

# Anterior medial meniscal root avulsions due to malposition of the tibial tunnel during anterior cruciate ligament reconstruction: two case reports

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**Abstract** The meniscal roots are essential for preserving the native biomechanical and structural properties of the tibiofemoral joint. Meniscus root avulsions, which disrupt the normal meniscus anchoring points, have been reported to result in deleterious biomechanics and clinical outcomes. In this series, two cases of iatrogenic medial meniscus anterior root avulsions after anterior cruciate ligament (ACL) reconstruction are reported. Iatrogenic medial meniscus anterior root avulsions after malpositioning of the tibial tunnels during ACL reconstruction have not been previously reported in the literature and may account for poor long-term outcomes seen in some patients after ACL reconstruction. Therefore, careful attention must be paid to correct tibial tunnel placement during ACL reconstruction.

*Level of evidence* Case series, Level IV.

**Keywords** Anterior cruciate ligament · Meniscus · Meniscus root · Root avulsion · Anterior cruciate ligament reconstruction · Medial meniscus

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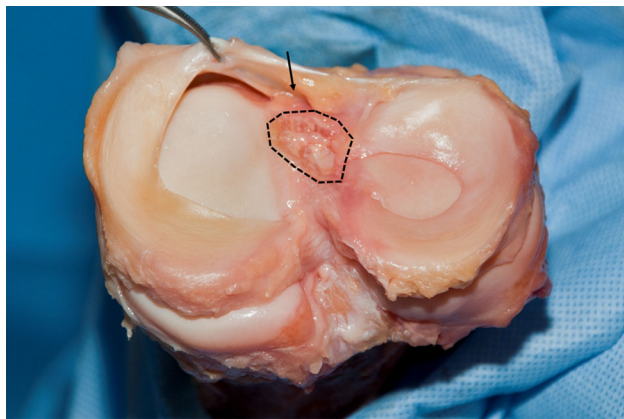
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## Introduction

The meniscal roots have recently gained increased attention because of their critical roles as an anchor and shock absorber in the knee joint [10, 18, 23]. A meniscus root injury disrupts the normal conversion of axial loads into hoop stresses in the knee joint via loss of the essential anchor point for the circumferential fibres of the meniscus [10, 18, 23]. In addition, disruption of the meniscal root may lead to meniscal extrusion, which is defined as displacement of the meniscus from the tibial plateau, and a higher risk for developing osteoarthritis [13, 14].

Presently, the anatomy (Fig. 1) and injury mechanisms of the anterior medial meniscus root are poorly understood. Current anatomical studies report the relationship of the medial meniscus anterior root to the anterior cruciate ligament (ACL), but not in relation to other pertinent arthroscopic landmarks; the three-dimensional anatomy of the medial meniscus anterior root is still largely undefined [3, 26, 27]. As for the incidence of these tears, Costa et al. [4] reported that anterior horn medial meniscal tears accounted for 11 % of all meniscal tears in their study. However, they did not specifically examine the root attachment of the medial meniscus. Currently, only case reports have explicitly described anterior medial meniscal root tears [5, 16, 19]. These reports present cases of iatrogenic anterior medial meniscus root avulsions created either during cyst resection or due to variant attachments of the medial meniscus root [5, 16, 19].

The purpose of this series is to illustrate two cases of iatrogenic anterior medial meniscus root avulsion due to malposition of the tibial tunnels during ACL reconstruction. The authors believe that these iatrogenic injuries may presently be unrecognized due to a lack of understanding of anterior medial meniscus root anatomy. Furthermore, in a



**Fig. 1** Cadaveric photograph demonstrating the position of the medial meniscus anterior root attachment (*black arrow*) in relation to the ACL footprint (*black dotted line*) (right knee)

yet undetermined percentage of patients, these iatrogenic injuries may contribute to unsatisfactory long-term outcomes that have been reported after ACL reconstruction.

### Case reports

Both patients in this case report underwent an ACL reconstruction at outside institutions and were diagnosed with a failed ACL reconstruction at the time of presentation.

