

Traumatic soft tissue strain injuries of the lower extremities in high-performance athletes

Lesiones traumáticas por tracción de tejidos blandos de las extremidades inferiores en atletas de alto rendimiento

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Summary

Traumatic soft-tissue strain injuries of the lower imbs are rare in the general population but occur more frequently in high-performance athletes. It is essential to understand the imaging characteristics of these injuries in order to make an accurate diagnosis, enable optimal treatment, and ensure an early and safe return to competition. A series of cases are presented illustrating the most common traumatic injuries of the lower limbs from the hip to the ankle, including avulsion fractures of the hip and the knee; and a traction injury of the flexor retinaculum of the ankle.

Resumen

Las lesiones traumáticas por tracción de los tejidos blandos en los miembros inferiores son poco frecuentes en la población general, pero ocurren con mayor frecuencia en los deportistas de alto rendimiento. Es indispensable conocer las características imagenológicas de estas lesiones para obtener un diagnóstico adecuado, permitir un tratamiento óptimo y garantizar un retorno a la competición temprano y seguro. Se presenta una serie de casos que ilustran las lesiones traumáticas más comunes de los miembros inferiores, desde la cadera hasta el tobillo, incluyendo fracturas por avulsión de la cadera y de la rodilla, y una lesión del retináculo flexor del tobillo.

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Introduction

Traumatic soft-tissue strain injuries occur most frequently in high-performance athletes but are rare in the general population. These injuries result from excessive stretching, intense mechanical traction, and overexertion. Among the injuries affecting the lower extremities, those involving the hip, knee, and ankle are particularly notable. It is essential to understand the imaging characteristics of each of these injuries in order to make an accurate diagnosis that allows for timely decisions regarding management and ensures an early and safe return to play.

We present a series of cases involving traumatic traction injuries to the major joints of the lower extremities. The presentation begins with illustrative cases of avulsion injuries of the hip (anterosuperior iliac spine avulsion and hamstring avulsion), followed by the knee, where a case of jumper's knee and a Segond avulsion fracture are presented; finally, an injury to the flexor retinaculum of the ankle is included.

Anterosuperior Iliac Spine Avulsion

Avulsion injuries result from acute trauma or chronic repetitive stress at the site where a ligament or tendon inserts into the bone. The most common sites of avulsion fractures in the hip are the anterior superior iliac spine (ASIS), the anterior inferior iliac spine (AIIS), and the ischial tuberosity (1).

Two muscles originate at the ASIS: the sartorius and fibers of the fascia lata. These are affected in cases of traction injuries. The mechanism of injury involves forced hip extension and occurs most frequently in athletes who perform jumps and in high-speed runners (2).

Avulsion injuries of the pelvis are rare in adult patients; they are more common in children and adolescents, in whom the apophysis is not yet fully fused (2). An avulsion fracture occurs when the tensile force at the enthesis (the site of attachment of a ligament or tendon) remains intact, resulting in a bone fracture distal to the insertion with a displaced bone fragment (2).

Imaging findings

Although the diagnosis can be made using X-rays and computed tomography (CT), magnetic resonance imaging (MRI) improves the detection of subtle lesions and can show the extent of soft-tissue damage, including retraction and detachment of the sartorius muscle and the fascia lata (2, 3).

On X-rays and CT scans, it is common to see the displaced bone fragment, a finding that is sometimes difficult to detect on MRI. However, on MRI, bone edema at the site of the avulsion fragment and cortical irregularity are key to the diagnosis (1).

Case 1: An 18-year-old male patient, a high-performance athlete who competes in wrestling. He presented with hip pain (Figure 1).

