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REVIEW ARTICLE

Ultrasonographic Examination of the Adult Hip

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Hip pain is a common clinical complaint arising from various causes. Although hip X-ray is simple and widely available, it provides limited information regarding soft tissue pathologies around the hip joint. Ultrasonography (US) is increasingly used to evaluate pathologies of both intra-articular and extra-articular soft tissues including muscles, tendons, and bursae. Moreover, US allows dynamic evaluation, and is also a valuable tool in guiding intervention around the hip joint for both diagnostic and therapeutic purposes. This article provides a comprehensive review of US evaluation and intervention of the hip.

Introduction

Ultrasonography (US) has recently become the imaging tool of choice for assessing musculoskeletal diseases due to its advantages of easy accessibility, availability, lack of radiation exposure, and low cost. US examination of the hip is challenging because of its deep location and complex anatomy. Despite some limitations, US plays a vital role in the diagnosis, dynamic evaluation, and guiding intervention of hip pathology.

The high-frequency linear transducer, typically with frequencies at approximately 7–12 MHz, may have adequate penetration for hip examination. However, a lower-frequency sector transducer may be required if the patient is obese. Before US examination of the hip joint, the examiner should make accurate differential diagnoses based on careful history taking and physical findings. In order to focus on the relative appropriate structures of the hip, we usually subdivide the hip area into four quadrants during US examination: the anterior, medial, lateral, and posterior aspects.

Anterior hip

Acetabulum and hip joint recess

We generally examine the anterior quadrant first. The patient assumes the supine position with the hip in neutral and slight abduction during US examination. The transducer is placed in a longitudinal-oblique plane over the inguinal ligament area.

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The anterior labrum of the acetabulum, which is made of fibrocartilage, can be detected as a homogeneously hyperechoic triangular structure [1] (Fig. 1A). Caudal to the labrum, using the femoral head and neck as a landmark, the anterior synovial joint recess can be visualized. In the absence of an intra-articular effusion, the two layers adhered together and expressed as one layer. Effusions, most effectively evaluated along the femoral neck, are observed as a hypoechoic to anechoic fluid collection that distend the capsule (Fig. 1B). The distance between the anterior layer and the femoral neck is measured on US for detecting the effusion. Joint effusion is diagnosed when the distance between the anterior layer of synovium and the femoral neck is greater than 7 mm, or a difference between both hips is greater than 1 mm [2]. The presence of hip effusion is found frequently in the adults suffering from hip pain [3]. A US-guided aspiration of joint effusion for diagnostic or therapeutic purposes can be performed in this longitudinal-oblique plane along the axis of the femoral neck. The needle is introduced along the longitudinal plane of the transducer preferentially from the lateral side, away from the medially located neurovascular bundle [4] (Fig. 1C).

Iliopsoas tendonopathy, bursitis, and snapping iliopsoas tendon

In the longitudinal-oblique plane, the iliopsoas muscle is identified above the acetabulum and the femoral head (Fig. 1A). In the transverse plane near the inguinal ligament area, the iliopsoas muscle and tendon are located laterally to the femoral neurovascular bundle. The iliopsoas tendon is a hyperechoic anisotropic fibrillar structure located in a deep eccentric position within the posterior and medial part of the muscle belly and lies over the iliopectineal eminence [1,5] (Fig. 2A). In tendinopathy, the iliopsoas tendon appears hypoechoic, swollen, and lacks a fibrillary pattern. The iliopsoas bursa is collapsed and cannot be visualized in the normal subjects. Because 15% of the iliopsoas bursa communicates with the hip joint, iliopsoas bursitis sometimes is associated with hip joint pathology [6]. In the transverse plane of US, the distended bursa is located between the femoral neurovascular bundle (medially) and the iliopsoas muscle (laterally) and appears as an anechoic or hypoechoic fluid collection without apparent walls [1]. The distended bursa should not be mistaken for a paralabral ganglion cyst, which appears as a lobulated, hypoechoic cystic lesion with a well-defined border and cannot be compressed by the transducer [1,7].

