

# Meniscus Root Tear: Extended Classification and Arthroscopic Repair Techniques



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**Abstract:** The meniscus root is an attachment of the anterior and posterior horns of the meniscus onto the tibia, and its primary function is to prevent extrusion under axial load. Meniscus root tear constitutes 15% to 20% of meniscus tear. With the increased incidence of root tears being diagnosed commonly, many newer morphologic patterns of root tears have been detected, and the need to extend the conventional classification arises. At the same time, preserving the meniscus root necessitates novel techniques to repair this newer pattern. In this Technical Note, we describe the extended classification of root tears and arthroscopic repair techniques to achieve stable and secure fixation of meniscus roots.

**M**eniscus root tear is defined as soft tissue or bony avulsion of the root from its tibial attachment site or within 1 cm. Meniscus root injury is considered equivalent to total meniscectomy due to increased peak forces, rapid cartilage damage, and a greater risk of progressive arthrosis. Lateral-sided meniscus root tear is commonly acute, traumatic, and associated with anterior cruciate ligament (ACL) tear in 80% of cases.<sup>1</sup> Medial meniscus root tear in contrast is mostly chronic, degenerative, and associated with cartilage degeneration.<sup>2,3</sup> Classification of root tears, based on the morphology of the tear, was described by LaPrade et al.<sup>4</sup> in 2015. They described 5 different morphologic patterns of root tears, with type 2 being subdivided into 3 subtypes. In this article, we describe 3 more morphologic patterns of root tears and extend the classification of LaPrade as type 6, 7, and type 8 root tears along with surgical methods for these individual types.

## The Original Classification of Root Tear

The original classification of root tear is as follows (Figs 1 and 2): (1) type 1: partial root tear; (2) type 2: complete radial tear within 9 mm of the bony attachment; (3) type 3: complete root tear with concomitant bucket handle; (4) type 4: complete root tear with an oblique meniscus tear; and (5) type 5: bony avulsion fracture of root attachment.

## Extended Classification of Root Tear

Apart from the aforementioned 5 morphologic patterns, other types are as follows (Figs 3 and 4): (1) type 6: complete root tear with horizontal cleavage tear of the meniscus with or without extension into the root. (2) Type 7: complete root tear with meniscocapsular separation (subtype 7a: root with a concomitant ramp on the medial side and Subtype 7b: T-shaped tear at lateral meniscus). (3) Type 8: complete root tear with substance loss of meniscus extending more than 1 cm from root.

Surgical treatment options available for root repair are the transtibial pull-out technique and the suture anchor repair technique. We prefer to use the suture anchor technique for type 6, the hybrid double-row technique for type 7, and root reconstruction using gracilis autograft for type 8 root tears.

## Surgical Technique (With Video Illustration)

### Positioning

The patient is positioned supine, and the knee is in 90° of flexion at the edge of the table (Fig 5). A thigh

From Galaxy Hospital, Bhopal, India.

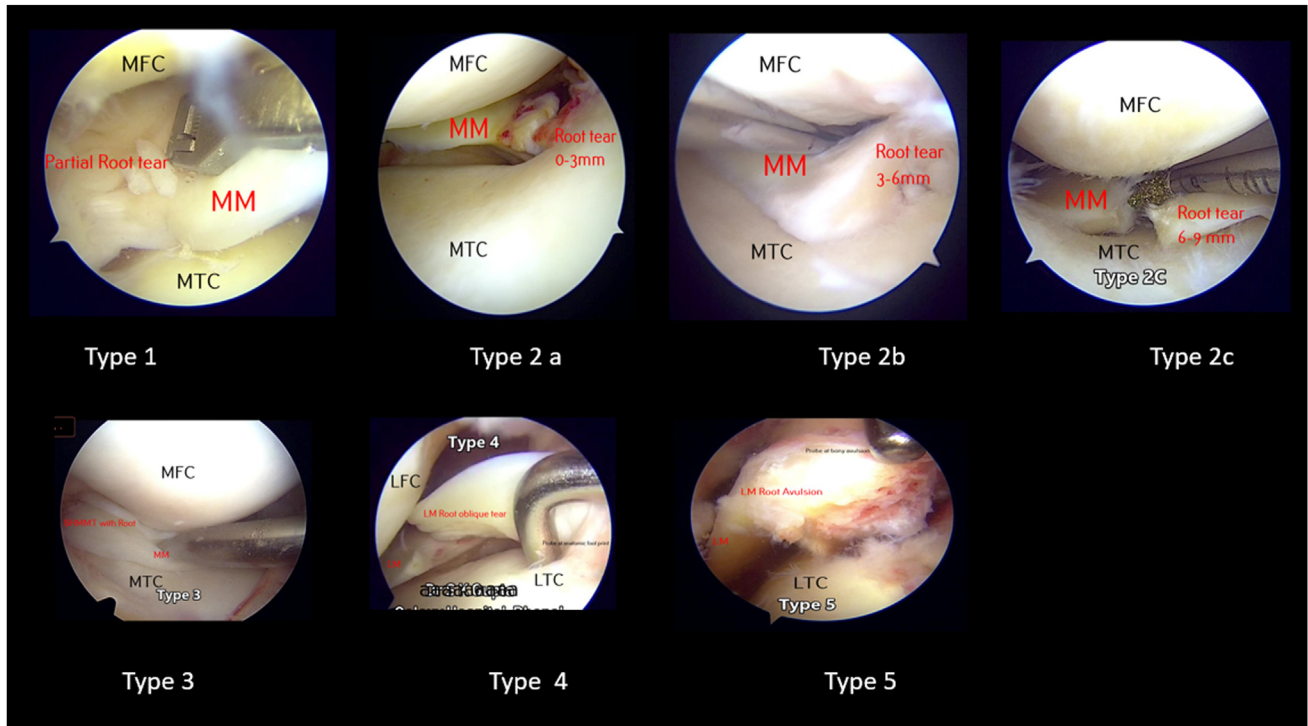
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**Fig 1.** LaPrade classification of meniscus root tear with type 1: Partial root tear; type 2: Complete radial tear 2a: 0-3 mm, 2b: 3-6 mm, 2c: 6-9 mm from root bony attachment; type 3: Complete root tear with concomitant bucket handle; type 4: Complete root tear with an oblique meniscus tear; and type 5: Bony avulsion fracture of the root attachment. (BHMMT, bucket-handle medial meniscus tear; LFC, lateral femoral condyle; LM, lateral meniscus; LTC, lateral tibial condyle; MFC, medial femoral condyle; MM, medial meniscus; MTC, medial tibial condyle.)

support and tourniquet are placed high on the thigh. Using an aseptic sterile technique, the operative site is prepared, draping is done, and a tourniquet is inflated.