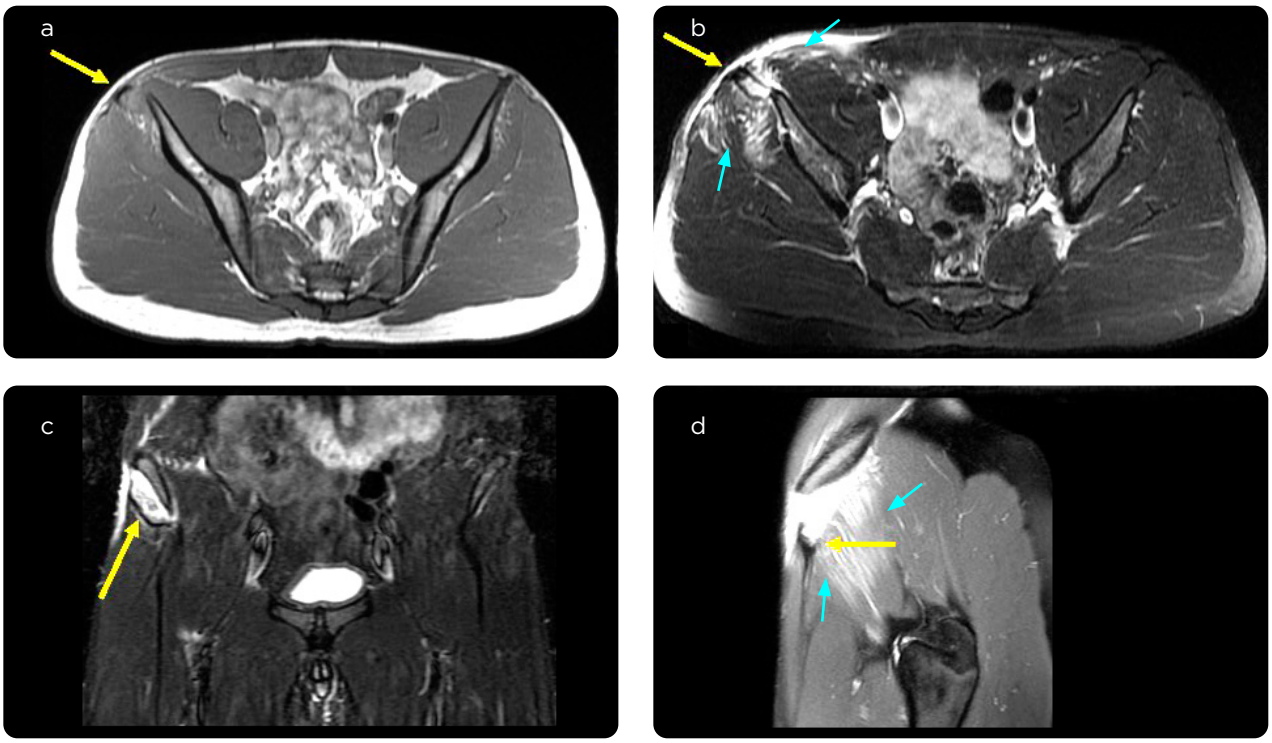


Figure 1. Bone avulsion of the right ASIS. Axial MRI images: a) proton density (PD) and b) PD with fat saturation. c) Coronal STIR sequence. d) Sagittal T2-weighted sequence. The yellow arrows indicate the site of bone avulsion of the right ASIS with distal retraction of approximately 2 cm. Bone marrow edema and edema of the surrounding soft tissues (blue arrow) are identified on fluid-sensitive sequences.

Hamstring muscle avulsion

The hamstring muscles are located in the posterior region of the leg and originate at the ischial tuberosity. The hamstring complex consists of the long head of the biceps femoris, the semitendinosus, and the semimembranosus muscles. The biceps femoris and semitendinosus originate from a common tendon located posteromedially to the semimembranosus tendon (1, 4).

Injuries to the hamstring complex are classified according to the site of involvement; they occur at the point of greatest weakness in the bone-tendon-muscle junction. These points of greatest weakness tend to change with age (1). Avulsion injuries are more common in children and include fractures of the ischial tuberosity and rupture of the proximal hamstring tendon (4). Injuries at the myotendinous junction are more common in adolescents and young adults (1). Finally, tendon injuries and muscle contusions (4) are more common in adults (1).

High-performance athletes in sports such as soccer, runners, and dancers sustain these types of injuries when they experience trauma with the hip flexed and the knee extended (4). Following the initial trauma, athletes clinically present with acute pain in the gluteal region and proximal thigh, which is more pronounced when sitting than when standing (2).

Imaging findings

MRI accurately detects traumatic injuries to the hamstring complex, thereby enabling the diagnosis of avulsion injuries that include both bone fractures and tears without fractures or hematomas (2).

An avulsive, displaced fracture of the ischial tuberosity is easily detected on X-ray. The characteristic finding is a crescent-shaped bone fragment with sharp margins adjacent to the ischial tuberosity. On MRI, the bone fragment may not be detected, and findings manifest as a hematoma and periosteal tear at the insertion site with tendon retraction (4). It is important to emphasize that these fractures are more common in children; therefore, comparison with the contralateral side is essential to rule out an unfused apophysis (4).

Case 2: A 16-year-old female patient, an athlete and soccer player. She presented with severe pain in her left hip (Figures 2 and 3).