The abnormal iliopsoas tendon motion is the common cause of extra-articular snapping hip [8]. To evaluate the snapping iliopsoas tendon, the transducer is placed just above the hip joint parallel to the public bone in the transverse-oblique plane oriented along the short axis of the iliopsoas tendon. The patient is asked to place the hip in the flexion-abduction-external rotation position (frog leg position), and then return to full extension (neutral position) (Fig. 3). While the hip is moving to the frog leg

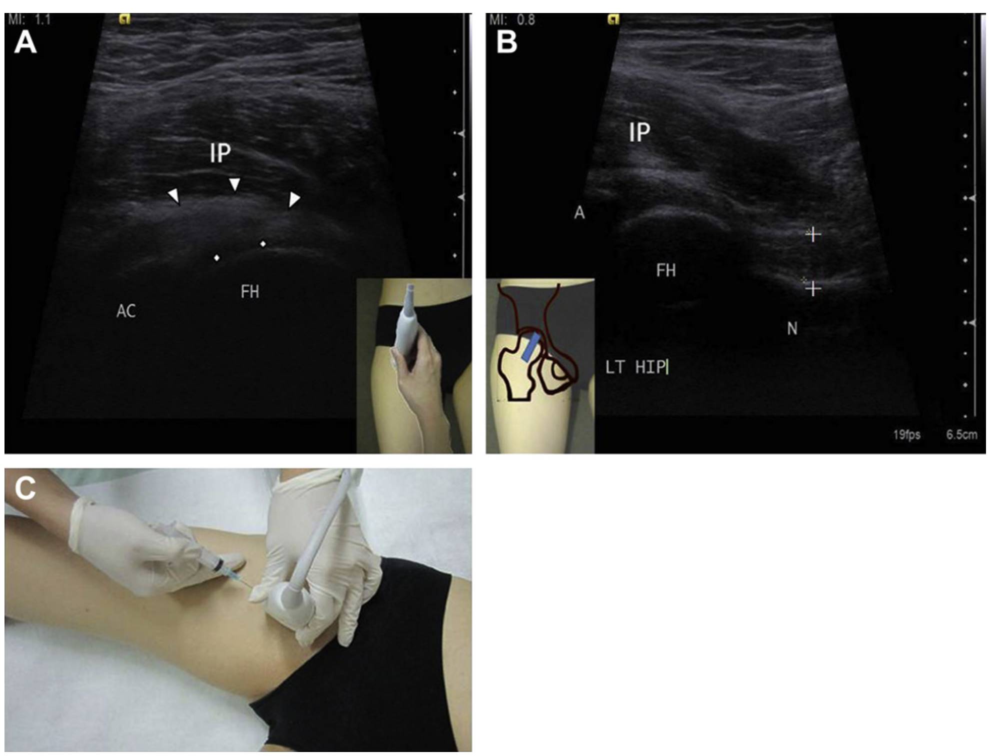

Fig. 1 (A) Longitudinal-oblique plane of ultrasonography (US) image of the anterior hip joint. The homogeneously hyperechoic triangular labrum (arrowhead) is demonstrated arising from the rim of the acetabulum (AC) and covering the articular cartilage (rhombi) of the femoral head (FH). The iliopsoas (IP) muscle lies above the acetabulum and femoral head in this plane. (B) Caudal to the labrum along the femoral head (FH) and neck (N), a bulging joint capsule at the anterior hip recess (calipers) of up to 7.7 mm is found. (C) US-guided aspiration of hip joint effusion. The transducer is positioned in the longitudinal-oblique plane along the axis of the femoral neck. The needle is inserted into the target site under the longitudinal plane of the transducer.

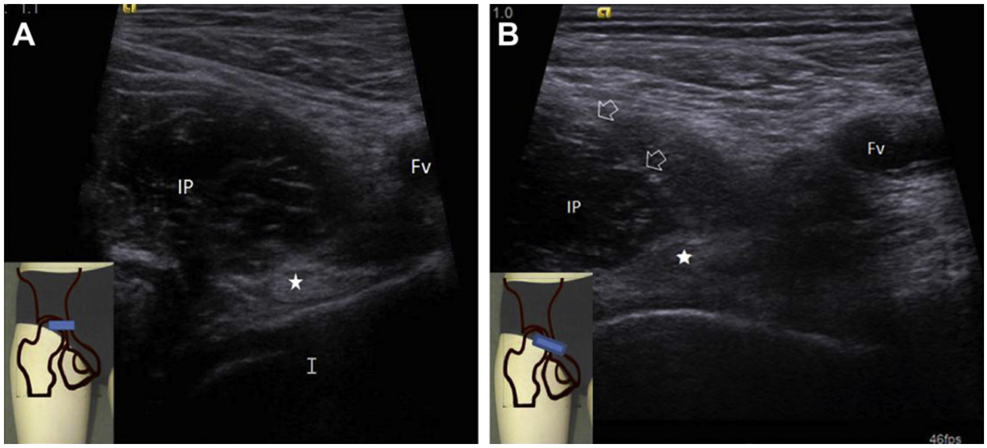

Fig. 2 Iliopsoas muscle and tendon. (A) Transverse plane of ultrasonography (US) at the inguinal ligament shows the transverse view of the iliopsoas muscle (IP) and tendon (asterisk), lateral to the femoral neurovascular bundle (Fv). I, iliac bone. (B) US-guided injection into the right iliopsoas tendon. The transducer is placed in the transverse-oblique plane at the superior pubic ramus level. The swollen iliopsoas tendon is on the posteromedial side of the iliopsoas muscle. The needle (empty arrow) is introduced from the lateral side of the transducer and is proceeded medially.

