EURO-MUSCULUS/USPRM Dynamic Ultrasound Protocols for (Adult) Hip

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This feature is a unique combination of text (voice) and video that more clearly presents and explains procedures in musculoskeletal medicine. These videos will be available on the journal's Website. We hope that this feature will change and enhance the learning experience.

Walter R. Frontera, MD, PhD
Editor-in-Chief

Abstract: In this dynamic scanning protocol, ultrasound assessment of the adult hip is described using different maneuvers for various conditions. Real-time patient examination and ultrasound scanning videos are coupled for convenience as well as for better insight. The text covers the common conditions around the hip where especially dynamic ultrasound scanning provides valuable information in addition to static imaging. The protocol is prepared by an international consensus of several experts in the field of musculoskeletal ultrasound.

Key Words: Ultrasonography, Snapping, Labrum, Piriformis, Acetabulum

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The history of ultrasound (US) assessment of the hip dates back to 1980s—particularly with regard to screening for congenital hip joint dislocation in neonates and infants.[1] Later, coupled with the development of higher-quality US equipment and standard scanning protocols, US assessment has also become commonplace in the evaluation of adult hip disorders.[2,3] As an important part of comprehensive examination, dynamic scanning is crucial in several conditions where static imaging would not fully explain the clinical scenario. To this end, an international group of experts elaborated this scanning protocol for dynamic US examination of the hip.

ANTERIOR AND MEDIAL VIEW

Technique

The examination begins in the neutral position, that is, the patient lying supine on the examination bed with the lower limbs extended. Hip flexion/extension and abduction/adduction can be performed in this position. Notably, flexion can be only "partially" assessed because of the inconvenient/challenging positioning of the probe along the anterior surface of the hip. Having the patient in proximity to the edge of the examination bed, the extension of the hip can be performed to achieve maximal range of motion. The probe is placed anteriorly in the inguinal region to obtain a view of the bony structures (femoral neck and head, acetabular rim) and surrounding soft tissues (eg, labrum, joint capsule, iliofemoral ligament, and iliopsoas muscle), or at the medial aspect of the hip to visualize the hip adductors. Regarding the latter, the initial scanning can start with flexion, abduction, and external rotation of the hip ("frog position")—simulating the FABER (or Patrick) test. Depending on the specific maneuver, the examiner intends to perform, and the probe and patient positioning is changed whenever needed. Given the deep-seated anatomy of the hip joint, low-frequency or curvilinear probes can be used (particularly in obese patients).

Clinical Indications

Joint Effusion

The examiner slowly flexes/extends (or eventually rotates) the hip to reveal an intra-articular effusion in the anterior synovial recess, deep to the iliopsoas muscle (Video 1, http://links.lww.com/PHM/B706; Fig. 1A). In the presence of fluid, hip flexion or rotation is associated with bulging of the iliofemoral ligament-joint capsule complex at the level of the femoral head-neck junction. The echogenicity of the fluid depends on its nature (eg, septic, hemorrhagic, or serous).[4] Furthermore, redistribution/flow of the fluid can help differentiate it from synovial hypertrophy (Video 2, http://links.lww.com/PHM/B707). Eventual communication between the hip joint and the iliopsoas bursa can suggest focal

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USPRM: Ultrasound Study Group of the International Society of Physical and Rehabilitation Medicine (ISPRM).