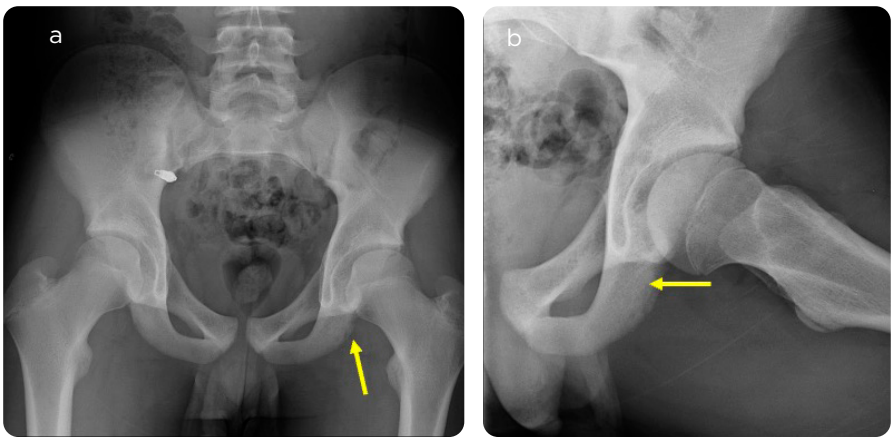


Figure 2. Avulsion of the left ischial tuberosity. Pelvic X-ray, a) anteroposterior and b) oblique views. Irregularity of the left ischial tuberosity suggestive of avulsion (arrows).

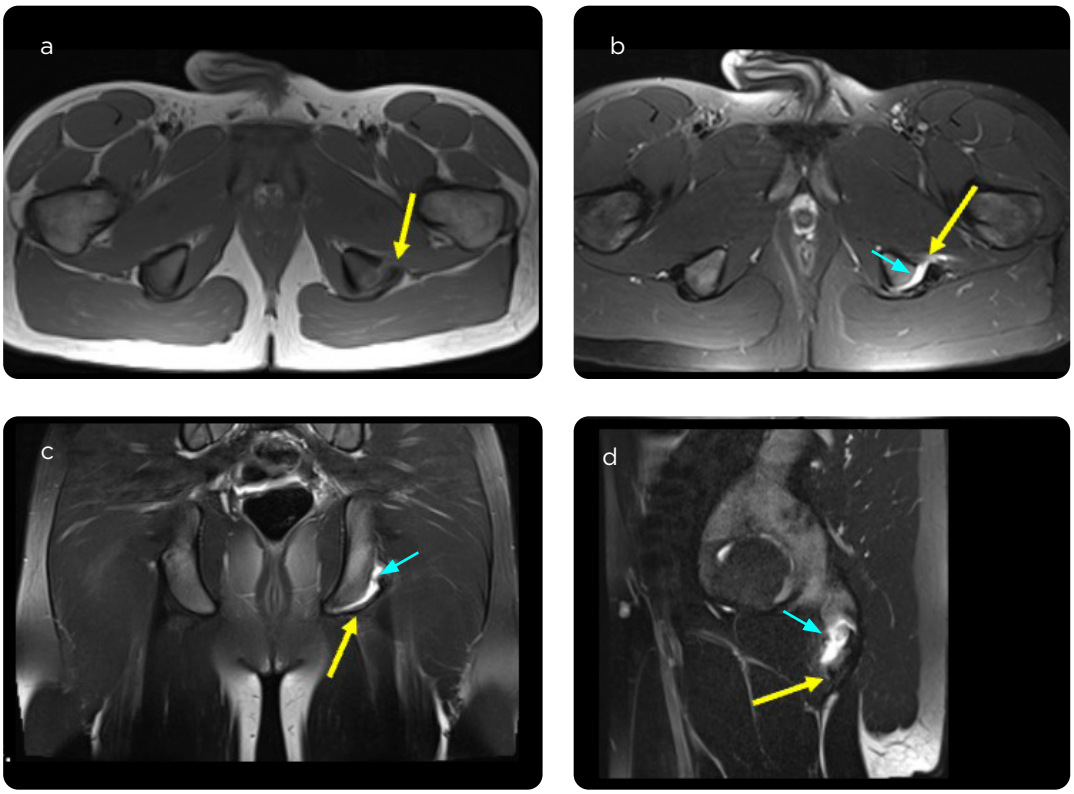


Figure 3. Avulsion fracture of the left ischial tuberosity. MRI, axial images in the following sequences: a) DP and b) fat-saturated DP; c) coronal STIR and d) sagittal T2-weighted. The yellow arrows indicate avulsion of the left ischial tuberosity apophysis with mild distal retraction of 1.5 cm. In the fluid-sensitive sequences, fluid is visible between the apophysis and the ischium (blue arrows).