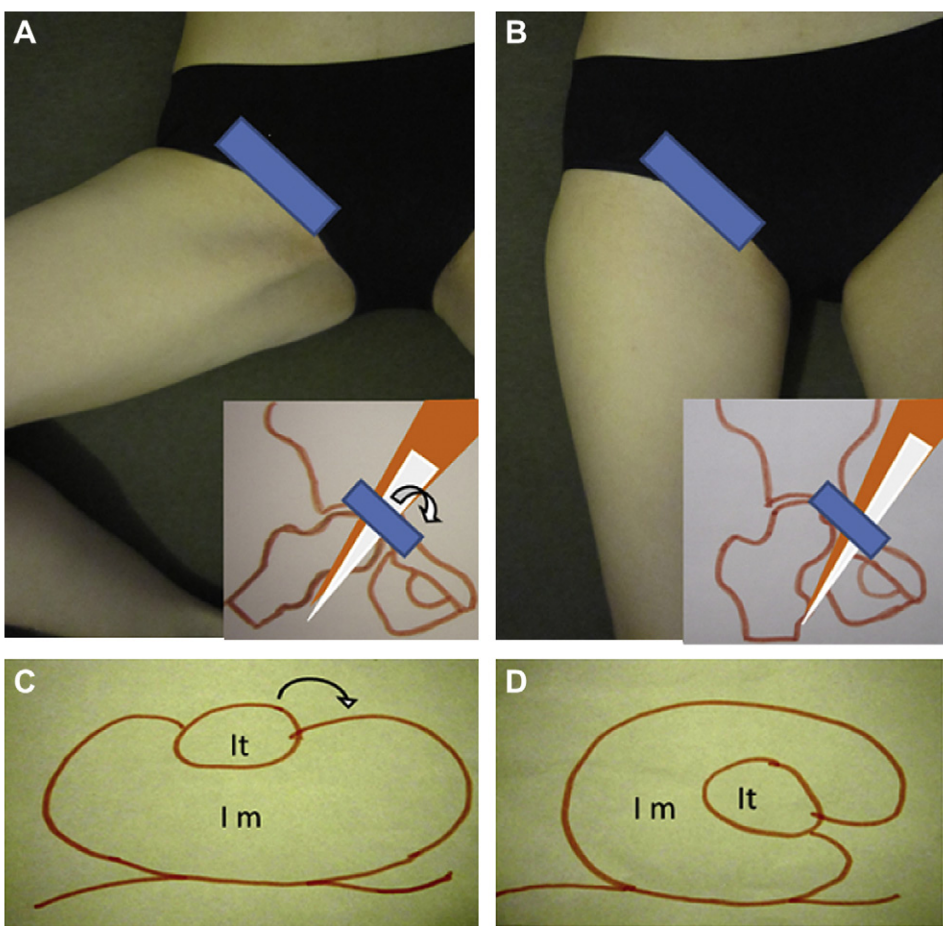

Fig. 3 Snapping iliopsoas tendon. The snapping iliopsoas tendon can be evaluated in the transverse-oblique plane along the short axis of the tendon. The transducer is placed at the level of superior pubic ramus. (A) The patient is asked to place the hip in the flexion-abduction-external rotation (frog leg position) initially. (C) While maintaining this position, the iliopsoas tendon (It) moves laterally and rotates anteriorly to part of the iliopsoas muscle (Im). (B) As the hip is returned to a neutral position, the iliopsoas tendon slides smoothly back to the posteromedial side of the iliopsoas muscle (D).

position, the iliopsoas tendon moves laterally and rotates anteriorly to the iliopsoas muscle, and it slides back smoothly to the posteromedial side of the iliopsoas muscle when the hip is returned to neutral position. In the snapping iliopsoas tendon, an abrupt return of the tendon from the lateral-to-medial position is observed, combined with an audible snap sound [8–10]. Therapeutic US-guided iliopsoas bursal/peritendinous injections are performed by placing the transducer in the transverse-oblique plane over the inner iliac wing [11]. The needle is introduced from the lateral side of the transducer and is proceeded medially (Fig. 2B), positioned between the tendon and the hip capsule or directly into the distended bursa.

