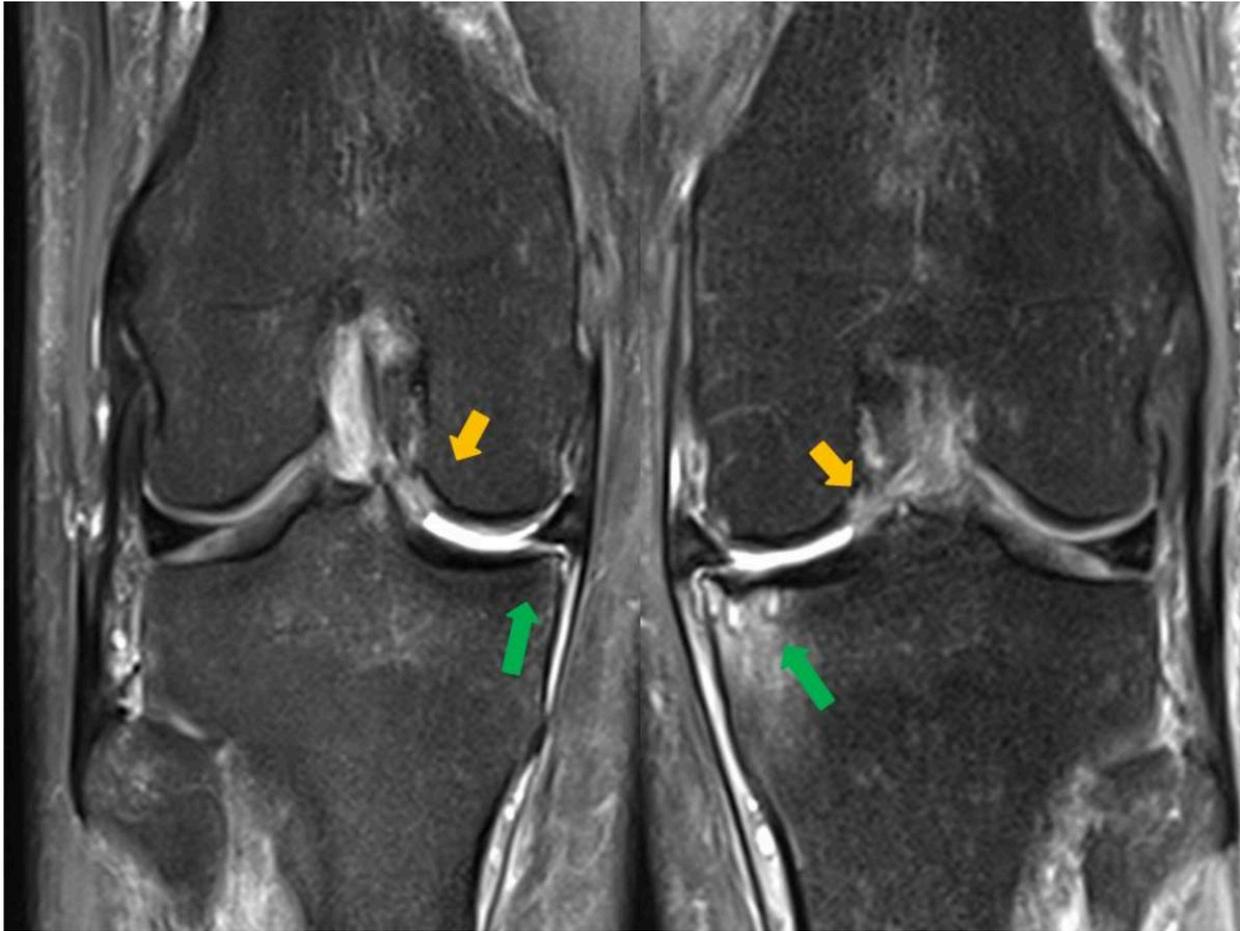
**Fig. 5:** Fat-suppressed proton-density-weighted MR images shows a complete radial tear a complete radial tear (arrow) to the posterior root of the medial meniscus, with complete discontinuity of the meniscal root and a fluid gap. Direct signs for a complete radial meniscal root tear include a radial linear defect on axial MR images, a "cleft" sign on coronal MR images, and a "ghost meniscus" on sagittal MR images.

