Hamstrings

12

Davide Orlandi and Luca Maria Sconfienza

The hamstring (ischiocrural) muscle complex consists of three main muscles that share a common origin site from the ischial tuberosity and occupy the entire posterior compartment of the thigh: from lateral to medial, the long head of the biceps femoris muscle, the semitendinosus muscle and the semimembranosus muscle (Fig. 12.1). It also includes the ischiocondylar portion of the adductor magnus muscle, located deeply in the medial compartment.

The hamstrings span two joints, the hip and the knee, and they are primarily extensors of the thigh and flexors of the leg. The long head of the biceps femoris is also responsible for external rotation of the leg with flexed knee, while the semitendinosus and the semimembranosus muscles play a secondary role in internal rotation of the leg with flexed knee.

The short head of the biceps femoris muscle does not cross two joints and is not included in hamstring complex, but it is debated in this chapter for a more comprehensive overview.

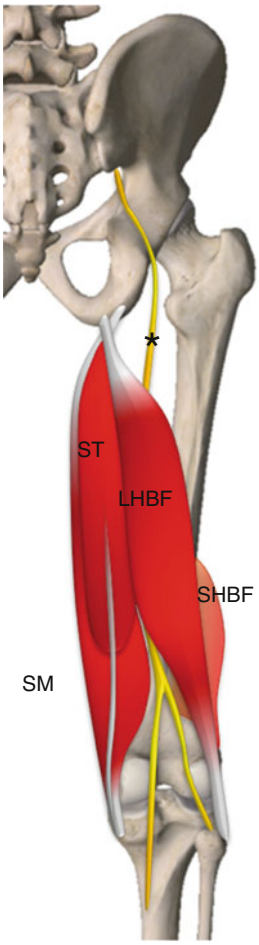

Fig. 12.1 Anatomical scheme of hamstring muscles: *SM* semimembranosus muscle, *ST* semitendinosus muscle, *LHBF* long head of biceps femoris muscle, (*) sciatic nerve. The short head of biceps femoris muscle (*SHBF*), included in the scheme, is not an ischiocrural muscle

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12.1 Anatomy Key Points

12.1.1 Biceps Femoris

The *long head of the biceps femoris* muscle (LHBF) arises from the inferomedial facet of the ischial tuberosity by way of a conjoined tendon with the semitendinosus muscle (Fig. 12.2). The LHBF muscle belly is covered by the gluteus maximus muscle at the root of the thigh and then runs superficially in the posterior thigh, just under the subcutaneous tissue, lateral to the semitendinosus muscle and posterior to the adductor magnus, the vastus lateralis and the short head of the biceps femoris muscles. Along its entire course, the LHBF muscle lies superficial to the sciatic nerve. At the distal third of the thigh, the LHBF diverge from the semitendinosus and the semimembranosus muscles delimiting the popliteal space. At this level the LHBF joins the short head forming a common distal tendon, which attaches onto the lateral aspect of the fibular head. Just prior to the insertion, the distal tendon of the biceps femoris muscle forms a conjoined tendon with the distal component of the lateral collateral ligament of the knee (a *synovial bursa* may be placed between these two fibrous structures). Some tendon fibres also reach the lateral tibial condyle and the distal iliotibial tract. From the apex of the popliteal space to its attachment onto the fibular head, the biceps femoris muscle and tendon course in close relationship with the common peroneal nerve.

The long head of the biceps femoris muscle is supplied by the inferior gluteal artery, perforating arteries and the popliteal artery. It is innervated by the tibial component of the sciatic nerve.

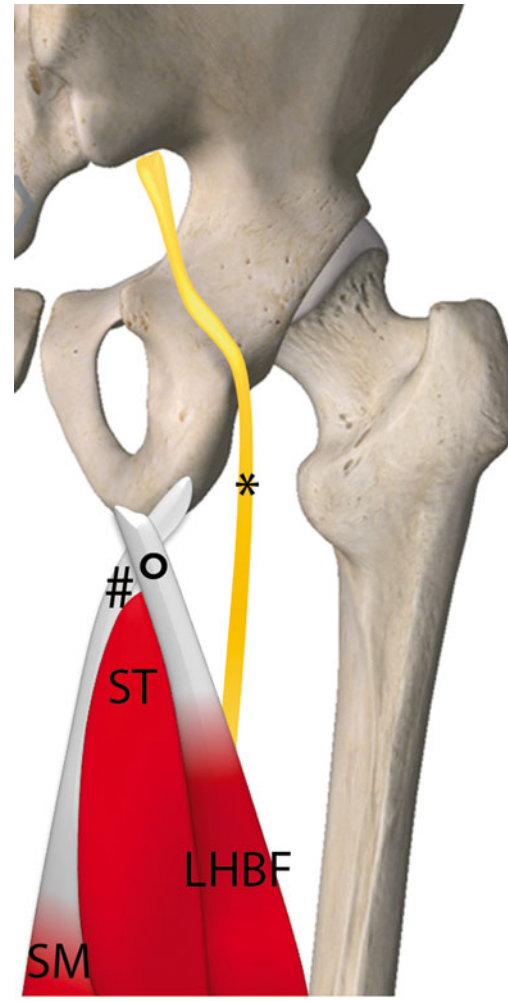

Fig. 12.2 Anatomical scheme of hamstrings proximal insertion: (#), semimembranosus tendon; (°) LHBF-ST conjoined tendon. *LHBF* long head of biceps femoris muscle, *SM* semimembranosus muscle, *ST* semitendinosus muscle, (*), sciatic nerve

The *short head of the biceps femoris* muscle (SHBF) takes its origin from the middle third portion of the lateral linea aspera, the lateral supracondylar line and the intermuscular septum. The muscle belly is placed at the distal thigh, deep to the LHBF. The fibres of the SHBF merge into those of the LHBF, contributing to the formation of the distal tendon, which inserts onto the fibular head.

