

Review

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Ultrasonography of the Hip

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Abstract

A complete physical examination of the hip is often difficult due to its size and deep position. During the last two decades, ultrasonography (US) of the hip has been widely accepted as a useful diagnostic tool in patients with hip pain and /or limited range of motion. It is commonly used in both adults and children. This technique allows evaluation of different anatomical structures and their pathological changes, such as joint recess (joint effusion, synovial hypertrophy), changes within the bursae (bursitis), tendons and muscles (tendinopathy, ruptures, calcifications), as well as changes in the bony profile of the joint surfaces, ischial tuberosity, and greater trochanter (erosions, osteophytes, calcific deposits). US is very useful for guided procedures in hip joint and periarticular soft tissues under direct visualization. The needle aspiration of synovial fluid and steroid injections are commonly-applied activities in daily rheumatology practice. The relatively limited acoustic windows available to the US beam are the principal limitations to hip US. Therefore, conducting a detailed examination of some important structures together with the interpretation of Doppler signal (sometimes undetectable) is not easy, requiring good knowledge of the modality. The aim of this review is to analyze the current literature about US of the hip and to describe the most frequently-observed normal and pathological findings.

Keywords: ultrasonography, hip, synovitis, bursitis, tendinopathy

Introduction

High-resolution ultrasonography (US) of the hip is commonly used for the assessment of hip pathology in adults and children as well. Due to its size and deep location, the physical examination of the hip joint is difficult. Only rarely effusions of the hip joint can be detected by clinical examination [1-6].

Over the last decade, US has proven to be a useful tool in the assessment of tendons, ligaments, muscles, nerves, synovial recesses, articular cartilage, bone surfaces and joint capsule. The goals of US imaging are to detect and localize pathological processes, to differentiate between intraarticular and extraarticular pathology, to perform diagnostic and therapeutic interventional procedures and to monitor the efficacy of the therapy. In addition, US has considerable advantages over CT and MRI: absence of radiation, good visualisation of the joint cavity, quantification of soft tissue abnormalities, possibility for multiple joint scannings, non-invasiveness, speed of performance, rapid side-to-side anatomic comparison, better characterization of fluid, relative low cost, good compliance with the patient as well as a dynamic real-time study of multiple planes [1-26]. Moreover, the direct contact with the patient allows for maneuvers that elicit symptoms to be evaluated while performing the US study

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[9]. Last but not least, another advantage of US over the above-mentioned techniques is the fact that direct US visualization offers the possibility of guided procedures in hip joint and periarticular soft tissues. [1-3,5,9,23-25]

The aim of this review is to analyze the current literature regarding US of the hip and to describe the most frequently-observed normal and pathological findings.

Technique

The routine scanning technique for US examination should consider the anterior, medial, lateral and posterior aspects of the hip as separate quadrants. Ultrasound equipment with multi-frequency linear transducer (5.0-12.5 MHz) can provide a general evaluation of musculoskeletal structures. Superficial structures are well visualized with linear multi-frequency 9-15-MHz transducers. Higher frequency probes provide better spatial resolution but with a limitation because of less penetration. The joint recess of the hip is well visualized with lower-frequency transducers (5.0-7.5 MHz) due to the deep location of the joint. Hip structures are more difficultly visualized in obese patients; and in these cases a frequency of 3.5-5 MHz can help the examination [1,2,3,11]. On some occasions, curved array probes can be used (convex transducers 3.5–5 MHz, traditionally used for abdominal imaging). In daily practice a combination of probes could be required [11]. For children examination 10-14 MHz transducers are recommended due to the relatively superficial position of the hip joint [1]. When inflammatory pathology is suspected, Doppler techniques should be used for the evaluation of increased

local perfusion considering that Doppler signal is detected with difficulties in deep areas [1].

The correct transducer position in relation to the underlying structure to be examined is the key element in achieving a good diagnostic image. Subtle changes in the angulation of the transducer can significantly influence the information obtained [10,11]. All findings should be documented in two perpendicular planes [6]. The examination of the contralateral hip is advisable for comparison. [1,8,12]. Table I shows the appropriate scans for the assessment of the hip joint and periarticular soft tissues.

