The 'Root' of All Evil: Mounting Evidence Supports Fixing Meniscal Root Tears

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In 1991, Pagnani et al., described an avulsion of the posterior horn of the medial meniscus in a young football player. Arthroscopic examination revealed the root tear and associated meniscal extrusion. Given the meniscus load-sharing design, losing the bone attachment can be the equivalent to functional loss of the entire meniscus. This biomechanical equivalent of a total meniscectomy can be even more problematic over time, especially in young patients.

It follows that other studies have suggested that these tears should not be taken lightly and, with few exceptions, should be repaired. In addition, in 2018, Robert F. LaPrade, MD, described these injuries as "a silent epidemic." Fig. 1a shows a root tear, in distinction from a radial tear near the root as shown in Fig. 1b. It is clear that recognizing root tears and their potential sequelae, as well as newer repair techniques, may become increasingly important in the future.

Epidemiology

Meniscal tears make up 12 percent to 14 percent of orthopaedic presentations involving the knee, with a prevalence of 60 to 70 per 100,000. Some estimate that "root" tears are present in approximately a fifth of those cases. Two-thirds of the root tears are medial, and a third are lateral. Anterior root tears are rare. Lateral root tears often present in younger patients, are traumatic in nature, and are associated with anterior cruciate ligament (ACL) tears. Medial root tears are more common in middle-aged females with elevated body mass index (BMI). The latter are more likely chronic and are more likely to be associated with underlying cartilage defects. Medial-sided tears also make up a higher proportion of tears. Until recently, such injuries were frequently treated with partial meniscectomy, which does little to correct the true mechanical pathology caused by loss of the bony attachment of the meniscus.

Anatomy

Cadaver studies have established the anatomic origin and insertion of the menisci. On the medial side, the anterior horn is firmly attached to the tibia, anterior to the ACL near the intercondylar fossa. The posterior horn of the medial meniscus is attached immediately anterior to the side of the posterior cruciate ligament (PCL). In the lateral meniscus, the anterior horn is attached to the intercondylar fossa adjacent to the ACL. The posterior horn is attached to the PCL and medial femoral condyle through the meniscofemoral ligaments of Wrisberg (posteriorly) and Humphrey (anteriorly). It also attaches to the popliteus tendon. It is important to note that the lateral anterior root is at risk during nonanatomic tibial tunnel placement for ACL reconstruction, and the medial anterior root is at risk during tibial intramedullary nailing.

Diagnosis

Root tears are challenging to diagnose with simple clinical evaluation. There is no pathognomonic clinical test or sign. More chronic tears may display subtle symptoms. Patients often describe deep posterior knee pain, especially with maximum knee flexion or squatting. They may or may not have joint line pain. If there is extrusion of the medial meniscus, it can sometimes be palpated with a varus stress test in full extension, called an extrusion test. Traditional tests for meniscal pathology may or may not be positive.

When symptoms continue, plain weight-bearing films of the affected knee and standing full-length films are obtained to determine any malalignment. If those do not yield a contraindication to arthroscopic treatment, MRI is recommended.

With MRI, root tears are best assessed on T2 weighted sequence. Even with MRI, detection of root tears does not have 100 percent sensitivity and specificity; studies have demonstrated ranges from 60 percent to 100 percent. There are, however, four characteristic findings on MRI sequences that suggest meniscal root tear (see sidebar). Once diagnosed, there are five types of root tear (see sidebar).

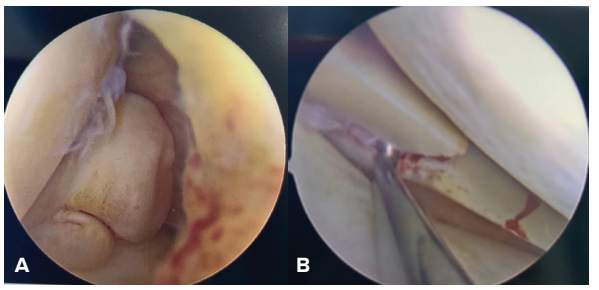

Fig. 1 (**A**) Arthroscopic view from a left knee looking medially from the notch next to the posterior cruciate ligament. Avulsion from the bone with some scarring of the meniscus edge. The patient is a 15-year-old soccer player with an anterior cruciate ligament tear, medial meniscus root tear, and a radial tear of the lateral meniscus (**B**). Note the distinction of the tear location from the medial meniscus root tear in **A** and the posterior lateral meniscus radial tear in **B**.
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Why fix them?