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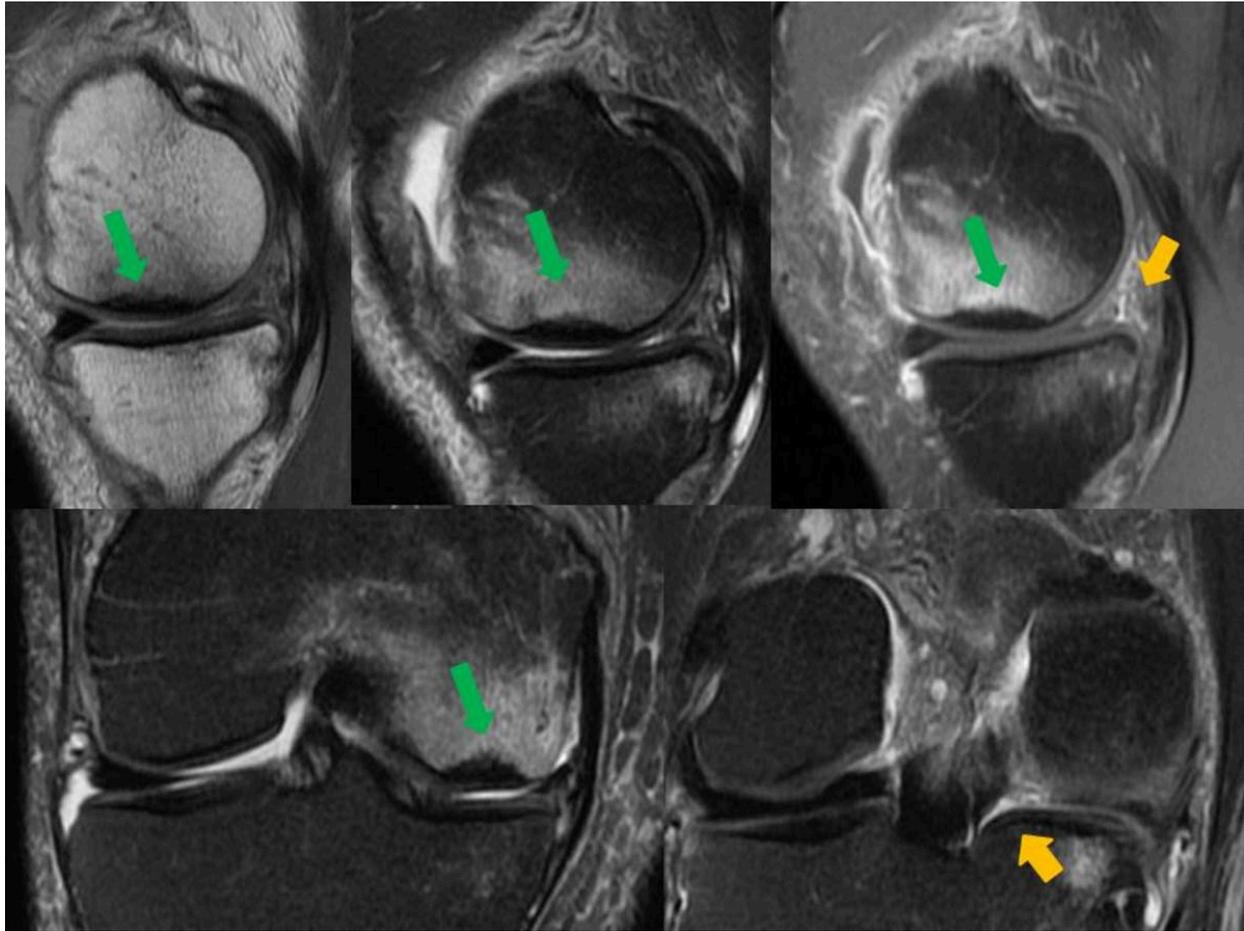
**Fig. 6:** Fat-suppressed proton-density-weighted MR images show a complete radial tear (arrow) to the posterior root of the medial meniscus, with complete discontinuity of the meniscal root and a fluid gap. (Laprade type 2C)