The SHBF is not part of hamstrings because it does not span two joints.

Sometimes, the SHBF may be absent.

Unlike the long head, the short head of the biceps femoris muscle is innervated by the peroneal division of the sciatic nerve.

12.1.2 Semitendinosus

The *semitendinosus* (ST) is a fusiform polyarticular muscle, which originates from the inferomedial aspect of the ischial tuberosity via a conjoined tendon with the LHBF. Together with the semimembranosus muscle, they are known as medial hamstrings.

The semitendinosus can be considered as a digastric muscle because it shows an internal raphe inside the proximal third of the muscle belly onto which the proximal fibres insert.

Just caudal to the ischial tuberosity, the semitendinosus rapidly becomes bulbous with the LHBF-ST conjoined tendon lying lateral to it and the semimembranosus tendon lying anterior to it. The muscle belly is placed superficially in the posterior thigh, medial to the LHBF, lateral to the semimembranosus and posterior to the adductor magnus muscle.

At the middle-distal third of the thigh, the semitendinosus forms a long thin superficial tendon that posteriorly overcomes the semimembranosus muscle and inserts along the medial aspect of the proximal tibia, forming the pes anserinus complex together with the sartorius and gracilis tendons. As opposed to the semimembranosus muscle, the semitendinosus is entirely tendinous in the distal thigh.

The semitendinosus muscle is supplied by the inferior gluteal artery and perforating arteries. The innervation is represented by the tibial component of the sciatic nerve.

12.1.3 Semimembranosus

The *semimembranosus* (SM) muscle arises from the superolateral surface of the ischial tuberosity by way of an elongated tendon, which runs deep to the proximal semitendinosus muscle belly. The proximal tendon, which has connections with the adductor magnus tendon and the LHBF-ST conjoined tendon, course down running anteromedial to the semitendinosus muscle belly and the LHBF-ST conjoined tendon. Then, it continues in a large coronal-oriented aponeurosis extending in the proximal half of the thigh and giving origin to the muscle fibres.

The semimembranosus muscle belly is almost entirely located in the mid-distal thigh, anteromedial to other hamstrings, posterior to the adductor magnus muscle and posterolateral to the gracilis muscle. It has a closer relationship with the semitendinosus distal tendon, which course superficially.

Unlike the semitendinosus muscle, which is thin and band-like, the semimembranosus muscle is composed of short unipennate and multipennate fibres. Moreover, the semimembranosus, as its name implies, have a thin and wide tendon in the upper thigh, while the semitendinosus is more tendinous distally.

The semimembranosus distal insertion has multiple attachment points, the main two onto the infraglenoid tubercle of the posteromedial proximal tibial condyle (direct tendon) and onto the medial aspect of the proximal tibial epiphysis (indirect tendon). Other tendinous expansions also reach the posterior capsule of the knee joint and the popliteal fascia. The semimembranosus distal tendon is intimately connected with the medial collateral ligament of the knee from which it may be separated by a synovial bursa that sometimes communicate with the femorotibial joint.

Fig. 12.3 Lower limb position to evaluate hamstring complex

The semimembranosus muscle is supplied by gluteal arteries and the *profunda femoris artery* (deep femoral artery). The innervation is provided by the tibial portion of the sciatic nerve.

The patient lies prone with the lower limb extended in a neutral position (Fig. 12.3).

12.2 Ultrasound Examination Technique

Palpate the ischial tuberosity, a key bony landmark for hamstrings evaluation, and place the probe on it in an axial plane to identify ischiocrural proximal insertion (Fig. 12.4). At this level the LHBF-ST conjoined tendon and the semimembranosus tendon cannot be visualized as distinct structures because they are intimately superimposed. The sciatic nerve is located lateral to the ischial tuberosity.

Focus On

The *sciatic nerve*, the longest and largest peripheral nerve in the body, supplies the lower back, the hamstrings, the adductor magnus muscle and, with its terminal branches, the leg. It is composed of two distinct portions, a medial and a lateral fascicle, which continue at the popliteal space as tibial and common peroneal nerve, respectively.

The sciatic nerve exits the greater sciatic foramen of the pelvis, passing between the ventral aspect of the piriformis muscle and the posterior surface of the quadratus femoris muscle. At the upper thigh, the sciatic nerve is placed lateral to the hamstrings attachment on the ischial tuberosity; then, it runs distally the posterior thigh between the adductor magnus muscle (anterior) and the long head of the biceps femoris and semitendinosus muscles (posterior). Reached the apex of the popliteal fossa, where it lies between the biceps femoris (on the lateral side) and the semitendinosus and semimembranosus muscles (on the medial side), it divides into the tibial nerve and the common peroneal nerve.

Shifting the probe just caudally, the semitendinosus is immediately seen as a muscle belly, and the first visible separation of the LHBF-ST conjoined tendon from the semimembranosus tendon can be identified (Fig. 12.5). Remember that the LHBF-ST conjoined tendon has an eccentric position in respect to the semitendinosus muscle belly that extends lateral to the tendon itself.

Note the relationship between the LHBF-ST conjoined tendon and the sciatic nerve.

