MRI and US in Hamstring Sports Injury Assessment: Anatomy, Imaging Findings, and Mechanisms of Injury

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Most muscle tears occur in the lower extremities, especially in the hamstrings. The hamstring muscle complex consists of the semimembranosus (SM), semitendinosus (ST), and biceps femoris (BF) muscles. They originate from the ischial tuberosity, and while the BF inserts into the head of the fibula, the ST and SM muscles attach to the medial aspect of the tibia. The hamstrings are primarily hip extensors and knee flexors. Tears mostly occur during sport practice, particularly during forceful stretching or high-speed running, and typical sites are grouped and classified according to their location within the muscle anatomy. Sprint and stretching injuries typically affect the BF and SM, respectively. MRI and US are key complementary modalities for the diagnosis, treatment, and prognosis of hamstring injuries, as injury length, connective tissue involvement, and tear location determine evolution, recovery strategies, and return to play.

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Abbreviations: BF = biceps femoris, BFlh = biceps femoris long head, BFsh = biceps femoris short head, IT = ischial tuberosity, MTJ = myotendinous junction, PMTJ = proximal MTJ, RTP = return to play, SM = semimembranosus, ST = semitendinosus, STIR = short tau inversion recovery

TEACHING POINTS

- US and MRI are the methods of choice for evaluating muscle and tendon injuries. They complement each other and should be optimized by the radiologist.
- MRI helps to define proximal injuries better than US and can be routinely used to rule out tendon affection and avulsion injury from the proximal attachment of the hamstrings to the IT.
- The most significant risk factor for hamstring injury is a previous hamstring injury, which is associated with a high reinjury rate.
- Sprinting is the most common mechanism of BFlh injury, and stretch injuries are often associated with SM involvement.
- The precise location of the muscle injury and the specific anatomic tissue structures affected are the most crucial prognostic factors. The prognosis is poorer when a great extent of connective tissue is involved.

Introduction

The hamstring muscle complex consists of three muscles located on the back of the thigh. From lateral to medial, they are the biceps femoris (BF) long head (BFlh), BF short head (BFsh), semitendinosus (ST), and semimembranosus (SM). All of these muscles attach proximally to the ischial tuberosity (IT), except for the BFsh, which originates at the linea aspera in the middle thigh. The BF and ST muscles are attached to the IT through a conjoint tendon (1). The proximal SM tendon attaches to the anterior aspect of the IT. The conjoint tendon and SM tendon run close to the greater sciatic nerve throughout its entire length (Fig 1). The BF attaches distally to the lateral side of the fibula, while the ST and SM attach to the tibia (1).

While some authors classify the adductor magnus as a hamstring muscle, it will not be regarded as such for the academic purposes of this article (2). Hamstring injuries are common among athletes, lead to prolonged absence from sports, and have a high recurrence rate. The most commonly involved muscles are the BFlh, followed by the SM, and finally the ST (3). This article describes the clinical characteristics, mechanisms, and locations of hamstring injuries based on MRI and US findings and highlight key factors for guiding treatment strategies and preventing recurrent injuries.

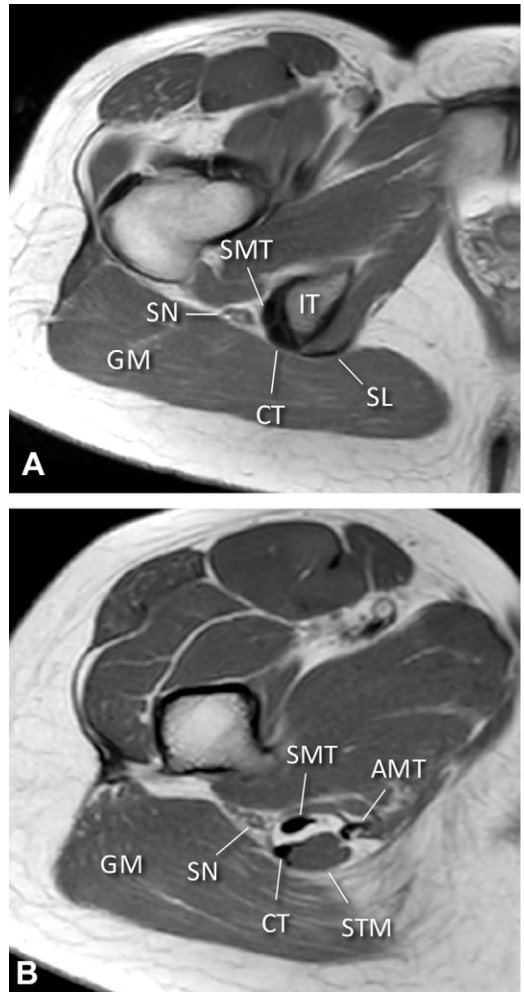

Figure 1. **(A)** Axial proton density–weighted T2-weighted MR image through the IT shows the anatomic origin of the hamstring muscles: the proximal SM tendon *(SMT)* lateral and anterior to the conjoint tendon *(CT)* of the BF and ST muscles. The sacrotuberous ligament *(SL)*, sciatic nerve *(SN)*, and gluteus maximus *(GM)* are identified. **(B)** Image with the same sequence and slightly distal to **A** shows these structures and the origin of the adductor magnus tendon *(AMT)* and the ST muscle belly *(STM)*.

Anatomy and Lesion Patterns

In order of severity, tendinous injuries (pure connective tissue lesions) can manifest as elongation or stretch injuries, partial tears, or complete tears with a gap and loss of tendon continuity (4–6). The myoconnective junction (MCJ) includes the myotendinous junction (MTJ) and the myofascial or myoaponeurotic junction (7). In this area, the muscle fibers are anchored to the connective tissue, transitioning through various thicknesses (tendon-aponeurosis) until they become less visible at imaging (fascia). The MCJ can be centrally located (myotendinous) or peripherally located (myofascial or myoaponeurotic) in relation to the muscle belly in the different hamstring muscles (7) (Fig 2).

When the MCJ is disrupted, it is common to observe interstitial edema in a "feathery" pattern (where edema separates the interstitial space between muscle fibers). Interstitial edema can occur without muscle fiber disruption, with muscle fiber gaps or a loss of connective tissue tension. Moreover, muscle fiber injuries can appear as architectural distortion with poor fiber definition at imaging or as discrete tears with a gap or defect, at the anchorage point to the tissue connective with subsequent loss of the pennation angle, or within the muscle belly itself (intramuscular tear). In larger tears, intramuscular hematomas may develop. Intermuscular edema is often observed but may not have prognostic significance (7).

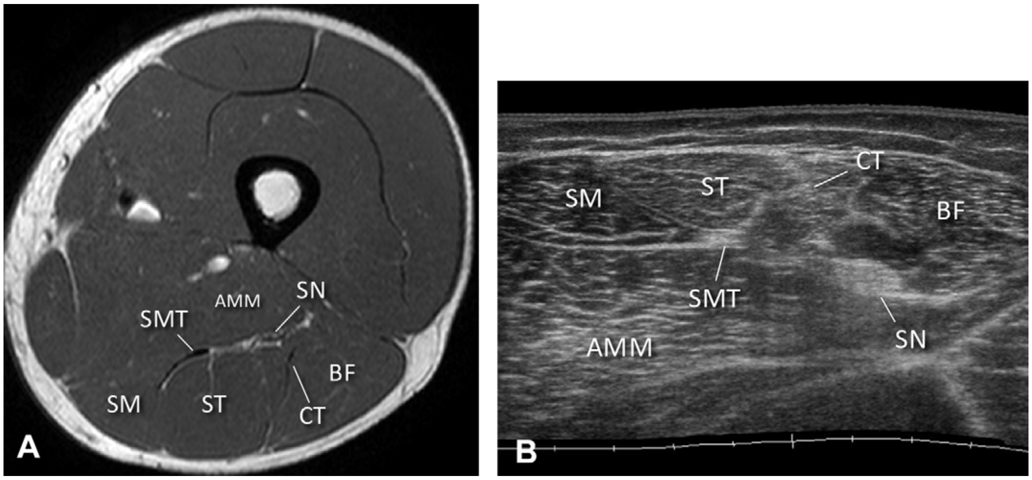

Figure 2. Axial T1-weighted MR **(A)** and transverse US **(B)** images show the anatomy of the hamstrings in the proximal thigh: adductor magnus muscle *(AMM),* BF muscle, conjoint tendon *(CT)*, SM, SM tendon *(SMT)*, sciatic nerve *(SN)*, and ST.