#### Case 1

A 20-year-old female presented to clinic after sustaining a right knee injury while bouldering approximately 1 year after undergoing a single-bundle autograft hamstring ACL reconstruction. She reported feelings of instability and occasional clicking in her knee. On physical examination,

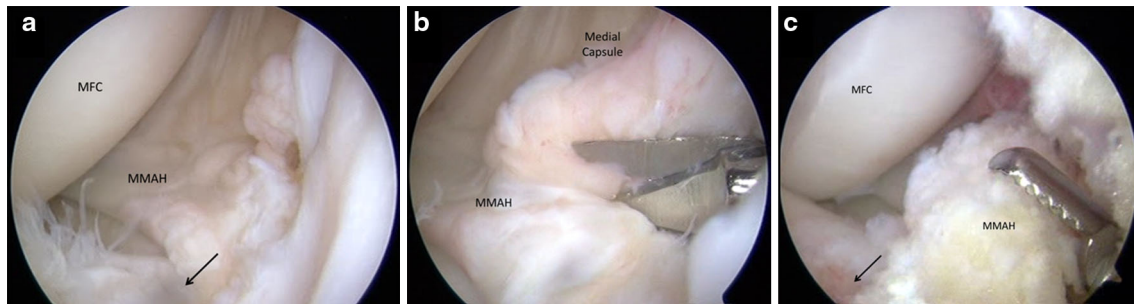
there was a moderate effusion in the right knee, mild tenderness to palpation in the medial joint line, and a palpable subluxed medial meniscus along the medial compartment. There were 2+ Lachman and pivot shift tests. In addition, there was side-to-side asymmetry in her range of motion, with motion limited from 0° to 125° of flexion in her right knee compared to the uninjured left knee, which demonstrated 5° of hyperextension and 135° of flexion.

Long-leg radiographs demonstrated a neutral alignment bilaterally. There was concern that her tibial reconstruction tunnel was located too far anteriorly on the lateral radiograph. Her femoral tunnel appeared very high on the roof of the intercondylar notch and was non-anatomically positioned. Magnetic resonance imaging (MRI) scans revealed a detachment of the anterior root of the medial meniscus due to the presence of a high signal replacing the normal dark meniscal signal at the meniscal root attachment. Computed tomography (CT) scans also demonstrated tunnel widening and non-anatomical placement of her tibial reconstruction tunnels (Fig. 2).

A staged procedure was planned consisting of bone grafting of her ACL tunnels and a medial meniscus anterior root repair followed by a revision ACL reconstruction. On arthroscopic evaluation, the presence of a medial meniscus anterior root tear was confirmed at the aperture of the tibia tunnel, and the meniscus root was retracted approximately 1.5 cm medially (Fig. 3a). The anterior aspect of the medial femoral condyle articular cartilage had Outerbridge grade I chondromalacia. Using an arthroscopic scissors, the medial meniscus anterior root was released from its adhesions along the medial capsule (Fig. 3b), reduced to its native anatomical position (Fig. 3c), and secured using a transtibial pull out repair technique, similar to a technique previously reported for medial meniscus posterior root repairs [1]. This was secured over a button at 90° of knee flexion. Finally, bone graft was placed in the tibial reconstruction tunnel.

