

# Ultrasound Features of the Proximal Hamstring Muscle-Tendon-Bone Unit

Marco Becciolini, MD , Giovanni Bonacchi, MD, Stefano Bianchi, MD 

The hamstring muscle complex is made by a group of posterior biarticular thigh muscles, originating at the ischial tuberosity, which extend the hip and flex the knee joint. Proximal hamstring injuries are frequent among athletes, commonly involving their long myotendinous junction during an eccentric contraction. In this pictorial essay, we describe the ultrasound technique to visualize the normal anatomy of the proximal hamstring muscle-tendon-bone complex and present ultrasound findings in patients with traumatic injuries and tendinopathies.

**Key Words**—athlete injury; biceps femoris; hamstring; musculoskeletal; myotendinous injury; tendinopathy; thigh muscles; ultrasound

**T**he hamstring muscle complex comprises a group of posterior biarticular thigh muscles, originating at the ischial tuberosity: the long head of the biceps femoris, semimembranosus, and semitendinosus. These muscles extend the hip and flex the knee joint.<sup>1</sup> Proximal hamstring muscle complex injuries are the most frequent among athletes, commonly involving the proximal myotendinous junction during an eccentric contraction.<sup>2,3</sup> So far, magnetic resonance imaging (MRI) has been considered as the modality of choice to evaluate tendinopathy and injuries.<sup>3–6</sup> In this pictorial essay, our aims are to describe the ultrasound (US) technique for visualizing the proximal hamstring muscle complex and to illustrate US findings in patients with traumatic injuries and tendinopathies.

This human study was performed in accordance with the Declaration of Helsinki. The study was approved by the Cabinet Imagerie Médicale. All parents, guardians, or next of kin provided written informed consent for the minors to participate in the study. All adult participants provided written informed consent to participate in the study.

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## Abbreviations

MRI, magnetic resonance imaging; US, ultrasound

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## Ultrasound Anatomy

### Technical Considerations

A linear transducer with frequencies between 5 and 14 MHz is required. For a larger body habitus, the use of a lower-frequency transducer might be helpful.<sup>7–9</sup> The patient lies prone with the hip and the knee in a neutral position; flexion of the hip using a pillow may be used to avoid artifacts produced by the gluteal fold.<sup>8</sup>

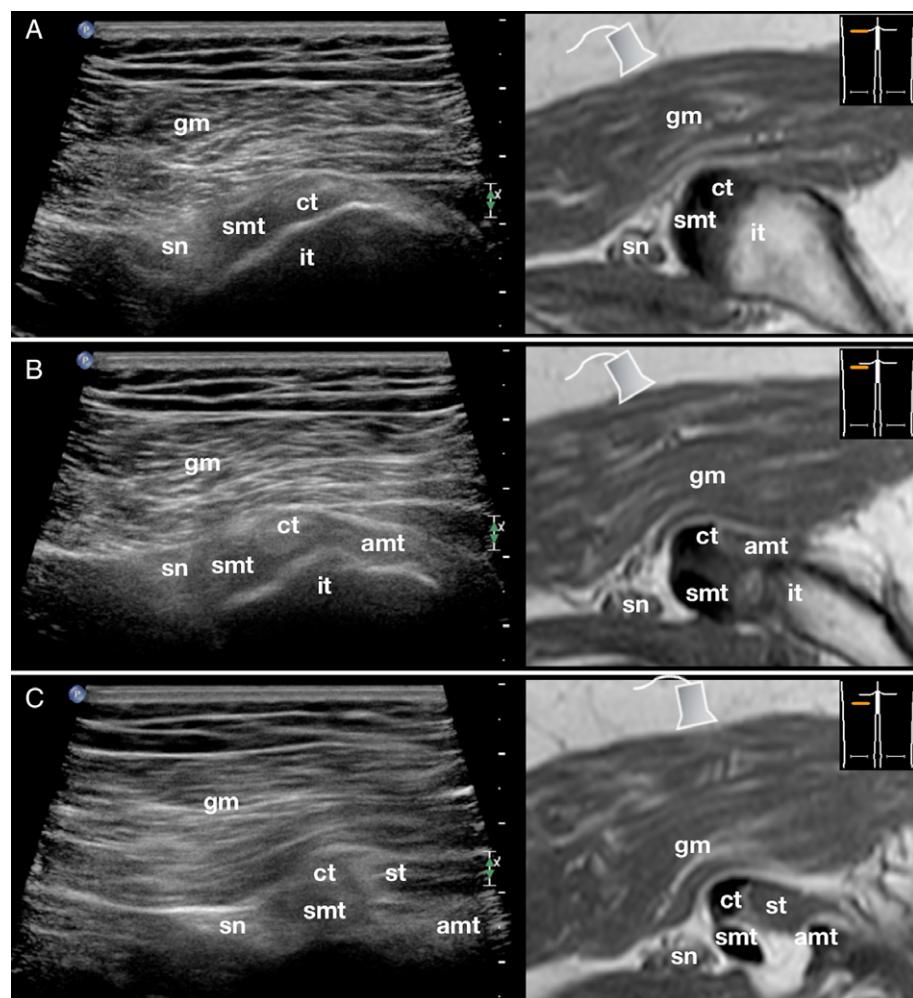
### Scanning Technique

The examination begins with axial US scans at the level of the ischial tuberosity, which can be palpated, being a good anatomic

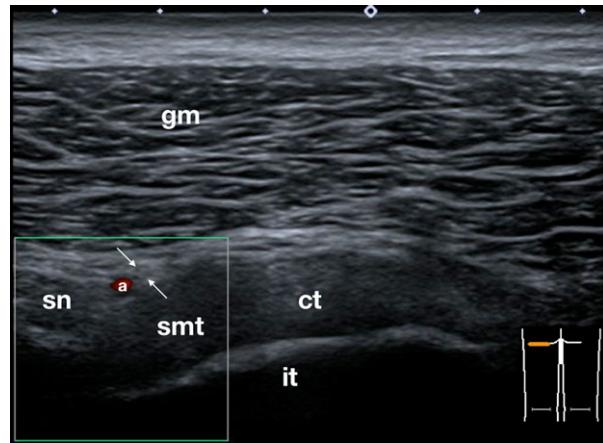
landmark. The long head of the biceps femoris and the semitendinosus muscle originate from a conjoint tendon at the medial and posterior aspects of the ischial tuberosity, whereas the semimembranosus tendon has a more lateral and anterior origin (Figure 1A).<sup>1,9</sup> To improve image quality, we suggest using a slight lateral approach (Figure 1, A and B), and the patient should be informed that the transducer may have to be pressed hard; this maneuver is also recommended in symptomatic patients to reproduce pain: so-called sonopalpation.<sup>10,11</sup> The examiner should remember to slowly tilt the transducer to avoid mistaking anisotropy,

which is present when a tendon is not scanned perpendicularly, for tendinopathy.<sup>12,13</sup> This action is needed because the conjoint and semimembranosus tendons have different courses so that in a US scan, one can appear hypoechoic to the other; in doubtful and subtle cases, a comparison with the opposite side is advised. Lateral to the hamstring muscle complex tendon, the sciatic nerve, a fascicular and flattened structure, can be easily shown: it descends between and deep to the long head of the biceps femoris and the semimembranosus tendon, superficial to the adductor magnus muscle.<sup>14</sup> A smaller nerve departing from the sciatic nerve, the posterior