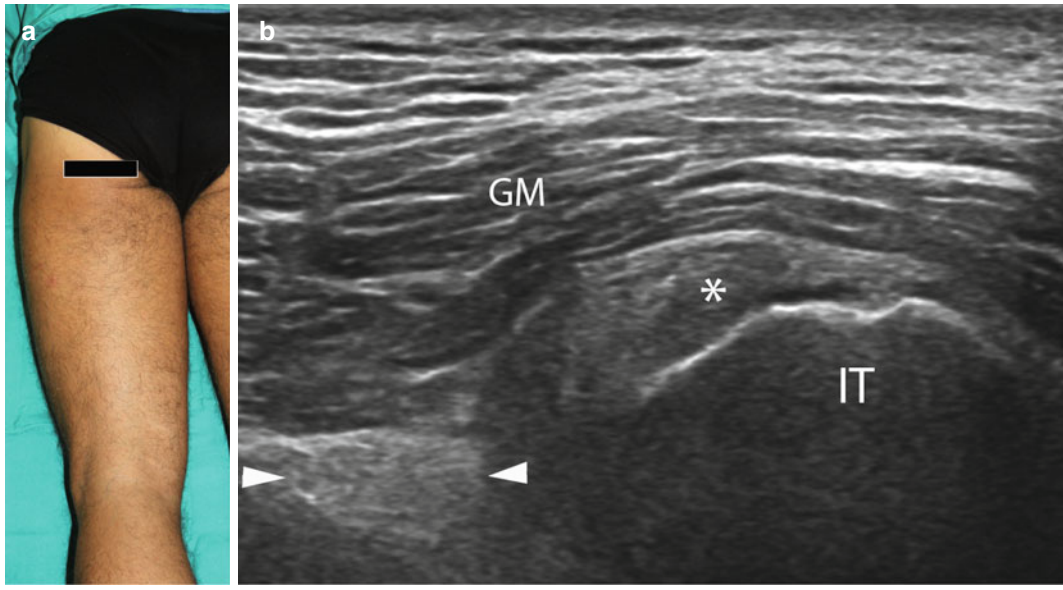

Fig. 12.4 (**a**) Probe position to evaluate hamstrings proximal insertion on the axial plane. (**b**) US axial scan of hamstrings common origin from the ischial tuberosity. The ischial tuberosity (*IT*) is seen as a hyperechoic band, deep to the LHBF-ST conjoined and the SM tendons; these two tendons cannot be separated and are imaged as a unique tendinous structure with a typical fibrillar hyperechoic appearance (*). The sciatic nerve (*white arrowheads*) is visualized as a rounded structure, with a fascicular hyperechoic appearance, lateral to the ischial tuberosity. *GM* gluteus maximus

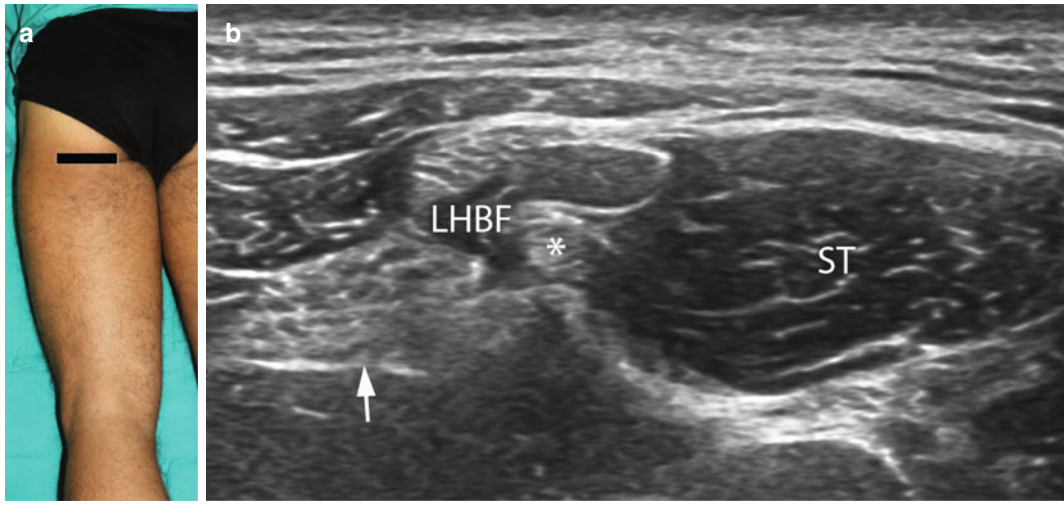

Fig. 12.5 (**a**) Probe position to visualize the LHBF-ST conjoined tendon on an axial plane. (**b**) US axial scan: note the hyperechoic "comma-shaped" appearance of the LHBF-ST conjoined tendon that is placed superficial and lateral to the ST muscle. *White arrow*, sciatic nerve

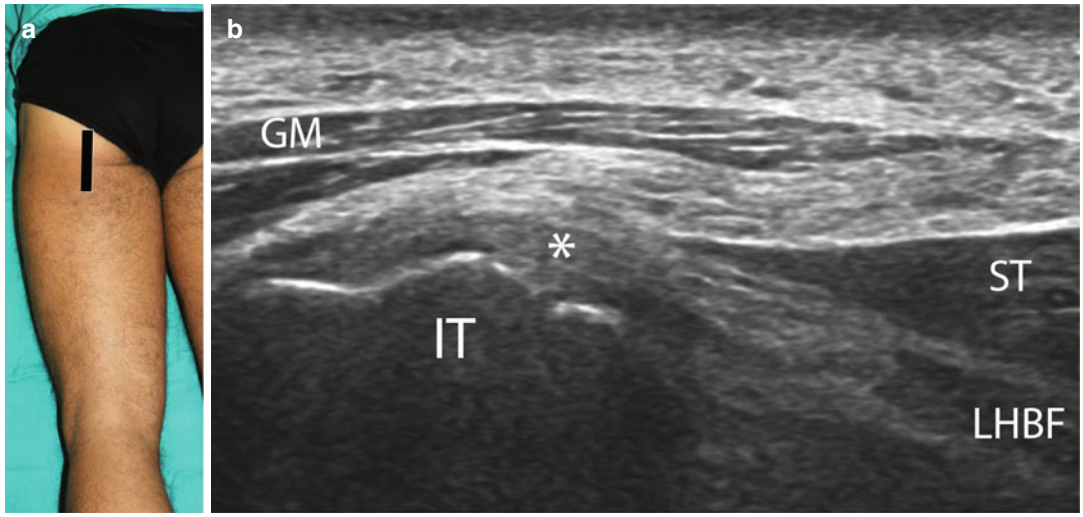

Fig. 12.6 (**a**) Probe position to evaluate the LHBF-ST conjoined tendon on a longitudinal plane. (**b**) US longitudinal scan: *IT* ischial tuberosity, (*) LHBF-ST conjoined tendon, *ST* semitendinosus muscle belly, *LHBF* long head of the biceps femoris muscle belly, *GM* gluteus maximus