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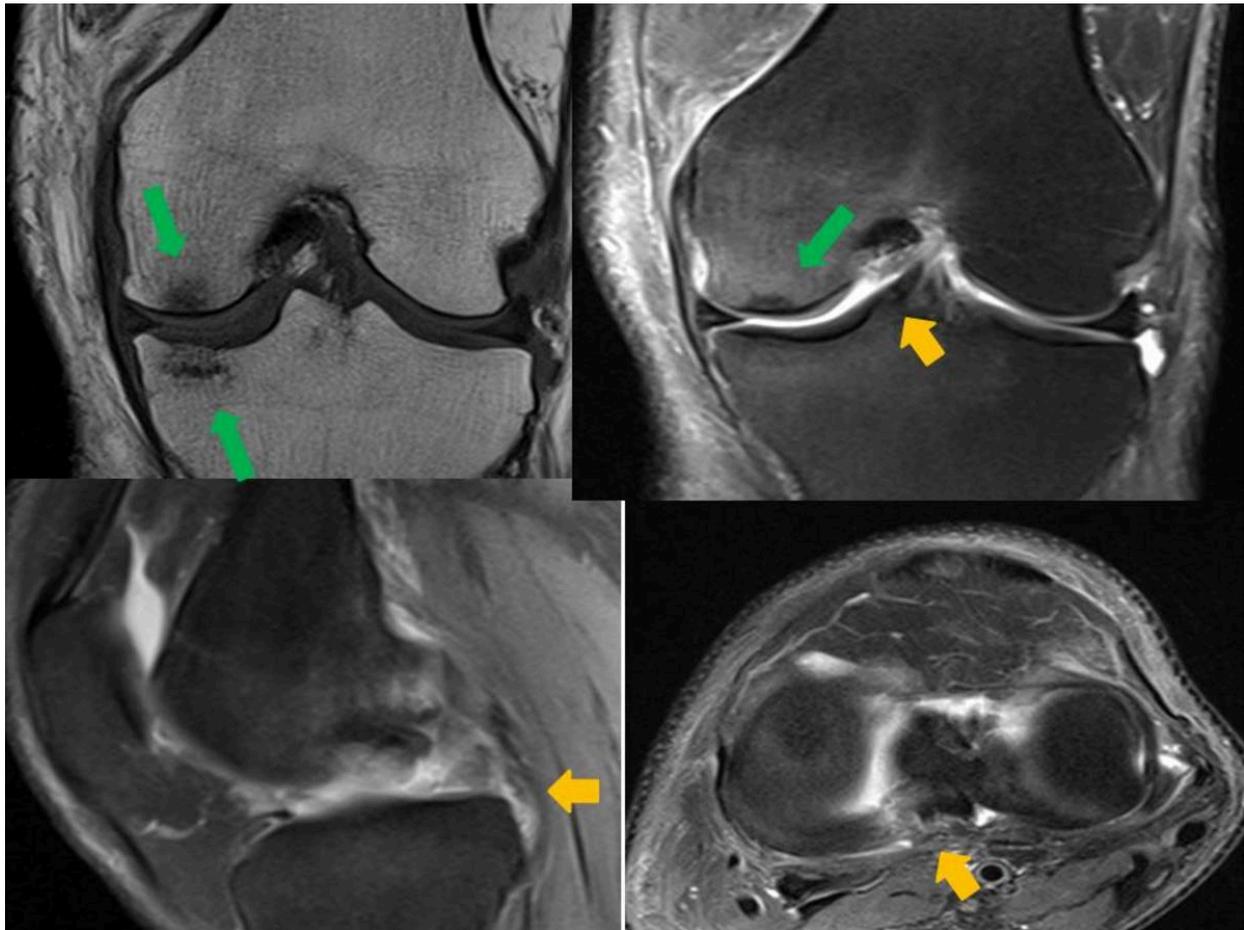
**Fig. 7:** Fat-suppressed proton-density-weighted MR images shows two images of right and left knee of the same patient with bilateral PMMRT demonstrated by a "cleft" sign (yellow arrow) on coronal MR images and meniscal extrusion (green arrow). In addition, the subchondral marrow edema and signs of osteoarthritis are seen on this picture.