Tensor fascia lata and rectus femoris

The tensor fascia lata (TFL) arises from the lateral aspect of the anterior superior iliac spine (ASIS). The short tendon of TFL expresses as a thin ribbon-like hyperechoic fibrillar structure at its insertion at ASIS in longitudinal view. In TFL tendinopathy, the swollen and cone-shaped origin with hypoechogenicity of the tendon is disclosed [12]. To examine the rectus femoris tendon, we place the transducer longitudinally over the anterior inferior iliac spine. The US image of the rectus femoris tendinopathy is similar to that of the tensor fascia lata. Tears in the proximal tendon of the rectus femoris occurs less frequently than in the midsubstance of the muscle belly or in the myotendinous junction [1,7].

Medial hip

To examine the medial hip, the patient is asked to lie in a supine position while keeping the hip abducted and externally rotated with the knee bent. The adductors should be evaluated initially in the transverse plane, starting from the muscle bellies. Three muscle layers are recognized: the superficial layer consists of the adductor longus (laterally) and the gracilis (medially); the intermediate layer is the adductor brevis; and the deep layer is the adductor magnus (Fig. 4A). Then, the transducer should be scanned upward to the insertion of the tendons at the level of pubis. To examine the adductor insertion, the transducer is placed longitudinally along the long axis of the tendon insertion to the pubis. Hip adductor injuries usually occur in combination with hip hyperabduction and abdominal wall hyperextension, occasionally with forced external rotation of the leg [13]. The most commonly affected muscles are the adductor longus and the gracilis [14]. In adductor tendinopathy, hypoechoic and thickening of the tendon can appear, as compared with the asymptomatic side (Fig. 4B). However, US has low sensitivity in low-grade injuries or chronic adductor tendinopathy, as compared with gadolinium-enhanced MR imaging [14].

Lateral hip

When scanning the lateral hip, the patient assumes the lateral decubitus position with the symptomatic side up and the hip slightly flexed. The transverse and longitudinal US imaging conducted cranially to the greater trochanter shows the gluteus medius muscle superficially and the gluteus minimus muscle deeply (Fig. 5A). Once the muscle bellies have been evaluated, the transducer moves caudally to reach the greater trochanter. In transverse US imaging, the gluteus minimus tendon is detected anteriorly as a hyperechoic structure, which inserts into the anterior facet of the greater trochanter. The gluteus medius tendon, located posteriorly, inserts into the lateral facet and posterosuperior facet of the greater trochanter [1]. On longitudinal view, the tensor fascia lata, appearing as a hyperechoic band, lies superficially and overlies the gluteus medius muscle, gluteus minimus tendon, and greater trochanter [1,5].

Several synovial bursae are located around the greater trochanter, allowing the tendons and fascia lata to glide against the bone smoothly. The trochanteric bursa is the

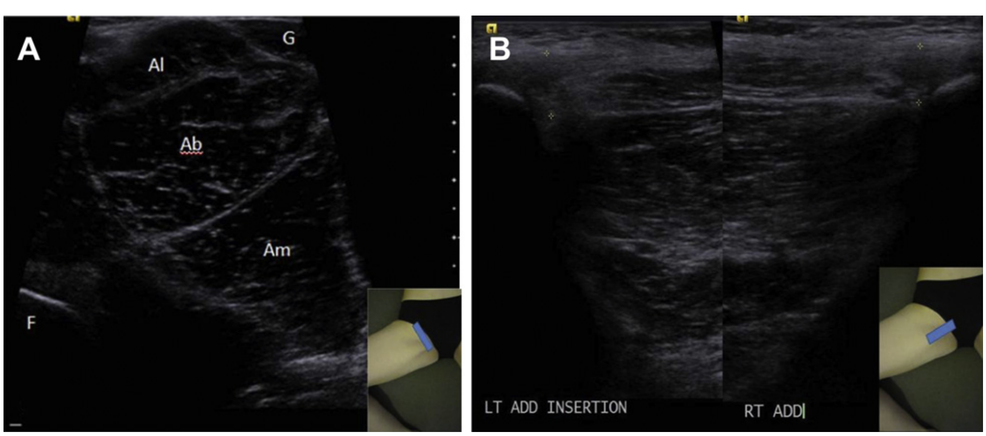

Fig. 4 Hip adductor muscle and tendon at the medial hip. The patient is asked to lie in supine position with the hip abducted and external rotated. (A) The adductor muscles are evaluated initially in the transverse plane. Three muscle layers located above the femoral bone (F) are as follows: the superficial layer refers to the adductor longus (Al) laterally and the gracilis (G) medially; the intermediate to the adductor brevis (Ab); and the deep to the adductor magnus (Am). (B) Adductor longus tendinopathy. This 30-year-old female dancer complained of left medial hip pain especially while stretching. Ultrasonography (US) examination showed a hypoechoic and thickened left adductor longus tendon (8.3 mm) at pubic insertion, as compared to the right side (7.2 mm).