Turn the probe by 90° to evaluate the LHBF-ST conjoined tendon on its long axis (Fig. 12.6).

From this position, move the transducer caudally to reach the *LHBF proximal myotendinous junction* (Fig. 12.7). Because this region is often affected by strain injuries during sports, a detailed US evaluation is very important in order to obtain a reliable diagnosis and grading.

Place again the transducer in the axial position shown in Fig. 12.4 and then slightly move the probe laterally and caudally, following the *LHBF* muscle belly along the lateral posterior thigh (Fig. 12.8).

At the distal third, pay attention to the site in which the LHBF fibres merge with the SHBF ones to form a common distal tendon: this is another critical area, frequently involved in strain injuries (Fig. 12.9). This fibres arrangement and the different innervation of the LHBF and the SHBF (the former is supplied by the tibial portion of the sciatic nerve and the latter by the peroneal one) could explain why this muscle has the highest frequency of strain injuries among the hamstring muscles. In this setting the double nerve supply probably determines asynchronies in the coordination and intensity of stimulation of the two heads, resulting in potential tears.

Remember to always evaluate the *biceps femoris distal tendon* up to its insertion onto the fibular head (Fig. 12.10) and then to rotate the transducer by 90° to better visualize the distal myotendinous junction and its tendon on a longitudinal plane (Figs. 12.11 and 12.12). Don't forget the close relationship between the biceps femoris muscle and tendon and the common peroneal nerve in proximity of the fibular head.

Focus On

The *common peroneal nerve* is the smaller of the two terminal branches of the sciatic nerve; at its origin, it courses along the lateral side of the popliteal space, in proximity to the lateral head of the gastrocnemius muscle, posteromedial to the biceps femoris muscle and tendon. Then, the nerve curves anteriorly, turning around the fibular head, to reach the fibular tunnel, in which it lies between the fibula and the proximal tendon of the peroneus longus muscle. At the lateral side of the fibular neck, it enters the anterolateral compartment of the leg and splits in its two terminal branches, the deep and the superficial peroneal nerves.

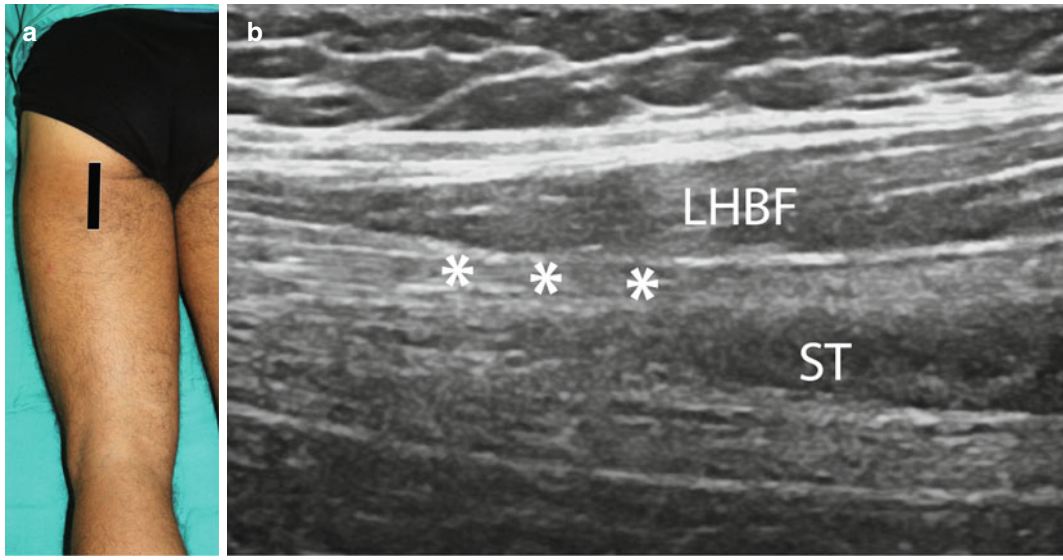

Fig. 12.7 (**a**) Probe position to evaluate the LHBF proximal myotendinous junction on the longitudinal plane (**b**) US longitudinal scan of the long head of biceps femoris proximal myotendinous junction. (*) LHBF-ST conjoined tendon; *LHBF* long head of biceps femoris muscle, *ST* semitendinosus muscle

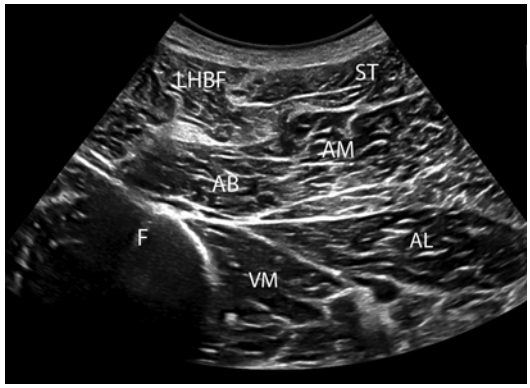

Fig. 12.8 US panoramic scan of the posterior thigh muscles and their relationship with the thigh medial muscles. *LHBF* long head of biceps femoris muscle, *ST* semitendinosus muscle, *AM* adductor magnus muscle, *AB* adductor brevis muscle, *AL* adductor longus muscle, *VM* vastus medialis muscle, *F* femur