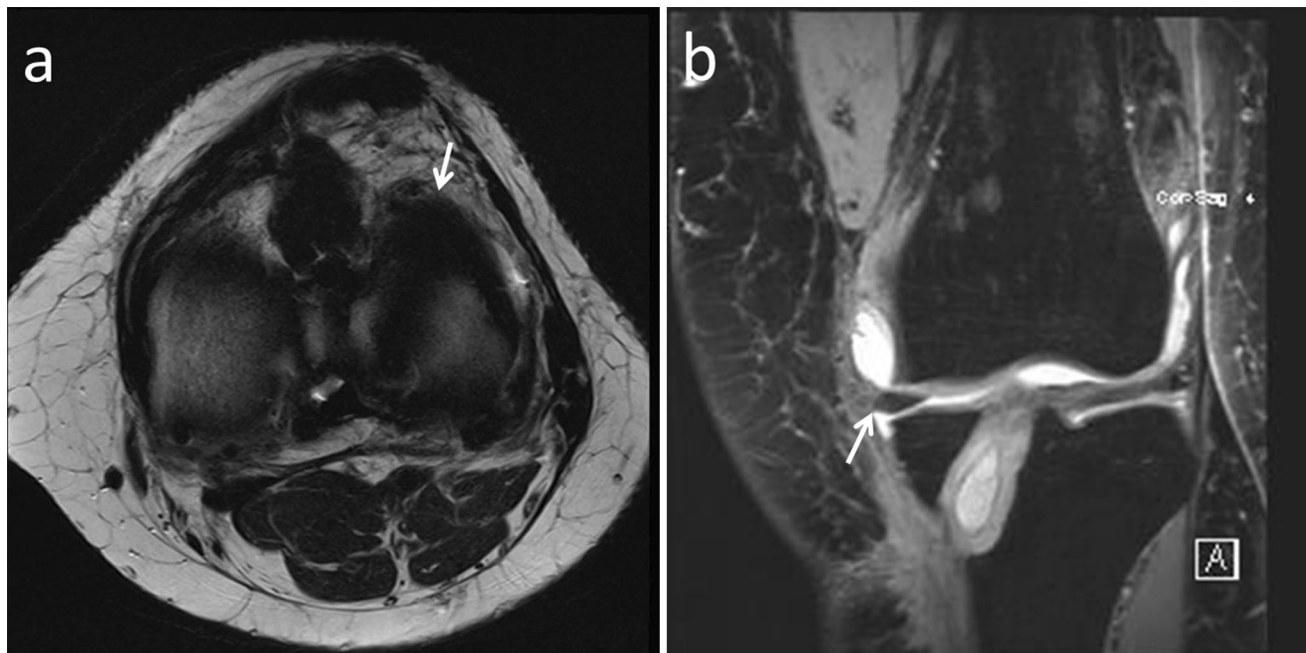


**Fig. 2** Computed tomography (CT) scans demonstrating a malpositioned tibial ACL reconstruction tunnel (*white arrows*) in the axial (**a**), coronal (**b**), and sagittal (**c**) planes (right knee)



**Fig. 3** Arthroscopic photographs of a medial anterior root tear (right knee). **a** Extruded and anatomically scarred root tear and ACL tibial tunnel (*black arrow*). **b** Release of the anteromedial extruded root with arthroscopic scissors. **c** Arthroscopic grasper reducing the

anterior root to the native attachment site. The ACL tibial tunnel indicated by the *black arrow*. *MFC* medial femoral condyle, *MMAH* medial meniscus anterior horn



**Fig. 4** Axial (**a**) and sagittal (**b**) MRI showing an extruded medial meniscus anterior horn off the medial tibial plateau (*white arrows*) due to an iatrogenic medial meniscus root avulsion after malpositioned ACL tibial tunnel reaming (left knee)

## Case 2

The second patient was a 38-year-old female who underwent a previous combined single-bundle autograft and allograft hamstring tendon ACL reconstruction in her left knee after sustaining an injury while skiing. In the months that followed, she reported residual instability in her left knee. On physical examination, range of motion was symmetric in both knees. She had 2+ Lachman and pivot shift tests. Varus gapping was noted at 30° compared to the contralateral knee.

Significant ACL reconstruction tunnel widening secondary to osteolysis in the anterior tibia was visualized on MRI. The MRI showed a detached and medially extruded anterior root of the medial meniscus, which is defined as a medial

meniscus that is partially displaced from the medial tibial plateau [13, 14], as well as a malpositioned tibial tunnel that had effectively taken out her medial meniscus anterior root attachment (Fig. 4). On arthroscopic evaluation, there was diffuse grade 1–2 chondromalacia in the medial compartment. Her ACL graft was absent, and the anterior horn of the medial meniscus was completely detached at the aperture of her tibial reconstruction tunnel. A meniscocapsular release was performed anteriorly to free the meniscus from its scarred in and extruded position. A grasper was then used to reduce the meniscus back to its anatomical attachment site. A suture anchor (DePuy Mitek, Inc., Raynham, MA, USA) was placed anteriorly at the normal attachment of the medial meniscus anterior horn. The meniscus was successfully secured in its native anatomical position.