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**Fig. 8:** Fat-suppressed proton-density-weighted and T1 MR images show signs of PMMRT (yellow arrow) associated with a discrete area of subchondral decreased signal intensity (green arrow) that reflects necrosis, surrounded by intermediate signal of fat and edema. This area of osteonecrosis (SONK) had no enhancement after the use of intravenous gadolinium.

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**Fig. 9:** Fat-suppressed proton-density-weighted and T1 MR images show signs of PMMRT (yellow arrow) with an ill-defined area of decreased signal in medial tibial plateau and femoral condyle that suggests the presence of insufficiency fracture (green arrow)

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## Conclusion

Meniscal root tears lead to altered biomechanics and progressive osteoarthritis of the knee. Posterior meniscal root tears represent an often overlooked pathology. We believe that a detailed description of PMMRL pathology would be helpful for orthopedic surgeons to manage PMMRL tears in clinical practice. With a greater understanding of the importance of meniscal root injuries, more emphasis has been placed recently on the development of surgical techniques to repair meniscal root tears, to prevent long-term sequelae.

## References

1. Brody JM, Hulstyn MJ, Fleming BC, Tung GA: The meniscal roots: gross anatomic correlation with 3-T MRI findings. *AJR* 188: W446-W450, 2007.
2. SAKAMOTO, Flávia Aiko et al. Raízes meniscais: anatomia e avaliação por meio da ressonância magnética. *Rev. Bras. Reumatol.* [online]. 2007, vol.47, n.5 [cited 2018-01-12], pp.370-375.
3. Posterior Root Meniscal Tears: Preoperative, Intraoperative, and Postoperative Imaging for Transtibial Pullout Repair. Andrew R. et al. *RadioGraphics* 2016 36:6, 1792-180
4. MR Imaging-based Diagnosis and Classification of Meniscal Tears. Jie C. et al. *RadioGraphics* 2014 34:4, 981-999
5. Gilbert Moatshe, Jorge Chahla, Erik Slette, Lars Engebretsen & Robert F Laprade (2016) Posterior meniscal root injuries, *Acta Orthopaedica*, 87:5, 452-458
6. Meniscal root tear repair: why, when and how? Davide et al. *Orthopedic Reviews* 2015; volume 7:5792
7. Meniscal Root Tears: Identification and Repair. Doherty et al. [Am J Orthop \(Belle Mead NJ\)](#). 2016 Mar-Apr;45(3):183-7.
8. Meniscal root tears: diagnosis and treatment. Koenig et al. [Arthroscopy](#). 2009 Sep;25(9):1025-32. doi: 10.1016/j.arthro.2009.03.015
9. Posterior Meniscal Root Repairs Outcomes of an Anatomic Transtibial Pull-Out Technique. Laprade et al. [Am J Sports Med](#). 2017 Mar;45(4):884-891. doi: 10.1177/0363546516673996. Epub 2016 Dec 5
10. Meniscal Root Tears: A Classification System Based on Tear Morphology. Laprade et al. *Am J Sports Med* published online December 1, 2014
11. Posterior root tear of the medial and lateral meniscos. Petersen W. et al. *Arch Orthop Trauma Surg* (2014) 134:237-255
12. Posterior Medial Meniscus Root Ligament Lesions: MRI Classification and Associated Findings. Choi et al. *AJR* 2014; 203:1286-1292
13. Stoller DW. *Magnetic resonance imaging in orthopaedics & sports medicine*. 3rd ed. Baltimore, MD: Lippincott Williams & Wilkins; 2007.