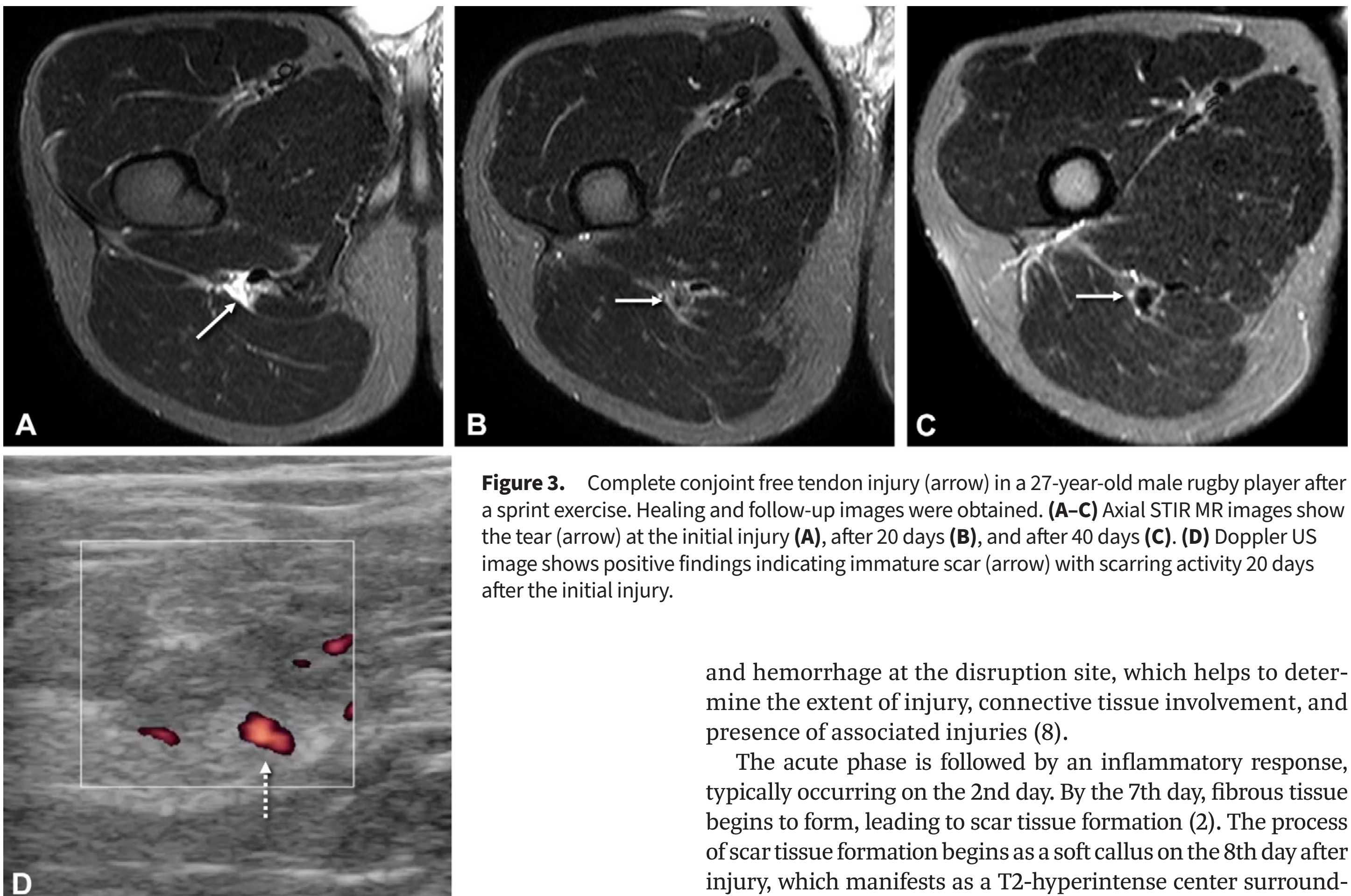

Figure 3. Complete conjoint free tendon injury (arrow) in a 27-year-old male rugby player after a sprint exercise. Healing and follow-up images were obtained. **(A–C)** Axial STIR MR images show the tear (arrow) at the initial injury **(A)**, after 20 days **(B)**, and after 40 days **(C)**. **(D)** Doppler US image shows positive findings indicating immature scar (arrow) with scarring activity 20 days after the initial injury.

Imaging Modalities

Magnetic Resonance Imaging

US and MRI are the methods of choice for evaluating muscle and tendon injuries. They complement each other and should be optimized by the radiologist. In the acute phase of a muscle injury (first 24 hours), the most effective diagnostic modality is MRI with fluid-sensitive sequences (short tau inversion-recovery [STIR], T2-weighted, or proton density fat-saturated sequences). This allows visualization of muscle fiber edema and hemorrhage at the disruption site, which helps to determine the extent of injury, connective tissue involvement, and presence of associated injuries (8).

The acute phase is followed by an inflammatory response, typically occurring on the 2nd day. By the 7th day, fibrous tissue begins to form, leading to scar tissue formation (2). The process of scar tissue formation begins as a soft callus on the 8th day after injury, which manifests as a T2-hyperintense center surrounded by a thin and hypointense peripheral line. This progresses to the filling in and loss of signal intensity, and then finally the formation of a hard callus with low signal intensity on T1- and T2-weighted images (9). In addition, MRI can aid in determining the chronicity of the lesion and the changes in the signal intensity of the fibrotic tissue related to its evolution (2) (Fig 3).

Isern-Kebschull et al (9) performed MRI in professional athletes within 7 days of return to play (RTP) after hamstring strain injuries. The authors found that the presence of transversal and/or mixed connective tissue gap, tendon tension loss, intermuscular edema, callus gap, and interstitial feather edema patterns increased the risk of reinjury when at least two of these findings

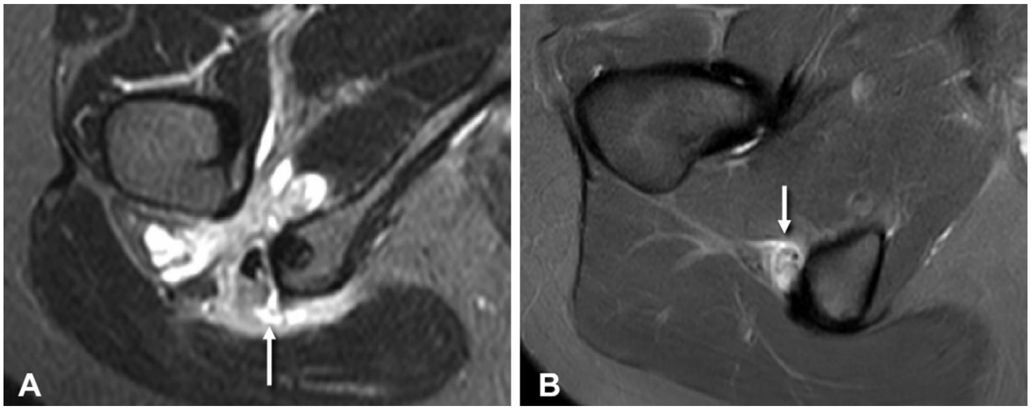

Figure 4. Proximal avulsion of the hamstring tendon. **(A)** Axial STIR MR image in a 35-year-old male recreational soccer player shows the complete avulsion of the conjoint tendon origin (arrow). **(B)** Axial STIR MR image in a 24-year-old female amateur soccer player shows complete injury of the SM tendon origin (arrow).

Table 1: Indirect Hamstring Injuries

Injury Mechanism	Biomechanics	Muscle Affected
Sprinting	Observed during the late swing phase of the running gait cycle, just before a touchdown	BF is most susceptible to injury during active lengthening; could involve insertions, the free tendon, and the intramuscular MTJs or PMTJs
Stretching	Eccentric contraction with the hip flexed and the knee extended	Proximal hamstrings insertion at the ischium or MTJ of the SM

Note.—PMTJ = proximal MTJ.

were present. However, a systematic review article by Reurink et al (10) found insufficient evidence to support any MRI finding as a reliable predictor for RTP after hamstring injuries.