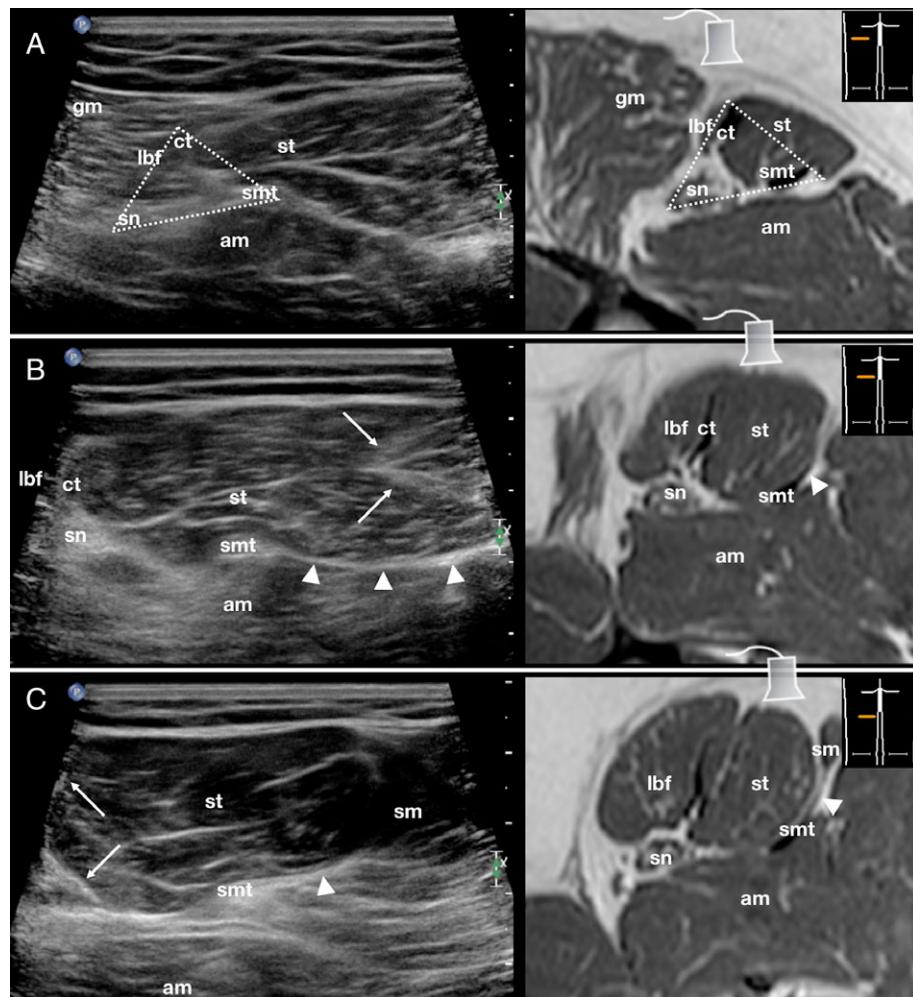
**Figure 1.** Hamstring muscle complex origin anatomy. **A–C**, Proximal-to-distal axial US scans (left), as described in the US anatomy part of the article, with MRI comparison (right); amt indicates adductor magnus tendon; ct, conjoint tendon; gm, gluteus maximus; it, ischial tuberosity; smt, semimembranosus tendon; sn, sciatic nerve; and st, semitendinosus muscle.



**Figure 2.** Axial color Doppler US scan at the level of the ischial tuberosity (it) in a healthy 22-year-old man. In this slender volunteer, US is able to show a small branch of the inferior gluteal artery (a), interposed between the sciatic nerve (sn) and a small honeycomb structure (arrows), consistent with the posterior femoral cutaneous nerve. Note the close relationship of the nerve and the proximal tendons of the hamstring muscle complex, which can explain its irritation in proximal hamstring tendinopathy. The semimembranosus tendon (smt) in this view appears slightly hypoechoic because of anisotropy; ct indicates conjoint tendon; and gm, gluteus maximus.



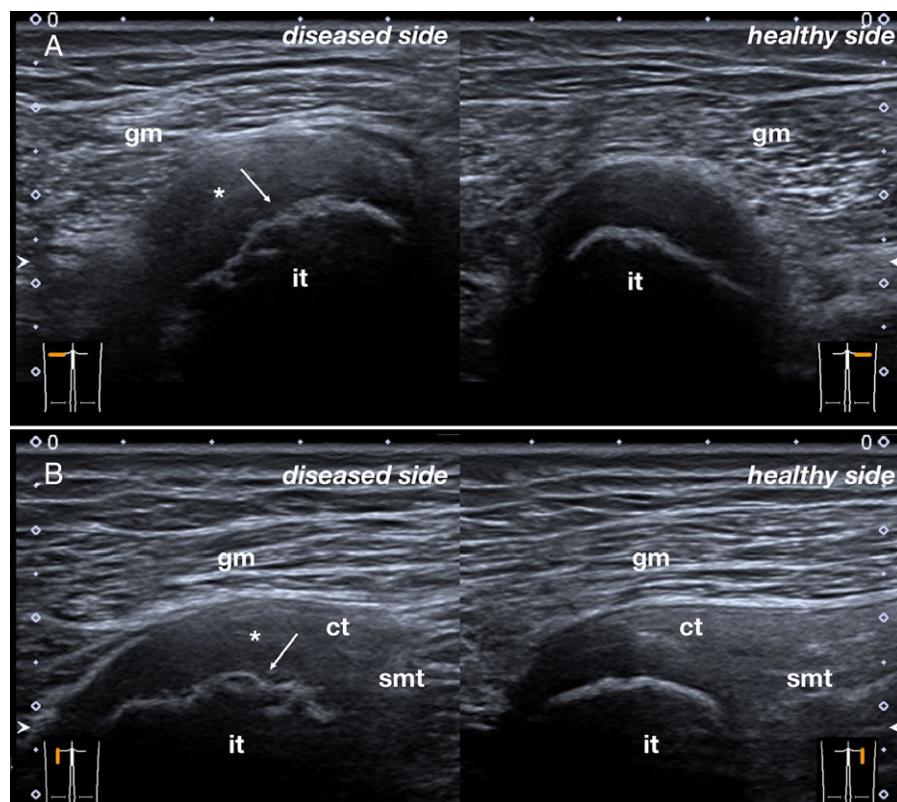
**Figure 3.** Proximal anatomy of the hamstring muscle complex. **A–C**, Proximal-to-distal axial US scans (left), as described in the US anatomy part of the article, with MRI comparison (right). Dashed lines in **A** indicate the Cohen triangle; am, adductor magnus muscle; arrowhead, semimembranosus membrane; arrows, semitendinosus raphe; ct, conjoint tendon; lbf, long head of biceps muscle; sm, semimembranosus muscle; smt, semimembranosus tendon; sn, sciatic nerve; and st, semitendinosus muscle.



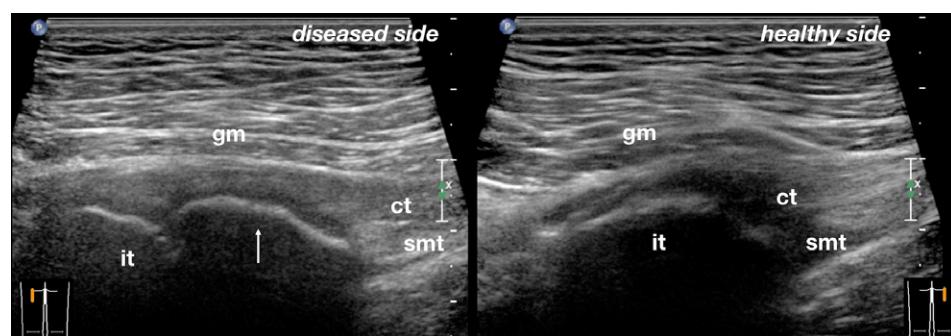
femoral cutaneous nerve, may be sometimes depicted as well in healthy and slender patients, accompanied by the inferior gluteal artery

(Figure 2); it distally passes superficial to the long head of the biceps femoris and gradually surfaces up to the cutaneous layer.<sup>15,16</sup>

**Figure 4.** Images from a 10-year-old boy who had sudden posterior pain while playing soccer. **A** and **B**, Axial and sagittal US scans obtained 4 days later. The cortical surface of the ischial tuberosity (it) of the affected side (left) appears irregular (arrows), and the hamstring muscle complex proximal origin (asterisks) looks swollen compared with the healthy side (right). Ultrasound palpation was painful. Clinical and US findings are compatible with a minimal apophyseal injury without tendon displacement. The patient was treated conservatively with a good outcome; ct indicates conjoint tendon; gm, gluteus maximus; and smt, semimembranosus tendon.