Jumper's Knee

"Jumper's knee" is the common name given to a rupture of the patellar tendon. This tendon is part of the knee's extensor mechanism, along with the quadriceps tendon and the patella (5). The distal and deep fibers of the quadriceps tendon run across the surface of the patella and continue as the patellar tendon (6). The patellar tendon inserts proximally into the anterior and inferior surfaces of the patella and distally into the anterior tibial tuberosity (7).

The traumatic mechanism results from a sudden, forceful contraction of the quadriceps, which causes traction and rupture (8). These ruptures can be classified as partial or complete, depending on the extent of fiber involvement. The most common ruptures occur in the proximal third, near the inferior border of the patella. A high patella is frequently observed when the rupture involves the entire thickness of the tendon (8).

Imaging findings

On MRI, the normal patellar tendon appears as a low-signal intensity structure on all sequences. Tendinopathy is characterized by increased signal intensity in the tendon fibers on T1- and T2-weighted images, associated with reactive medullary edema on the patellar surface. A complete tendon rupture is usually accompanied by detachment and retraction of the tendon (1).

Case 3: A 19-year-old male patient, a volleyball player, presenting with medial knee pain (Figure 4).

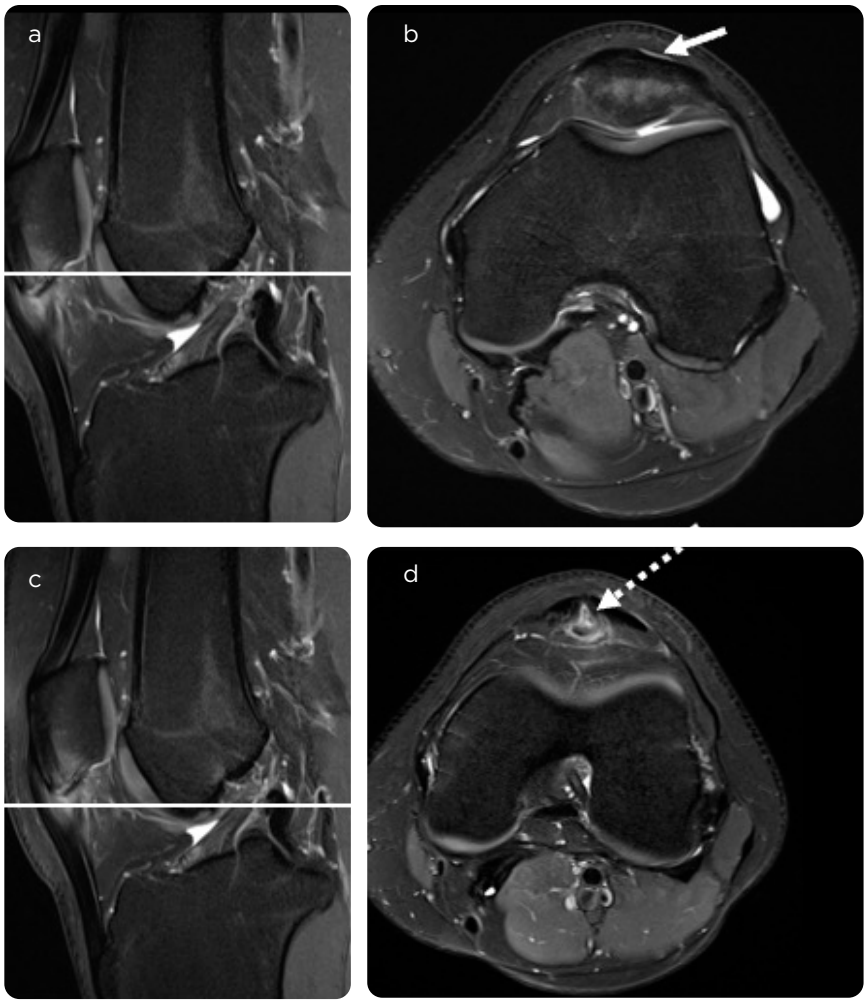


Figure 4. Jumper's knee. MRI. a and c) Sagittal views and b and d) axial views in fat-suppressed DP sequences. Medullary bone edema of the inferior pole of the patella with mild avulsive detachment of the periosteum from the quadriceps tendon (white arrow). Partial tear of the deep proximal fibers of the patellar tendon (dotted arrow).