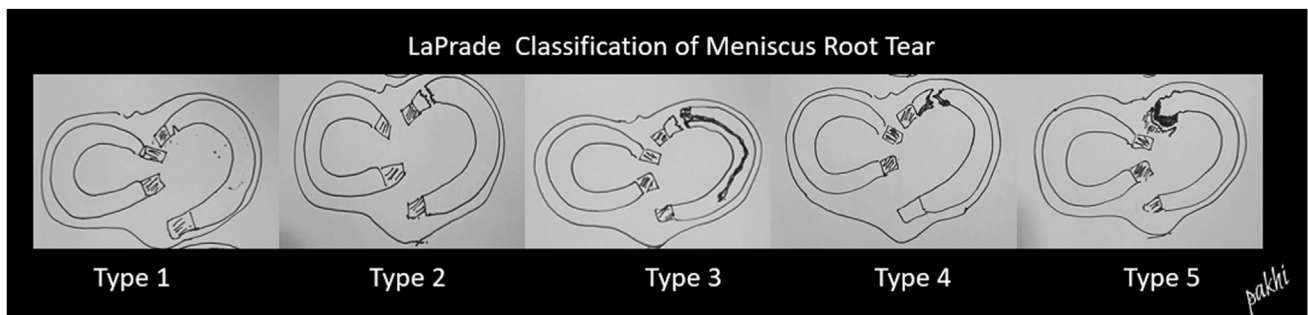
**Operative Steps**

**Arthroscopy and Portal Placement**

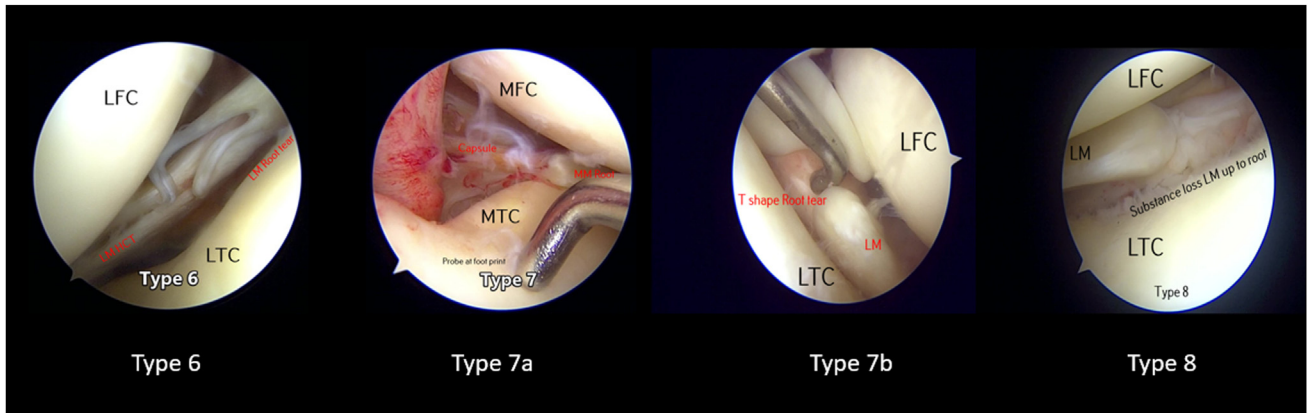
The anterolateral portal is made just next to the patellar tendon in a palpable soft spot. A second anteromedial portal is made 1 cm above the joint line and 1 cm medial to the patellar tendon in a palpable soft spot. Diagnostic arthroscopy is performed.

For identification of lateral meniscus root lesion, a figure of 4 position is made and probing is done from

the anteromedial portal. For medial meniscus root tear, extension, valgus, and external rotation is done. Pie crusting of medial collateral ligament is done for better identification and repair of medial-sided lesions. In type 6 root tear as shown in Figure 6, lateral meniscus root tear is seen as lifting off from bony attachment along with horizontal cleavage tear (HCT) extending from the posterior horn up to the body of the meniscus. In, type 7 root tear as shown in Figure 7A, the medial meniscus root is torn and retracted up to 2 cm along with meniscocapsular disruption equivalent to a ramp lesion (Fig 7B). Type 8 root tear is shown in Figure 8; the lateral meniscus posterior horn substance is missing for



**Fig 2.** Schematic representation of LaPrade meniscus root tear classification, type 1 to type 5.



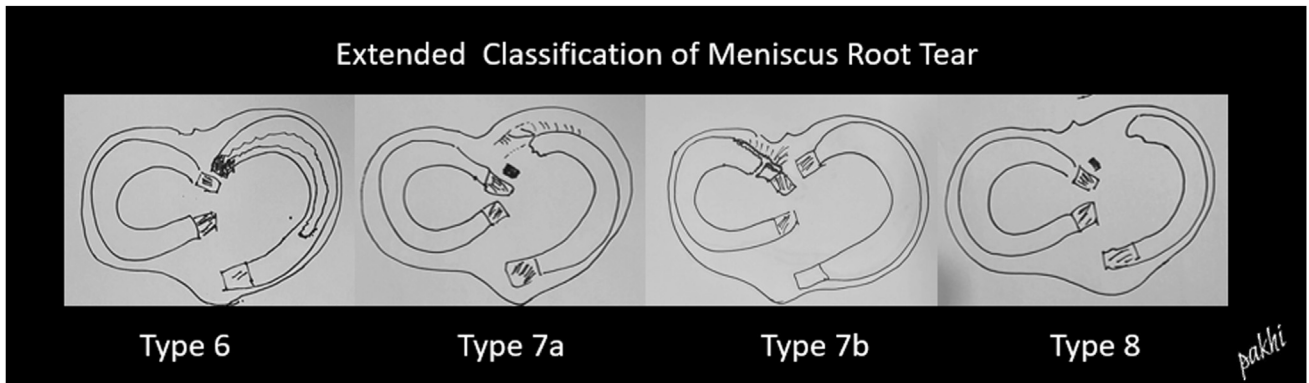
**Fig 3.** Extended classification of meniscus root tear: type 6: Complete root tear with horizontal cleavage tear of the meniscus. Type 7: Complete root tear with meniscocapsular separation; type 7a: root with a concomitant ramp on the medial side and type 7b: T-shaped tear at lateral meniscus). Type 8: Complete root tear with substance loss of meniscus extending more than 1 cm from root. (LFC, lateral femoral condyle; LM, lateral meniscus; LMHCT, lateral meniscus horizontal cleavage tear; LTC, lateral tibial condyle; MFC, medial femoral condyle; MM, medial meniscus; MTC, medial tibial condyle.)