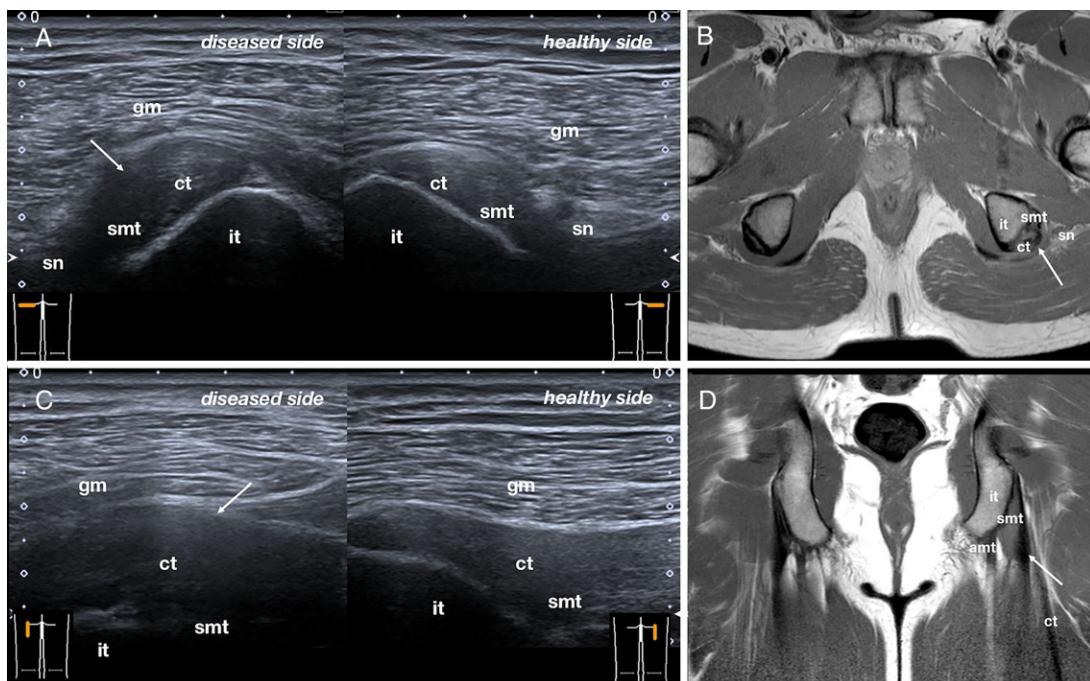
**Figure 5.** Images from a 20-year-old man evaluated for chronic pain at the level of the left ischial tuberosity (it). Comparative longitudinal US scans depict a large calcification casting an acoustic shadow (arrow). The finding is consistent with a previous avulsion, as referred by the patient who recalled a hamstring muscle complex origin injury at the age of 12 years; ct indicates conjoint tendon; gm, gluteus maximus; and smt, semimembranosus tendon.



The examination continues with axial caudal US scans. At the distal medial tip of the ischial tuberosity, another tendon originates: the adductor magnus, which also has a wider pubofemoral insertion; because of this anatomy, it is also called the “mini-hamstring” (Figure 1B).<sup>17</sup> Below the ischial tuberosity, the semitendinosus muscle is the first to appear, medially to the conjoint tendon; at this level, the semimembranosus tendon starts to travel medially (Figure 1C). Caudally, the second muscle to appear is the long head of the biceps femoris; here, a good anatomic landmark, the Cohen triangle,<sup>8</sup> is composed of the aponeurosis of the conjoint tendon, the sciatic nerve, and the semimembranosus tendon (Figure 3A). Considering the conjoint tendon, according to a dissection study on 56 hamstring muscle complexes by van der Made et al,<sup>1</sup> the total length of the semitendinosus tendon is  $12.3 \pm 3.6$  cm with a myotendinous junction of 12.2 cm, whereas the long head of the biceps femoris tendon is  $19.6 \pm 4.1$  cm with a myotendinous junction of 14.6 cm. The semimembranosus tendon continues

to descend between the semitendinosus muscle and the adductor magnus muscle, giving a “membrane” medially from which the first muscular fascicle of the semimembranosus muscle originates. At this level, a sigmoid raphe inside the semitendinosus muscle, which travels the muscle from proximal-medial to distal-lateral, is another key anatomic landmark for a US evaluation of the hamstring muscle complex (Figure 3B).<sup>8</sup> At the middle third of the thigh, the semimembranosus tendon reaches the muscle (Figure 3C); its total length according to van der Made et al<sup>1</sup> is  $24.3 \pm 3.9$  cm with a myotendinous junction of 14.9 cm. Usually just below this level, the long head of the biceps femoris, the semitendinosus muscle, and the semimembranosus muscle belly have a similar size.<sup>8</sup> Anatomic variations, such as the absence of the semimembranosus muscle, or a separate origin of the long head of the biceps femoris and semitendinosus tendons, have been reported.<sup>2</sup> We perform longitudinal-axis scans of the hamstring muscle complex in cases of disorders to confirm it and to show its craniocaudal involvement.

**Figure 6.** Posttraumatic tendinopathy related to a partial-thickness tear with remodeling of the hamstring muscle complex origin in a 35-year-old soccer player, evaluated 2 months after an indirect trauma for persistent pain. **A** and **C**, Axial and sagittal US scans (left) of the left ischial tuberosity (it) show a swollen and inhomogeneous (arrows) conjoint tendon (ct) and semimembranosus tendon (smt) compared with the healthy contralateral side (right). **B** and **D**, Corresponding MRI (**B**, axial; **D**, coronal); gm indicates gluteus maximus; and sn, sciatic nerve.



### **Limitations of US**

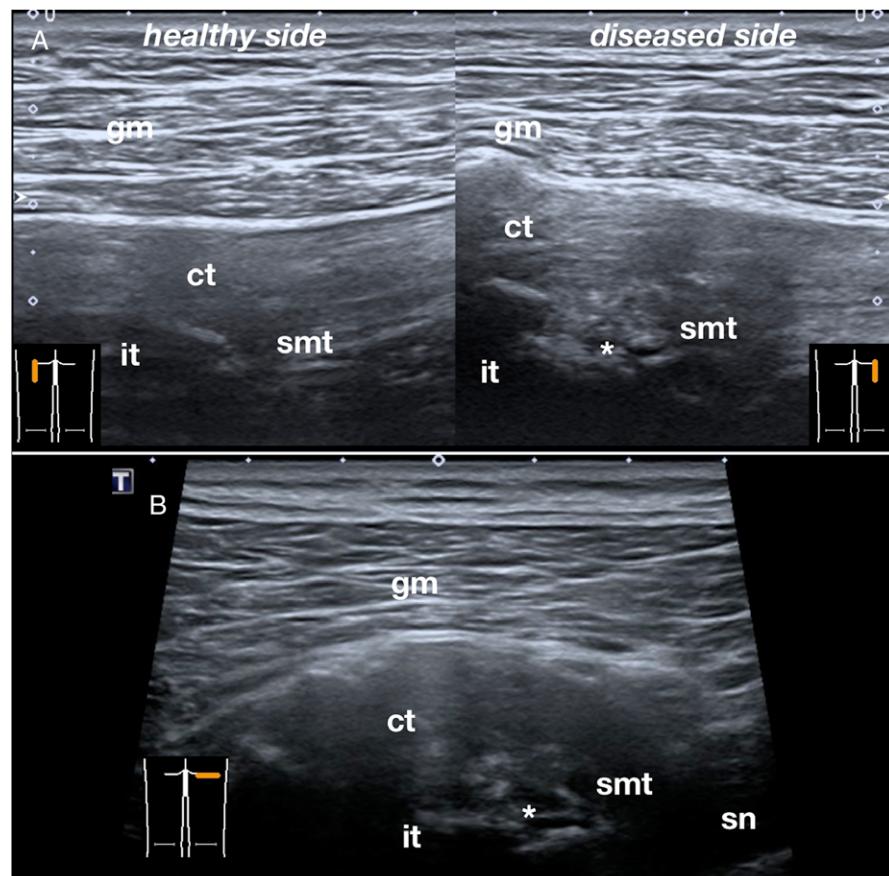
Ultrasound has some limitations in evaluations of the posterior thigh in older and obese patients because of muscular fatty degeneration and increased thickness of the subcutaneous fat,<sup>7,8</sup> especially at the level of the ischial tuberosity region; in these patients, it may be helpful to search for the other described anatomic landmarks (eg, Cohen triangle and semitendinosus raphe) and then to move the transducer cranially to the ischial tuberosity. The distal course of the hamstring muscle complex goes beyond the purpose of this pictorial essay, as well as the anatomy of the short head of the biceps femoris.