## Discussion

The most important findings in this case series were iatrogenic anterior medial meniscus root tears due to malpositioning of tibial ACL reconstruction tunnels. The authors are confident that the combination of diagnostic MRI and CT imaging and arthroscopic findings were able to correctly diagnose the aetiology of these avulsions as being iatrogenic complications after malpositioned ACL reconstruction tibial tunnels; however, alternative explanations cannot be definitively ruled out. For the first patient, the root may have avulsed along with the ACL graft failure during a bouldering accident, while the second patient may have experienced injury due to chronic instability after her primary ACL reconstruction. However, given that diagnostic imaging and arthroscopic visualization demonstrated that the tibial tunnels were reamed through the anatomical attachments of the anterior medial meniscus root, these alternative explanations seem unlikely to have been the initial mechanism of anterior medial meniscus root avulsion. This case series reinforces the importance of anatomically accurate tibial tunnel placement during ACL reconstruction and raises awareness of the possibility of iatrogenic anterior meniscal root pathology in patients experiencing short- and long-term complications after ACL reconstruction.

While the posterior meniscal root attachments have been quantitatively defined in relation to pertinent bony and ligamentous arthroscopic landmarks in the knee [8], knowledge of the medial meniscus anterior root anatomy is limited. Previous studies have reported that the posterior aspect of the medial meniscus was an average of 7 mm from the anterior aspect of the ACL and approximately 11.5 mm from the centre of the ACL footprint [3, 9]. Qualitative descriptions also have described the medial meniscus anterior root as either aligning with the medial tibial eminence or in reference to landmarks such as the articular margin of the anteromedial tibial plateau and the anterior intercondylar fossa [9]. The posterior aspect of the medial meniscus anterior root also has been reported to attach to the anterior intermeniscal ligament in approximately 70 % of cases [9, 11, 17]. While these studies have been helpful in establishing basic anatomical relationships of the medial meniscus anterior root attachment to arthroscopically pertinent ACL anatomy, future studies are needed to better pinpoint the footprints of the anterior meniscus root attachments in relation to other bony and soft tissue landmarks.

Meniscus tears or avulsions also increase the risk of degenerative cartilage lesions. Previous studies have reported that ACL injury with associated meniscal tears result in significantly more osteoarthritic radiographic changes than isolated ACL tears [20, 25]. More

specifically, Costa et al. reported that all of the medial meniscus anterior horn tears in their study resulted in levels of meniscal extrusion ( $>3$  mm) that have shown to be significantly associated with higher incidences of osteoarthritis and cartilage degeneration, leading to a situation where the knee is “functionally meniscal-deficient” [4, 10, 14]. In fact, Costa et al. reported that 89 % of anterior horn tears in their study group resulted in  $> 6$  mm of meniscal extrusion, which is twice as much as the clinical standard that has been correlated with increased cartilage degeneration [4, 10, 14]. With regard to the meniscal roots, extrusion has typically been described after posterior root avulsions [2, 15], though more recently extrusion has also been documented in cases of medial meniscus anterior root avulsions [5], as well as in this case series. It follows that many of the adverse sequelae seen in posterior root avulsion patients, such as degenerative cartilage changes, may also be seen in patients with anterior medial meniscus root avulsion and meniscal extrusion.

Loss of either the medial or lateral posterior meniscal root attachment has been shown to result in increased tibiofemoral contact pressures and decreased contact areas that may damage the articular cartilage [2, 6, 12, 15, 21, 22]. In addition, posterior root avulsions result in peak contact pressures and mean contact areas similar to those reported after a total meniscectomy [2, 6]. While total meniscectomies are no longer a common clinical practice, long-term follow-up studies have described higher levels of osteoarthritis and surgical reoperations after partial meniscectomy [7, 24]. For this reason, meniscus root repair is recommended over partial or total meniscectomy in patients with meniscus root pathology.

This case series had some limitations. Both patients in this study underwent previous ACL reconstruction at an outside institution. However, using a combination of diagnostic MRI and CT scans along with assessment of intraoperative findings, the authors are confident that the aetiology of the anterior root pathology observed in these patients was iatrogenic injury. Nevertheless, it would have been easier to definitively diagnose these injuries as due to malpositioned tibial tunnels if these patients had their primary ACL reconstruction performed at the authors' institutions. Further studies should investigate short- and long-term outcomes after anterior meniscus root repair in patients who experience this complication after an ACL reconstruction.

## Conclusions

This series describes two cases of iatrogenic medial meniscus anterior root avulsions due to incorrect tibial tunnel placement during ACL reconstruction. Due to

limited knowledge of the anatomy and mechanisms of injury of the anterior medial meniscal root attachment, additional studies are needed to define the quantitative anatomy of the anterior medial meniscus root attachment and the epidemiology of anterior medial meniscal root injury.

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