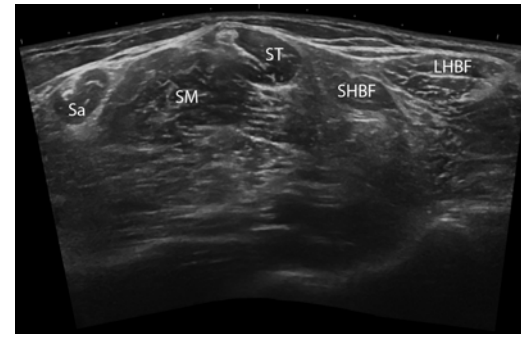

Fig. 12.9 Extended-field-of-view of the posterior thigh. Look at the critical area in which the short head of the biceps femoris fibres (*SHBF*) joint with the long head ones (LHBF). *ST* semitendinosus muscle, *SM* semimembranosus muscle, *Sa* Sartorius muscle

Reposition the probe on the ischial tuberosity, as shown in Fig. 12.4, and then shift it caudally along the central posterior thigh to examine the semitendinosus muscle belly on an axial plane (Fig. 12.13).

At the middle third, the semitendinosus progressively becomes tendinous, while the LHBF and the semimembranosus remain still bulbous (Fig. 12.14).

Move the transducer caudally, from lateral to medial, to follow the semitendinosus long and superficial distal tendon up to its attachment onto the medial proximal tibia, forming the *pes anserinus* complex (Fig. 12.15).

Rotate the probe by 90° to appreciate the distal tendon on the longitudinal plane and move it cranially to reach the *semitendinosus distal myotendinous junction*, best visualized on its long axis (Fig. 12.16). The distal myotendinous

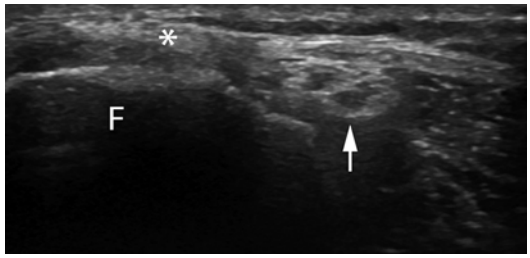

Fig. 12.10 US axial scan of the biceps femoris distal insertion onto the fibular head. (*) biceps femoris distal tendon; *F* fibula. Note the close proximity with the common peroneal nerve (*white arrow*) which courses just posterior and medial to the biceps femoris distal tendon

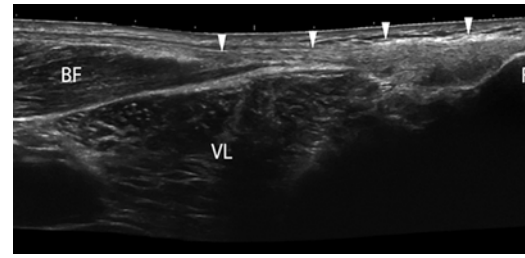

Fig. 12.11 Extended-field-of-view of the biceps femoris distal myotendinous junction (*white arrowheads*). *BF* biceps femoris muscle, *VL* vastus lateralis muscle, *F* fibula

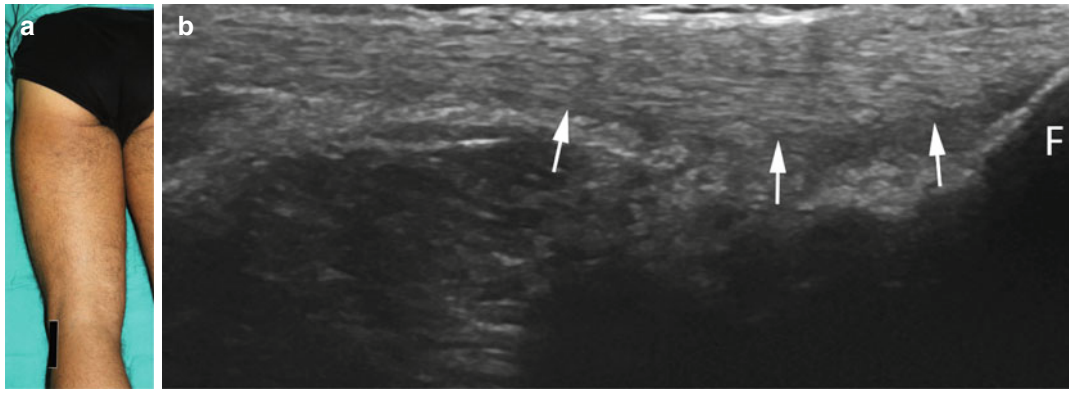

Fig. 12.12 (**a**) Probe position to evaluate the biceps femoris distal insertion onto the fibular head on the longitudinal plane. (**b**) US longitudinal scan of the biceps femoris distal tendon (*arrows*). The biceps femoris distal tendon and the lateral collateral ligament of the knee have a conjoined attachment point onto the tip and the lateral aspect of the fibular head (*F*)