## **Ultrasound Findings**

### **Apophyseal Injuries**

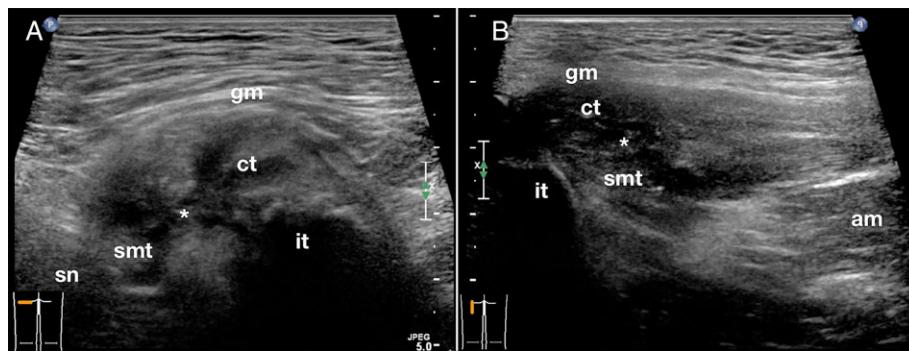
The weakest part of the hamstring bone-tendon-muscle unit is linked to the patient's age<sup>2</sup>: in children, it is the apophyseal region of the ischial tuberosity; therefore, injuries may lead to an avulsion of a bony fragment, which can be assessed by radiography. Ultrasound is able to confirm the injury, depicting the avulsed fragment as well as the retracted tendon.<sup>18</sup> Ultrasound is particularly helpful in mild cases, in which the apophysis is nondisplaced, by showing irregularities in the ischial tuberosity and cartilage compared with the contralateral side (Figure 4).<sup>19</sup>

**Figure 7.** Partial tear of the semimembranosus tendon (smt) in a 28-year-old soccer player with tendinopathy. **A**, Long-axis view of the hamstring muscle complex proximal tendon (right) compared with the healthy contralateral side (left) shows a tear in the right semimembranosus tendon (smt), highlighted by a hypoechoic-to-anechoic area related to edema or blood products (asterisks); the conjoint tendon (ct) is also swollen and heterogeneous, reflecting tendinopathy. **B**, Axial view of the right hamstring muscle complex proximal tendon confirms the findings; gm indicates gluteus maximus; and it, ischial tuberosity.

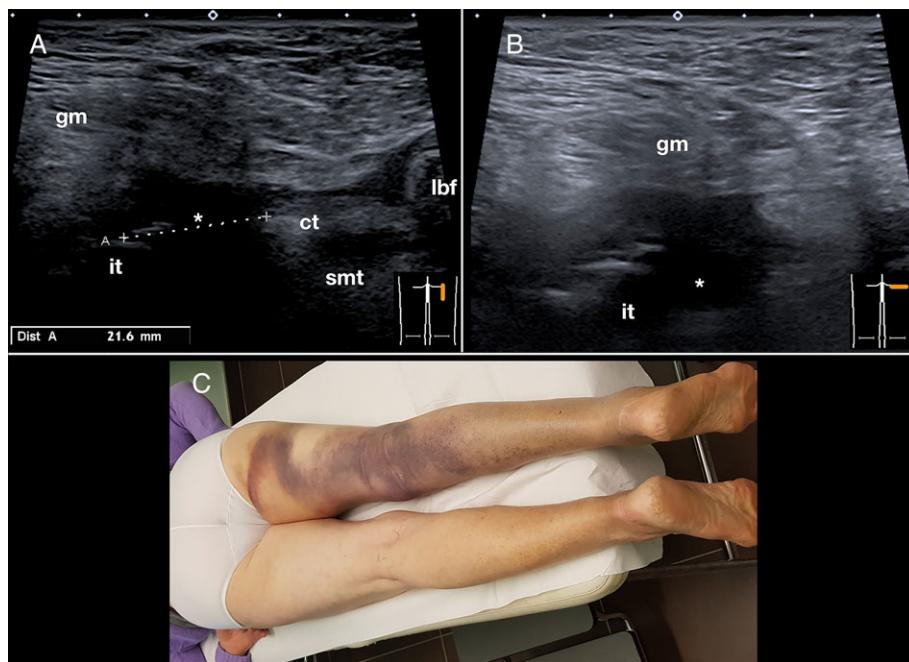


Magnetic resonance imaging should be performed in doubtful cases and, as in the case of a complete tendon rupture, when there is a retraction and surgery is an option.<sup>2,5,8</sup> Chronic avulsion injuries may result in posttraumatic heterotopic ossification (Figure 5).<sup>18</sup>

**Figure 8.** Subcomplete tear of the hamstring muscle complex proximal tendons in a 75-year-old patient with tendinosis. The patient was referred for sudden pain 3 days previously after falling while gardening on uneven ground. **A**, Axial US scan at the level of the ischial tuberosity (it). The conjoint tendon (ct) and semimembranosus tendon (smt) show fiber disruption associated with a hypoechoic-to-anechoic area of edema or blood products (asterisk) highlighting the tear. **B**, Corresponding long-axis view of the hamstring muscle complex origin; am indicates adductor magnus; and gm, gluteus maximus.



**Figure 9.** Complete avulsion of the hamstring muscle complex origin tendons, which are retracted distally, in a 68-year-old patient who fell while walking downstairs and was referred for a snap below the buttock. A US examination was done 5 days later. **A** and **B**, Longitudinal and axial US scans at the level of the ischial tuberosity (it) show the retracted proximal tendons. The retraction is measured (between calipers); am indicates adductor magnus muscle; asterisks, hematoma; ct, conjoint tendon; gm, gluteus maximus; lbf, long head of the biceps muscle; and smt, semimembranosus tendon. **C**, Note clinically how the hematoma has spread distally.



### Tendinopathies

Tendinopathies may be found in young adults and are usually related to trauma with microtears (Figure 6), which may lead to partial or complete tears (Figure 7); however, tendon injuries are more

frequent in older adults because of tendon degeneration (Figure 8).<sup>2,3</sup> When a complete avulsion is shown, the distance between the ischial tuberosity and the retracted tendon should be reported (Figure 9); surgery may be considered if there is displacement of greater than 2 cm.<sup>3</sup> In tendinosis, the tendon loses its normal fibrillar pattern, becoming thickened and hypoechoic on a US evaluation. Ultrasound findings are similar in patients with a chronic partial tear, as it may coexist (Figure 6).<sup>13,20</sup> Hamstring syndrome is a clinical entity described by Puranen and Orava<sup>21</sup> as pain in the lower gluteal area with caudal irradiation to the posterior thigh, which is related to hamstring muscle complex proximal

tendinopathy, commonly seen in athletes. Hamstring syndrome may be associated with sciatic involvement. Pain with sitting may be also related to posterior femoral cutaneous nerve entrapment because of its closer proximity to the hamstring muscle complex proximal tendons, as this sensory nerve provides the innervation for the inferolateral gluteal region and posterior aspect of the thigh, the superomedial perineal region, and the skin at the popliteal fossa.<sup>14,16,22</sup>

Painful snapping of the hip, also called coxa saltans, might be subsequent to proximal hamstring muscle complex injury and tendinopathy, caused by subluxation of the conjoint tendon over the ischial tuberosity. Dynamic US has been shown to be capable of depicting this kind of snapping during hip flexion.<sup>23</sup>

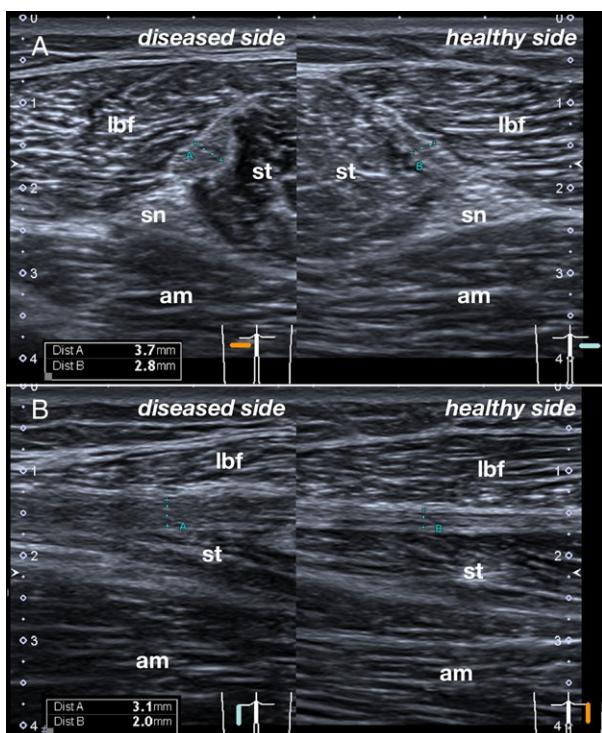
The examiner should keep in mind that tendinopathy may affect only a tract, possibly the intramuscular distal part of the tendons, leading to nonspecific posterior thigh pain, and therefore should check the tendons in their whole course with axial US scans: only a systematic and comparative evaluation allows the diagnosis necessary for the athlete to plan rehabilitation and avoid injuries (Figures 10 and 11).