more than 2 cm along with the root. Root reducibility up to anatomical footprint is checked for types 6 and 7 (Fig 9 A-D), and underlying cartilage is denuded for better healing of the meniscus (Fig 10 A and B). An additional central portal is made just below the lower pole of the patella for suture management.

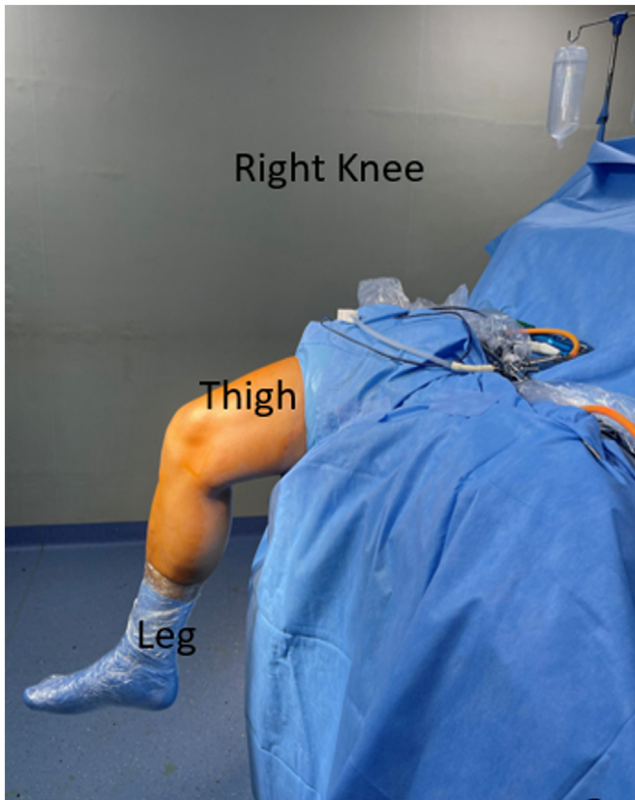
**Type 6: Circumferential Continuous Compression Stich and Suture Anchor Repair**

HCT and root combined lesions are managed by repairing HCT first followed by root repair. Viewing from the anterolateral portal, the margins of the meniscus are debrided and rasping is done. From the anteromedial portal, an 8-mm passport cannula is passed. Circumferential closure of HCT is done using a knee scorpion (Arthrex, Naples, FL) and 2-0 FiberWire (Arthrex). This can be achieved by interrupted or continuous sutures (Fig 11). With the knee in 90° of flexion and viewing from the anterolateral portal, an ACL tibial guide is introduced from the anteromedial portal. The guide is placed aimed at the anatomical

footprint (Fig 12) of the lateral meniscus root, the bullet of the guide is on the anteromedial aspect of the tibia close to the tibial tuberosity. The drill pin is placed onto the bone and drilling is done; the guide/drill pin emerges at the anatomical point intra-articularly. The pin is removed from the anterior cortex and a long-cannulated needle loaded with looped chia is passed through this tunnel track; the chia loop will come intra-articularly, onto which the relay suture is mounted. A double-loaded RootFix Anchor (double-loaded anchor with 0 number sutures and kit for passage of anchor; Osteocare, Ahmedabad, India), which is an all-suture anchor, is mounted on this loop and the anchor is deployed at the lateral meniscus root attachment site. Of the 4 sutures, 2 are white and 2 are blue. Now 3 sutures (2 blue and 1 white) are taken out through the central portal and parked. This step avoids suture entanglement. The white suture in the anteromedial portal is mounted on to scorpion and the bite is taken through the meniscus, now this suture is parked in the central portal and another white suture is taken