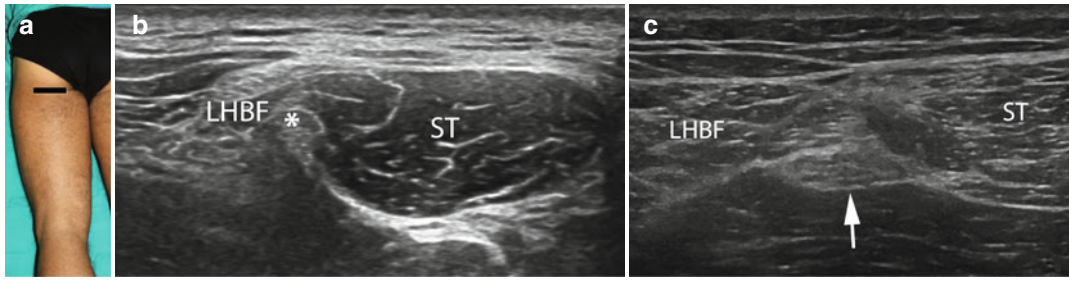

Fig. 12.13 (**a**) Probe position to examine the semitendinosus muscle belly. (**b**) US axial scan of the upper posterior thigh to evaluate the semitendinosus muscle belly. *LHBF* long head of biceps femoris muscle, *ST* semitendinosus muscle, (*) LHBF-ST conjoined tendon. (**c**) US axial scan at the level of the proximal third of the thigh. Note the close proximity of the semitendinosus (medial) and the long head of the biceps femoris (lateral) muscle bellies with the sciatic nerve. *White arrow*, sciatic nerve

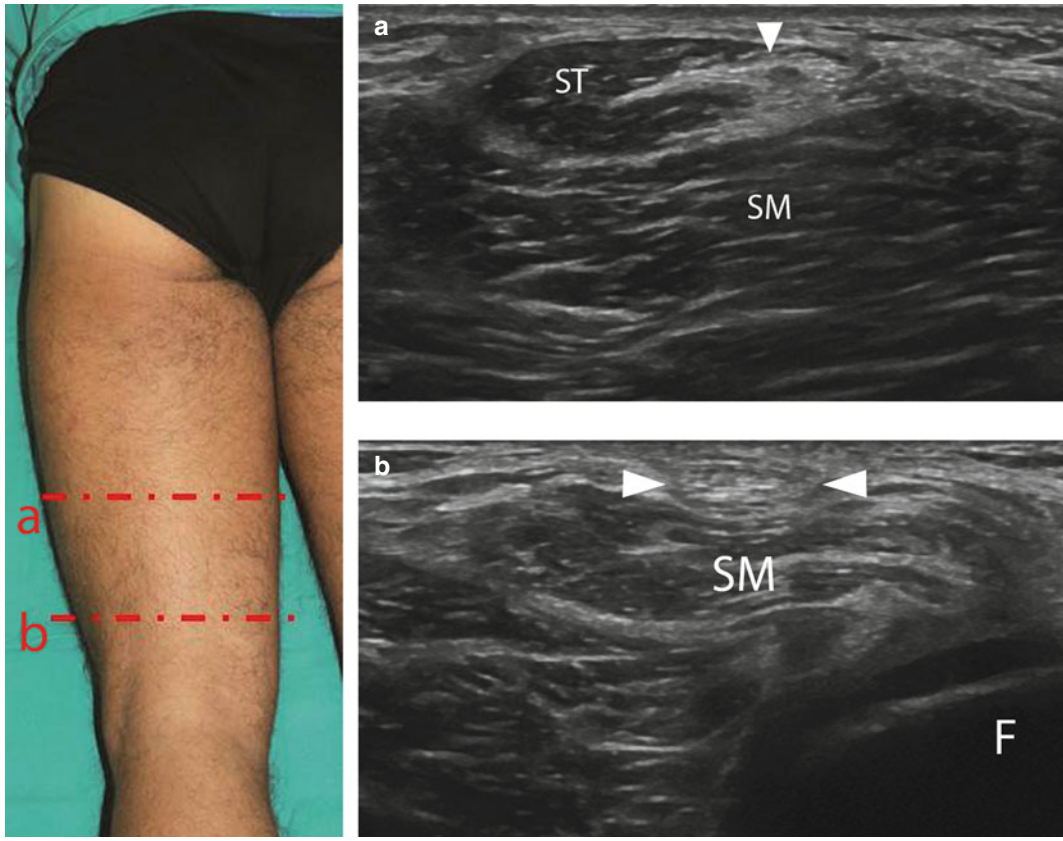

Fig. 12.14 US axial scans of the semitendinosus distal tendon at different levels and its relationship with the semimembranosus muscle belly. (**a**) At the level of the middle third of the posterior thigh, the semitendinosus muscle overcome the semimembranosus and progressively becomes tendinous. *ST* semitendinosus muscle belly, *white arrowhead* distal tendon fibres of the semitendinosus muscle, *SM* semimembranosus muscle. (**b**) At the level of the middle-distal third of the posterior thigh, the semitendinosus distal tendon (*white arrowheads*) lies superficial to semimembranosus muscle belly. *SM* semimembranosus muscle, *F* fibula

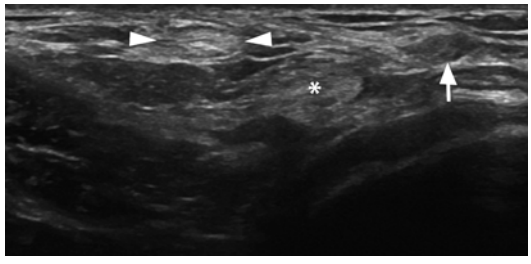

Fig. 12.15 US axial scan of the semitendinosus distal insertion; *white arrowheads*, semitendinosus distal tendon; (*), semimembranosus distal tendon; *white arrow*, gracilis distal tendon

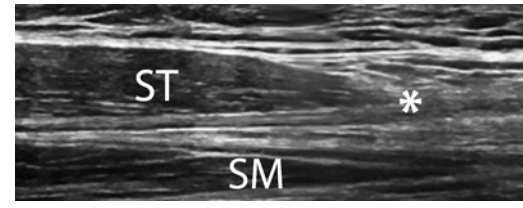

Fig. 12.16 US longitudinal scan of the semitendinosus distal myotendinous junction and tendon (*); *ST* semitendinosus muscle, *SM* semimembranosus muscle