Anterior examination

The patient lies supine with the hips and knees extended / neutral position/ with a mild degree of external rotation of the hip /10–15°/ obtained when the heels are kept together [1,4,10,13,19]. In that position a wider acoustic window is obtained and a larger area of the joint is exposed to the US beam on anterior scans [1,8,10].

Anterior joint recess

In longitudinal view, the transducer is placed in a sagittal oblique plane parallel to the long axis of the femoral neck [1,3,6,10,13,19]. The latter lies lateral to the palpable pulsations of the femoral artery. The probe is moved from proximal to distal and then from lateral to medial regions to scan the entire hip recess [10]. Four osseous structures are identified as highly reflective lines when moving from proximal to distal regions: the antero-inferior iliac spine, acetabular rim, femoral head and femoral neck [1,2,9,10,13,14].

Table I. US scans of the Hip:

Anterior examination

Anterior recess of the hip
Bony profile
Anterior regional muscles

Medial examination

Insertion of the iliopsoas tendon
Pelvic insertion of the adductor muscles

Lateral examination

Greater trochanter
Gluteus minimus and medius tendons
Fascia latae

Posterior examination

Ischial tuberosity
Hamstrings and sciatic nerve

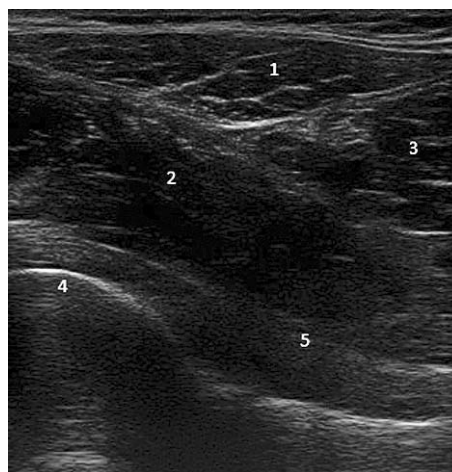


Fig 1. Sagittal oblique image of normal anterior hip joint: 1-sartorius muscle; 2-iliopsoas muscle, 3-rectus femoris muscle; 4-femoral head; 5-iliofemoral ligament.



Fig 2. Transverse oblique image of normal anterior hip joint: 1-iliopsoas muscle; 2-rim of the acetabulum 3-femoral head.

The synovial recess lies between the profound fascia of the iliopsoas and the femoral neck (fig 1). Over the femoral head and neck the joint capsule can be seen as a concave thin linear hyperechoic structure extending from the acetabular rim to its distal insertion to the femoral neck [1,10]. The joint capsule bounds the joint cavity which appears as a hypo/anechoic area, containing a small physiological amount of synovial fluid [1,15,16,17]. In the absence of an intraarticular effusion, the two layers of the capsule are visualized together as a hyperechoic line [1,2]. The distance between the bony profile and the capsule should be at its greatest point less than 7- 8 mm in normal joints. However, the most important finding for effusion diagnosis is the symmetry between the two sides (right-left difference < 1 mm) [1,3,8,13]. The hyperechoic rounded surface of the femoral head is covered by a thin hypoechoic layer of hyaline articular cartilage [10,11,19].

The anterior superior labrum can be visualized sonographically as a triangular, echo-bright structure extending inferiorly from the acetabulum and draping over the femoral head. Under US, only the anterior superior labrum is satisfactorily visualized [10,11].

In transverse view, the probe is placed transversely to the long axis of the femoral neck and then moved from proximal to distal and from lateral to medial regions to scan the entire hip recess [10]. When moving from proximal to distal regions, the acetabular rim and the femoral head are identified. The joint capsule can be seen as a hyperechoic band covering the femoral head and the articular cartilage as a thin anechoic layer between the joint capsule and the femoral head [2,6,9-11] (fig 2). Anterior transverse scans are commonly used during US

guided procedures to identify vessels and structures of the inguinal area and to ensure the correct needle position within the joint [1].

Anterior regional muscles, iliopsoas tendon and bursa

The probe is placed parallel to the long axis of the femoral neck and it is moved from proximal to distal and from lateral to medial /longitudinal view [10].

The pennate structure of several muscles can be identified in this region: superficially the sartorius muscle as a longitudinal band parallel to the subcutaneous tissue with an oblique course into the anterior thigh; on its lateral side, tensor fascia lata muscle. The deep layer at this level consists of the rectus femoris iliopsoas and pectineus muscles [10]. The muscles pennate structure is seen on the US screen as contiguous hypoechoic muscular bundles /fascicles/ separated from one another by hyperechoic lines/ perimysium [9,11].