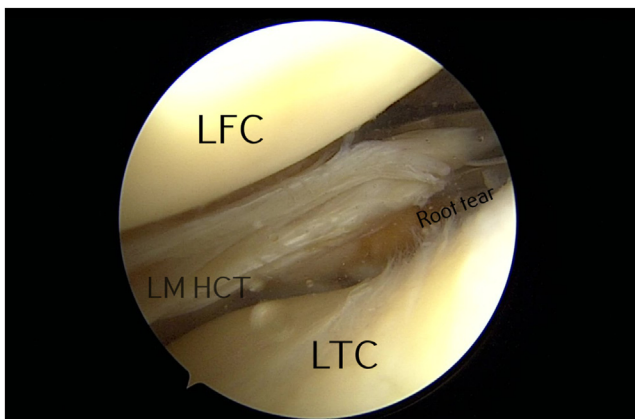


**Fig 4.** Schematic representation of extended meniscus root tear classification type 6 to type 8.

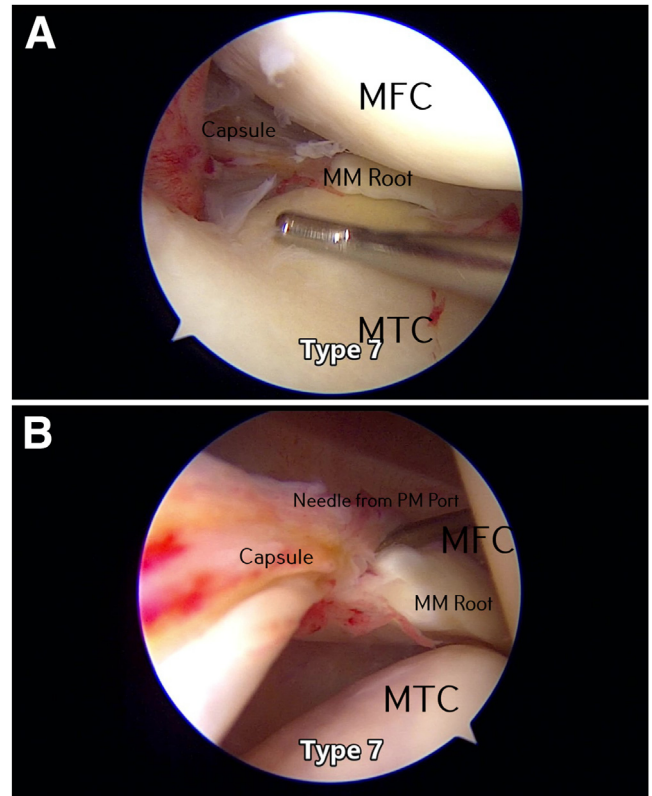


**Fig 5.** Right knee, 90° flexion position of the knee for arthroscopic meniscus root repair.

through the meniscus in a mattress fashion. A similar step is repeated for the blue suture in a simple configuration (Fig 13). The first blue set of sutures is taken from an anteromedial portal and tied, which reduces the root, followed by white sutures, which compress the root at the anatomical footprint. Sutures are cut and



**Fig 6.** Right knee, a figure of 4 position, visualization from the anterolateral portal, scorpion from the anteromedial portal, showing complete root tear with horizontal cleavage tear of the meniscus. (LFC, lateral femoral condyle; LMHCT, lateral meniscus horizontal cleavage tear; LTC, lateral tibial condyle.)

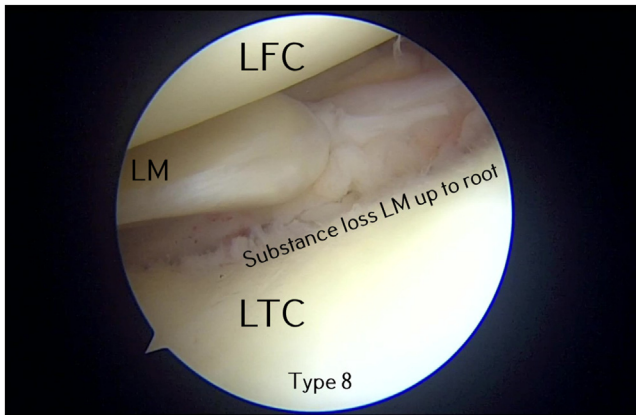


**Fig 7.** (A) Right knee, 20° flexion and valgus position of the knee, visualization from the anterolateral portal, probe from the anteromedial portal, showing complete retracted root tear with meniscocapsular separation. (B) Right knee, 90° flexion position of the knee, visualization from the anterolateral portal, a spinal needle from the posteromedial portal showing capsular separation. (MFC, medial femoral condyle; MM, medial meniscus; MTC, medial tibial condyle.)

probing is done to confirm the secure fixation of HCT as well as root tear (Fig 14).

#### Type 7: All-Inside Double-Row Hybrid Repair

With the knee in 90° of flexion and looking from the anterolateral portal, an ACL tibial guide is introduced from the anteromedial portal. The guide is placed aimed at the medial extent of the anatomical footprint (Fig 15) of the medial meniscus root; the bullet of the guide is on the anteromedial aspect of the tibia close to the tibial tuberosity. The drill pin is placed onto the bone and drilling is done; the guide/drill pin emerges at the anatomical point intraarticular. The pin is removed from the anterior cortex and a spinal needle loaded with 1 ETHILON (Ethicon, a Johnson & Johnson Company, Somerville, NJ) is passed through this tunnel track; a looped suture will come intra-articularly (Fig 16). This loop is taken out from the anteromedial portal. Then, the ACL tibial guide is placed again at the anatomical site of the medial meniscus root and the guidewire is passed, followed by drilling with a 4.5-mm endobutton drill guide to make a tunnel for pull-out



**Fig 8.** Right knee, a figure of 4 position, visualization from the anterolateral portal, showing complete substance loss of meniscus up to the root. (LFC, lateral femoral condyle; LM, lateral meniscus; LTC, lateral tibial condyle.)

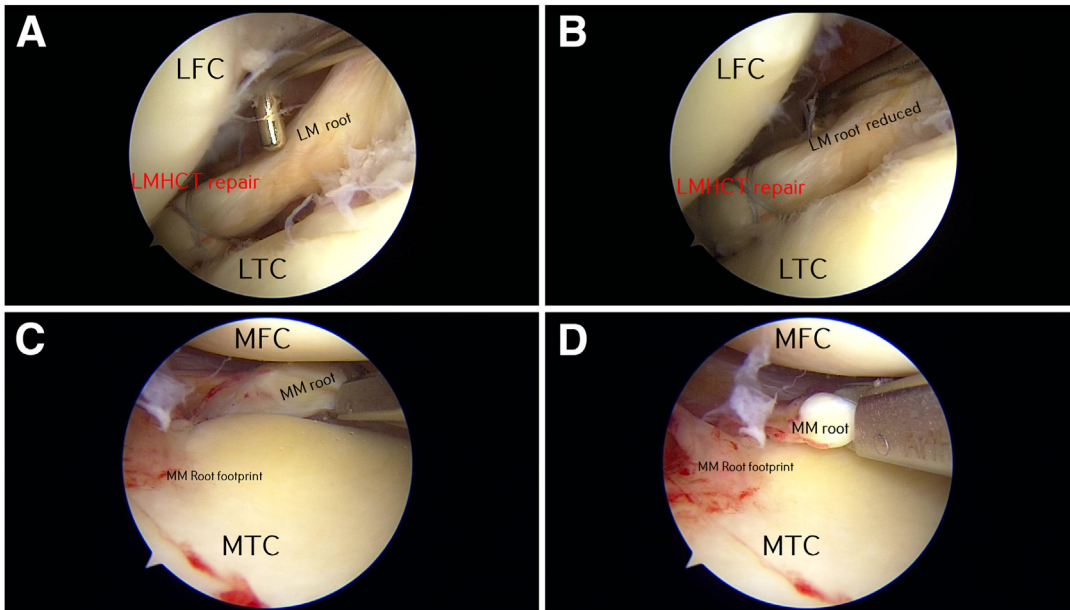
fixation. Then, an 8-mm passport cannula (Arthrex) is placed in the anteromedial portal.