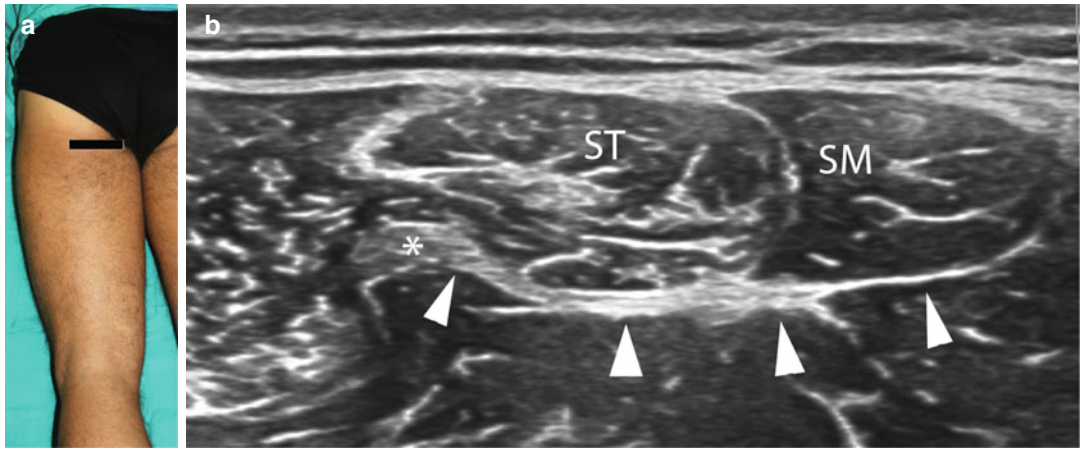

Fig. 12.17 (**a**) Probe position to examine the semimembranosus muscle belly on the axial plane. (**b**) US axial scan of the semimembranosus proximal tendon (*) and its aponeurosis (*white arrowheads*). *ST* semitendinosus muscle, *SM* semimembranosus muscle

junction is often affected in semitendinosus muscle injuries.

Also for the semimembranosus muscle, the ischial tuberosity represents the main landmark to start the US evaluation. From the position shown in Fig. 12.4, shift the probe caudally to obtain the image shown in Fig. 12.5 and move it just medially: the *semimembranosus proximal tendon* can be visualized deep and medial to the ST muscle belly (Fig. 12.17). Note the large aponeurosis, connected to the medial aspect of the tendon, from which the muscle fibres arise.

Slightly move the probe medially and caudally along the medial posterior thigh to examine the proximal myotendinous junction, placed at the level of the mid-third of the thigh, and the semimembranosus muscle belly on the axial plane (Fig. 12.18). Note the typical triangular appearance of the proximal semimembranosus due to its fibres arrangement. Pay particularly attention to the sites in which the semimembranosus fibres attach to the large aponeurosis because traumatic tears often occur at this level.

Distally the semimembranosus increases in size and, at the distal third, progressively becomes tendinous.

Remember to always follow the *semimembranosus distal tendon* up to its insertion onto the posteromedial proximal tibia (Fig. 12.19).

Then, rotate the probe by 90° to evaluate the *semimembranosus distal myotendinous junction* and tendon best imaged on the longitudinal plane (Fig. 12.20).