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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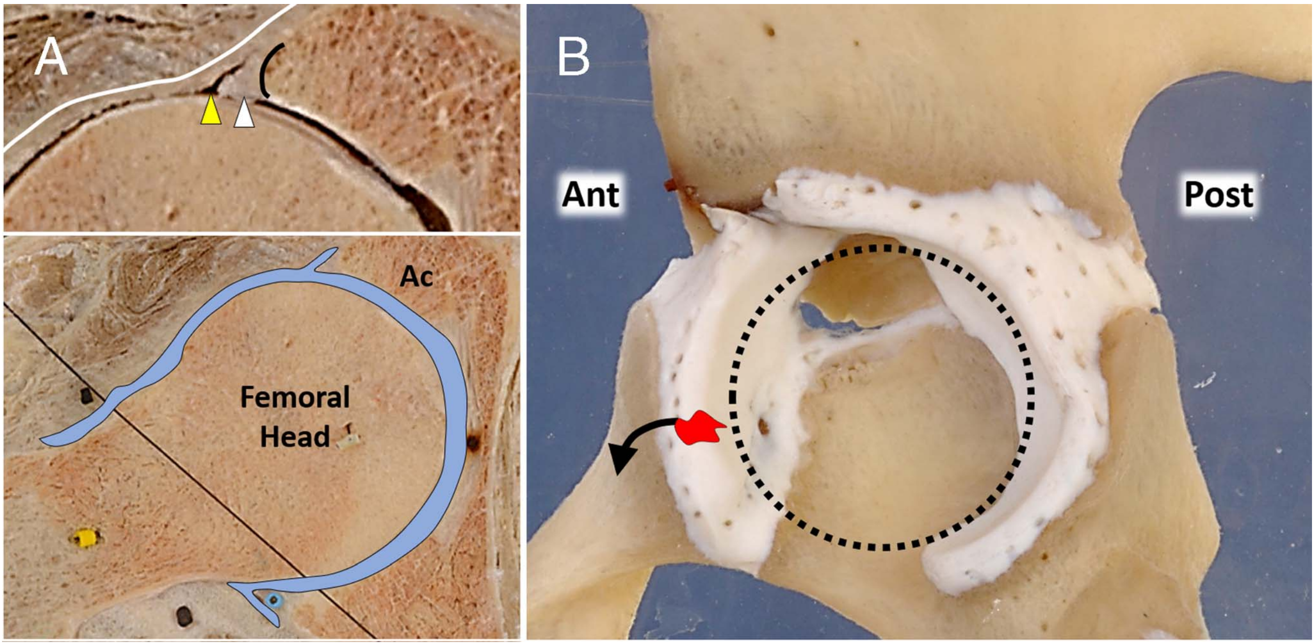

FIGURE 1. Dynamic assessment of the hip joint allows real-time visualization of the motions of the intra-articular effusion (blue) within the anterior capsular recess (white line) observing "how" the synovial fluid interacts with the surrounding anatomical structures—the labrum (white arrowhead), the paralabral recess (yellow arrowhead), and the chondrolabral junction (black line, A). Of note, in pathological conditions, active movements of the femoral head (black dotted line) can increase the intracapsular pressure "pushing" the articular effusion (black arrow) through a focal defect (red spot) of the hip labrum (B). Ac, acetabulum; Ant, anterior; Post, posterior.

capsular gaps, either congenital or degenerative in patients with hip osteoarthritis. Herein, it is important to maintain the same (symmetric) hip rotation/position when comparing the right-left sides for femoral neck-joint capsule distance, to interpret fluid presence in mild cases (≥7–9 mm).[5]

Labral Injury

To elucidate acetabular labrum tear, the bony acetabulum, anterosuperior portion of the acetabular labrum, and the femoral head and neck are first imaged in its long axis (Fig. 1B). The examiner then performs hip flexion and internal/external rotation to stress the labrum and to assess its morphological integrity (Video 3, http://links.lww.com/PHM/B708). Abnormal motion of the anterior labrum during the dynamic assessment can be associated with the avulsion of the base of the fibrocartilage (Video 4, http://links.lww.com/PHM/B709). In addition, the examiner may apply manual long-axis traction of the hip to elicit potential gapping of the labral tear.[6] Notably, the hypoechoic cleft extending through the labrum can also result from the presence of sublabral recess, a normal anatomical variant.[7,8] An advantage of the dynamic assessment over the static one is the possibility to see the "flow" of the synovial fluid (as a "natural contrast agent") within a focal gap of the fibrocartilage, hence better visualizing the injury. Occasionally, small gas microbubbles (physiologically dissolved in the synovial fluid) can be seen moving during the dynamic maneuver. A paralabral cyst, if present, can also be assessed dynamically for its (non)compressibility and mobility (Video 5, http://links.lww.com/PHM/B710).