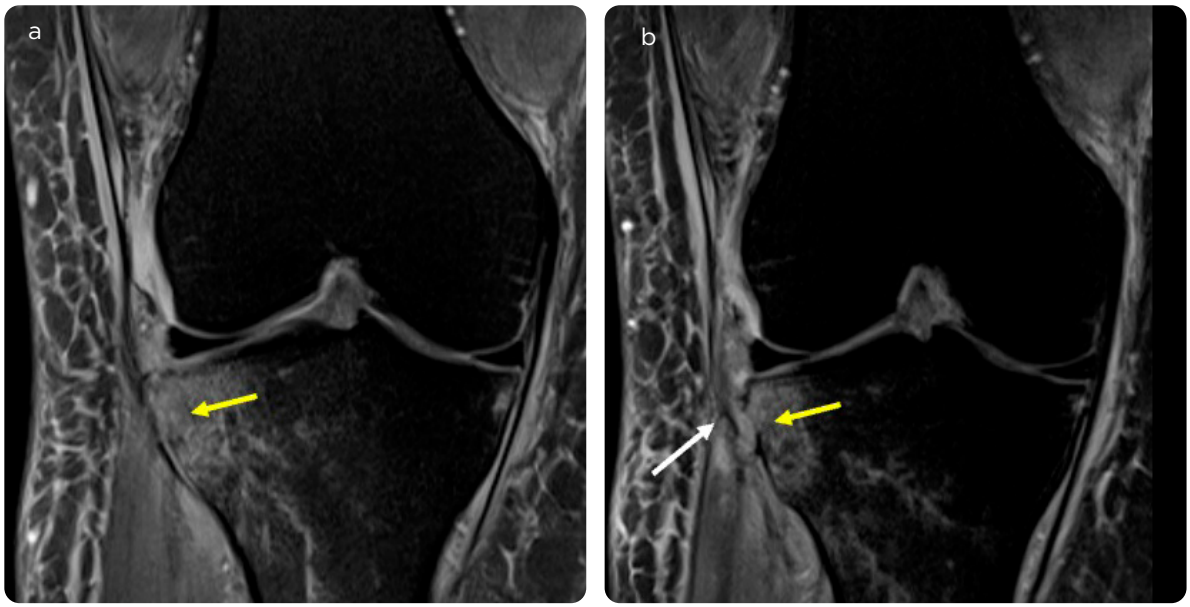


Figure 5. Segond fracture. MRI. Coronal planes, STIR sequence. a and b) The yellow arrows show periosteal detachment along the anterolateral aspect of the proximal tibia where the anterolateral ligament inserts, consistent with a Segond fracture. The white arrow points to the anterolateral ligament attached to the detached bone fragment.

Segond avulsion fracture

A Segond fracture is described as an avulsion fracture of the anterolateral region of the proximal tibia and results from forced internal rotation of the knee. The injury leads to anterolateral instability of the knee and is frequently associated with anterior cruciate ligament rupture and meniscal tears (9).

A Segond fracture is an avulsion fracture in which the detached bone fragment is attached to the anterolateral ligament of the knee, a structure first described in 1879 by Paul Segond (10). This ligament is a band originating from the lateral femoral epicondyle that runs obliquely until it inserts in a fan-shaped pattern on the proximal tibia, below the tibial plateau, superior and posterior to Gerdy's tubercle (11).

Imaging findings

MRI studies can identify, in addition to the fracture, other injuries such as tears and damage to adjacent structures (12). Bone edema and cortical irregularity at the site of avulsion confirm the diagnosis. It is sometimes difficult to visualize the bone fragment on MRI, so the findings must be correlated with the X-ray, on which the fragment is easily detected (12).

Anterior cruciate ligament (ACL) rupture is the most common associated injury, occurring in 94% of cases (12); therefore, a thorough evaluation of the integrity of this ligament is essential. Additionally, the menisci should be examined, as they may be affected in up to 75% of cases (12).

Case 4: A 32-year-old male patient, a soccer player and high-performance athlete, presented with generalized knee pain following a rotational injury (Figure 5).