Calcifications related to tendinopathy and chronic injuries may also involve the hamstring muscle complex tendons (Figure 12).<sup>6</sup> Calcific tendinopathy, due to deposition of calcium hydroxyapatite crystals within the tendons, which is common in the rotator cuff, has also been described at the level of the proximal hamstring muscle complex tendons (Figure 13) and may be the cause of atraumatic acute ischial pain, likely during the resorptive phase.<sup>9,24</sup>

### **Myotendinous Junction and Proximal Muscle Injuries**

In young athletes, the weakest point of the hamstring muscle complex is represented by the myotendinous junction; in these patients, a powerful eccentric contraction with the hip and the knee on extension may cause a partial (Figures 14 and 15) or a complete (Figure 16) tear. These injuries are frequent in water skiers and football players.<sup>2-4,8</sup> Clinically, the patients recall sudden onset of pain after specific indirect trauma. A US examination should be performed at least 48 hours after the trauma; otherwise, the massive soft tissue edema/blood products may produce architectural distortion, which makes a detailed

**Figure 10.** Images from a 25-year-old soccer player evaluated for mild chronic pain at the proximal posterior thigh distal to the ischial tuberosity. The patient did not recall a hamstring injury. **A** and **B**, Transverse and sagittal US scans (left) at the proximal posterior thigh show slight thickening of the distal part of the conjoint tendon (between calipers) at the level of the myotendinous junction, without fissurations, compared with the healthy contralateral side (right). The conjoint tendon at the ischial tuberosity appeared normal (not shown); am indicates adductor magnus muscle; lbf, long head of the biceps muscle; sn, sciatic nerve; and st, semitendinosus muscle.

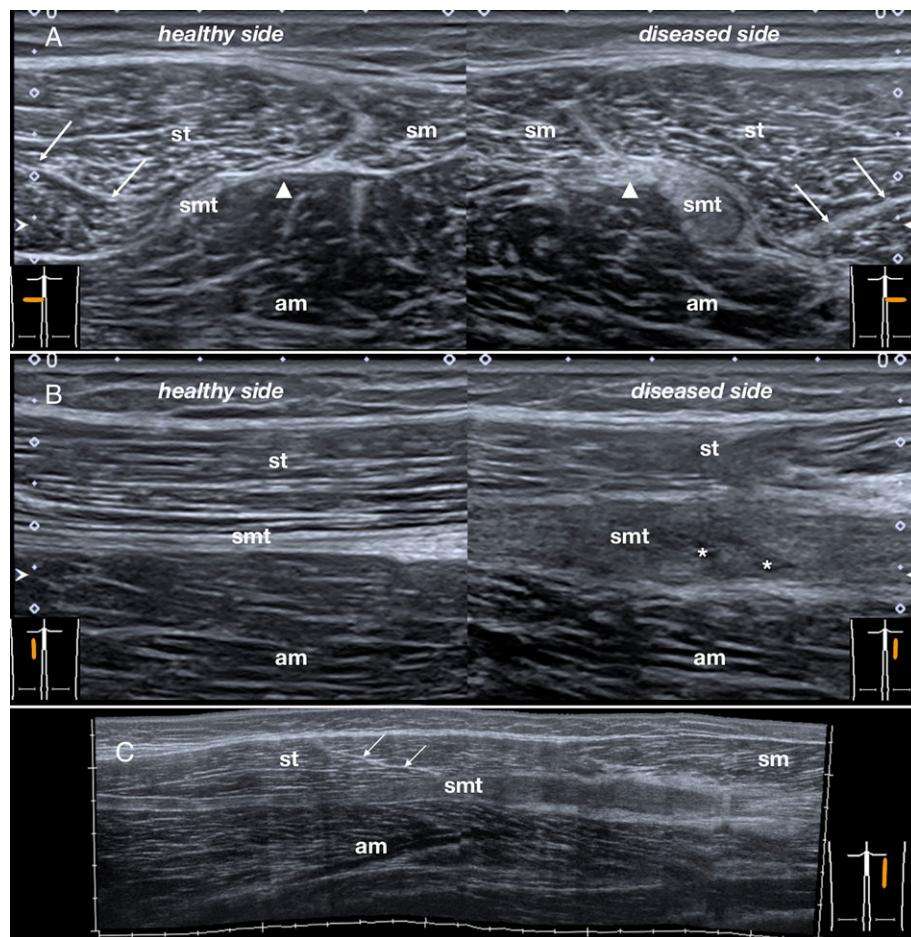


evaluation difficult.<sup>25</sup> Ultrasound findings include a poorly defined hyperechoic or heterogeneous area with or without muscular architectural alterations, the presence of an anechoic hematoma, and a complete tear with muscular retraction, which can be confirmed by dynamic imaging during muscle contraction.<sup>8,25</sup> Myotendinous junction tear classification is not presented in this pictorial essay. Delayed-onset muscle soreness refers to a benign condition in which symptoms (muscular tenderness, soreness, or stiffness) develop approximately 24 to 48 hours after strenuous exercise, with a peak at 2 or 3 days and resolution usually within 7 to 10 days. Ultrasound may depict

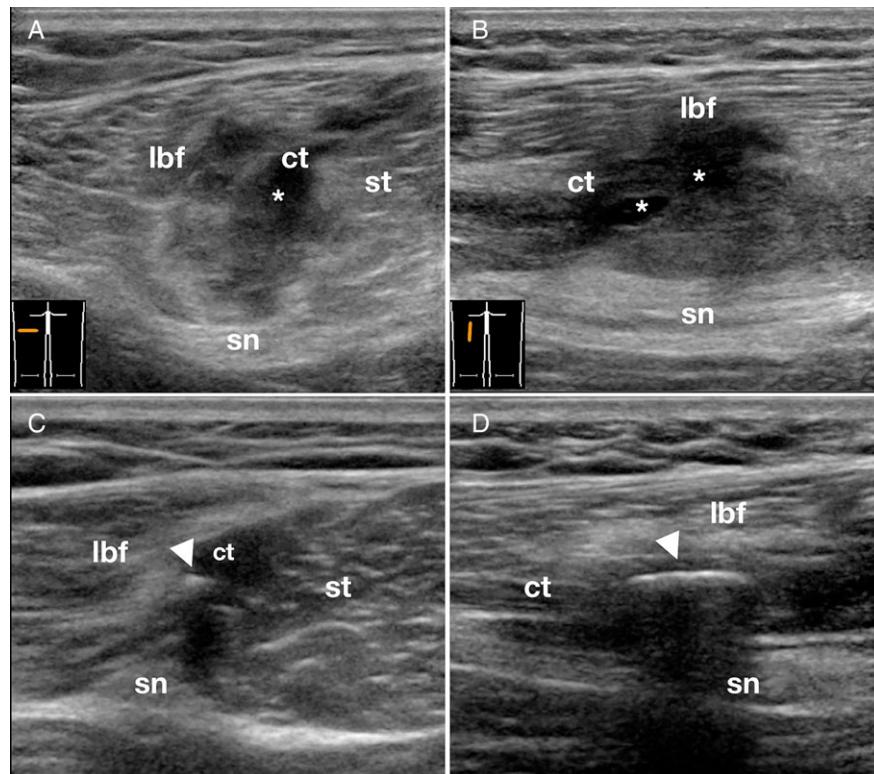
diffuse or focal hyperechogenicity and an increased size of the involved muscle(s), likely correlated with edema, which can be shown by MRI (Figure 17).<sup>2,8,26</sup>

Color Doppler imaging is widely used to assess tendinopathy<sup>20</sup>; however, in our practice, we find it not effective for evaluation of proximal hamstring muscle complex tendons because of their deep course: the needed transducer pressure will artificially hide neovascularity present in tendinosis. Instead, we find that it has an important role in follow-up of myotendinous junction tears, in which the disappearance of hyperemia indicates a subacute-to-chronic phase of injury (Figure 18).<sup>8,25</sup>