Ultrasonography

US has great sensitivity 72 hours after injury (8) and can help detect fluid collections, edema, or hemorrhage around and along the injured muscle. It can be used to accurately determine the location and extent of hamstring injuries and assess noninsertional injuries by comparing them with injuries in the contralateral healthy region (2). US can also depict calcifications, which could be associated with local chronic pain. Scar tissue areas have a heterogeneous echotexture and irregular morphologic features, which are worth identifying since recurrent strain may occur near these regions (2).

Dynamic US offers high-resolution imaging, enabling a direct correlation with physical examination findings. Color or power Doppler US can be used to assess neovascularization, inflammation, and healing (2) (Fig 3). Moreover, sports facilities can have a portable US machine for immediate injury diagnosis and even echo-guided infiltrations (11). As disadvantages, the use of US heavily relies on the examiner's experience (long learning curve) and has limitations in assessing deep structures and evaluating the severity of reinjuries (9). MRI helps to define proximal injuries better than US (8) and can be routinely used to rule out tendon affection and avulsion injury from the proximal attachment of the hamstrings to the IT (12) (Fig 4).

Risk Factors

According to Ahmad et al (11), several risk factors for hamstring injuries have been suggested, including overload, fatigue, inadequate warm-up, muscle weakness, strength imbalance, lower extremity flexibility, dehydration, and poor core stability. Considering that hamstring injuries typically occur toward the end of a competition, fatigue and overload are key factors to consider. The most significant risk factor for hamstring injury is a previous hamstring injury, which is associated with a high reinjury rate (11).

Mechanism of Hamstring Injuries

Most hamstring strains are caused by noncontact mechanisms. Askling et al (13,14) describe two injury mechanisms that lead to hamstring tears at different sites: high-speed running (sprint) and hyperstretching (Table 1). The sprinting gait can be divided into two phases: the stance or support phase in which one foot is on the ground, and the swing or recovery phase in which both feet are off the ground (15) (Fig 5). The BF is most prone to injury during active lengthening, which occurs toward the end of the swing phase of the sprinting gait cycle (16), just before the foot strike (17).

Hyperstretching mechanisms, which involve a combination of extensive hip flexion and knee extension, are common in artistic gymnastics, classic ballet, and waterskiing during fast or slow movements and usually affect the SM along the proximal tendon at the intramuscular level or the free tendon (18). Sprinting is the most common mechanism of BFlh injury, and stretch injuries are often associated with SM involvement.

Hamstring Injury Classification System

The three most commonly used classifications for muscle injuries are the Munich consensus (19), British Athletics Muscle Injury Classification (BAMIC) (20) (Table 2), and Football Club (FC) Barcelona Muscle Injuries Classification (21).

Figure 5. Photographs show the sprinting gait cycle.

Table 2: British Athletics Muscle Injury Classification System*

Grade	Description	MRI Findings
0	Focal or generalized muscle pain after exercise	Normal or patchy high-signal-intensity change throughout one or more muscles
1a	Small myofascial tear	High-signal-intensity change evident at the fascial border, with <10% extension into the muscle belly Craniocaudal distance of <5 cm
1b	Small muscular or muscle-tendon junction tear	High-signal-intensity change in the muscle cross-sectional area of <10%, usually at the muscle-tendon junction High-signal-intensity change in the craniocaudal length of <5 cm (may note fiber disruption of <1 cm)
2a	Moderate myofascial tear	High-signal-intensity change evident at the fascial border, with extension into the muscle High-signal-intensity change in the cross-sectional area between 10% and 50% at the maximal site High-signal-intensity change in the craniocaudal length of >5 cm and <15 cm Architectural fiber disruption is usually noted as <5 cm
2b	Moderate muscle-tendon junction tear	High-signal-intensity change evident within the muscle, usually at the muscle-tendon junction High-signal-intensity change in the cross-sectional area between 10% and 50% at the maximal site High-signal-intensity change in the craniocaudal length of >5 cm and <15 cm Architectural fiber disruption is usually noted as <5 cm
2c	Moderate-sized intratendinous tear	High-signal-intensity change extends into the tendon, with a longitudinal length of tendon involvement <5 cm Cross-sectional area of tendon involvement <50% in the maximal tendon cross-sectional area No loss of tension or discontinuity within the tendon
3a	Extensive myofascial tear	High-signal-intensity change is evident at the fascial border with extension into the muscle High-signal-intensity change in the cross-sectional area of >50% at the maximal site High-signal-intensity change in the craniocaudal length of >15 cm Architectural fiber disruption is usually noted as >5 cm
3b	Extensive muscle-tendon junction tear	High-signal-intensity change in the cross-sectional area of >50% at the maximal site High-signal-intensity change in the craniocaudal length of >15 cm Architectural fiber disruption is usually noted as >5 cm
3c	Extensive intratendinous tear	High-signal-intensity change extends into the tendon Longitudinal length of tendon involvement >5 cm Cross-sectional area of tendon involvement >50% of the maximal tendon cross-sectional area Possible loss of tendon tension, although no discontinuity is evident
4	Full-thickness tear of the muscle	Complete discontinuity of the muscle with retraction
4c	Full-thickness tear of the tendon	Complete discontinuity of the tendon with retraction

Source.—Reprinted, with permission, from reference 20.
* If any characteristics of a higher grade injury are present, the injury is assigned the highest grade.

According to the Munich consensus, muscle injuries are classified as functional (fatigue-induced injuries, delayed-onset muscle soreness, and neuromuscular disorders) and structural (minor, moderate, and complete muscle tear) (19). According to the BAMIC system, the severity of muscle injury is based on MRI findings, and five categories are proposed (neuromuscular injury or generalized muscle soreness, small muscle tear, moderate muscle tear, extensive muscle tear, and complete muscle tear), which can be further divided into subgroups depending on the site and