A 1.7-mm double-loaded all-suture FiberTak suture tape anchor (Arthrex) is unwound from its shaft so that the free anchor with 2 suture tails (blue and black) is ready. A no. 5 ETHIBOND (Ethicon) suture is looped around all suture anchors, which acts as a leading suture for anchor passage. A suture retriever is used to

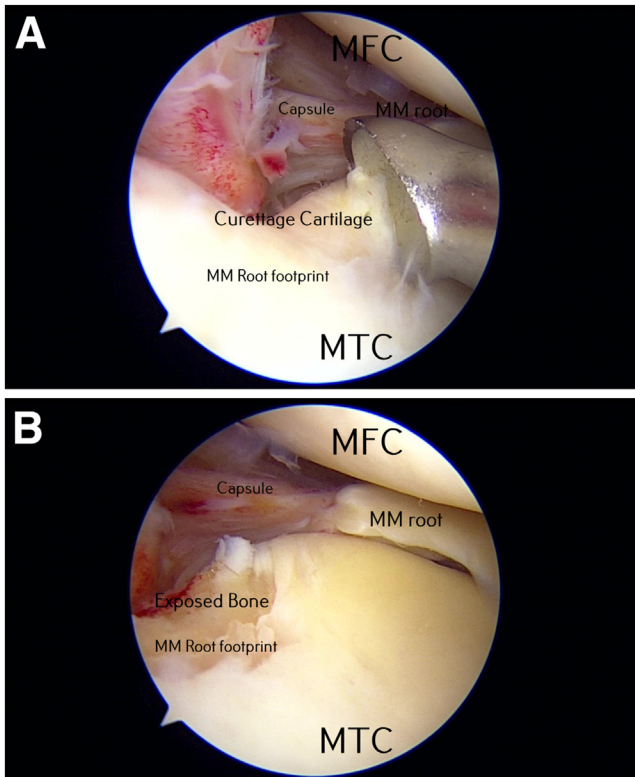
retrieve the ETHILON loop from the anteromedial portal and on the loop a no. 5 ETHIBOND (Ethicon) leading suture is passed for relaying. The ETHILON is pulled from the anteromedial cortex and now the no. 5 ETHIBOND is ready at the anterior cortex, this suture is pulled, and the under-vision anchor is passed intra-articularly to be lodged in the predrill track for about 2 cm (Fig 17). Once the suture is inside, it is pulled back, as to make it flower shape for the deployment of an anchor at the lateral footprint of the meniscus root. Now except for one, the remaining 3 sutures are retrieved from the central portal (Fig 18). These sutures are mounted on a scorpion (Arthrex) one by one, and the bite is taken from the meniscus and capsule sequentially. Once all 4 suture tapes are passed through the meniscus and capsule, they are pulled out through the second row 4.5-mm tunnel. Once all 4 sutures are pulled at the anterior cortex, root and capsule gets reduced (Fig 19), and this is fixed on the anterior cortex using a knotless swive lock anchor (Arthrex). Probing is done to check both the stability of the root and capsule tear repair.

**Type 8: Meniscus Root Reconstruction Using Autograft**

Viewing from the anterolateral portal, the extent of the defect in the meniscus is measured using a probe

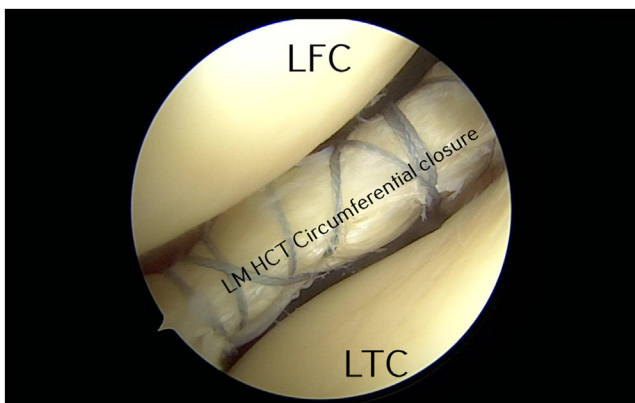


**Fig 9.** (A) Right knee, a figure of 4 position, visualization from the anterolateral portal, showing repair of horizontal cleavage tear of the meniscus with continuous stitch. The probe from the anteromedial portal at the lateral meniscus root shows a tear. (B) Right knee, a figure of 4 position, visualization from the anterolateral portal, showing repair of horizontal cleavage tear of the meniscus with continuous stitch. The probe from the anteromedial portal at the lateral meniscus root shows a reduction of the root. (C) Right knee, 20° flexion and valgus position of the knee, visualization from the anterolateral portal, grasper from the anteromedial portal, showing pulling of retracted root tear. (D) Right knee, 20° flexion and valgus position of the knee, visualization from the anterolateral portal, grasper from the anteromedial portal, showing reduction of retracted root tear. (LFC, lateral femoral condyle; LM, lateral meniscus; LMHCT, lateral meniscus horizontal cleavage tear; LTC, lateral tibial condyle; MFC, medial femoral condyle; MM, medial meniscus; MTC, medial tibial condyle.)