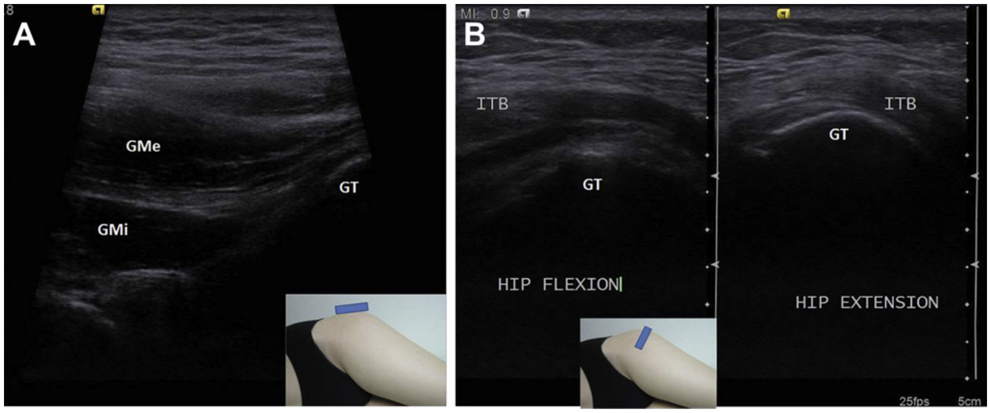

Fig. 5 (A) Gluteus medius (GMe) and gluteus minimus (GMi) muscles. Longitudinal ultrasonography (US) imaging conducted cranially to the greater trochanter (GT) shows the GMe superficially and the GMi deeply. (B) A 16-year-old girl with snapping iliotibial band of the hip. The probe is placed in the transverse plane over the greater trochanter (GT). The iliotibial band (ITB) is located posterior to the greater trochanter while the hip is in extension, and abruptly jerks anterior to the greater trochanter when the hip is flexed. The left side of the screen is the anterior aspect of the patient.