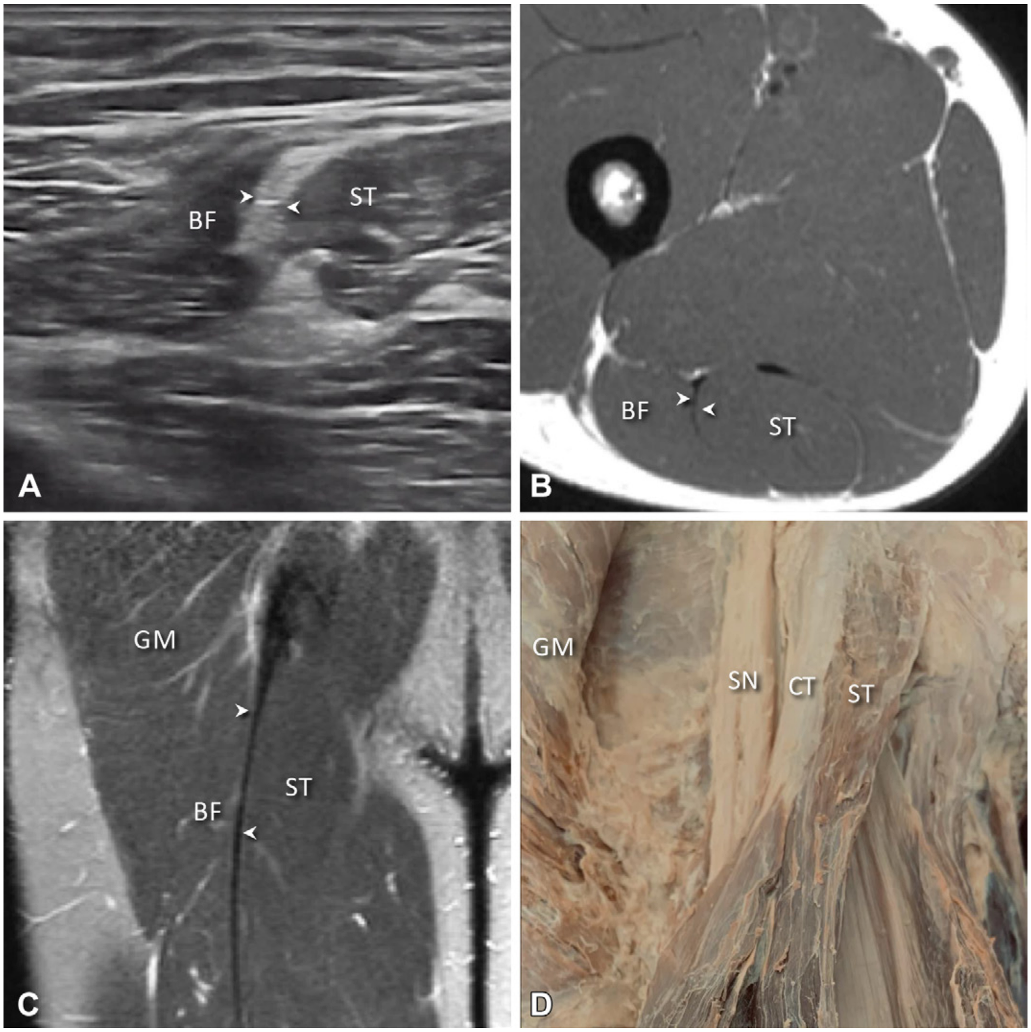

Figure 6. PMTJ of the ST and BF. **(A)** US image shows the conjoint tendon *(CT)* (arrowheads), BF, and ST muscle fibers. **(B, C)** Axial **(B)** and coronal **(C)** T1-weighted MR images show the conjoint tendon *(CT)* (arrowheads) origin and length. **(D)** Cadaveric correlation image shows the gluteus maximus *(GM)* and sciatic nerve *(SN)*.

extent of the injury (myofascial or peripheral location, muscle belly or muscle-tendon junction, and extension of the injury to the tendon) (20). The FC Barcelona Muscle Injuries Clinical Classification describes injuries based on their mechanism, location, and MRI findings (categorized by the type of connective tissue damaged, percentage of the cross-sectional area of the affected muscle, and reinjury) (21).

The complexity and variability of the architecture of different muscle groups make it exceedingly difficult to generalize the prognosis. In addition, the injured muscle, its specific function, and the type of sport performed are crucial factors in determining the severity and implications of the injury. These points of interest limit the practical use of these classifications (3). Nevertheless, it is important to determine the location and extent of myoconnective tissue involvement, as this can help determine the necessary treatment and predict the recovery time before RTP. Isern-Kebschull et al (7) suggest the need for a standardized method of reporting muscle injuries to ensure consistency in the description of injuries, findings at follow-up, and potential reinjuries.

Biceps Femoris

The BF consists of two components: the BFlh and BFsh. The long head shares a common origin with the ST muscle at the posterior and medial aspect of the IT through a conjoint tendon. This proximal conjoint tendon is approximately 5 cm long from its origin to the insertion of the proximal muscle fibers of the BFlh, also known as the free tendon. The conjoint tendon extends into the thickness of the BFlh and ST muscle bellies, forming the proximal MTJ (PMTJ) (22). The intramuscular conjoint tendon then divides into two separate tendons: one for the ST and one that progresses toward the distal third of the BFlh muscle belly (22) (Fig 6). In the midportion, the opposing epimysial condensations at the anterolateral aspect of the long head and the posterolateral aspect of the short head form the distal MTJ (DMTJ), which appears as a T-shaped structure (Fig 7). Finally, the distal tendon inserts into the lateral aspects of the fibula head (23). BF injuries (Table 3) most commonly occur in the hamstring muscle complex and are usually associated with the sprinting mechanism. The most affected muscle is the BFlh, and injuries can occur along its entire length: at the proximal insertion into the IT (injury that involves the free tendon), at the PMTJ at the level of the conjoint tendon (injury with or without its disruption), along the intramuscular proximal tendon that extends to the mid distal third of the thigh, or at the DMTJ with or without T-shaped compromise and the distal tendon insertion (8,16) (Fig 8).

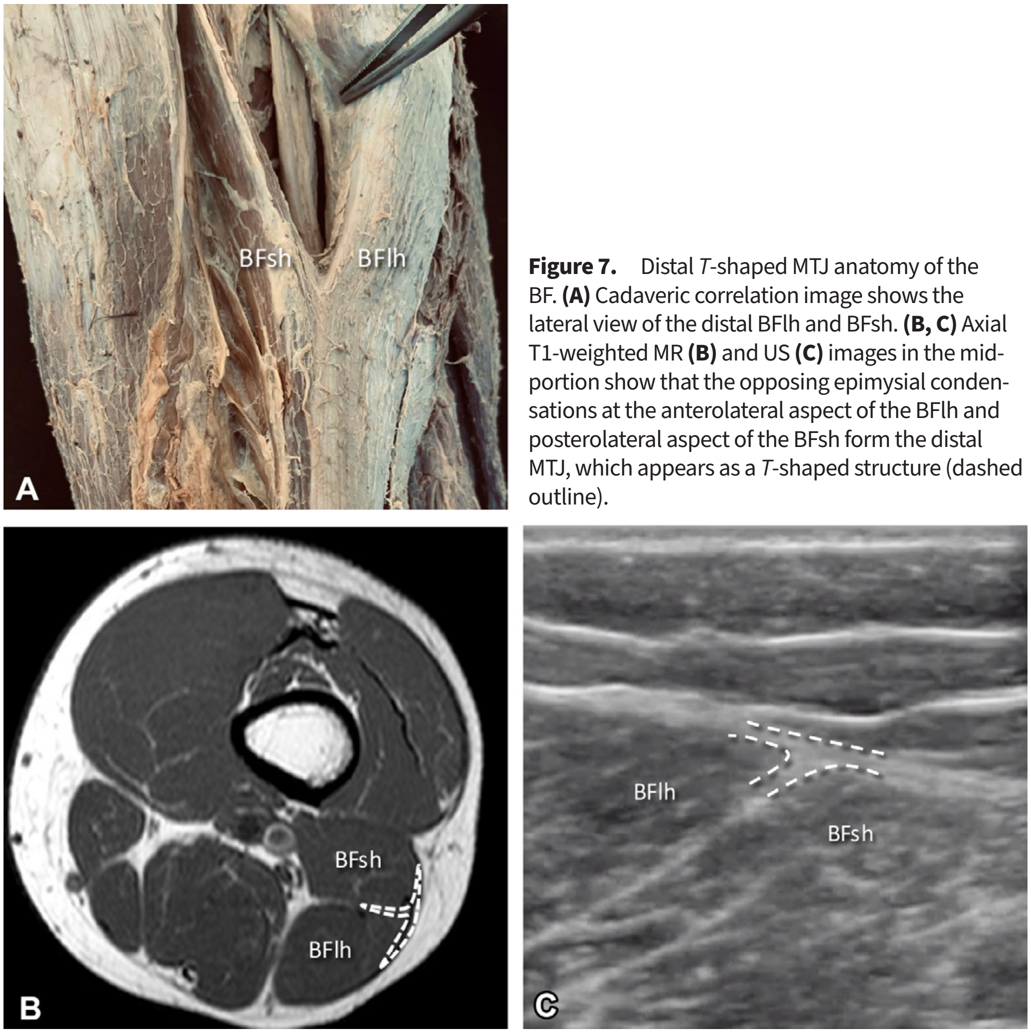

Figure 7. Distal *T*-shaped MTJ anatomy of the BF. **(A)** Cadaveric correlation image shows the lateral view of the distal BFlh and BFsh. **(B, C)** Axial T1-weighted MR **(B)** and US **(C)** images in the midportion show that the opposing epimysial condensations at the anterolateral aspect of the BFlh and posterolateral aspect of the BFsh form the distal MTJ, which appears as a *T*-shaped structure (dashed outline).