Femoroacetabular Impingement

Different types of femoroacetabular impingement can be confirmed by the evidence of abnormal mechanical contact/motion between the acetabular/labral side and the femoral head/neck during real-time imaging (with hip flexion and internal rotation; Video 6, http://links.lww.com/PHM/B711, Video 7, http://links.lww.com/PHM/B712, Video 8, http://links.lww.com/PHM/B713).[9,10] To assess femoral head instability, the hip joint is stressed using the "apprehension position." To achieve stress on the anterior structures, the patient holds the contralateral knee to maintain the contralateral hip flexion in the supine position. Meanwhile, the ipsilateral hip is being extended, the knee is flexed, and the shin hangs over the bed. The probe is positioned in the long axis along the acetabulum-femoral head and neck junction. The examiner then applies hip external/internal rotation to evaluate anterior translation of the femoral head (Video 9, http://links.lww.com/PHM/B714).[11]

Intra-Articular Loose Bodies

Mobile/suspected loose bodies within the anterior capsule-synovial recess of the hip joint can be observed during dynamic examination. In this way, differential diagnosis for a loose body versus hypertrophic synovium can also be possible. While the former can show "random" movements within the anterior capsular recess, the latter usually presents with an anchor pedicle attached to the capsule-synovial wall of the hip joint with limited ("floating") movements. Likewise, dynamic maneuvers can be used for the differential diagnosis of intra-articular calcific loose body versus dystrophic calcification of the hip labrum. Indeed, the latter is "attached" to the anterior acetabulum with no movements within the joint capsule. Notably, loose bodies, torn labrum, osteochondral fractures, and hip joint effusion can also be possible causes of "intra-articular snapping hip."[12,13]

Anterior Snapping Hip Syndrome

Ultrasound imaging allows for static/dynamic imaging of the periarticular tendons/muscles. For sure, dynamic examination better serves to uncover any mechanical conflict under real-time imaging—also interacting with the patient and simulating/eliciting the daily life symptoms. When there is a perceptible or audible click during the hip motion, the condition is commonly called "snapping hip" (alternatively "coxa saltans"). Notably, pain might also accompany the scenario, and it would be paramount to unmask the exact cause.

Iliopsoas muscle–preinsertional segment is one of the common causes of snapping hip syndrome. A specific maneuver by moving the leg from extension, adduction, and internal rotation to the "frog position" and back to the neutral position can be performed while the transducer is held in an oblique transverse plane over the femoral head (Video 10, http://links.lww.com/PHM/B715).[14] In healthy individuals, the tendon moves laterally and anteriorly when the maneuver is performed and returns back when the leg is straightened in the initial position.[15] In patients with snapping hip syndrome, dynamic examination can detect the abnormal motion of the iliopsoas tendon during the "snapping" sensation (Video 11, http://links.lww.com/PHM/B716). Of note, it is sometimes challenging to detect the rapid rotatory or lateral-medial movement of the tendon.

The tendon-muscle rotation is a commonly accepted mechanism despite variations among patients.[16] This theory assumes the transitional wedging of the medial fibers of the iliacus muscle between the superior pubic ramus and the psoas major tendon in the frog position. During movement to the neutral (extended) position, the iliacus muscle's medial fibers move laterally, while the psoas muscle rolls dorsally.[15] (Nother theory assumes the role of iliopsoas muscle/tendon snapping over the iliopectineal eminence.)[17] Less common causes such as tendon bifurcation (with heads flipping over each other) or mass lesions (eg, paralabral cyst, iliopsoas bursitis) would be other imaging findings as well.[18–20]

Other Mechanical Muscle/Tendon Problems

Iliopsoas muscle–insertional segment can also be examined using the FABER maneuver.[21] The transducer is initially placed over the femoral head in the anterior longitudinal view and then moved slightly oblique, after the iliopsoas tendon crossing the hip joint and distally inserting on the lesser trochanter.[21] Herein, if the patient performs resisted adduction, partial/complete tear of the muscular belly, tendon, and the myotendinous junction, or even avulsion of the lesser trochanter can be examined. In clinical practice, these could be useful during preoperative planning or for posttenotomy evaluation.[21]

The FABER positioning also allows for dynamic visualization of the contact between the tendon and the acetabular cup in diagnosing iliopsoas impingement syndrome after total hip arthroplasty.[22] In symptomatic patients, the iliopsoas tendon was reported to be displaced anteriorly and medially by the acetabular component.[23] Friction between the tendon and the acetabular cup (a piece of cement) or the cup fixation screws could be verified using dynamic examination, observing abnormal motion of the swollen and hypodense muscle/tendon.[24]

Rectus femoris muscle can be scanned to visualize its direct head as the transducer is placed at the level of the anterior inferior iliac spine.[14] Moving the transducer laterally and inferiorly (while the sound beam is being directed perpendicular to the lateral acetabular cortex to eliminate anisotropy), the indirect head can be visualized.[25] Possible pathologies such as bursitis, tendon tears, or tendinosis (including those with calcium deposits leading to snapping) can be examined with dynamic techniques.[26,27] For instance, extension and external rotation of the hip joint can be used to provoke the snapping phenomenon in such patients.