The foundation for fixing meniscal root tears lies in biomechanical studies. Allaire et al., demonstrated a 25 percent increase in peak contact pressure experienced by torn meniscal root tear that returned to normal when the meniscal root was repaired. The relationship held true across all tested angles of knee flexion. LaPrade et al., demonstrated that the torn meniscal root has to be repaired and fixed in an anatomic position to correct the functional loss. Their cadaver study demonstrated that a repair just 5 mm away from the anatomic insertion did not adequately restore tibiofemoral contact pressures and contact areas.

A few other clinical studies have supported fixing meniscal root tears. Chung et al., examined 37 medial meniscal root tears that received refixation and 20 partial meniscectomies over a five-year period. Repaired roots had better subjective outcome scores and were less likely to progress and require total knee arthroplasty (TKA) during that time. A more recent study by Bernard et al., compared nonoperative management with partial meniscectomy and root repair. Although they were unable to detect subjective differences among the three groups, they found the same outcome as Chung et al. The longest follow-up study to date involved 91 patients who were assessed for a mean 84 months; the study showed that there was a 99 percent survival of repair at five-year minimum follow-up, with only one patient requiring TKA. All but three patients in the repair group reported improved subjective outcomes.

When *not* to fix them

A 2019 systematic review conducted to determine which factors influence patient outcomes after meniscal root repair found that patients with preexisting high-grade cartilage breakdown as well as varus alignment greater than five degrees were more likely to have poor outcomes. Some studies also have suggested that BMI > 30 kg/m^2 and preexisting evidence of subchondral collapse may be relative contraindications to surgery. Patients who are not candidates for surgery should receive nonoperative treatment. Surgical candidates with healthy articular surfaces and acute meniscal root tears should undergo arthroscopic meniscal root repair. Patients with chronic meniscal root tears in the setting of little to no articular cartilage wear (Outerbridge grade 1 or 2) are candidates for meniscal root repair, whereas those with symptomatic tears demonstrating advanced degenerative changes (Outerbridge grade 3 or 4) are candidates for arthroscopic meniscectomy. Patients with excessive varus deformity should also be evaluated for possible staged or concomitant high tibial osteotomy.

How to fix them

Techniques to repair these injuries have come a long way. Initially, repair was done through an open approach in the back of the knee, but it has evolved to use meniscal root-specific instruments in arthroscopic repair. The most recently recognized techniques are suture anchor repair and transtibial pullout repair. Only one study has compared outcomes of the techniques in terms of reduction of tear, gap distances, and rates of healing. A total of 22 patients were in each group and were followed for a mean 25 months. The study observed similar outcomes from the two repair

Tear classifications

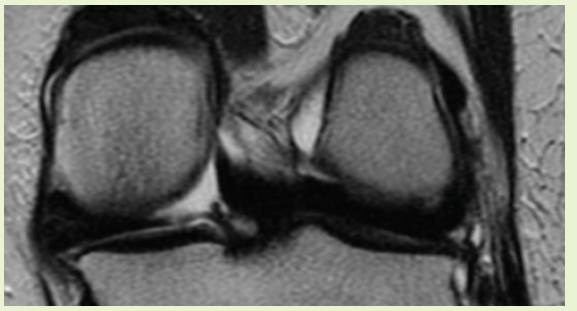
Once identified, tears are classified based on their injury patterns:

- Type I tears are partial tears and are stable.
- Type II tears are the most common and occur as complete radial tears within 9 mm from the attachment of the meniscal root.
- Type III tears are bucket-handle tears with complete root detachment.
- Type IV tears are complex oblique or longitudinal tears with root detachment.
- Type V tears are bony avulsions of the root attachment.

SOURCE: LAPRADE CM, JAMES EW, CRAM TR, ET AL: MENISCAL ROOT TEARS: A CLASSIFICATION SYSTEM BASED ON TEAR MORPHOLOGY. *AM J SPORTS MED* 2015;43:363-9.