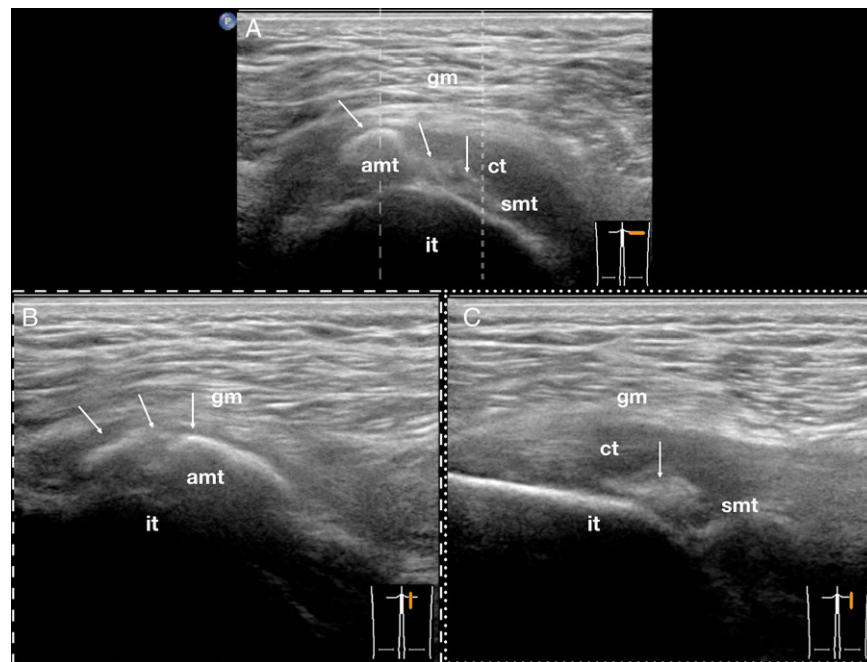
**Figure 11.** Images from a 42-year-old amateur marathoner referred for chronic posterior discomfort at the middle third of the thigh, which worsened during a sprint. A US examination performed at 1 week. **A** and **B**, Transverse and sagittal US scans (right) depict tendinopathy of the distal part of the semimembranosus tendon (smt) and membrane (arrowheads), with fissurations (asterisks) related to partial tear, compared with the healthy contralateral side (left). **C**, Panoramic view of the semimembranosus tendon shows that the tendon is involved distally, whereas proximally it shows a normal thickness; am indicates adductor magnus muscle; arrows, semitendinosus raphe; sm, semimembranosus muscle; and st, semitendinosus muscle.



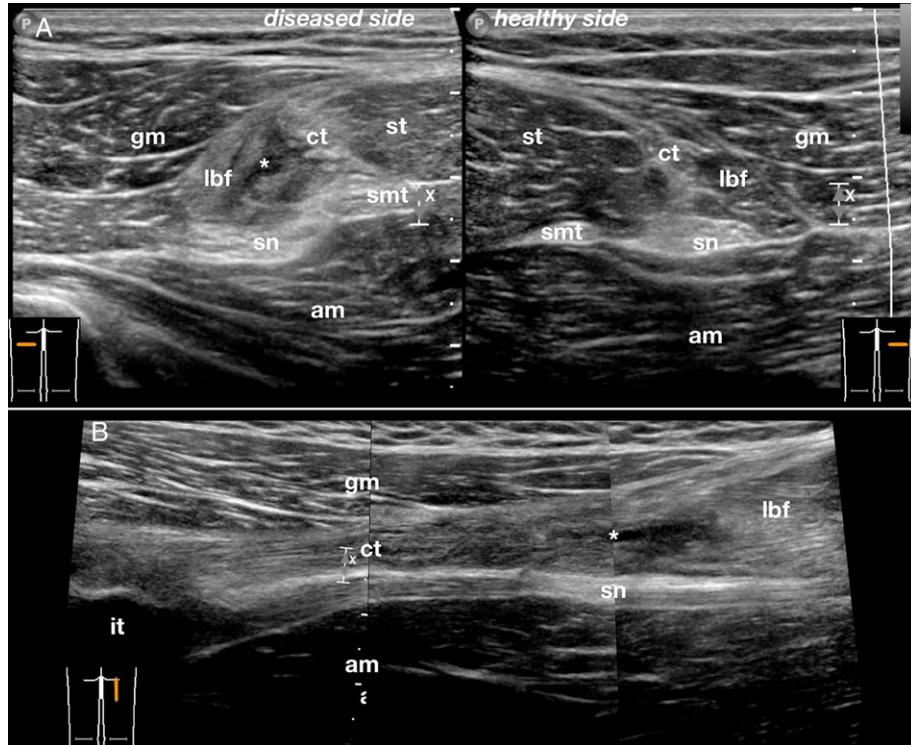
**Figure 12.** Images from a 24-year-old athlete referred for indirect trauma at the posterior thigh during a sprint. **A**, Transverse US scan at 15 days depicts the tear, involving the myotendinous junction of the long head of the biceps femoris (lbf) as well as the intramuscular part of the conjoint tendon (ct). A small hematoma is shown (asterisk). **B**, Corresponding sagittal US scan confirms the injury. **C** and **D**, Transverse and sagittal US scans obtained during follow-up at 2 months show the disappearance of the hematoma; the conjoint tendon is thickened and hypoechoic; along its course, a calcification (arrowheads) with a faint acoustic shadow can be seen as an outcome of the trauma; sn indicates, sciatic nerve; and st, semitendinosus muscle.



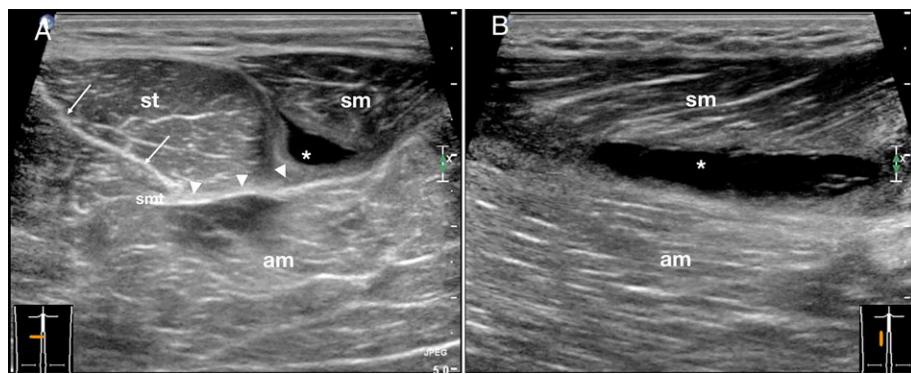
**Figure 13.** Calcific tendinopathy of the hamstring muscle complex origin tendons and the adductor magnus tendon (amt) in a 58-year-old woman presenting for acute posterior hip pain in the absence of a trauma. **A**, axial US scan at the level of the ischial tuberosity (it) shows calcific deposits (arrows) in part with a faint acoustic shadow and in part “slurry.” Symptoms were likely related to the colligation of the calcification with resultant local inflammatory changes. Dashed lines in **A** indicate the sagittal US planes in **B** and **C**; ct, conjoint tendon; gm, gluteus maximus; and smt, semimembranosus tendon.