Injuries to the flexor retinaculum of the ankle

The ankle retinacula are areas of localized thickening of the deep fascia (13). They consist of an inner sliding layer, a thick middle layer, and an outer layer of connective tissue with an average thickness of 0.9 mm (14). The function of the retinacula is to act as a protective sheath that covers and holds in place the tendons, nerves, and blood vessels as they pass through the structures of the ankle (13). They play an important role in the dynamic stabilization of the ankle joint and include: the extensor retinaculum (superior and inferior), the peroneal retinaculum, and the flexor retinaculum (13). The mechanism of injury is forced dorsiflexion and eversion of the ankle (14).

The flexor retinaculum is located on the medial aspect of the ankle. Its proximal end attaches to the posterior border of the medial malleolus, and its distal end connects to the medial tubercle of the calcaneus, where it joins the posterior tibial tendon and the superficial deltoid ligament. The retinaculum forms the roof of the tarsal tunnel and surrounds the flexor tendons and the neurovascular bundle (15).

The anterior origin of the flexor retinaculum continues as the superficial deltoid ligament, with its aponeuroses extending over the medial malleolus. For this reason, a tear of the superficial deltoid ligament affects the retinaculum (13). Isolated injuries to the flexor retinaculum are rare, which necessitates ruling out damage to the proximal fibers of the deltoid ligament (13). It has been reported that one-third of patients with traumatic injury to the superficial deltoid ligament have associated damage to the medial flexor retinaculum (14).

Injuries to the flexor retinaculum are usually found at the tibial origin and present with a wide range of clinical manifestations. These range from thickening and edema at the bony insertion to complete elevation of the periosteum associated with medial subluxation of the posterior tibial tendon (13).

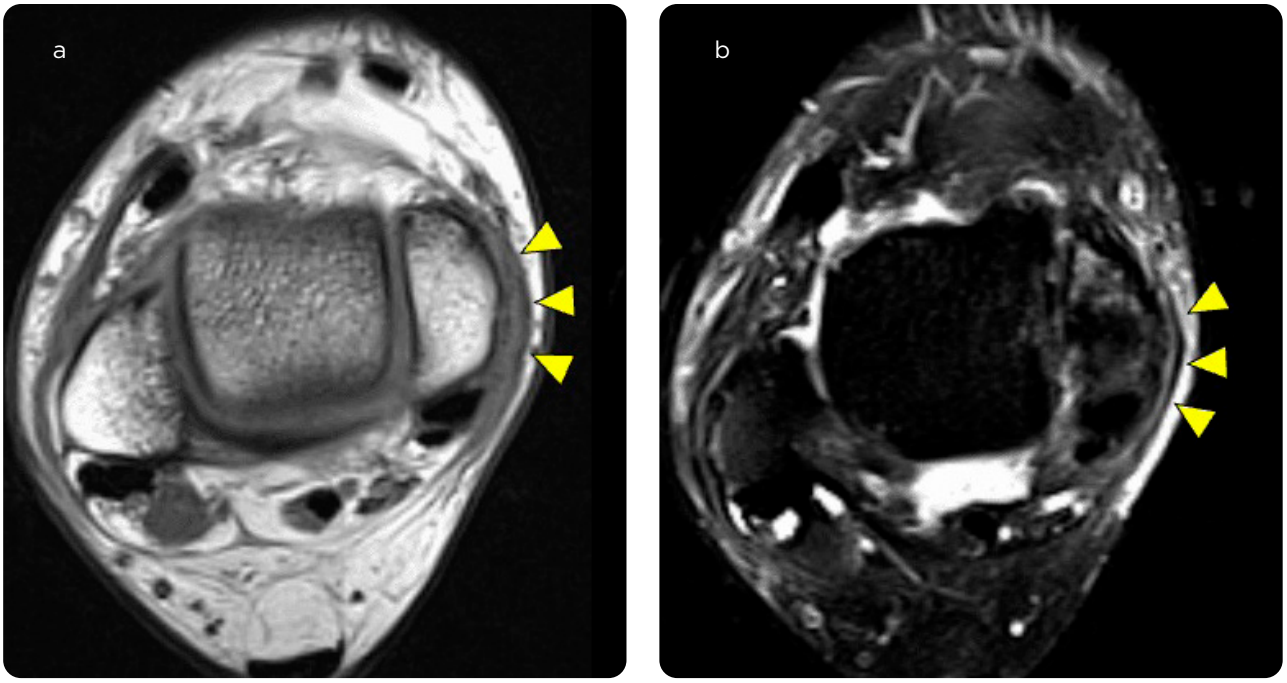


Figure 6. Avulsion of the flexor retinaculum. MRI. Axial images: a) T1-weighted and b) T2-weighted with fat saturation. Avulsion of the flexor retinaculum at the anterior aspect of the medial malleolus. The avulsed fibers appear thickened and heterogeneous (arrowheads).