Table 3: BF Injuries

Location of Lesion	Mechanism of Injury	RTP	Modality*	Considerations
Free tendon (proximal insertion)	Sprint-heel (soccer) Jackal process (rugby)	8–12 wk	MRI	Assess for surgery, US-guided drainage
PMTJ	Sprint	8–10 wk	MRI, US	Carefully evaluate the conjoint tendon
Central MTJ (conjoint tendon disruption)	Sprint	6–8 wk	US	Most common injury in sports
Central MTJ (without conjoint tendon disruption)	Sprint	4 wk	US	Common injury and low reinjuries
PMTJ	Sprint	3–4 wk	US	Less common than a central lesion
T-shaped MTJ	Sprint-heel (soccer)	6–8 wk	US	BFlh: tibial nerve; BFsh: peroneal nerve; frequent reinjuries
Distal tendon insertion	Sprint	8–12 wk	MRI, US	Multiligament knee injury

Source.—Reference 8.
* Preferred modality of the authors.

The most common site of injury in sports worldwide is the PMTJ of the BFlh. It is essential to differentiate between a free tendon and a purely myotendinous injury, as injuries in the former tend to be more severe. As previously mentioned, MRI is the most sensitive imaging modality for proximal injuries (24).

The precise location of a muscle injury and the specific anatomic tissue structures affected are the most crucial prognostic factors. The prognosis is poorer when a great extent of connective tissue is involved. Injuries that involve the intramuscular tendon and adjacent muscle fibers usually require a shorter

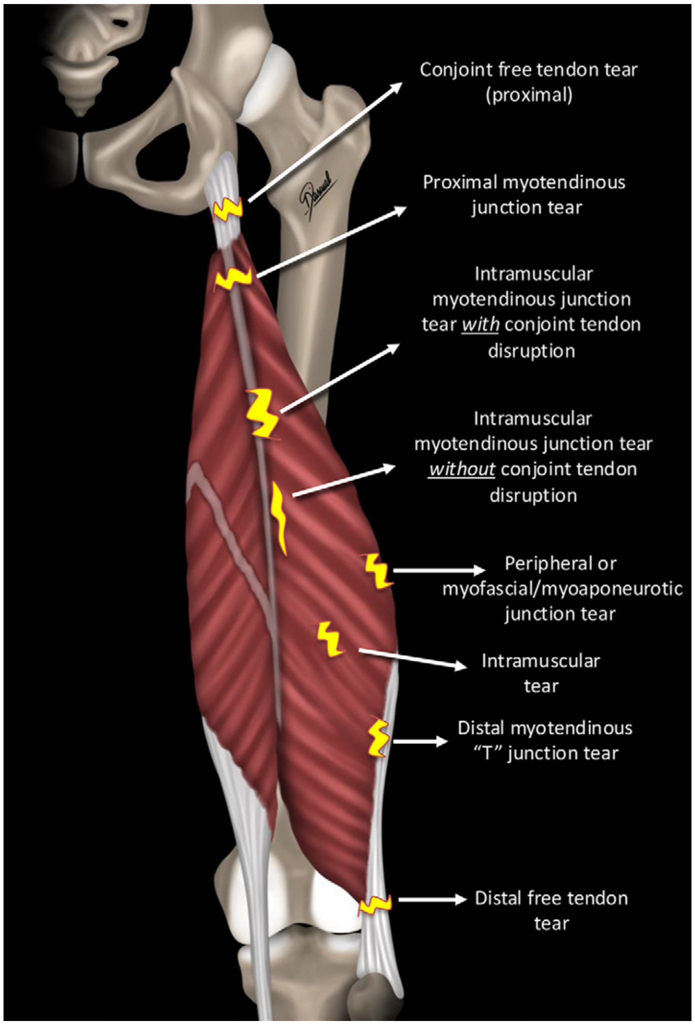

Figure 8. Common lesion sites of the BF.

RTP time than those that affect the proximal free tendon (18). The RTP time for injuries along the intramuscular MTJ with intramuscular tendon disruption is significantly longer than the RTP for injuries that involve only the muscle fibers, and there is a substantial risk of reinjury (25) (Figs 9, 10).

Injuries with the worst prognosis and a long recovery period are injuries of the BF free tendon, injuries of the PMTJ that involve the conjoint tendon (high recurrence rate), lesions that affect the T-shaped junction, and lesions that affect the distal tip of the proximal intramuscular tendon (8) (Fig 11). Muscle belly injuries are less common, can occur with direct trauma or contusion, and have better evolution than those with connective tissue involvement (11).

SM Muscle

The SM muscle is the innermost of the three hamstring muscles. It originates separately from the BFlh and ST muscles at the IT. Its muscle mass originates more distally and increases toward the distal and medial parts of the thigh. It has a large muscle belly and a well-defined PMTJ, characterized by a triangular fan-shaped aponeurosis. The base of the aponeurosis is in the mid proximal third of the thigh, and the upper vertex is in the proximal thigh (24) (Fig 12).

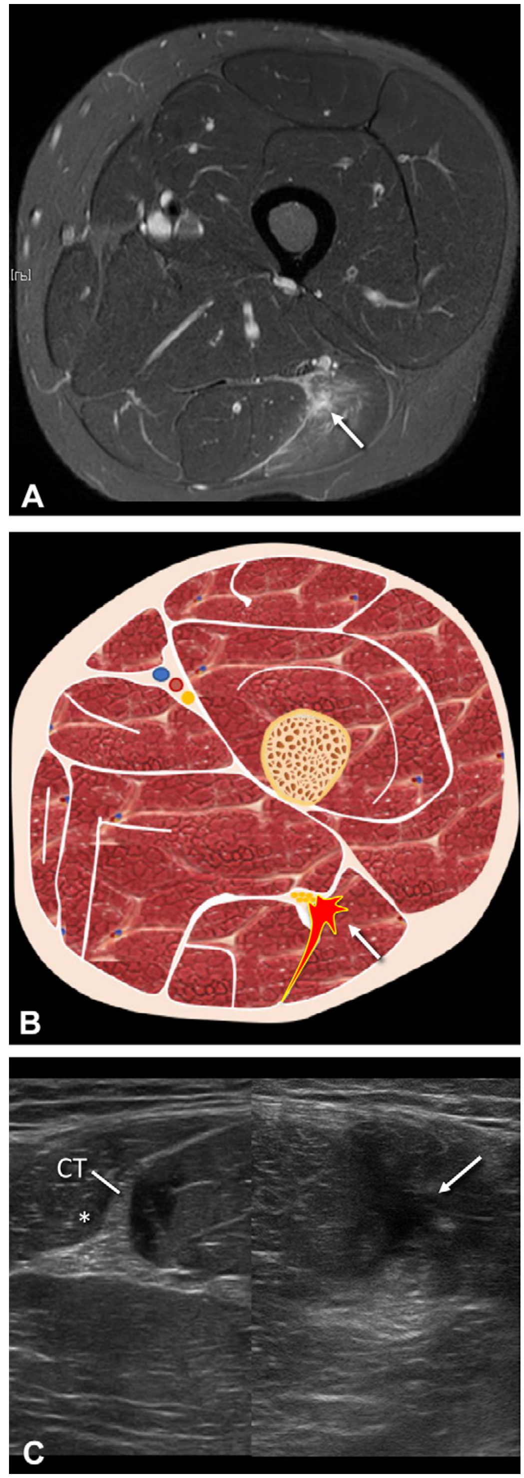

Figure 9. Injury of the central MTJ of the BF in a 25-year-old male professional soccer player who had posterior thigh pain after a sprint exercise. **(A, B)** Axial fat-saturated T2-weighted MR image **(A)** and schematic drawing **(B)** show a tear of the central MTJ of the BF with disruption of the conjoint tendon (arrow). **(C)** US images show these findings (arrow) in comparison with the normal contralateral site (*). *CT* = conjoint tendon.