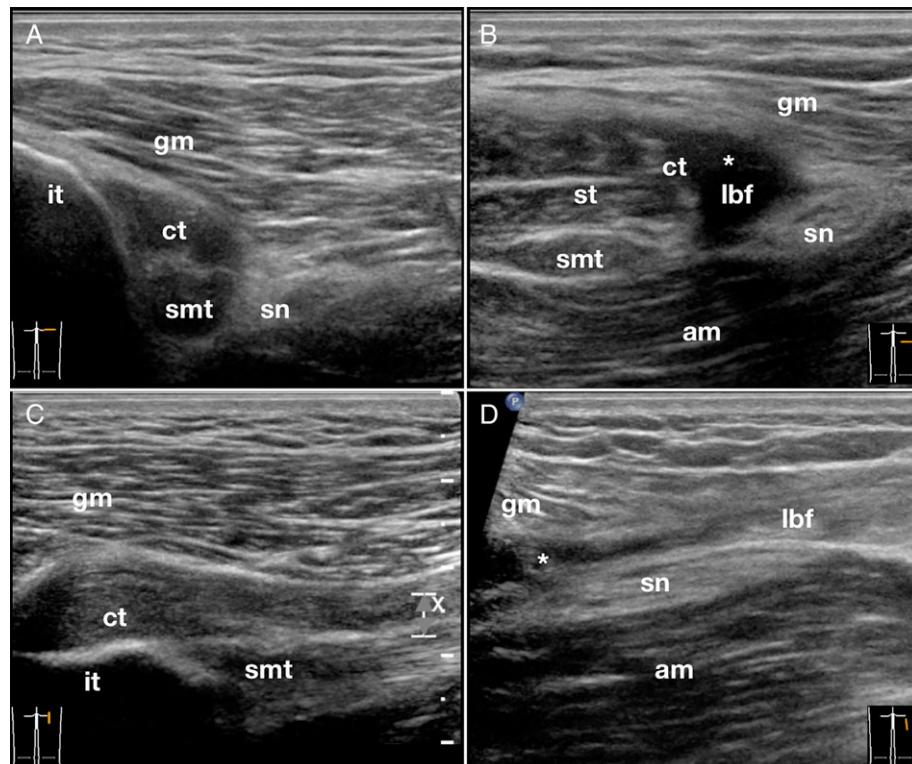
**Figure 14.** Images from a 26-year-old soccer player who sustained indirect trauma at the proximal third of the posterior thigh while kicking, causing him to leave the game. **A**, Transverse US scan (left) shows the tear, located at the long head of the biceps femoris (lbf) myotendinous junction, compared with the healthy contralateral side (right). The Cohen triangle is easily depicted. **B**, Corresponding sagittal extended view confirms the injury, also involving the middle third of the conjoint tendon (ct); am indicates adductor magnus muscle; asterisks, hematoma; gm, gluteus maximus; smt, semimembranosus tendon; and st, semitendinosus muscle.



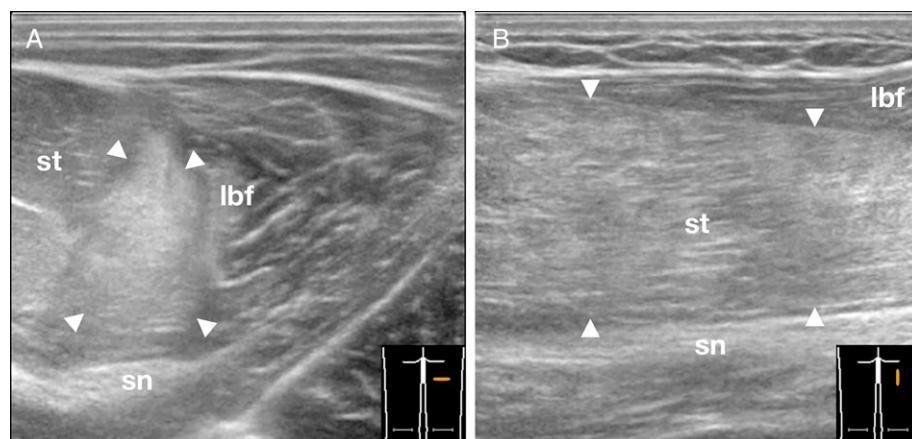
**Figure 15.** Images from a 23-year-old athlete referred for indirect trauma of the posterior medial thigh while sprinting. **A** and **B**, Axial and longitudinal US views, obtained 3 days later at the middle third of the thigh, show the tear, involving the semimembranosus (sm) myotendinous junction in the proximity of its membrane (arrowheads); am indicates adductor magnus muscle; arrows, semitendinosus raphe; asterisks, hematoma; smt, semitendinosus tendon; and st, semitendinosus muscle.



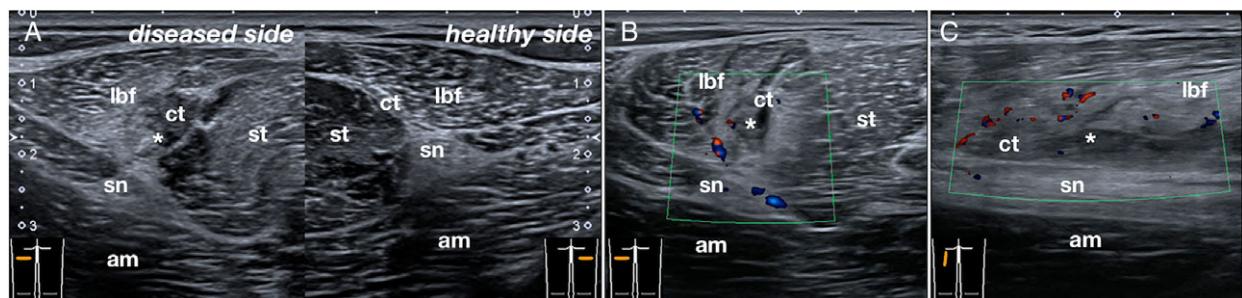
**Figure 16.** Images from a 37-year-old athlete who had severe posterior thigh pain while sprinting, involving the whole hamstring muscle complex proximal unit. Axial US scans of the right posterior hip from cranial (**A**) to caudal (**B**), obtained 4 weeks after the injury. The hamstring muscle complex proximal tendon is swollen and hypoechoic (**A**). There is a complete rupture of the long head of the biceps femoris (lbf) at the myotendinous junction (**B**). **C** and **D**, Corresponding longitudinal US scans confirm the described findings; note the retracted long head of the biceps femoris in **D**; am indicates adductor magnus muscle; asterisks, hematoma; gm, gluteus maximus; it, ischial tuberosity; smt, semitendinosus tendon; sn, sciatic nerve; and st, semitendinosus muscle.



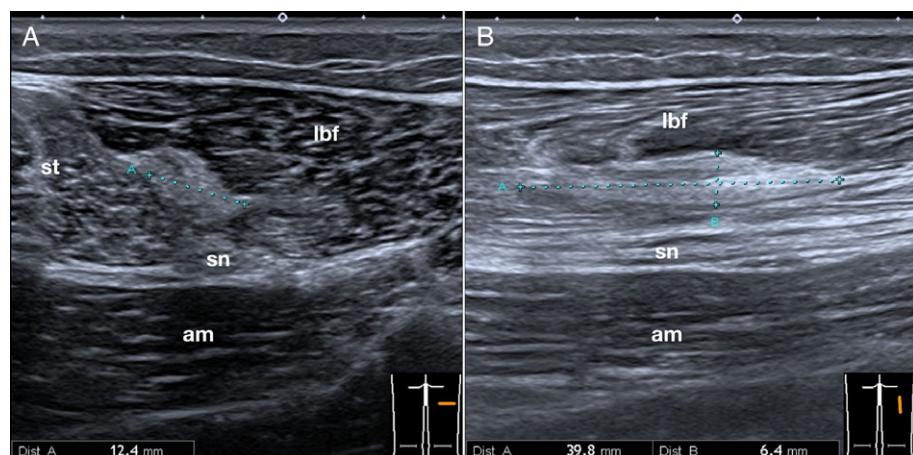
**Figure 17.** Images from a 20-year-old man evaluated for posterior thigh pain with onset approximately 1 day after intense activity (cross-fit). A US examination was performed at 4 days. **A**, Transverse US scan shows a focal area of increased echogenicity (arrowheads) within the lateral part of the semitendinosus muscle (st) without tears. **B**, Sagittal view of the involved part of the semitendinosus muscle. Note the adjacent normal long head of the biceps femoris muscle (lbf). The patient had complete relief of the symptoms at 7 days. The US and clinical findings were consistent with delayed-onset muscle soreness; sn indicates sciatic nerve.



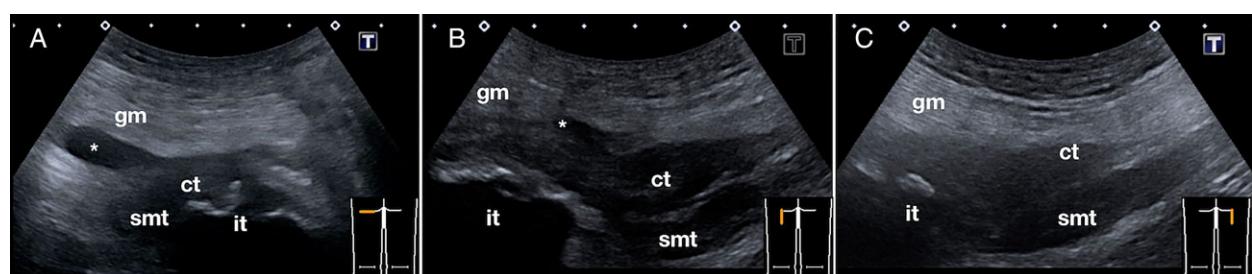
**Figure 18.** Images from a 33-year-old man with a history of an indirect soccer injury of the posterior thigh muscles. A US examination was performed at 10 days. **A**, Transverse US image (left) depicts a tear of the conjoint tendon (ct) and myotendinous junction of the long head of the biceps femoris (lbf), associated with a small hypoechoic-to-anechoic area of edema or blood products (asterisk), compared with the healthy contralateral side (right). **B** and **C**, Transverse and sagittal color Doppler images show local hyperemia consistent with the normal reparative process in action; am indicates adductor magnus muscle; sn, sciatic nerve; and st, semitendinosus muscle.