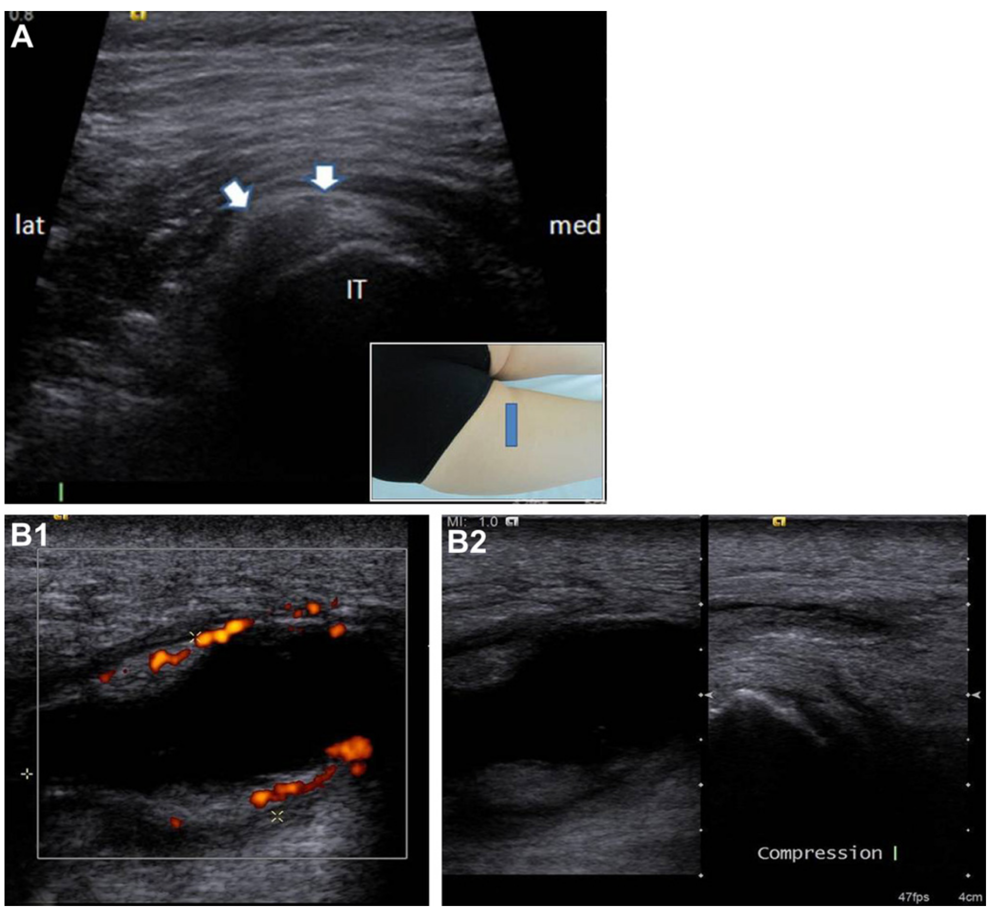

Fig. 6 Ultrasonography (US) transverse imaging at the posterior hip over the ischial tuberosity (IT) level. (A) Hamstring tendons insertion at the IT. At the level just below the IT, the conjoint tendon of the semitendinosus and biceps femoris (arrow) extends superficially and laterally, and can be distinguished from the semimembranosus tendon. (B) Ischiogluteal bursitis. (B1) Hypoechoic to anechoic fluid accumulation with increasing vascularity in hypertrophic synovium is demonstrated. (B2) The bursa filled with fluid has marked compressibility.

largest, and is located superficially to the posterior insertion of the gluteus medius tendon and lateral aspect of the greater trochanter and deep to the gluteus maximus [1,4].

Greater trochanteric pain syndrome

The leading cause of greater trochanteric pain syndrome is traditionally thought to be associated with bursopathy. However, studies using US or magnetic resonance imaging (MRI) all indicated that the hip abductor tendinopathy or tear, especially in the gluteus medius tendon, is the main cause of this syndrome [15–18]. Hypoechogenicity and focal swelling with preservation of fibrillar pattern of the gluteus medius tendon represents gluteus medius tendinopathy [15]. Hyperechoic spots indicating calcification may occasionally be found at the tendon insertion site. A partial-thickness tear, representing as a focal anechoic area or discrete fiber, usually involves the deep portion of the anterior gluteus medius tendon [15]. In a complete tear, a retracted tendon end with anechoic fluid accumulation can be determined between the gluteus medius tendon and the naked greater trochanter [19,20].

Snapping iliotibial band syndrome

Extra-articular lateral snapping hip is caused by intermittent impingement of the posterior border of the fascia lata or the anterior portion of the gluteus maximus over the bony prominence of the greater trochanter. This condition is similar to the snapping iliopsoas tendon, but the snapping sensation is felt laterally. US imaging reveals hypoechoic thickening of the fascia lata. The patient is in a side-lying position with the hip extended and then flexed. The transducer is placed transversely at the level of the greater trochanter. An ellipsoid-shaped iliotibial band over the