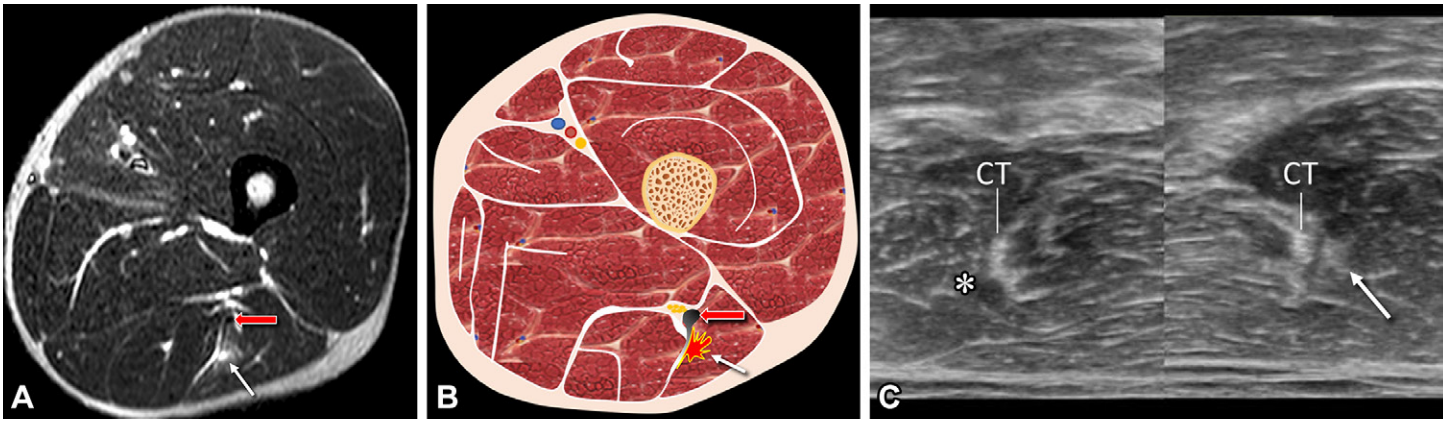

Figure 10. BF injury in a 30-year-old male professional soccer player with posterior thigh pain after a sprint exercise. **(A, B)** Axial T2-weighted MR image **(A)** and schematic drawing **(B)** show a tear of the central MTJ of the BF (white arrow) without disruption of the conjoint tendon (red arrow). **(C)** US images show these findings (arrow in right image) in comparison with the normal contralateral site (∗ in left image). *CT* = conjoint tendon.

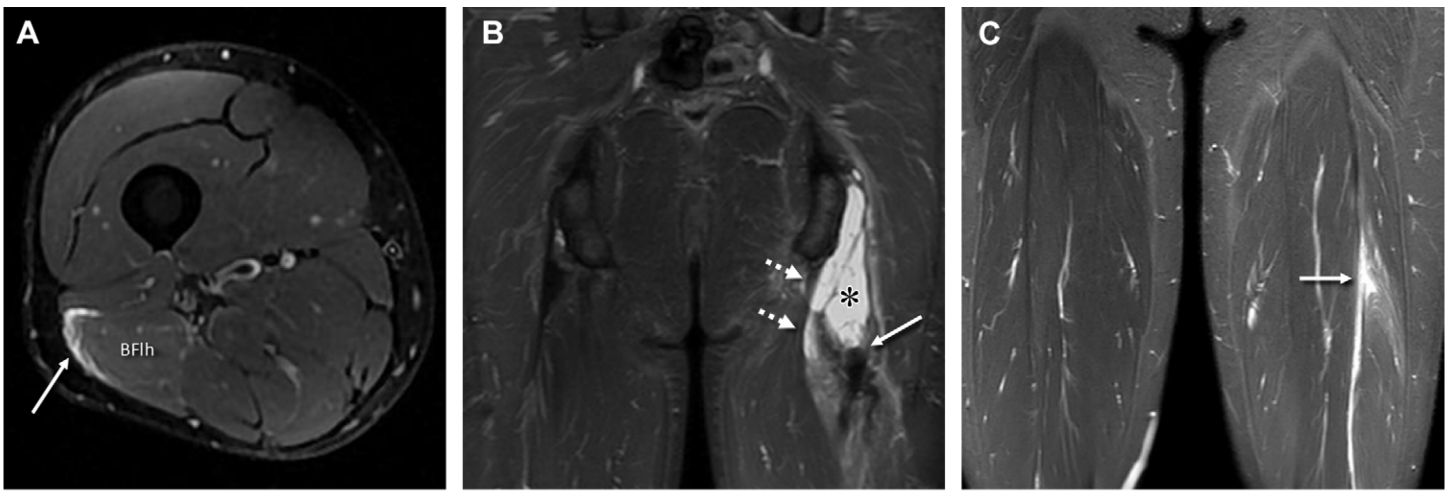

Figure 11. Muscle injuries with the worst prognosis for RTP in four patients. **(A)** Axial STIR MR image in a 38-year-old male recreational soccer player shows a partial tear of the BFlh component of the distal T-shaped MTJ of the BF (arrow) that occurred during sprinting. There is peritendinous edema and blood fluid. **(B)** Coronal STIR MR image in a 28-year-old male rugby player shows complete avulsion of the hamstring tendons (solid arrow) and a large hematoma (∗) that formed during the "jackal process." Note the intact adductor magnus tendon origin (dotted arrows). **(C)** Coronal STIR MR image in a 26-year-old male soccer player shows a tear of the conjoint tendon with myofibrillar edema (arrow) that occurred during sprinting. **(D)** Coronal STIR MR image in a 27-year-old male rugby player shows a proximal free tendon tear (arrow) that occurred after a sprint exercise.

This proximal aponeurosis manifests as a reinforcement in the lateral sector to form the proximal tendon of the SM, which has a length of approximately 30 cm from the middle third of the thigh to its origin in the anterolateral sector of the IT (26). The tendon then progresses to the middle third of the muscular belly, adjacent to the lateral muscle fibers, next to the ST belly (26).

The muscle fibers originate from the proximal tendon and their aponeurosis in different directions (PMTJ) (7). Muscle fibers can be classified according to their origin into three regions (Fig 13). In region A, the fibers arise from the medial part of the proximal tendon. In region B, the fibers arise from the medial and lateral parts of the proximal tendon (Fig 14). Region C has a bipennate origin and the fibers arise from the distal myoaponeurotic junction (27). This differentiation is important to consider in the prognosis of the lesions, as they are worse in regions B and C (27) (Figs 15–17).

The distal SM tendon is short and powerful and inserts into the medial and proximal sector of the tibia. It serves as the primary stabilizer of the posteromedial complex of the knee (24).

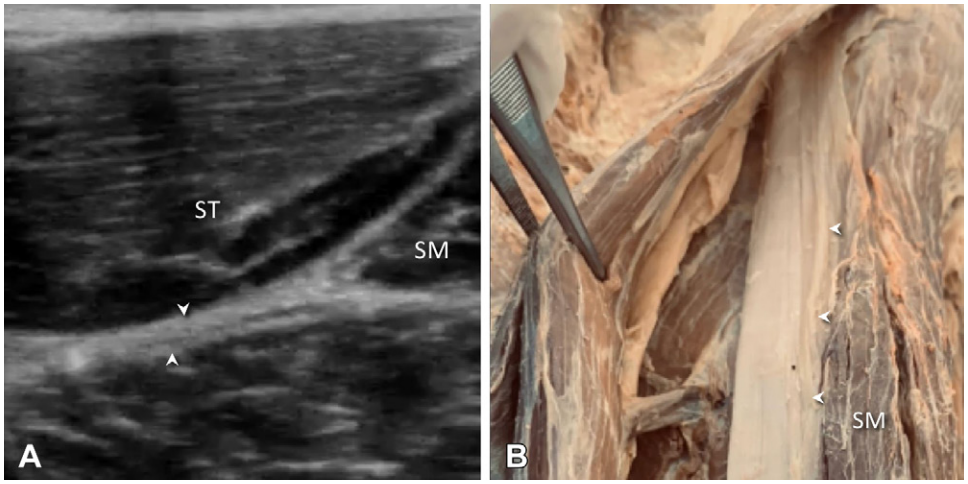

Figure 12. Normal SM proximal to the large MTJ. **(A)** US image shows extensive aponeurosis (arrowheads) next to the ST. **(B)** Cadaveric correlation image shows extensive aponeurosis of the SM (arrowheads).