As a side note, the term "subspine impingement" refers to the mechanical conflict between the femoral neck against the bony protuberance at the anteroinferior iliac spine, which is commonly curved toward the femoral neck.[28,29] The impingement at this site can also develop because of avulsion fracture of the anteroinferior iliac spine or calcific tendinitis of the proximal insertion of the rectus femoris tendon. Likewise, these conditions can also be examined as described previously.

Adductor muscles/tendons can be imaged for substance tears or avulsion injuries, while the examiner applies resistance against active hip adduction again in the "frog position" (Video 12, http://links.lww.com/PHM/B717, Video 13, http://links.lww.com/PHM/B718, Video 14, http://links.lww.com/PHM/B719; Fig. 2A).[30]

Symphysis Pubis Diastasis/Instability

Measurement of the interpubic gap is commonly the criterion standard to assess postpartum diastasis. The diagnosis is supported if the distance between the narrowest level between upper branches of the pubic bones is more than 10 mm (Fig. 2B).[31] To scan the symphysis dynamically, pelvic compression and distraction can be performed while the probe is held in the transverse plane over the pubic bones. During this maneuver, the examiner (or an assistant) places hands on the anterior and medial aspects of the patient's right and left anterior superior iliac spine while applying a gentle posterior force (Video 15, http://links.lww.com/PHM/B720). Of note, a postpartum diastasis recti abdominis can be assessed with US—first at a resting state and in a sit-up position. The increased interrectus distance can usually be seen at the umbilicus level.[32]

LATERAL VIEW

Technique

Dynamic examination of the lateral hip is performed in the lateral decubitus position. The transducer is held in the transverse view over the greater trochanter.[33] The examiner or the patient moves the adducted hip from extension to flexion and back to the initial position to detect abnormal motion (Video 16, http://links.lww.com/PHM/B721). The "bicycle test" can be used by asking the patient to simulate the pedaling motion with the affected lower limb. For sure, the patient may be asked to reproduce his/her symptoms in any position possible. In some cases, the patient needs to stand and bear weight on the affected limb while performing the provoking movement. For imaging the tensor fascia lata's proximal attachment, the examiner can ask the patient to actively abduct the hip—with or without resistance—to visualize the motion abnormalities reproducing the pain at the iliac crest.