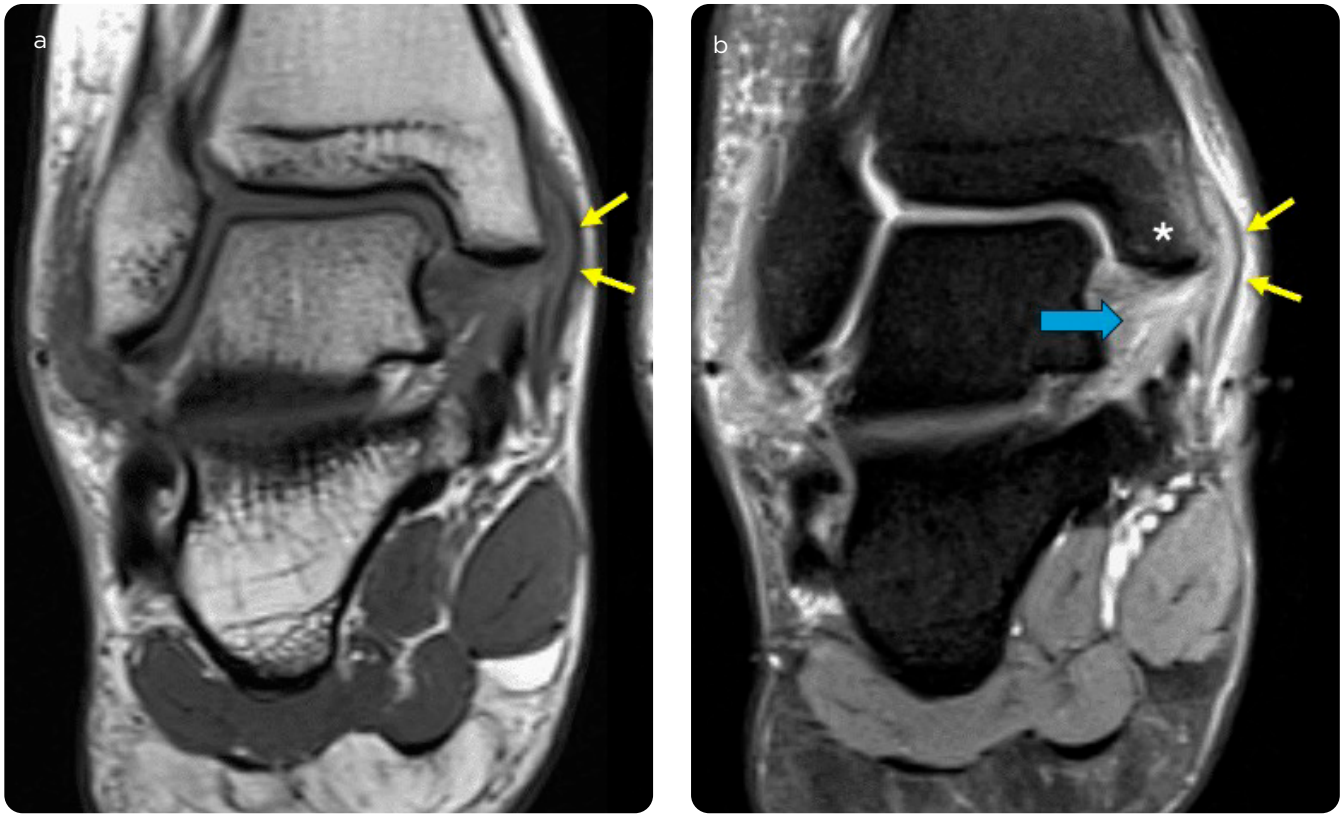


Figure 7. Avulsion of the flexor retinaculum. MRI. Coronal images: a) T1-weighted and b) fat-suppressed. Avulsion of the flexor retinaculum from the medial malleolus (arrowheads) with reactive bone marrow edema (asterisk). Edema of the posterior tibiotalar ligament consistent with a Grade 1 sprain (blue arrow).

Imaging findings

MRI is a highly accurate diagnostic modality for evaluating the ankle ligament complex. It provides information on the position and integrity of the tendons, particularly the posterior tibial tendon (13). It is essential to evaluate all structures to identify dislocations and tears of this tendon (13).