MRI finding diagnostic of a root tear

1. A vertical linear defect of the root on coronal imaging (Fig. 2a)
2. Evidence of > 3 mm of meniscal extrusion on coronal sequencing (Fig. 2b)
3. A radial tear of the root on axial imaging (Fig. 2c)
4. The "ghost sign" is the clear appearance of the meniscus on sagittal imaging that disappears on subsequent cuts. (There is sometimes a volume averaging effect near the defect and the normal dark meniscus triangle will be followed by a lighter gray one, a ghost-like meniscus, and then a missing triangle before the bone attachment site.) (Fig. 2d)



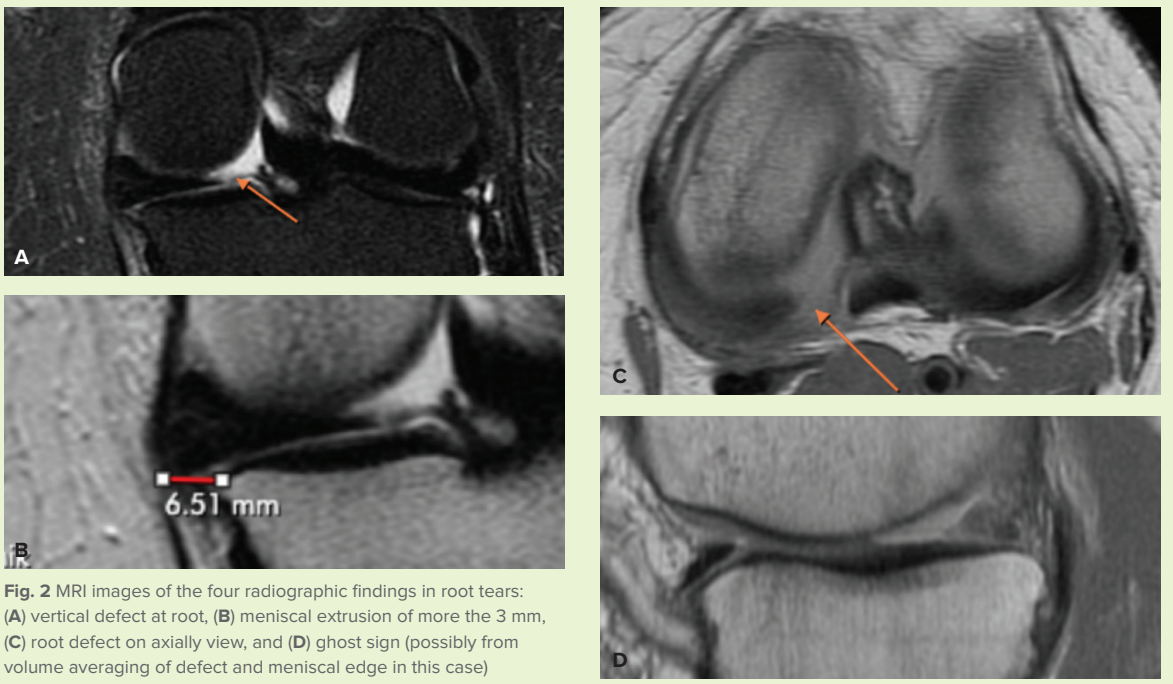


Fig. 2 MRI images of the four radiographic findings in root tears: (**A**) vertical defect at root, (**B**) meniscal extrusion of more the 3 mm, (**C**) root defect on axially view, and (**D**) ghost sign (possibly from volume averaging of defect and meniscal edge in this case)
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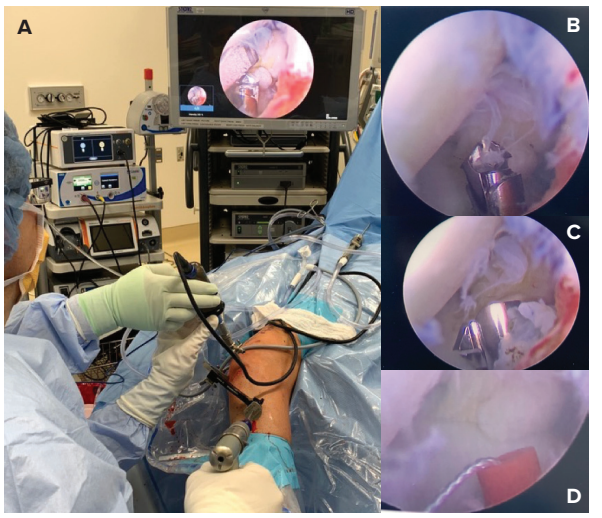