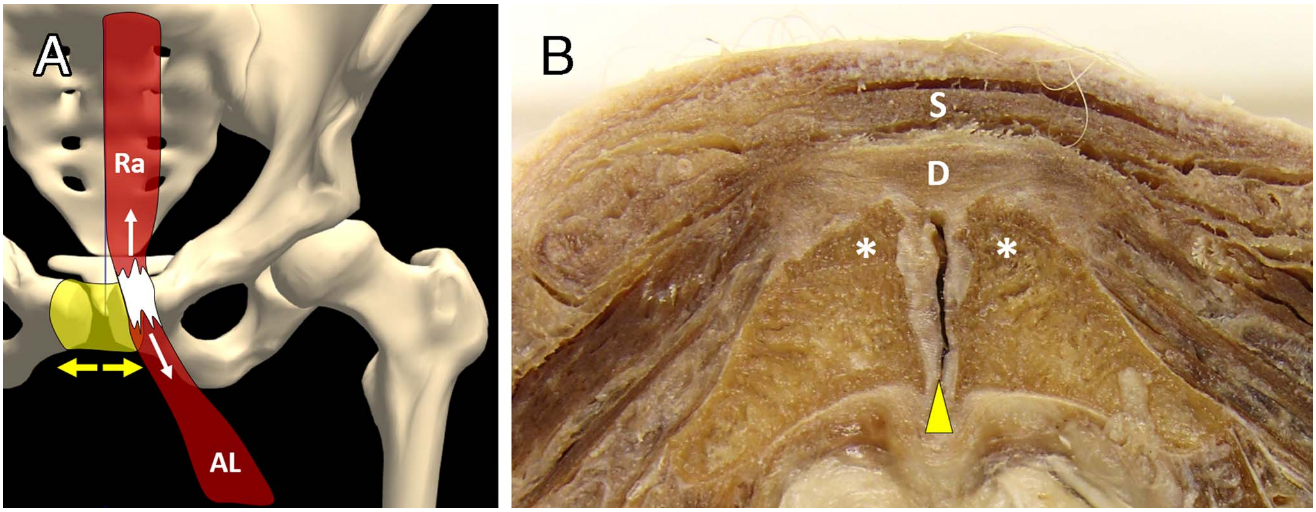

FIGURE 2. Dynamic assessment can be performed in adduction against resistance—to put in tension (white arrows), the common aponeurosis (white) linking the tendons of AL and Ra muscle (A). In addition, an eventual diastasis (yellow arrows) of the pubic symphysis (yellow) can be evaluated during the dynamic technique (A). Of note, anatomically, the pubic symphysis (yellow arrowhead), at the level of pubic tubercles (white asterisks), presents a thick wad of aponeurotic tissue—the pubic plate (B). In the S layer, the superficial fibers of the AL and the external oblique (of the opposite side) interact with each other; instead, in the D layer, the anterior capsule merges with the Ra, the inguinal ligament, the deep fibers of AL, and the anterior fibers of adductor brevis (B). AL, adductor longus; D, deep; Ra, rectus abdominis; S, superficial.

Clinical Indications

Lateral Snapping Hip Syndrome

Dynamic examination can visualize the movement of the posterior border of the iliotibial band or the anterior portion of the gluteus maximus muscle across the greater trochanter (Figs. 3A–C, 4A–C).[14] This subluxation of the affected structures accompanied by snapping is sometimes called external (or "lateral") snapping hip. Furthermore, the examiner can visualize possible thickening or hypoechoic changes of the iliotibial band and the underlying thickened trochanteric bursa or calcifications of the soft tissues (Video 17, http://links.lww.com/PHM/B722, Video 18, http://links.lww.com/PHM/B723).[34]