Under normal conditions, the retinaculum appears as a low-signal-intensity structure on all sequences (16). Traumatic injuries are characterized by increased signal intensity, thickening, or detachment of the retinaculum's periosteal insertion at the medial malleolus, accompanied by bone and soft-tissue edema. In addition, there may be displacement and dislocation of the posterior tibial tendon (13).

Case 5: An 18-year-old male patient presented with a rotational injury to his right ankle (Figures 6 and 7).

Conclusion

Acute traumatic injuries caused by excessive stretching and mechanical traction of structures such as tendons, ligaments, and retinacula primarily affect high-performance athletes and have increased in recent years. It is essential for radiologists to be familiar with the MRI findings of these injuries in order to make an accurate and timely diagnosis. This case series presents avulsion injuries of the hip and knee, as well as a traction injury of the flexor retinaculum of the ankle.

References

1. Agten CA, Sutter R, Buck FM, Pfirrmann CWA. Hip Imaging in athletes: sports imaging series. Radiology. 2016;280(2):351-69.
2. Albtoush OM, Bani-Issa J, Zitzelsberger T, Springer F. Avulsion injuries of the pelvis and hip. RoFo: Fortschritte Auf Dem Gebiete Der Rontgenstrahlen Und Der Nuklearmedizin [Internet]. 2020;192(5):431-40.
3. Nachtrab O, Cassar-Pullicino VN, Lalam R, Tins B, Tyrrell PNM, Singh J. Role of MRI in hip fractures, including stress fractures, occult fractures, avulsion fractures. Eur J Radiol. 2012;81(12):3813-23.
4. Bencardino JT, Mellado JM. Hamstring injuries of the hip. Magn Reson Imaging Clin N Am. 2005;13(4):677-90.
5. Yu JS, Petersilge C, Sartoris D, Patbria M, Resnick D. MR imaging of inj uries of the extensor mechanism of the knee1. RadioGraphics. 1994;(14):541-51.
6. Wangwinyuvirat M, Dirim B, Pastore D, Pretterklieber M, Frank A, Haghighi P, et al. Prepatellar quadriceps continuation: MRI of cadavers with gross anatomic and histologic correlation. Am J Roentgenol. 2009;192(3):W111-6.
7. Fazal MA, Moonot P, Haddad F. Radiographic features of acute patellar tendon rupture. Orthop Surg. 2015;7(4):338-42.
8. Fritz B, Fritz J. MR imaging of acute knee injuries. Radiol Clin North Am. 2023;61(2):261-80.
9. Helito PVP, Bartholomeeusen S, Claes S, Rodrigues MB, Helito CP. Magnetic resonance imaging evaluation of the anterolateral ligament and the iliotibial band in acute anterior cruciate ligament injuries associated with segond fractures. Arthrosc J Arthrosc Relat Surg. 2020;36(6):1679-86.
10. Porrino J, Maloney E, Richardson M, Mulcahy H, Ha A, Chew FS. The anterolateral ligament of the knee: MRI appearance, association with the segond fracture, and historical perspective. Am J Roentgenol. 2015;204(2):367-73.
11. Claes S, Vereecke E, Maes M, Victor J, Verdonk P, Bellemans J. Anatomy of the anterolateral ligament of the knee. J Anat. 2013;223(4):321-8.

12. Campos JC, Chung CB, Lektrakul N, Pedowitz R, Trudell D, Yu J, et al. Pathogenesis of the Segond fracture: anatomic and MR imaging evidence of an iliotibial tract or anterior oblique band avulsion. Radiology. 2001;219(2):381-6.
13. Karthikeyan I, Gregory KM, Beale D, Prem H, Gavvala SN, Botchu R. Isolated, periosteal stripping injuries of the flexor retinaculum: Case series of 3 patients with clinico-radiological review. J Clin Orthop Trauma. 2023;36:102082.
14. Lewis SD, Chew FS. Ankle medial flexor retinaculum avulsion fracture. Radiology Case Reports. 2019;14(9):1144-7.
15. Demondion X, Canella C, Moraux A, Cohen M, Bry R, Cotten A. Retinacular disorders of the ankle and foot. Semin Musculoskelet Radiol. 2010;14(03):281-91.
16. Numkarunarunrote N, Malik A, Aguiar RO, Trudell DJ, Resnick D. Retinacula of the foot and ankle: MRI with anatomic correlation in cadavers. Am J Roentgenol. 2007;188(4):W348-54.

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