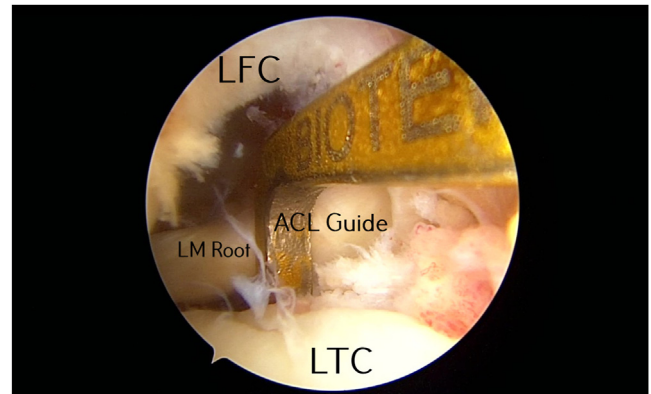


**Fig 10.** (A) Right knee, 30° flexion position of the knee, visualization from the anterolateral portal, curette from the anteromedial portal, showing cartilage denudation at the footprint. (B) Right knee, 30° flexion position of the knee, visualization from the anteromedial portal, showing exposed bone at footprint for better healing of root. (MFC, medial femoral condyle; MM, medial meniscus; MTC, medial tibial condyle.)

from the anteromedial portal. Two tunnels of 4.5 mm are drilled, one at the root footprint and the second at the end of a defect in the meniscus (Fig 20 A and B). Harvested gracilis graft is cut at about 8 to 9 cm (adding



**Fig 11.** Right knee, a figure of 4 position, visualization from the anterolateral portal, showing repair of horizontal cleavage tear of the meniscus with continuous stitch. (LFC, lateral femoral condyle; LMHCT, lateral meniscus horizontal cleavage tear; LTC, lateral tibial condyle.)

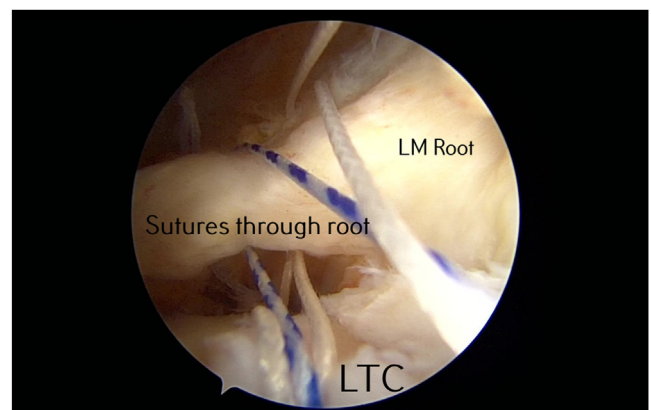


**Fig 12.** Right knee, a figure of 4 position, visualization from the anterolateral portal, ACL guide from anteromedial portal placed at lateral meniscus root for drilling with the guidewire. (ACL, anterior cruciate ligament; LFC, lateral femoral condyle; LM, lateral meniscus; LTC, lateral tibial condyle.)

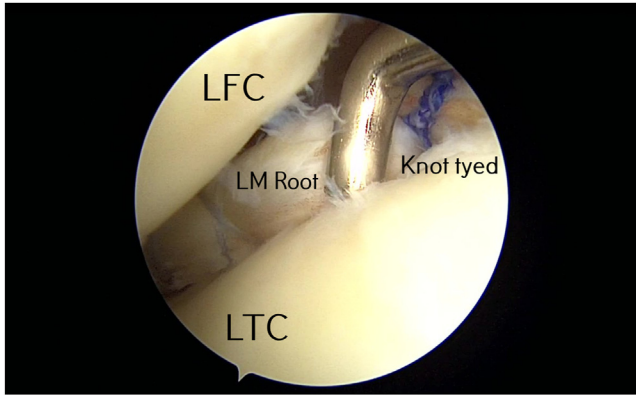
2.5 cm on each side of the total defect size) and prepared using no. 2 ETHIBOND. This prepared graft is passed using the relay suture method in both tunnels, so that ends of the ETHIBOND suture come out through both tunnels at the anterior cortex. Now the gracilis is acting as a bridge between the meniscus and the root. This autograft is sutured with the remaining meniscus using a scorpion and fiber wire. Further sutures are passed between the capsule and the Gracilis graft. Newly reconstructed roots along with the meniscus can be seen as stable on probing (Fig 21).

### Postoperative Rehabilitation

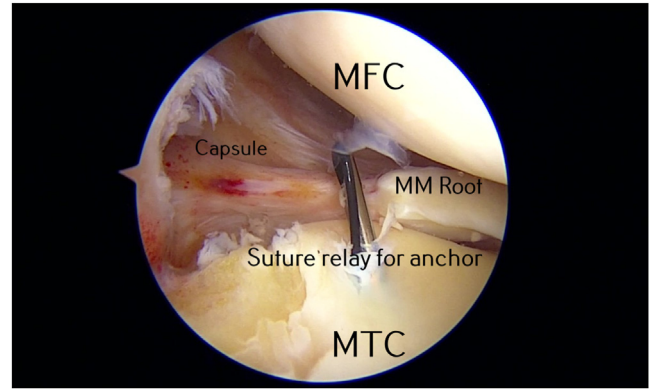
From the next day, quadriceps tightening, ankle pumping, and hip rotation exercises are advised. Toe-touch weight-bearing and passive range of motion up to 45° are permitted in the first 2 weeks. From the fourth to the sixth week, 0 to 90° of motion with partial



**Fig 13.** Right knee, a figure of 4 position, visualization from the anterolateral portal, one blue and two white sutures are seen passing through the root. (LM, lateral meniscus; LTC, lateral tibial condyle.)



**Fig 14.** Right knee, a figure of 4 position, visualization from the anterolateral portal, showing repair of horizontal cleavage tear of the meniscus with continuous stitch. The probe from the anteromedial portal at the lateral meniscus root shows the fixation of the root with a suture anchor. (LFC, lateral femoral condyle; LM, lateral meniscus; LTC, lateral tibial condyle.)



**Fig 16.** Right knee, 30° flexion position of the knee, visualization from the anterolateral portal, looped suture passed through first tunnel for anchor placement and 6 mm away second tunnel of 4.5 mm at anatomical footprint for double-row fixation. (MFC, medial femoral condyle; MM, medial meniscus; MTC, medial tibial condyle.)

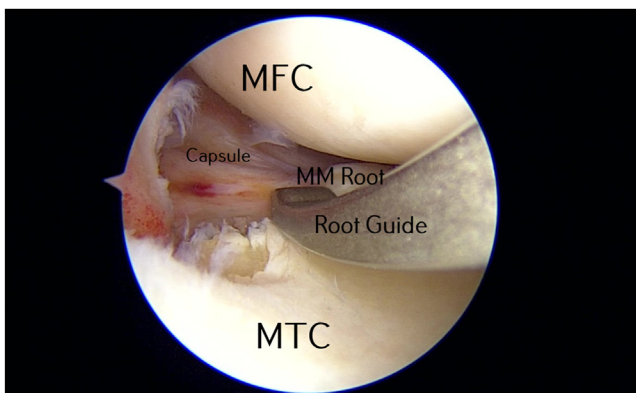
weight-bearing is allowed. After 6 weeks, full weight-bearing is allowed in types 6 and 7 and at 8 weeks in type 8. At 8 weeks, motion beyond 90° is started. Squatting is allowed after 7 months. Return to sports activities are permitted after 9 months in type 6 and 7 and at 1 year in type 8.