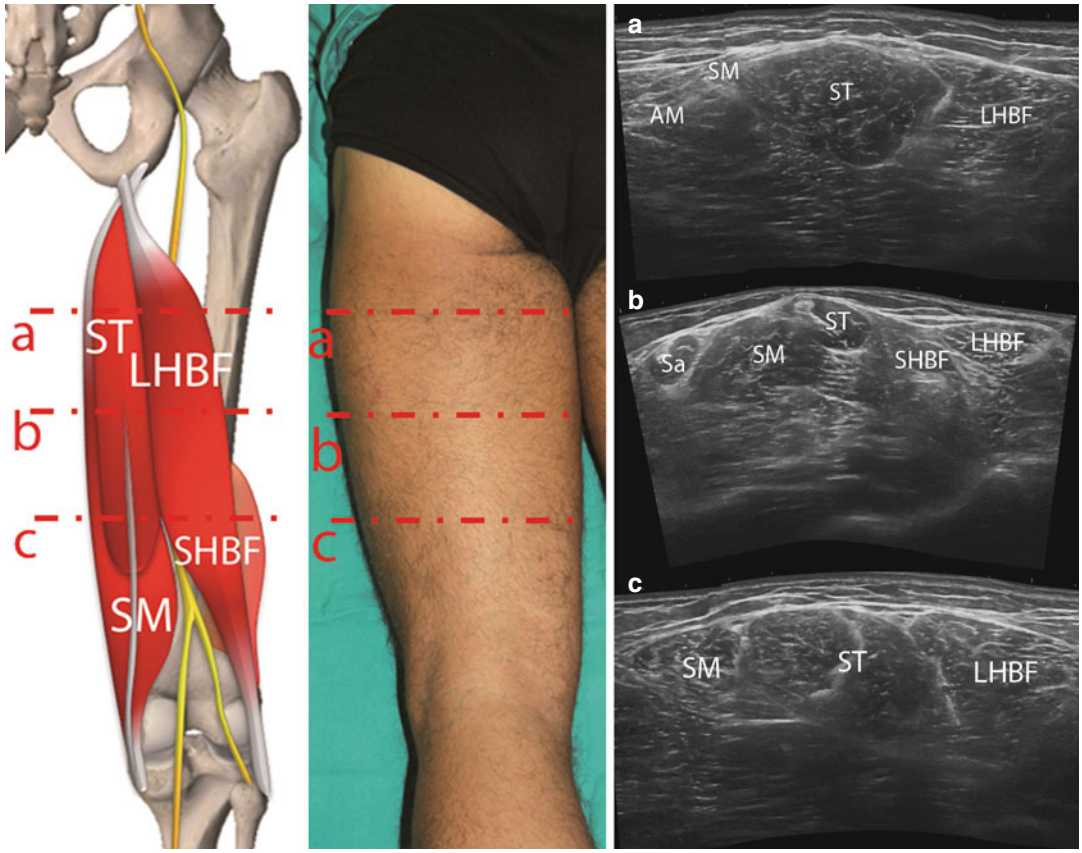

Fig. 12.18 Anatomical scheme of hamstrings correlated to extended-field-of-view axial scans of the semimembranosus muscle belly at different levels, proximal (**a**), middle (**b**) and distal (**c**) third of the posterior thigh. *SHBF* short head of the biceps femoris, *LHBF* long head of the biceps femoris, *ST* semitendinosus muscle, *SM* semimembranosus muscle, *Sa* sartorius muscle, *AM* adductor magnus

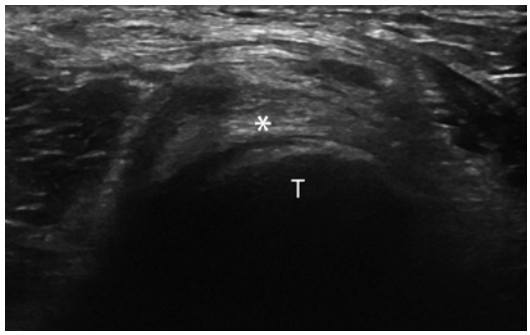

Fig. 12.19 US axial scan of the semimembranosus distal tendon (*). *T* tibia

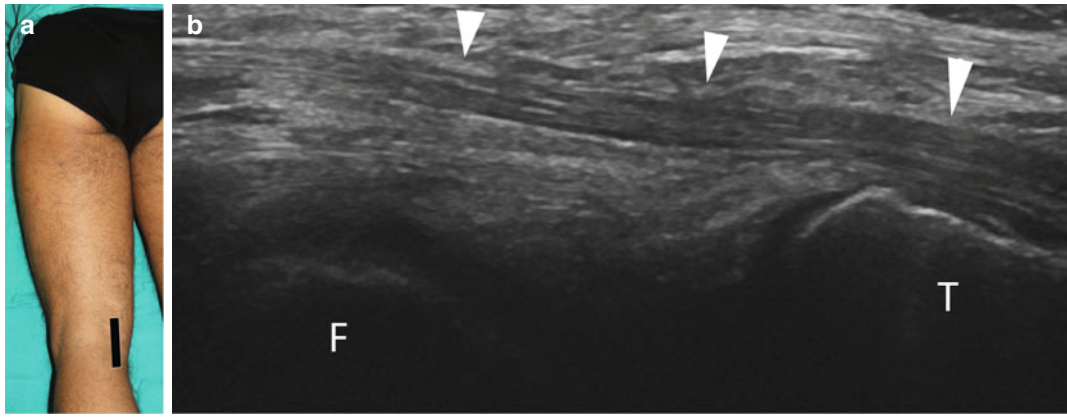

Fig. 12.20 (**a**) Probe position to examine the semimembranosus distal tendon on the longitudinal plane (**b**) US longitudinal scan of the semimembranosus distal tendon insertion (*arrowheads*) onto the posteromedial proximal tibia (*T*). *F* medial femoral condyle onto the posteromedial proximal tibia

12.3 Summary Table

Muscle	Origin	Insertion	Nerve supply	Action
Long head of the biceps femoris	Inferomedial facet of the ischial tuberosity (conjoint tendon with the semitendinosus)	Fibular head (conjoined tendon with the lateral collateral ligament), lateral tibial condyle, iliotibial tract	Tibial portion of the sciatic nerve	Extension of the thigh Flexion of the leg External rotation of the leg with flexed knee
Semitendinosus	Inferomedial facet of the ischial tuberosity (conjoint tendon with the long head of the biceps femoris)	Medial aspect of the proximal tibia (pes anserinus)	Tibial portion of the sciatic nerve	Extension of the thigh Flexion of the leg Internal rotation of the leg with flexed knee
Semimembranosus	Superolateral facet of the ischial tuberosity	Posteromedial (direct tendon) and medial (indirect tendons) aspect of the proximal tibia, posterior capsule of the knee joint, popliteal fascia	Tibial portion of the sciatic nerve	Extension of the thigh Flexion of the leg Internal rotation of the leg with flexed knee
Short head of the biceps femoris	Lateral linea aspera, lateral supracondylar line, intermuscular septum	Fibular head (conjoined tendon with the lateral collateral ligament), lateral tibial condyle, iliotibial tract	Peroneal portion of the sciatic nerve	Flexion of the leg External rotation of the leg with flexed knee

Suggested Reading

Koulouris G, Connell D (2005) Hamstring muscle complex: an imaging review. RadioGraphics 25:571–586
Lee JC, Mitchell AWM, Healy JC (2012) Imaging of muscle injury in the elite athlete. Br J Radiol 85:1173–1185
Maffulli N, Chan O, Del Buono A, Best TM (2012) Acute muscle strain injuries: a proposed new classification system. Knee Surg Sports Traumatol Arthrosc 20:2356–2362
Mariani C, Caldera FE, Kim W (2012) Ultrasound versus magnetic resonance imaging in the diagnosis of an acute hamstrings tear. Am Academy Phys Med Rehab 4:154–155
Martinoli C, Bianchi S (2007) Ultrasound of the musculoskeletal system. Springer, Berlin