In normal conditions, the iliopsoas bursa, located between iliopsoas muscle and the hip joint, communicates with the joint cavity in 10-15 % of cases and cannot be visualized with US because its cavity contains only a thin film of synovial fluid. The bursa can be seen, when distended, along the medial aspect of the hip joint as an anechoic/hypoechoic mass [1,2,11].

The iliopsoas tendon overlies the labrum medially. This tendon is a hyperechoic band running on the posterior aspect of the iliopsoas muscle. The distal attachment of the iliopsoas tendon can be difficult to identify with US in this position [11].

Anterior regional muscles and iliopsoas tendon are also evaluated in transverse scanning. This view is performed with the probe placed transversely to the long axis of the femoral neck and moved from proximal to distal and from lateral to medial regions. The sartorius muscle is located superficially under the subcutaneous tissue, the rectus femoris muscle laterally to the femoral head, and the iliopsoas muscle medially covering the femoral head [2,10,11].

Medial examination

Femoral neurovascular bundle

The patient lies supine with the hips and knees extended / neutral position [10].

In both views /longitudinal and transverse, the femoral vein, artery and nerve can be identified in that order from medial to lateral. In transverse scan, the femoral nerve appears as several small, hypoechoic spaces, each surrounded by a hyperechoic thin rim. The femoral vein and artery are easily identified with Power Doppler [2,10,11]. The femoral vein has a greater cross-sectional

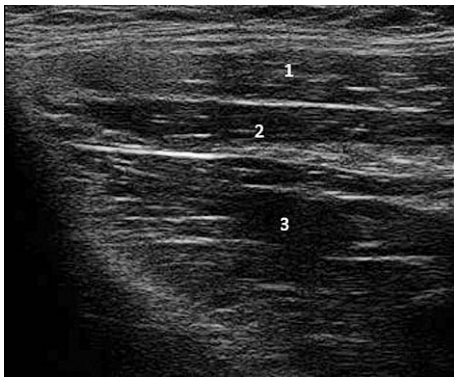


Fig 3. Longitudinal view of adductor insertion on pubis: 1-adductor longus; 2-adductor brevis; 3-adductor magnus.



Fig 4. Transverse view over the greater trochanter, anterior facet: 1-greater trochanter; 2-insertion of gluteus minimus tendon.

area than the artery and it is easily compressible with the probe [2,11]. The femoral nerve is lateral and the vein is medial to the artery [9].

Pelvic insertion of the adductor muscles longus, brevis and magnus/adductor compartment

The patient keeps his/her thigh abducted and externally rotated with knee flexion [2,9,11,14]. This is similar to the frog position for paediatric radiography [9].

The adductor compartment (fig 3) includes three adductor muscles (from anterior longus, brevis and magnus) descending into the thigh capped by the more medially placed and perpendicularly lying gracilis muscle [9]. The US scan of the myotendinous insertions of these muscles and their tendons up to the pubis - longitudinal and transversal approach - demonstrates a fibrillar internal structure [2,6,9,11,14]. The adductor longus is the prominent and the most easily recognizable muscle. It has both muscular and tendinous components close to its origin. The most superficial muscles are the adductor longus and gracilis. Both of them arise from the body of symphysis itself and can be traced distally. The adductor brevis and then the larger adductor magnus are found deep to this muscle pair [9].

Lateral examination

The patient lies in lateral decubitus with hip joint in full extension [10].

Greater trochanter and Gluteus minimus and medius tendons

The transducer is placed longitudinally, parallel to the femoral diaphysis. The probe should be moved from anterior to posterior to scan the gluteus tendons insertions. The profile of the greater trochanter can be seen as a hyperechoic line (fig 4). The gluteus tendons insertion can be seen as a hyperechoic fibrillar triangle over the greater trochanter and deep to the subcutaneous tissue [10]. Cranially to the greater trochanter are the superficial gluteus medius and the deep gluteus minimus muscles. The gluteus minimus tendon is detected anteriorly as a hyperechoic structure that arises from the deep aspect of the muscle to insert into the anterior facet of the greater trochanter [2]. Gluteus maximus is not attached to the greater trochanter, as it inserts proximally into the iliotibial band. Dynamic imaging with external rotation followed by extension may reveal a snapping gluteus maximus or iliotibial band over the greater trochanter [2,11].