### Discussion

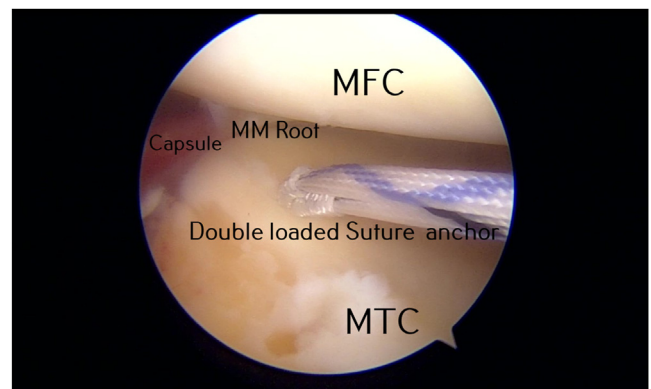
Anatomical repair of the meniscus root is essential for restoring normal kinematics and joint loading. Surgical repair of the root can be done using the suture anchor technique or transtibial pull-out technique. The pull-out technique is used more commonly and is the gold standard method.<sup>5</sup> Disadvantages of the transtibial technique are micromotion of meniscus root, bungee effect due to suspensory fixation away from pathology, and tunnel interferences with

concomitant ligament reconstruction and osteotomy.<sup>6</sup> The suture anchor technique has greater load-to-failure strength, better healing rates, and less bungee effect.<sup>7</sup> We prefer to use the suture anchor technique for LaPrade type 2 and its subtypes and also for the type 4 root tear pattern.

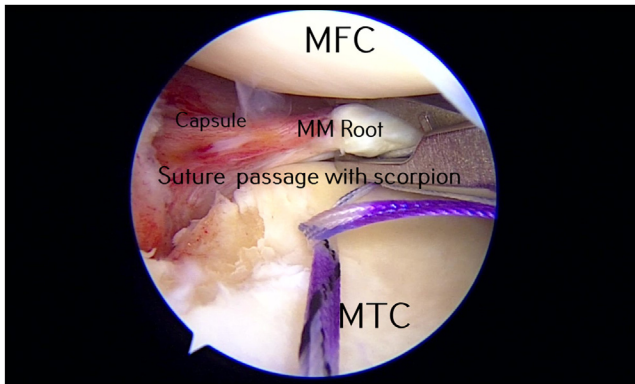
Type 6 as described previously is a concomitant HCT with root tear and both components require secure repair. Untreated HCTs can progress to meniscus extrusion,<sup>8</sup> which will be further compounded by the presence of a root tear. HCT also propagates and deforms with knee flexion and leads to increased peak pressure and chondral damage. We have used continuous circumferential closure for HCT and suture anchor technique for root repair in type 6 root tears to achieve



**Fig 15.** Right knee, 30° flexion position of the knee, visualization from the anterolateral portal, root guide placed medially 6 mm away from the footprint for anchor placement and double-row fixation. (MFC, medial femoral condyle; MM, medial meniscus; MTC, medial tibial condyle.)



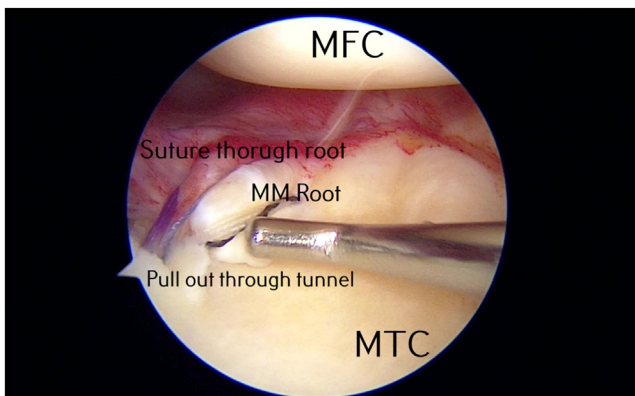
**Fig 17.** Right knee, 30° flexion position of the knee, visualization from the anterolateral portal, double-loaded suture anchor with tape is deployed at the first drill hole. In addition, 6 mm away, the second tunnel of 4.5 mm at anatomical footprint for double-row fixation is seen. (MFC, medial femoral condyle; MM, medial meniscus; MTC, medial tibial condyle.)



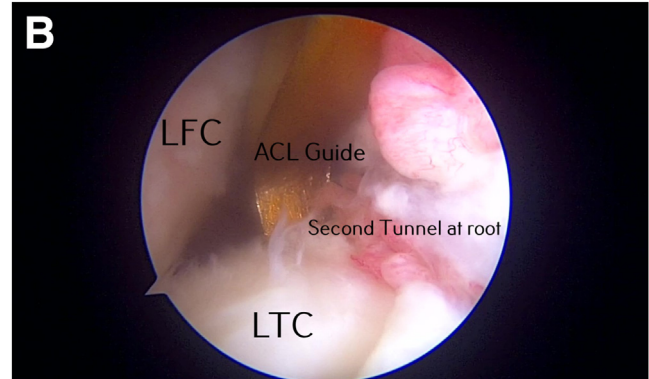
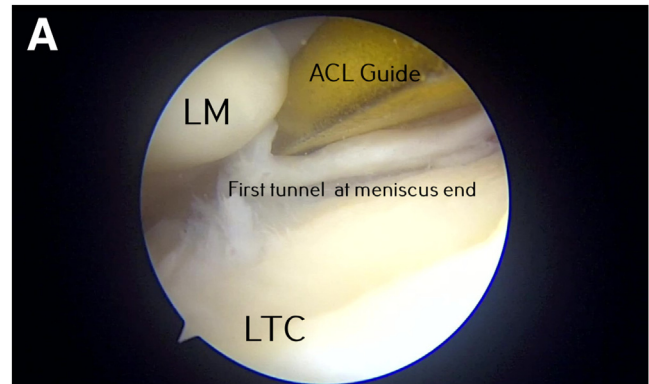
**Fig 18.** Right knee, 30° flexion position of the knee, visualization from the anterolateral portal, scorpion from the anteromedial portal. Double-loaded suture anchor with tape is passed using a scorpion at the meniscus root. (MFC, medial femoral condyle; MM, medial meniscus; MTC, medial tibial condyle.)

better stability and prevent the progression of extrusion and arthritis.