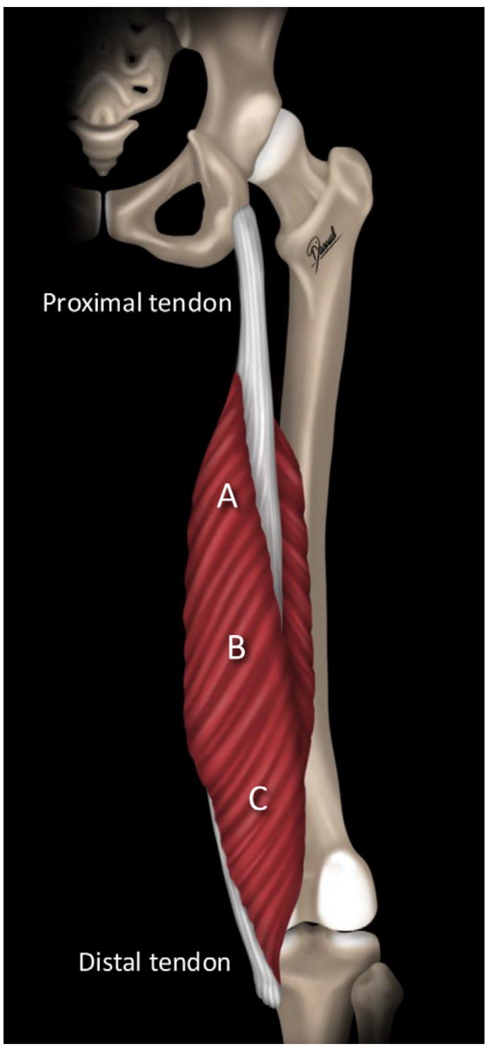

Figure 13. Three anatomic regions *(A, B, C)* of the SM muscle.

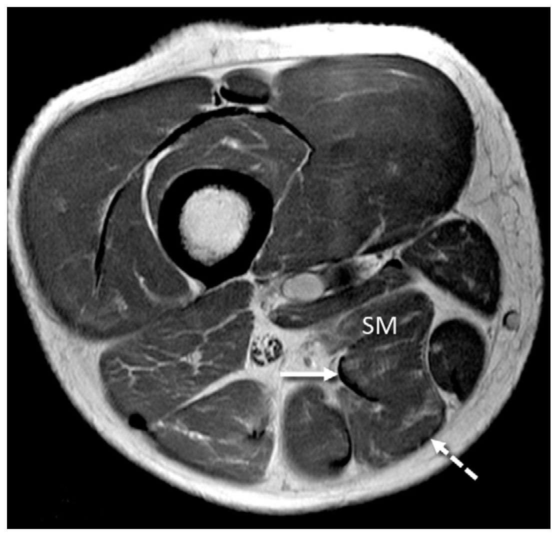

Figure 14. Axial proton density–weighted T2-weighted MR image shows the anatomy of the SM muscle in region B. (See Fig 13 for corresponding regions.) Note the proximal (solid arrow) and distal (dashed arrow) MTJs identified in the same section.

An SM injury is the second most common hamstring injury after injuries of the BFlh (28). Due to the characteristics of the three hamstring muscles, the SM is the least flexible and therefore has greater difficulty in adapting to a lengthening stretch mechanism (27).

SM injuries are the most common type of injury that occurs during hyperstretching activities, especially with a slow stretch mechanism (27). These injuries typically occur in the proximal free tendon and are usually located in the SM at a mean distance of 2.3 cm distal to the IT (22). Another common site of injury is the PMTJ of the SM muscle. It is important to verify the integrity of the proximal tendon, rule out longitudinal splits, and evaluate the status of the intramuscular tendon (26). Distal SM muscular tears are far less common (29).

ST Muscle

The ST muscle has a proximal common origin with the BFlh at the posteromedial aspect of the IT. In addition to the common origin, muscle fibers of the ST are often seen directly attached to the IT (22) (Fig 1). The ST has the longest muscle belly of all the hamstring muscles. It is divided into superior and inferior regions by a tendinous septum, known as the raphe, which sometimes causes the ST to be considered a digastric muscle. The raphe runs from proximal to distal and from medial to lateral (22) (Fig 18).

The long thin distal tendon of the ST (mean length, 25 cm) lies above the superficial muscle fibers of the SM and

Figure 15. Coronal STIR MR image with complete proximal detachment of the SM tendon (arrow) with distal retraction (*) in a 23-year-old female professional volleyball player after hyperstretching.

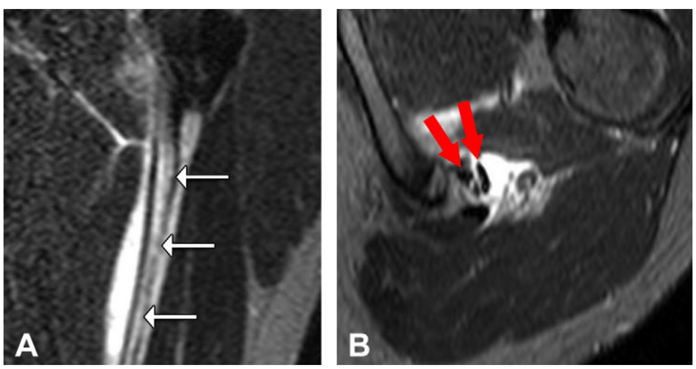

Figure 16. PMTJ injury of the SM muscle with longitudinal proximal tendon tear in a 27-year-old male recreational soccer player after hyperstretching. Sagittal **(A)** and axial **(B)** STIR MR images show the longitudinal tear (arrows in **A**), and the injury at the IT insertion shows two subtendons (arrows in **B**).

inserts distally into the medial surface of the tibia, posterior to the attachment of the sartorius and distal to the attachment of the gracilis (30).

The presence of the raphe may influence the injury pattern and help protect the ST, which could explain the low frequency of isolated lesions (30) (Fig 19). These uncommon ST-isolated injuries generally involve the distal tendon due to its great length. While distal tendon avulsion of the hamstring is uncommon, avulsion of the ST is likely the most frequent (Fig 20) and usually occurs in the context of a previous or long-term injury, with degenerative changes as the most probable contributing factors. A history of an anterior cruciate ligament repair made with the ST and gracilis tendons from the same side is another causative factor (2).

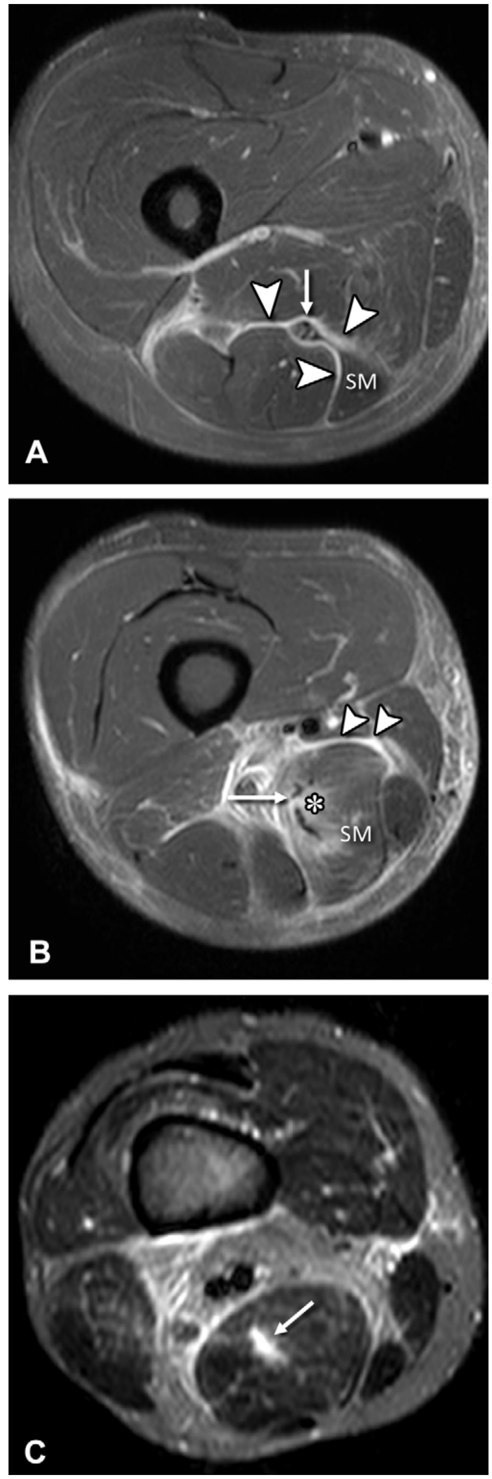

Figure 17. Axial fat-saturated T2-weighted MR images show SM tears in two patients. (See Fig 13 for corresponding regions.) **(A)** Injury in region A in a 59-year-old male amateur soccer player with partial tear of the PMTJ (arrow) and perifascial fluid (arrowheads). **(B)** Image of the same patient as in **A** shows extension of this lesion to region B with several ruptured foci of the intramuscular tendon (arrow), muscle edema (*), and a small extramuscular laminar fluid collection (arrowheads). **(C)** Intramuscular hematoma (arrow) in region C in a 28-year-old male rugby player.