For transverse scan of the greater trochanter the probe is placed transversely to the femoral diaphysis. The probe should also be moved from anterior to posterior. The gluteus tendons insertions can be seen as hyperechoic fibrillar structures over the hyperechoic line of the greater trochanter [10]. There is a number of bursae that surrounds the greater trochanter and including the gluteus minimus, the gluteus medius anteriorly, and the gluteus maximus bursa posteriorly. All of them are a potential space for fluid collection or thickening [11]. The bursae around the greater trochanter are not visible with US in normal conditions. Lateral hip tendons are best imaged by tilting the probe parallel to their long axis in order to avoid anisotropic effects [1,2].

Fascia lata

The fascia lata arises from the iliac crest anteriorly and appears as a linear hyperechoic band joining the anterior edge of the gluteus maximus and the posterior portion of the tensor fasciae latae muscle [1,9]. Distally this structure forms the fibrous iliotibial tract [9]. It can be seen with US as a hyperechoic fibrillar structure.

Posterior examination

The posterior hip quadrant is rarely examined with US, being less commonly affected by pathological changes than other quadrants [2].

The patient is placed prone with the legs and knees extended with his/her feet hanging over the edge of the examination bed [2,11].

Ischial tuberosity, hamstrings, ischiogluteal bursa, and sciatic nerve

Ischial tuberosity is the main landmark of this area. It is easily apparent on US screen, due to the posterior acoustic shadowing of the bone. Once located, it allows an accurate detection of the surrounding anatomic structures. On its lateral aspect, US visualizes the conjoined insertion of hamstrings/extensor/ischiocrural tendons, consisting of semimembranosus, semitendinosus and biceps femoris. The last two extensors share a same tendon at the insertion point [2].

The ischiogluteal bursa is located between the ischial tuberosity and the gluteus maximus. In normal conditions, the bursa is invisible under an US examination because of the small amount of fluid inside it. Since the bursa has close contact with the sciatic and the posterior femoral cutaneous nerves, ischiogluteal bursitis may appear clinically as a radiculopathy. This proves once more the utility of US examination that is capable to differentiate between the two pathologies [2].

The sciatic nerve is always located on the lateral side of the ischiocrural tendons, posterior to gluteus maximus. More distally, it can be detected deep to the biceps muscle [2,11].

US Pathology

Joint Effusion

Ultrasound is the imaging modality of choice for detection of fluid collections inside the hip joint. The most common causes of hip effusions in adults are osteoarthritis and osteonecrosis (avascular necrosis). The most common synovial disease involving the hip joint in adults is rheumatoid arthritis. Using an accurate probe, as little as 1 mL of intraarticular fluid can be reliably seen [19]. US detected synovitis is defined as synovial hypoechoic hypertrophy or effusion (or both) measured as an increase of the distance neck-capsule (DNC) >8mm and asymmetric distension larger than 2 mm of the recess compared with the opposite side with possible positive power Doppler signal in the synovial tissue [1,13,15,16,23].

Effusion is depicted with US by convexity of the joint capsule on the abnormal compared to the normal side [1,9,22]. Other US signs of synovitis are the thickening of the joint capsule and the absence of the "stripe sign" [1]. Power Doppler is able to assess the increased vascularization involving synovial hyperplastic tissue and consequently to give information regarding the activity of the synovial pannus [1,14,18]. However, due to the deep position of the joint, the absence of Doppler signal does not necessarily mean lack of inflammatory process

inside the hip joint. Nonhomogeneous echogenicity of the synovial fluid and/or echogenic spots with or without acoustic shadowing can be generated by protein containing materials, cartilage fragments, crystal aggregates and calcified loose bodies [14]. The variable echogenicity of the collection usually depends on the nature of the fluid content (serous, bloody, infectious). Fine particulate debris floating in the synovial fluid is generally observed after long-standing or recurrent joint effusions or after intra-articular corticosteroid administration [11,14].