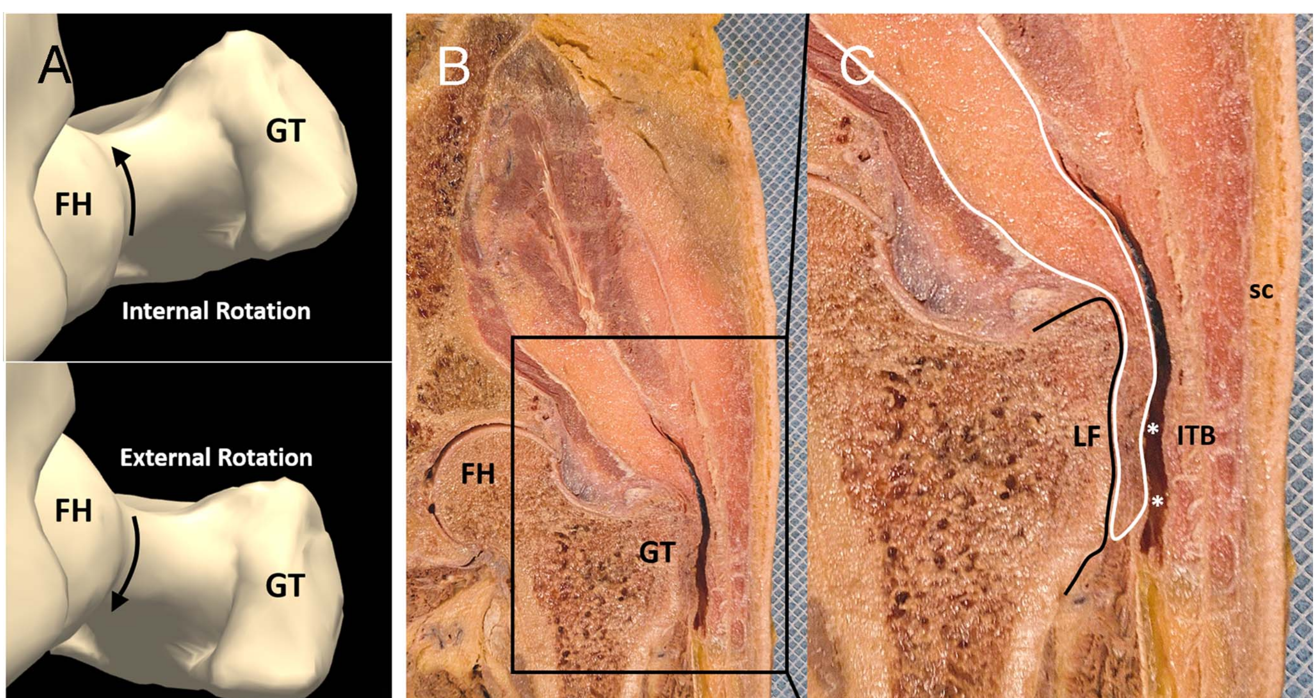

FIGURE 3. Internal/external rotation (black arrows) of the hip joint (A) allows real-time visualization of the dynamic interactions between the GT and the surrounding soft tissues (B). Of note, cadaveric specimen clearly shows the anatomical interface between the gluteus medius tendon (white line) and the ITB where a large synovial bursa (white asterisks) is located (C). GT, greater trochanter; FH, femoral head; ITB, iliotibial band; LF, lateral facet; sc, subcutaneous tissue.

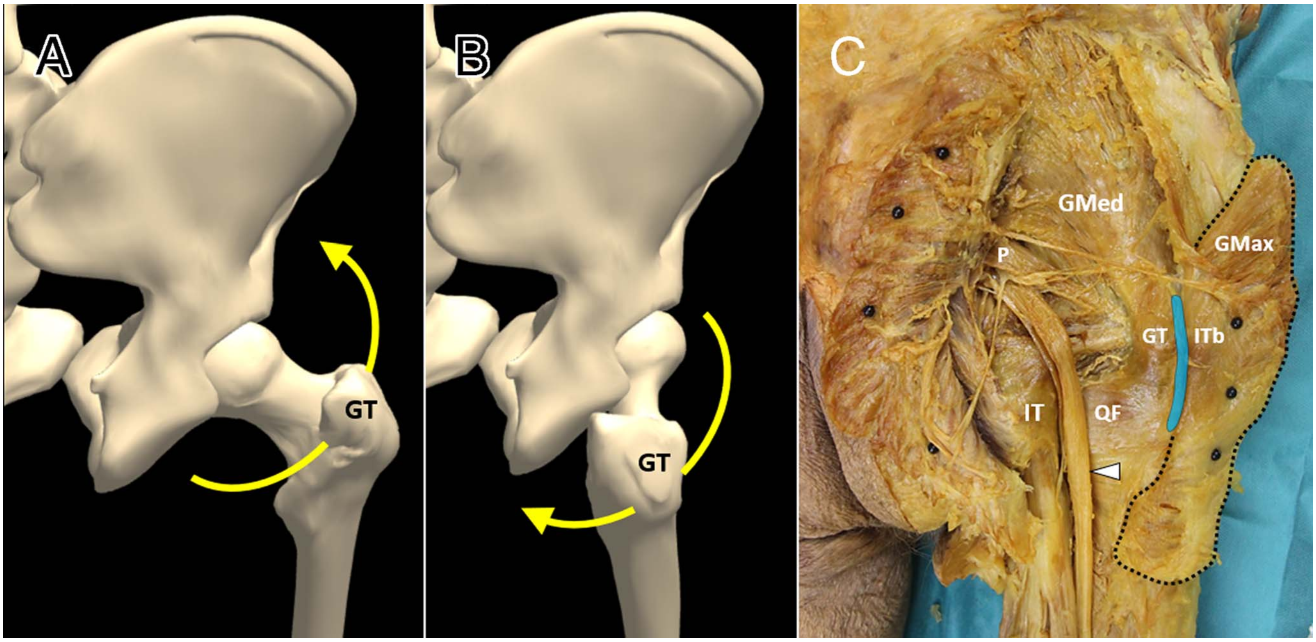

FIGURE 4. Dynamic assessment of the lateral hip can be performed—during active or passive movements (yellow arrows; A, B)—to directly observe an eventual impingement of the gluteus maximus-iliotibial band complex (black dotted line) over the GT (C). Of note, not only the muscle-tendon structures but also the trochanteric synovial bursa (blue) should be considered among the potential pain generators. GMax, gluteus maximus; GMed, gluteus medius; GT, greater trochanter; IT, ischial tuberosity; ITb, iliotibial band; P, piriformis; QF, quadratus femoris; white arrowhead, sciatic nerve.