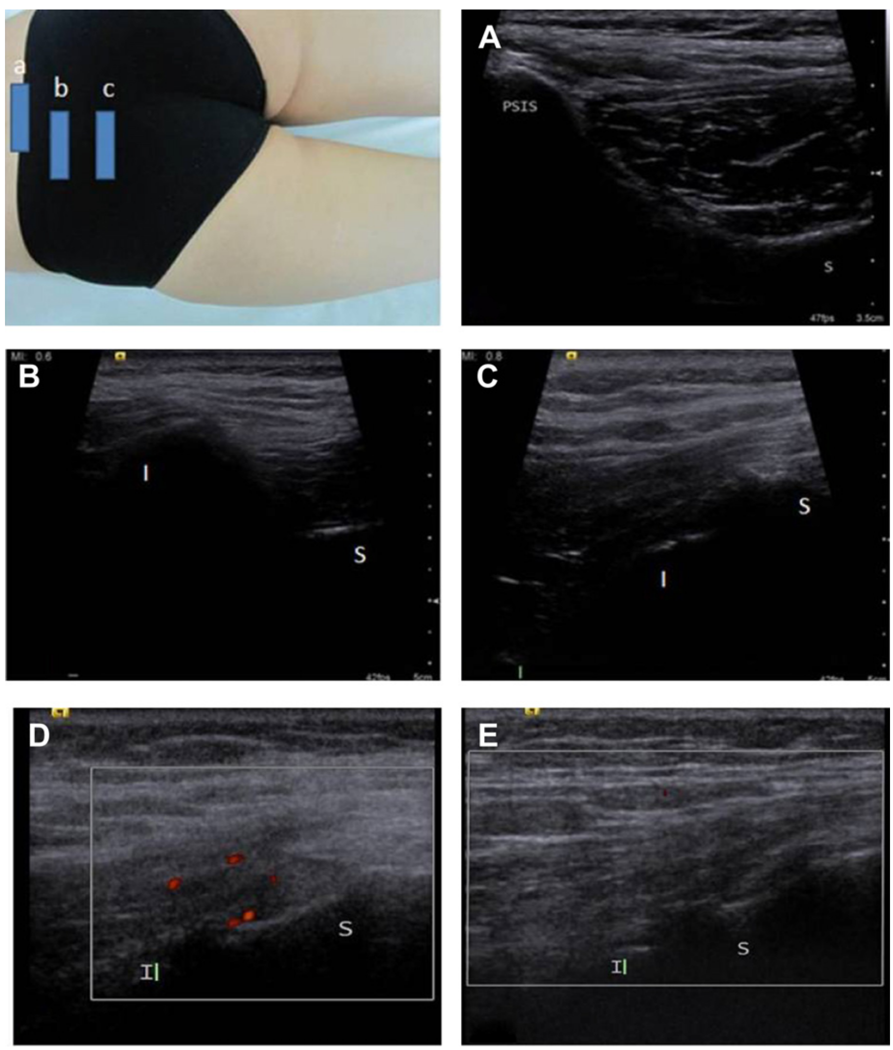

Fig. 7 Sacroiliac joint examination. (A) Initially, the transducer is placed in the transverse plane where the posterior superior iliac spine (PSIS) lies laterally and the lumbo-sacral spine lies medially. (B, C) The transducer is moved laterally and caudally in the paraxial plane. The gluteal surface of the ilium (I) lies laterally and the dorsal surface of the sacrum (S) lies medially. The hypoechoic cleft between both bony contours represents the sacroiliac joint. (D) Inflammation with increasing vascularity using the power Doppler technique was found at the sacroiliac joint. Ultrasonography (US)-guided injection with a mixture of 10 mg of triamcinolone and 1 mL of 2% lidocaine was performed. (E) Follow-up US 1 week after injection showed improvement of inflammatory signs.

greater trochanter abruptly jerks anterior to the greater trochanter when the hip is flexed (Fig. 5B). However, the snapping may be produced by gluteus maximus [8,21].

Posterior hip

To examine the posterior hip, the patient lies prone with the feet protruding over the edge of the bed. A low-frequency curvilinear transducer (3–5 MHz) may be required because of the bulk of subcutaneous tissue and gluteus maximus muscle in this area, especially in obese patients.

Hamstring tendons and muscles

Using the ischial tuberosity as a landmark, the transducer is initially placed in the transverse plane to recognize most effectively the most cranial portion of the hamstring tendons. At this level, these three tendons cannot be separated sonographically. Lateral to these tendons, the sciatic nerve can be observed as a flattened structure with a fascicular echotexture surrounded by hyperechoic fat [1]. Moving the transducer caudally, the conjoint tendon of semitendinosus and biceps femoris locates more superficially and laterally than the semimembranosus tendon (Fig. 6A). In chronic tendinopathy, the proximal attachment of the tendon appears hypoechoic and swollen. Calcification can occasionally be detected at the tendon insertion or within the tendon. Apophyseal avulsion, usually observed in adolescence, appears as a hyperechoic bony fragment and cortex irregularity at the insertion area with surrounding hematoma [6].

Ischiogluteal bursitis

Ischiogluteal bursitis is also known as "weaver's bottom", which is caused by prolonged sitting [22]. It also occurs in patients with cachexia or subjects with severe weight loss [23]. Hypoechoic to anechoic fluid accumulation of the ischiogluteal bursa is demonstrated on the hyperechoic bony cortex of ischial tuberosity (Fig. 6B).

Sacroiliitis local injection

The common inflamed site of sacroiliac (SI) joint is at the lower third of the joint, which is the true synovial component, whereas the upper portion of the joint consists of a fibrous structure [24,25]. Color Doppler US (CDUS) is sometimes used to detect vascularity over the dorsal SI joint.

While examining the SI joint, the patient is in the prone position. We first identify the prominent bony landmark of the posterior superior iliac spine (PSIS), then place the transducer in the transverse orientation with the PSIS laterally and the spinous process of the fifth lumbar vertebra medially. The transducer is moved laterally and caudally in the paraxial plane (Fig. 7). The hypoechoic cleft between the two bony contours represents the posterior