The root may be associated with a ramp lesion as described in type 7a, making it completely unstable. On the lateral side root along with a meniscocapsular tear, type 7b will give the appearance of a T shape. Failure to address meniscocapsular separation may lead to increased rotation instability and greater re-tear of the reconstructed ACL.<sup>9</sup> Although various techniques are described for ramp repair, including all-inside, inside-out, and posteromedial suture techniques, we have used a suture anchor for such combined type 7 root and ramp lesion. Sutures are taken both through the root and capsule in a mattress or simple configuration depending on tissue quality. These sutures are relayed in the transtibial tunnel and fixed on the anterior

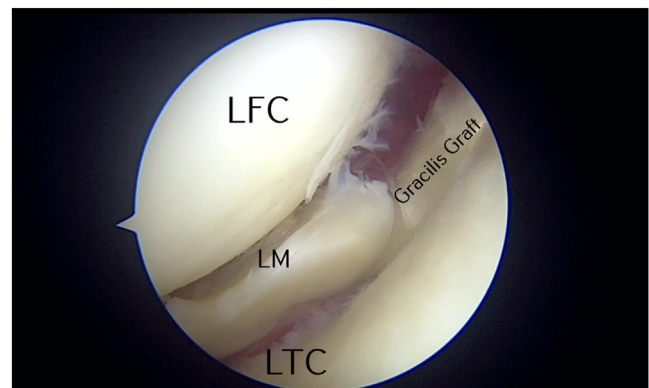


**Fig 19.** Right knee, 30° flexion position of the knee, visualization from the anterolateral portal, probe from the anteromedial portal, double-loaded suture anchor with tape is passed at meniscus root and capsule and pull-out through second tunnel for anatomic double-row hybrid fixation. (MFC, medial femoral condyle; MM, medial meniscus; MTC, medial tibial condyle.)



**Fig 20.** (A) Right knee, a figure of 4 position, visualization from the anterolateral portal, ACL guide from anteromedial portal placed just below lateral meniscus for first tunnel drilling. (B) Right knee, a figure of 4 position, visualization from the anterolateral portal, ACL guide from anteromedial portal placed at lateral meniscus root footprint for second tunnel drilling. (ACL, anterior cruciate ligament; LFC, lateral femoral condyle; LM, lateral meniscus; LTC, lateral tibial condyle.)

cortex, making it a very stronger and more stable construct desired for root repair. A similar technique using an anchor can be used for type 7b, that is T-shaped tear.



**Fig 21.** Right knee, a figure of 4 position, visualization from the anterolateral portal, gracilis graft root reconstruction seen completely filling the gap created by substance loss of meniscus. (LFC, lateral femoral condyle; LM, lateral meniscus; LTC, lateral tibial condyle.)



**Table 1.** Advantages and Disadvantages of Extended Root Tear Types Using Anchors

Advantages	Disadvantages
<ul style="list-style-type: none"> <li>• Combined repair of HCT meniscus and root in type 6 prevents future extrusion</li> <li>• Fixation is close to the meniscus root so less bungee effect and better healing</li> <li>• The use of an anchor both for the capsule and root for type 7 provides better stability and avoids the use of additional implants</li> <li>• The use of a hybrid technique, combined an anchor and pullout technique, gives a wide area of healing and secure fixation</li> </ul>	<ul style="list-style-type: none"> <li>• Technically more challenging as compared with the transtibial approach.</li> <li>• Poor bone quality may lead to pulling out of the anchor</li> <li>• Poor meniscal quality may lead to cut out of sutures</li> </ul>

HCT, horizontal cleavage tear.

**Table 2.** Pitfalls and Tips of Meniscus Root Repair Using Suture Anchors

Pitfalls	Tips
Suture anchor placement may be difficult	The use of the relay technique and the passage from the anteromedial portal leads to a smooth passage
The suture may cut out through the meniscus	Can use mattress configuration, rip-stop stitch, or Mason–Allen, using knee scorpion
Suture while passing individually through the meniscus may lead to entanglement	Park sutures in the central portal and use a passport cannula in the anteromedial portal

Chronic cases of ligament injury may present, with substance loss usually seen up to the body of the lateral meniscus at the level of the popliteus tendon. Type 8 root is a situation in which a large segment of the meniscus along with the root is absent for a length more than 1 cm from root attachment. Previously substance loss, particularly of the lateral meniscus, has been described by Ahn et al.<sup>10</sup> as a type 4 root tear. Ahn et al. described it as chronic inner loss of the meniscus and recommended repairing the remaining meniscus to a bony insertion flap to prevent meniscus extrusion.

Repair in cases of segment loss is possible if the loss is less than 1 cm. For a situation in which the loss of the meniscus is more than 1 cm, it can be managed by meniscus root reconstruction using an autogenous gracilis graft. Autogenous gracilis for meniscus root tear, although described previously by Lee et al.,<sup>11</sup> is for lesions without loss of meniscus substance. Our reconstruction uses the 2-tunnel technique. As more forces will be required to bring the meniscus anatomically, we have not passed a graft through the meniscus, as it may lead to cut-out through the meniscus and will lead to failure of reconstruction. We have used it as an autograft segmental transplant and incorporated construct with the remnant meniscus, capsule using side-to-side and anteroposterior sutures. The advantages and disadvantages of our technique are summarized in Table 1, and technical challenges can be overcome by pitfalls and tips of this technique are shown in Table 2.

**Disclosure**

The authors report no conflicts of interest in the authorship and publication of this article. Full ICMJE

author disclosure forms are available for this article online, as [supplementary material](#).

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