In patients with hip osteoarthritis, US can demonstrate thickening of the joint capsule due to fibrotic change, anterior osteophytes as hyperechoic projections arising from the junction between the head and the neck of the femur. US shows osteophytes as irregularities of the joint margins for new bone formation. Qvistgaard et al. describe "Osteophyte score" for the femoral osteophytes with 4 degrees as follows: 0 /no occurrence/; 1 /slight degree-irregularity on the cartilage-bone transition is just visible/; 2 /medium degree - well-defined osteophytes, shelf formation or irregularities on the femoral neck/; and 3 /severe degree -involvement of the whole femoral neck including shelf formation [3]. Also for better standardization of hip US, the mentioned article also scores curvature of the visible part of the femoral head (round/flattened) and the intraarticular effusion (present/absent), defining a global score for osteoarthritis of the hip. This score was proven correlated to the subjective pain of the patient, quantified by VAS.

US can reveal marginal erosions as cortical defects with an irregular floor located at the interface between bone and the articular cartilage which covers the femoral head and neck [1,2].

Periarticular US Pathology

Tendon pathology

Snapping of the Iliopsoas tendon

This entity is also known in medical literature as snapping hip and it associates hip pain with an audible click on walking. Dynamic US scanning can reveal a snapping iliopsoas tendon. Normally, the iliopsoas tendon is gliding smoothly over the ilium during hip movements. In cases of iliopsoas instability, abrupt sudden motions of the tendon are apparent [2]. Patients with groin pain and a clinically suspected snapping iliopsoas tendon can benefit from injection into the iliopsoas bursa even if the snapping tendon is not visualized sonographically [20].

Insertional tendinopathy of the Adductor muscles

This disorder is commonly described as pubalgia and clinically consists of diffuse tenderness over the groin area. Insertions appear on US thickened, inhomogene-

ous and hypoechoic and may show intratendinous pre-insertional calcifications at a later stage [1,7]. The adductor origin appears hypoechoic with irregularities in case of partial tears. If completely ruptured, the adductor longus tendon appears totally separated from symphysis pubis. It may be difficult to differentiate with US between the three adductors lesions in case of trauma [2].

Snapping Iliotibial Band

This entity is also known as extra-articular snapping hip and it associates hip pain in the external area with an audible click on walking. US can detect with maximal accuracy the cause of the click [22], as being either iliotibial band over greater trochanter or gluteus maximus muscle. Fascia lata may appear thickened and hypoechoic. Dynamic sonography shows sudden displacement of the iliotibial band or the gluteus maximus muscle overlying the greater trochanter as a painful snap during hip motion, mostly during flexion of adducted extended hip. Transverse US images obtained over the lateral aspect of the greater trochanter are the most useful to depict this condition [2,22].

Hamstrings tendinopathy

The proximal attachment of these muscles appears swollen and hypoechoic reflecting changes related to tendinopathy. Calcifications can be detected at the tendon insertion as irregular hyperechoic foci near the ischial tuberosity indicating a calcific enthesopathy. Extensor tendons of the hip represent the main area where tears /partial and full/ and avulsion can be identified. US can demonstrate the discontinuity of the affected tendon, which appears retracted downward and surrounded by local hematoma, whereas the adjacent non-affected tendon can be seen inserting normally into the hyperechoic cortex [2]. In cases of entesopathy/entesitis, US can demonstrate thickening of the insertion, also hypoechogenicity and/or Doppler signal and/or calcification [1].

Bursal pathology

Iliopsoas bursitis

On transverse US images, the iliopsoas bursa is located between the medial femoral vessels and the lateral iliopsoas muscle. Bursitis is seen as distension of the wall and presence of fluid collection within the bursa [1]. When the bursa is filled with synovial pannus, it appears as a para-articular mass with internal echogenic solid components [2]. By Doppler US, the activity of synovial proliferation /with or without local hyperemia can be distinguished [1].

Ischiogluteal bursitis

This disorder is also known as “weaver’s bottom”. Sometimes, it is encountered in neoplastic patients affected by cachexia and severe weight loss. It is assumed

that reduction in the thickness of subcutaneous fat in the buttock region may result in repetitive minor trauma on the bursa causing its inflammation and fluid distention. Ischiogluteal bursitis is often observed in patients with polymyalgia rheumatica [2].

US demonstrates hypo/anechoic fluid distention of the ischiogluteal bursa.