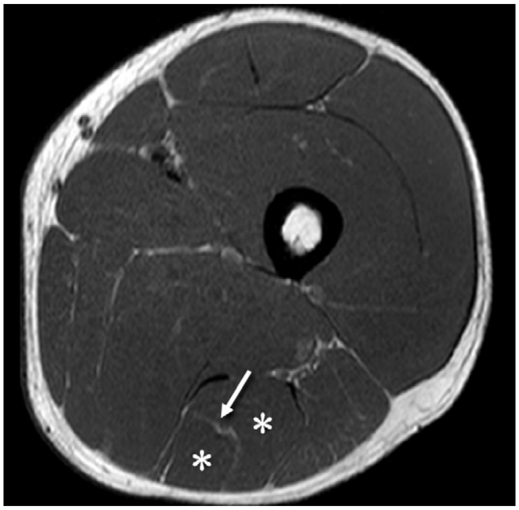

Figure 18. Axial T1-weighted MR image shows a normal intramuscular tendinous raphe of the ST (arrow) dividing the muscle in two distinct parts (*).

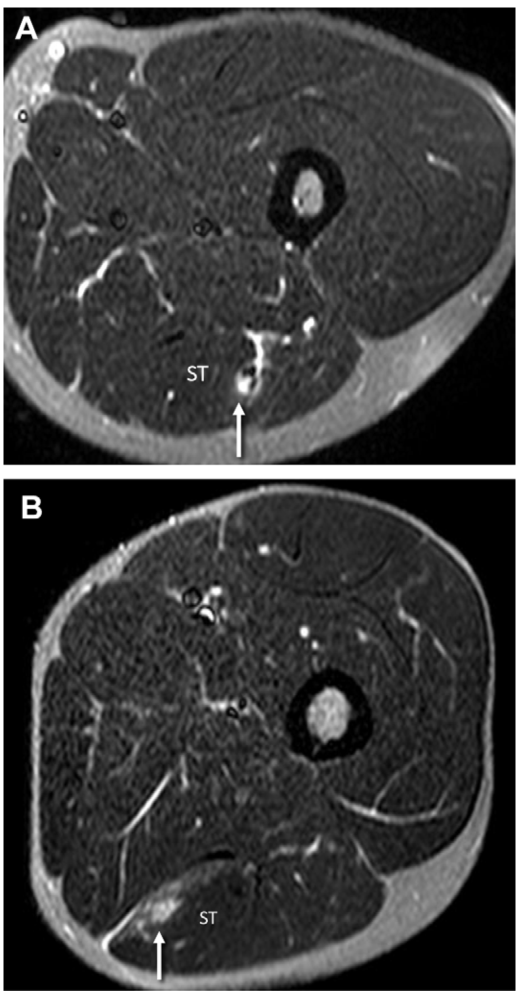

Figure 19. ST tear in two patients. **(A)** Axial STIR MR image in a 22-year-old man with a central type of lesion (arrow) next to the conjoint tendon and subtle posterior thigh pain after sprint exercise. **(B)** Axial STIR MR image in a 21-year-old male professional soccer player with a medial type of MTJ tear (arrow).

While MRI accurately shows distal tendinous avulsion and the degree of retraction, US offers superior spatial resolution and dynamic assessment of tendon integrity (2).

Conclusion

Considerations of the specific anatomic characteristics of the hamstring muscles are essential for an accurate radiology report and correct diagnosis. The combination of MRI and US is an ideal modality for assessing these lesions in terms of their extent, connective tissue involvement, and tear location. This information is crucial to avoid further injuries and to estimate RTP times.

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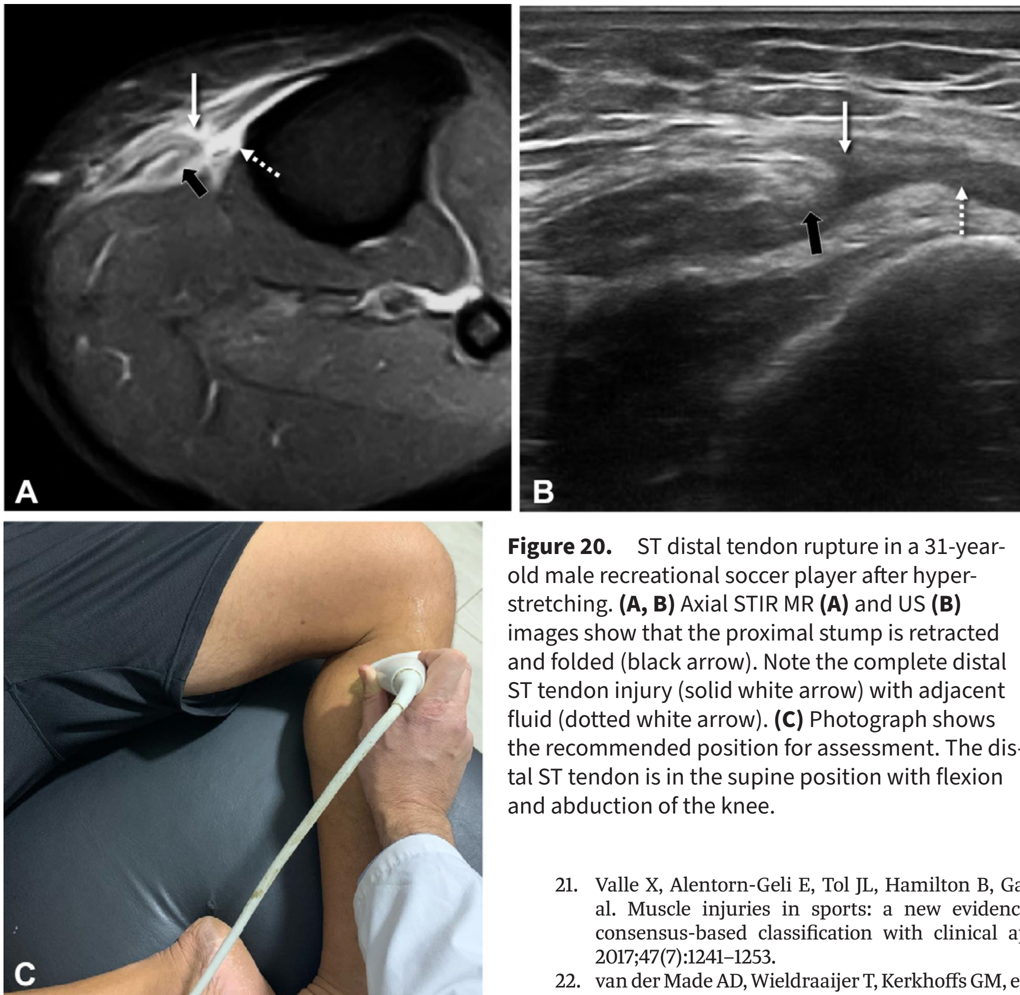

Figure 20. ST distal tendon rupture in a 31-year-old male recreational soccer player after hyper-stretching. **(A, B)** Axial STIR MR **(A)** and US **(B)** images show that the proximal stump is retracted and folded (black arrow). Note the complete distal ST tendon injury (solid white arrow) with adjacent fluid (dotted white arrow). **(C)** Photograph shows the recommended position for assessment. The distal ST tendon is in the supine position with flexion and abduction of the knee.

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