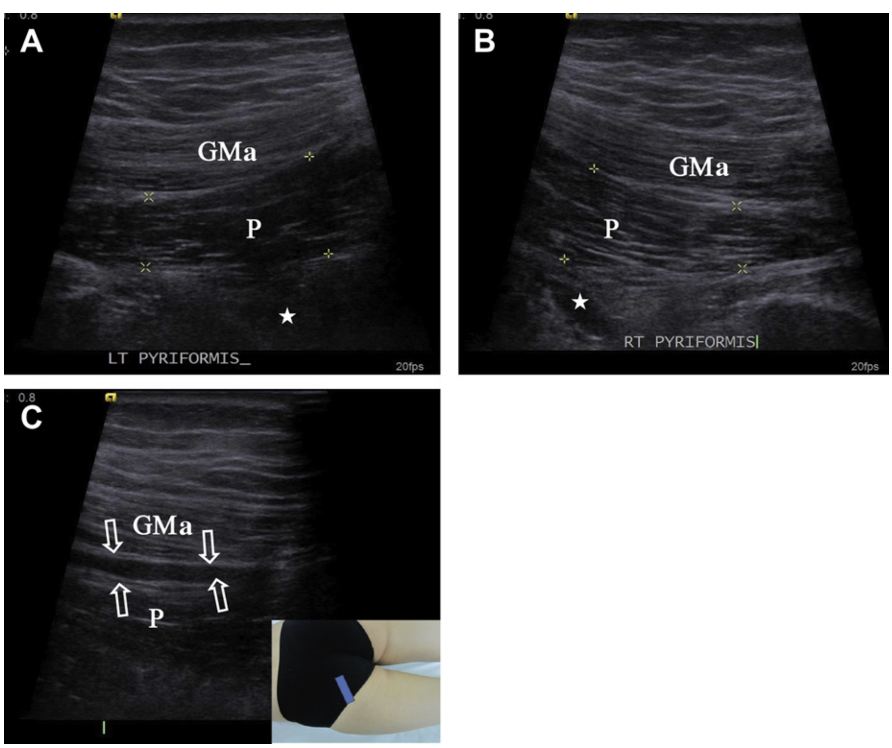

Fig. 8 Left piriformis syndrome. (A,B) In the transverse-oblique view of ultrasonography (US) parallel to the piriformis (P) muscle, hypoechoic and swollen change of left piriformis muscle was found, as compared with that on the right. The sciatic nerve and inferior gluteal artery (asterisk) were located beneath the piriformis muscle. (C) US-guided injection into the piriformis tendon sheath was performed using a medial-to-lateral approach parallel to the long axis of the transducer. Anechoic fluid was collected between the superiorly gluteus maximus muscle (GMa) and the inferiorly piriformis muscle.

aspect of the sacroiliac joint. The lower third of the SI joint, near the level of the second posterior sacral foramen [26], is the target location for injection (Fig. 7D and E). Mehmet et al [27] reported that the SI joint is approximately 5 cm away from the midline of the sacrum and the joint width is approximately 5 mm. An intra-articular injection is advised at approximately 1 cm above the lowest end of the joint. When performing injection, the needle is introduced in a medial-to-lateral direction according to the orientation of the SI joint [26].

Piriformis syndrome

The piriformis muscle originates from the anterior surface of the sacrum, runs inferolaterally through the greater sciatic notch, becomes tendinous, and inserts into the superior aspect of the greater trochanter. Piriformis syndrome, clinically characterized by buttock pain and sciatica, has been reported to be a contributing factor in up to 6–8% of patients with low back pain [28].

During US examination, the patient lies in prone position. To identifying the SI joint first, the transducer is moved caudally along the SI joint with the lateral sacrum at its medial side and the posterior inferior iliac spine (PIIS) at its lateral. The transducer is moved inferiorly below the level of the PIIS, at which point the hyperechoic signal of the ilium disappears, indicating the appearance of the greater sciatic notch. At this level, the piriformis muscle is identified as the muscle belly deep to the lateral border of the sacrum (whereas the gluteus maximus is superficial to the sacrum), transversing from the cephalomedial to caudolateral direction beneath the gluteus maximus. The transducer is rotated caudolaterally, parallel to the piriformis fiber. For confirmation of the piriformis muscle, passively rotate the hip internally and externally with the knee flexed. The piriformis muscle can be seen gliding underneath the gluteus maximus in this maneuver [29–32]. The inferior gluteal artery can be detected by the color power Doppler technique, and the sciatic nerve is identified below the piriformis muscle. Hypoechoic and swollen change of the piriformis muscle may be observed on the symptomatic side when compared with the sound side (Fig. 8).

When performing US-guided injection of piriformis muscle, a 22-gauge 3.5-inch spinal needle is advanced in a medial-to-lateral direction and parallel to the long axis of the muscle (Fig. 8C). After injecting into the sheath or into the piriformis muscle, rotate the hip to assist the spread of the injectant [30].

Conclusion

In summary, it is crucial to be familiar with the complex anatomy of the hip and conduct comprehensive clinical evaluation including medical history and physical findings before starting US examination. US is a useful tool not only in evaluation of intra- and extra-articular fluid collections and muscle or tendon pathologies, but also in studying snapping or clicking hip on dynamic examination. Moreover, the increasingly used US-guided aspiration or injection technique is valuable for both diagnostic and therapeutic purposes.

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