(Tensor) Fascia Lata Problems

Dynamic examination can be performed to detect partial/complete tears of the muscular belly/tendon, myotendinous junction, or proximal avulsion over the iliac crest.[35] Of note, gluteus maximus insertion to the fascial layers can be assessed during external/internal rotation of the hip. In cases of injury, the fascial detachment can be better defined dynamically (Video 19, http://links.lww.com/PHM/B724).

POSTERIOR VIEW

Technique

The patient is lying in prone position on the examination table with the gluteal region exposed. The knee is flexed to 90 degrees and held by the examiner, allowing passive internal and external rotation to perform a dynamic examination.

Piriformis muscle can be imaged by placing the probe in transverse plane over the sacrum toward the site being examined. The probe is then moved caudally to visualize the bony landmarks—sacroiliac joint and posterior superior iliac spine. Moving the probe caudally to the sacroiliac joint, the piriformis muscle can be visualized. To align the transducer with the long axis of the muscle, the lateral part of the transducer is placed more caudally (in the direction of the greater trochanter) in relation to the medial part of the transducer. As for dynamic examination, passive hip rotation can be performed to precisely evaluate the piriformis movement compared with more static gluteus maximus muscle.

Obturator internus muscle is assessed while the probe is moved caudally and medially from the "piriformis view" until the rounded structure of the ischium is seen. With passive hip rotation, the obturator internus muscle can be visualized and dynamically examined as it courses around the ischium. To align the probe with the long axis of the muscle's medial part, the probe is moved slightly caudally.

Quadratus femoris muscle can be assessed after moving the probe from the "obturator internus view" caudally and laterally, holding the probe in a transverse plane and looking for two bony landmarks—lateral aspect of the ischial tuberosity and the intertrochanteric ridge of the femur. The quadratus femoris muscle runs in between these two bony structures. Dynamic evaluation of the ischiofemoral impingement is performed via rotating the hip externally (Figs. 5A–C).

Hamstring muscles can be evaluated by initially detecting the ischial tuberosity as the bony landmark. The examination begins with an axial view at the level of the ischial tuberosity. Turning the probe 90 degrees, the hamstrings are also evaluated in their long axis. In obese or muscular patients where US identification might be difficult, the examination starts at the proximal midthigh. At this site, the helpful landmark would be the "Mercedes Benz sign" between the long head of the biceps femoris, semitendinosus, and adductor magnus muscles.[36] For dynamic examination (during hip flexion), the patient needs to be positioned sideways at the edge of the examination bed. Alternatively, the patient can be examined standing on the contralateral lower limb. The patient is asked to reproduce his/her symptoms by performing (alternatively resisted) hip flexion or forward flexion at the lumbar level.

Clinical Indications

Piriformis Syndrome

Piriformis muscle/tendon integrity can be evaluated statically and dynamically (Video 20, http://links.lww.com/PHM/B725).[37] The latter is similar to the Freiberg test, which assesses