Common /tendon and bursal/ pathology

Greater Trochanteric Pain Syndrome

US appears to be clinically useful in the greater trochanteric pain syndrome. The pathologic changes of the gluteus medius and minimus tendons represent the most common cause of the painful hip. US signs of tendinopathy include the focal or diffuse swelling of the affected tendon portion and the heterogeneous hypoechogenicity of the tendon and thickening with or without Doppler signal [1,2]. Hyperechoic spots related to calcifications may occasionally be found at the tendon insertion [2]. Intratendinous calcification may also be identified and appear as one or more hyperechoic foci within the body of the tendon with a posterior acoustic shadow [1]. Fluid distension of the trochanteric bursa appears as a well-circumscribed round-shaped hypoechoic to anechoic collection located superficially to the posterior insertion of the gluteus medius and the lateral aspect of the greater trochanter and deep to the gluteus maximus [2]. In a recently published study, a group of Australian orthopedists established correlations between US findings and surgical/ histological findings in 24 patients with great trochanteric pain in whom non-operative management had failed. US had a sensitivity of 0.79 and a positive predictive value of 1 regarding diagnosis of a tear of either tendon. When histology and US findings were computed in 15 patients with hip bursal pathology US showed a sensitivity of 0.61, a specificity of 1.0, a positive predictive value of 1.0, and a negative predictive value of 1.0 [21].

US-guided procedures

US is an ideal method for guiding interventional musculoskeletal procedures [9]. The main advantages of US guided hip injection are its safety, with no serious complications, portability and lack of ionizing radiation. [1,2,5,7,9,23-26]. In daily practice a hand-free US-guided anterior longitudinal approach technique is applied for puncture and/or injection. With the patient in the supine position and after triple skin disinfection, a needle (gauge 18-21, 0.8X80 mm) is inserted inferiorly 8–10 cm under the inguinal ligament towards the anterior or inferior cap-

sule below the femoral head. Guided by US, the needle is traced from 1 cm below the skin surface all the way to the joint. Joint fluid is aspirated, if present [3,23]. On this scan, when the needle is perpendicular to the US beam, it appears as a sharply-defined echoic band with strong posterior reverberations [14]. The best visualization of the shaft of the needle is reached at 90 degrees. With increasing obliquity, the needle becomes less evident [2].

The injection within the hip joint cavity with long-acting steroids using sometimes a local anesthetic added in a mixture, is widely used. Anesthetics are usually meant to obtain relief of the local pain during the procedure and to treat reactions to steroid crystals. Diffusion of the drug into the joint can be evaluated with US as a hyperechoic filling similar to the effect of US contrast agents. Immobilization after injection is not necessary [23], but the examiner should recommend the patient to keep the joint relatively immobile for maximizing the therapeutic effect of the injected drugs and reducing their possible diffusion into the adjacent tissues. Several randomized, placebo-controlled clinical trials have shown improvement of pain and hip disability after the intraarticular injection of corticosteroids in the last years [23,27,28].

US-guided intra-articular injections with hyaluronic acid/ viscosupplementation/ are widely used for the treatment of hip osteoarthritis [25-27]. After injection of 2 ml of hylan G-F 20 under ultrasound guidance, in an open label study, hip pain and disability measured by Lequesne algofunctional index [29] improved in 12 osteoarthritic patients [25]. In a prospective double blind study, using a randomized controlled trial with a three-armed parallel-group design, however, viscosupplementation did not show marked improvement of clinical indices, suggesting further studies are required in that area [27].

Limits

US accessing of the hip joint has one main limitation, namely the limited size and number of acoustic windows. This makes a detailed examination of some important structures e.g. the femoral cartilage impossible and the interpretation of power Doppler signal unreliable. The deep location of the hip joint can confer further problems to US scanning in obese or particularly muscular subjects. US gives little information in cases of bone fractures and labral tears [1].

Conclusion

High frequency US is a bedside diagnostic tool in patients with hip pain and limited range of motion. US of the hip provides high sensitivity in the detection of joint

effusion and synovitis. It can be very useful in the evaluation of periarticular pathologic findings, too. The standard scanning protocol includes multiplanar, dynamic and bilateral assessment. This protocol should be followed in order to avoid missing certain parts of the assessment of one or more anatomic structures. US is a highly-recommended method for guiding interventional procedures in the hip area.

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