**Figure 19.** Images from a 30-year-old man referred for chronic pain at the posterior thigh after an injury. **A**, Transverse US scan shows fibrotic scarring of the long head of biceps femoris (lbf) myotendinous junction near the sciatic nerve (sn). **B**, Sagittal US image depicts the scarring at its craniocaudal involvement; am indicates adductor magnus muscle; and st, semitendinosus muscle.



**Figure 20.** Ischial bursitis in an 85-year-old woman presenting for persistent left gluteal pain 1 month after direct buttock trauma. **A** and **B**, Axial and longitudinal US scans at the level of the left ischial tuberosity (it) depict anechoic fluid (asterisks) overlying the hamstring muscle complex proximal tendons, affected by high-grade tendinopathy. **C**, Contralateral longitudinal US scan shows bilateral tendinosis without bursitis. Due to muscle hypotrophy, a convex transducer was used; ct indicates conjoint tendon; gm, gluteus maximus; lbf, long head of the biceps muscle; and smt, semimembranosus tendon.



A possible complication of a myotendinous junction tear is muscle scarring. On a US scan, the fibrosis is depicted as a poorly defined hyperechoic spiculated area. The sciatic nerve's relationship with the fibrotic area should be evaluated to rule out adhesions (Figure 19).<sup>8</sup>

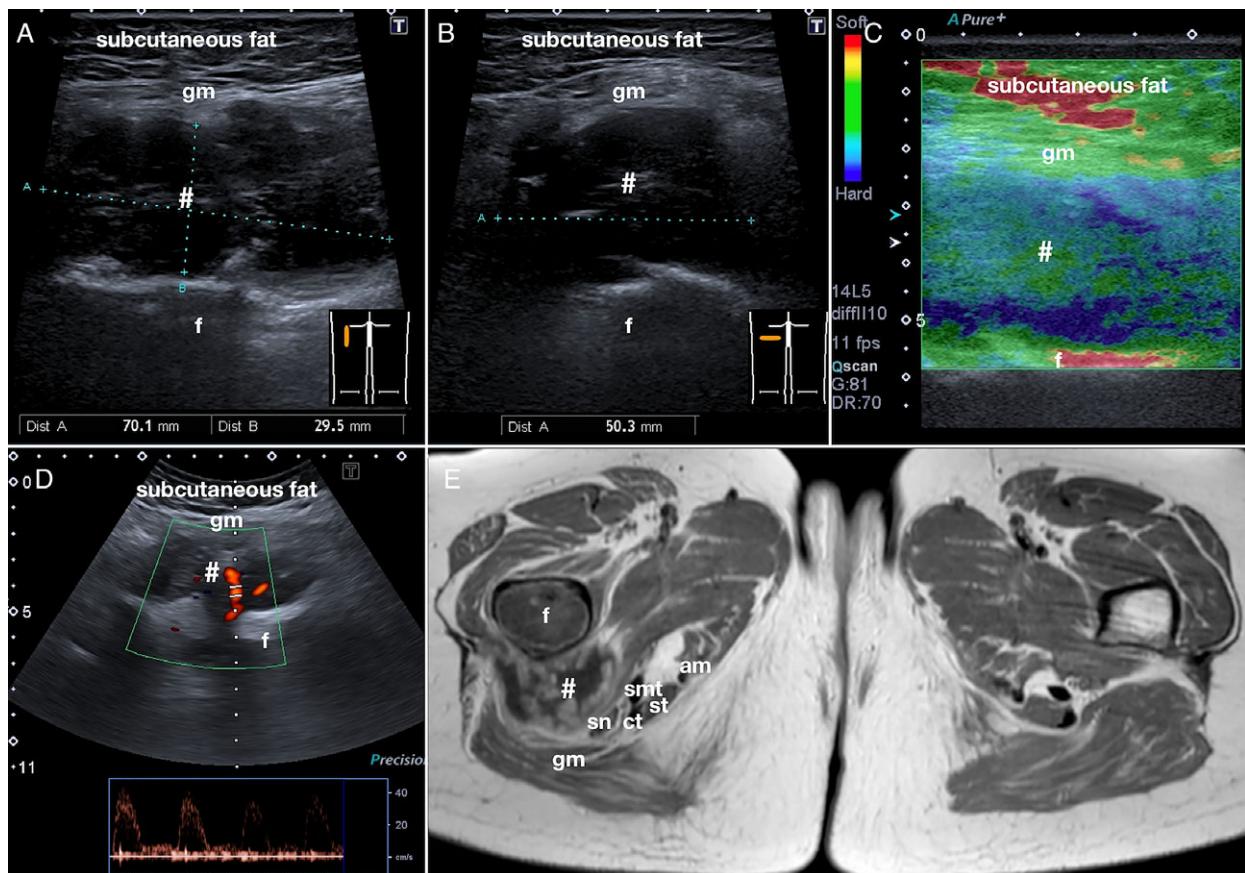
#### **Hamstring Injury Mimics: Differential Diagnosis**

The ischial bursa is an inconstant adventitial bursa superficial to the hamstring muscle complex proximal tendons at the ischial tuberosity. Ischial bursitis is usually related to chronic irritation or trauma and often leads to buttock pain; it appears as a fluid structure that may have irregular walls and internal septa

(Figure 20).<sup>9,27</sup> Deep venous thrombosis simulating a hamstring muscle complex injury and causing diffuse posterior thigh swelling has been described; US is able to show deep venous thrombosis and exclude a tear.<sup>28</sup>

Among uncommon causes of pain near the hamstring muscle complex origin, tumors must not be neglected (Figure 21). Ultrasound may show soft tissue masses and may suggest their benign or malignant nature, but its main role is to differentiate between cystic and solid masses and to guide biopsy.<sup>11</sup> When evaluating deep masses, we recommend completing the examination with a convex transducer, as it is more informative in showing a possible relationship

**Figure 21.** Images from a 55-year-old patient with Ollier syndrome presenting for suspected “hamstring syndrome.” **A** and **B**, Ultrasound scans show a hypoechoic mass (pound signs) with internal calcification and a hard pattern on strain elastography (**C**). **D**, A convex transducer was used to analyze its deep aspect; it can be seen arising from the femur (f). An internal color signal was shown on Doppler imaging; pulsed wave Doppler imaging revealed arterial flux with a high resistive index. **E**, Corresponding axial contrast-enhanced T1-weighted turbo spin echo MRI shows the mass displacing the hamstring muscle complex origin tendons and sciatic nerve (sn) medially. Biopsy revealed that the mass was a chondrosarcoma; am indicates adductor magnus muscle; ct; conjoint tendon; gm, gluteus maximus; smt; semimembranosus tendon; and st, semitendinosus muscle.



with the bone and vascularity on Doppler imaging (Figure 21D). The use of strain elastography may help improve the sensitivity of US for suspecting malignant lesions because of their increased stiffness (Figure 21C).<sup>29</sup> However, when a deep mass is suspected on a US scan, contrast-enhanced MRI has to be performed (Figure 21E).<sup>30</sup>

## Conclusions

Ultrasound is able to show the normal architecture of the proximal hamstring muscle complex as well as the appearance of bone-tendon-muscle unit injuries. Due to the long extension of the conjoint and semimembranosus tendons, the examination should be started at the ischial tuberosity and extended caudally to the middle third of the posterior thigh, adding a comparative scan to confirm pathologic findings. Magnetic resonance imaging should be considered in the presence of a discrepancy between clinical and US findings and in a case of proximal tendon avulsion to possibly plan surgery; it is also advised in elite athletes as a complementary examination.

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