Fig. 3 Tunnel preparation for suture fixation of the root: (**A**) drilling tunnel using special root guide, (**B**) drill with flip tip, (**C**) tip flipped, and (**D**) passing suture placed. (**A**) Arthroscopic set up to place guide over root attachment, drill in place while observing root position with the scope; (**B**) drill tip at root footprint; (**C**) drill flipped to create "landing pad" for repair; and (**D**) suture passed in tunnel for later repair
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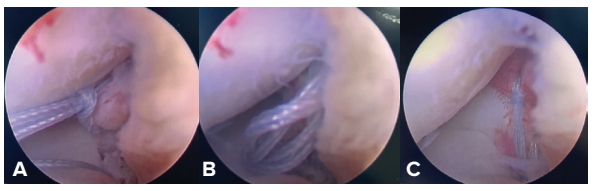

Fig. 4 Suture repair: (**A**) sutures in root, (**B**) passing sutures back into the prepared tunnel, and (**C**) root secured to the "landing pad" and restored to the anatomic location
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types; however, many surgeons prefer the transtibial pullout technique based on the technical difficulty of the suture anchor technique.

The repair is conducted with the patient placed supine on the operating table. Examination under anesthesia is performed for any concurrent ligamentous instability. A tourniquet is placed on the operative leg, which is placed into a leg holder, with the contralateral leg placed in an abduction stirrup. Standard anterolateral and anteromedial portals are made adjacent to the patellar tendon. The joint is filled with normal saline, and a 30-degree arthroscopic camera is used. Because these tears are difficult to identify preoperatively, a surgeon must always be prepared to repair intraoperatively identified root tears.

Once the tear is identified, attention is then turned to tibial socket preparation. The socket is created with a root-specific transtibial guide placed through the ipsilateral portal and centered on the medial footprint (Fig. 3a). A guide pin is introduced into the joint through an incision on the proximal medial tibia just medial to the tibial tubercle, followed by a flip-cutter-type drill to create a tibial socket (Fig. 3b and 3c). Following socket preparation, the flip cutter is exchanged for a fiber stick for future suture passage (Fig. 3d). For meniscus fixation, a free, nonabsorbent suture is passed through the torn meniscus in a simple cinch configuration with a self-retrieving suture-passing device. Two to three sutures are placed and tensioned through the tibial socket to reduce the meniscus root back to the native root attachment (Fig. 4). Tibial fixation is obtained with a cortical button or anchor with the knee at 90 degrees of flexion. The meniscus is then probed to ensure satisfactory reduction and fixation of the root.

Although there is no widely accepted postoperative protocol, patients typically are restricted to nonweight-bearing or touch-down weight-bearing with the knee in full extension for six weeks. They are allowed to move the knee but are restricted to 90 degrees of knee flexion. At six weeks postoperatively, the brace is discontinued, and they are allowed to progress their weight-bearing with unrestricted range of motion. They are restricted from loading the knee past 90 degrees of flexion until four months after surgery, and typically they return to activities after three months. Alan M. Reznik, MD, MBA, FAAOS, has a preference for nonweight-bearing for three to four weeks in a straight brace, then partial weight-bearing in a medial unloader brace until week seven, then advancement of weight-bearing in the unloader brace as comfort allows until full without pain. Because many patients have a stress overload of the compartment and even stress insufficiency fractures of the plateau, patients should continue using the unloader brace until four months postoperatively and then brace for impact activities as needed for as long as one year after surgery.

Future directions

Because this topic has recently gained attention in the sports literature, there are still several directions to explore. To date, no prospective studies have compared meniscal repair versus meniscectomy or conservative treatment. We do not yet have a great timeline to define acute versus chronic tears and how that may affect our judgement in terms of management. Limited clinical studies have compared the two main repair techniques in terms of outcomes, so more research is needed. Also, we do not have any justification to guide our rehabilitation protocols, and there is no rehabilitation protocol specific to meniscal root repairs. These are based only on expert opinion.

Conclusion

Meniscal root tears are distinct from other kinds of meniscal injury. Clinicians should have a high suspicion for these injuries, as they are challenging to diagnose clinically, even with MRI. In the right patients, meniscal root tears should be fixed, as conservative treatment may contribute to progressive arthritis. There is mounting evidence of great benefit to repairing meniscal root tears, with improved subjective and radiographic outcomes.

References for the studies cited can be found in the online version of this article, available at www.aaosnow.org.

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