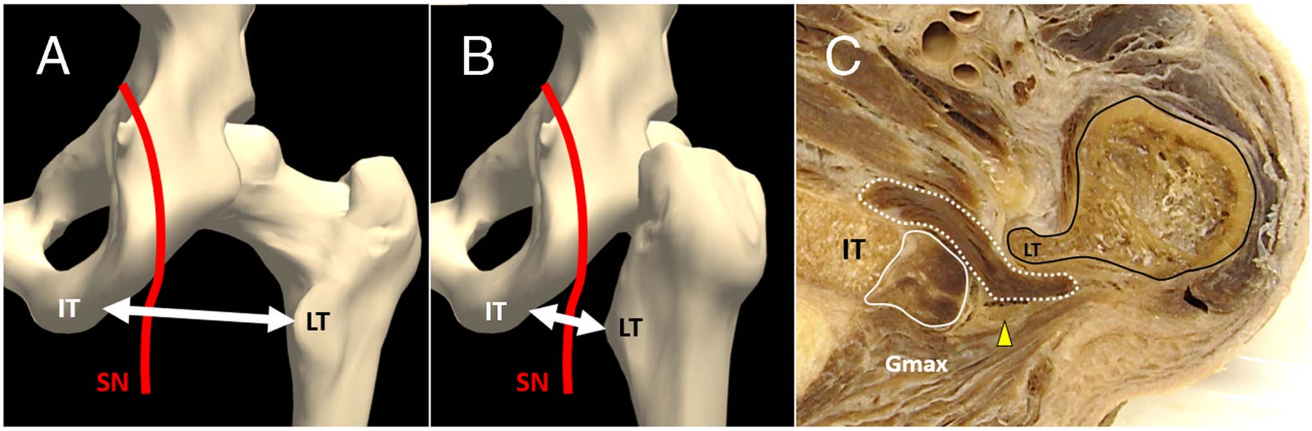

FIGURE 5. Internal (A) and external (B) rotation of the hip joint can be performed to dynamically assess the anatomical space (double white arrow) between the IT and the LT; within which, sciatic nerve and quadratus femoris muscle are located. Cadaveric image clearly shows how the quadratus femoris muscle (white dotted line) slips in between the hamstrings tendon (white line) and the LT of the femur (black line) in close proximity to the sciatic nerve (yellow arrowhead, B). GMax, gluteus maximus; IT, ischial tuberosity; LT, lesser trochanter; SN, sciatic nerve.

compression of the sciatic nerve caused by the piriformis muscle. Ultrasound examination to evaluate nerve compression by the piriformis muscle, the sciatic nerve snapping (Video 21, http://links.lww.com/PHM/B726), or the presence of anatomic variants such as double-headed piriformis that can cause sciatic nerve compression can easily be performed in subjects with normal body weight; however, it would be difficult in obese patients.[37,38] Significant increase in muscle thickness (compared with the asymptomatic side) measured by US has been reported.[39] Todorov and Batalov[40] also reported nonsmooth movements (catching and jumping) of the deep portion of the piriformis muscle over the iliac bone in piriformis syndrome. Notably, an anechoic fat pad overlying the piriformis tendon insertion should not be misinterpreted as fluid collection.[41] When there is a doubt regarding the previously mentioned hypoechoic/anechoic area, dynamic scanning aids to elucidate if there is any fluid being redistributed during hip rotation.

Obturator internus can also/similarly be evaluated for muscle tears, tendon pathologies, and bursitis using dynamic examination.[42]

Ischiofemoral Impingement Syndrome

As the place between ischial tuberosity and the intertrochanteric ridge is being reduced, quadratus femoris muscle becomes squeezed and displaced upwards ("eruption sign"; Video 22, http://links.lww.com/PHM/B727). The sciatic nerve can also be seen displaced during dynamic examination.[43]

Snapping Buttock—Coxa Saltans

There are reported cases of coxa saltans after proximal hamstring injuries. For instance, partial avulsion of the proximal hamstrings might cause snapping because of medial or lateral dislocation of the conjoint tendon over the ischial tuberosity (Video 23, http://links.lww.com/PHM/B728). Notably, the dislocated tendon can also displace the sciatic nerve.[44–46]

Apophyseal Injuries

The apophyseal region of the ischial tuberosity is the weakest part of the bone-tendon-muscle unit of the hamstrings in young athletes. Injuries might cause avulsion of the bony fragment. Ultrasound examination can depict the avulsed fragment and retracted tendon. It can also dynamically assess stability of the fragment during isometric contraction of the hamstrings. The probe is placed in the long axis of the hamstrings over the ischial tuberosity and the apophysis. Dislocation of the apophysis and the ischial tuberosity can be compared with the other (healthy) side.[47,48]

Proximal Hamstring Tears

The myotendinous junction is the weakest part of the hamstrings in young athletes. Ultrasound examination should be performed no earlier than 48 hrs after the injury to increase sensitivity. Ultrasound findings of the tear are alterations of the muscle structure and/or hypo/anechoic hematoma. Complete tear with muscle retraction can be confirmed with dynamic examination under isometric contraction (flexion of the knee against resistance).[47] Opening the gap within the injured tendon/muscle fibers can be observed. Noteworthy is also "sonopalpation" to locate the site of maximal tenderness. Dynamic evaluation can also be used to evaluate the "stability" of the scar after injury (eg, to plan for return to play).

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