US-guided Musculoskeletal Interventions in the Hip with MRI and US Correlation

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Abbreviations: HA = hyaluronic acid, IFS = ischiofemoral space, ITB = iliotibial band, LFCN = lateral femoral cutaneous nerve, PRP = platelet-rich plasma, QFS = quadratus femoris space

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Hip pain is a commonly reported primary symptom with many potential causes. The causal entity can remain elusive, even after clinical history review, physical examination, and diagnostic imaging. Although there are many options for definitive treatment, many of these procedures are invasive, are associated with risk of morbidity, and can be unsuccessful, with lengthy revision surgery required. Percutaneous musculoskeletal intervention is an attractive alternative to more invasive procedures and an indispensable tool for evaluating and managing hip pain. US is an ideal modality for imaging guidance owing to its low cost, portability, lack of ionizing radiation, and capability for real-time visualization of soft-tissue and bone structures during intervention. The authors review both common and advanced US-guided procedures involving the pelvis and hip, including anesthetic and corticosteroid injections, percutaneous viscosupplementation, platelet-rich plasma injection to promote tendon healing, and microwave ablation for neurolysis. In addition, specific anatomic structures implicated in hip pain are discussed and include the hip joint, iliopsoas bursa, ilioinguinal nerve, lateral femoral cutaneous nerve, greater trochanteric bursa, iliotibial band, ischiogluteal bursa, hamstring tendon origin, piriformis muscle, and quadratus femoris muscle. The relevant US-depicted anatomy and principles underlying technically successful interventions also are discussed. Familiarity with these techniques can aid radiologists in assuming an important role in the care of patients with hip pain.

SA-CME LEARNING OBJECTIVES

After completing this journal-based SA-CME activity, participants will be able to:

- Identify the clinical manifestations and imaging findings of common hip conditions that may warrant US-guided intervention.
- Describe the various indications for, contraindications to, and methods of performing US-guided hip interventions.
- Discuss the potential complications and expected outcomes associated with US-guided hip interventions.

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Introduction

Hip pain is a common condition reported by patients and will probably continue to grow in prevalence (1,2). There are many potential causes of musculoskeletal pain related to the hip. Structures from which this pain is generated include the hip joint itself, the surrounding musculotendinous structures, and numerous lumbar nerve branches innervating the hip region. The complexity of the hip region and myriad of potential sources of pain can make clinically isolating and managing the cause of a patient's hip pain challenging. Within this context, US-guided injections to manage hip pain have emerged as valuable tools for diagnostic and therapeutic applications (3). These injections can *(a)* help narrow the list of possible sources of pain, *(b)* serve as a primary method of managing pain, and/or *(c)* serve as a bridge to delayed surgery.

We review common and advanced US-guided procedures involving the hip. We also briefly describe the relevant medications and principles associated with imaging-guided interventions. Following this, we discuss individual procedures that are used to treat pain in the anterior, lateral, and posterior regions of the hip, with an overview of the relevant anatomy, common diseases, and various injection techniques. The information in this review can aid radiologists in effectively

TEACHING POINTS

- The complexity of the hip region and myriad of potential sources of pain can make clinically isolating and managing the cause of a patient's hip pain challenging. Within this context, US-guided injections to manage hip pain have emerged as valuable tools for diagnostic and therapeutic applications.
- Corticosteroid injections have several established potential adverse effects. These include rare but serious complications such as septic arthritis, tendon rupture, chondrotoxicity, and cutaneous atrophy and depigmentation. More common and transient adverse events include corticosteroid flare, facial flushing, transient headache, nausea and vomiting, stomach upset, hyperglycemia, hypertension, and chest fluttering.
- Regardless of the technique used, the most important safety tip is to always visualize the needle tip before advancing it toward the target. Real-time knowledge of the needle tip location will prevent unintended consequences of neurovascular injury.
- Therapeutic injections are elective and are typically deferred in cases of active infection owing to the risk of seeding the targeted structure in the patient. Patients are advised to reschedule their procedure for a time either after their symptoms have resolved or at least 1 week after they have stopped antibiotic therapy.
- The effect of corticosteroids is gradual, and symptom relief may not begin until 3–5 days after the procedure. Patients must be made aware that corticosteroids do not correct or heal the underlying insult that leads to the pain and that the therapeutic benefit typically lasts an average of 4–6 weeks.

introducing innovative therapeutic alternatives to surgery in the management of hip pain to their practice.

Basic Principles of Imaging-guided Intervention

Key Medications

Corticosteroids.—Injectable corticosteroids are used to treat a variety of painful conditions caused by inflammation or injury of the hip joint, synovium, bursa, tendon sheath, and spinal and peripheral nerves. The synthetic corticosteroids used for injections are derivatives of prednisolone, which is an analog of cortisol, a glucocorticoid class of steroid hormones that control metabolism and inflammation (4). Triamcinolone acetonide and methylprednisolone acetate are among the most frequently injected corticosteroids. These two agents are classified as insoluble, or particulate, steroids because the substances used to prepare them contain corticosteroid esters, which are highly insoluble in water and thus induce the formation of a microcrystalline suspension (4). Dexamethasone is another commonly used injectable corticosteroid, but it does not contain esters and thus is soluble in water, or nonparticulate (4). In general, particulate corticosteroids have a slower onset and longer duration of effect than do nonparticulate corticosteroids (4).

Table 1: Potential Adverse Effects of Corticosteroids

Rare complications
Septic arthritis
Tendon rupture
Chondrotoxicity
Cutaneous atrophy and depigmentation
Relatively common transient adverse effects
Corticosteroid flare
Facial flushing
Transient headache
Nausea and vomiting
Stomach upset
Hyperglycemia
Hypertension
Chest fluttering

Corticosteroid injections have several established potential adverse effects (Table 1). These include rare but serious complications such as septic arthritis, tendon rupture, chondrotoxicity, and cutaneous atrophy and depigmentation. More common and transient adverse events include corticosteroid flare, facial flushing, transient headache, nausea and vomiting, stomach upset, hyperglycemia, hypertension, and chest fluttering (4). Corticosteroid flare is a well-described paradoxical increase in pain caused by sterile chemical synovitis that is related to the instillation of corticosteroid crystals (5). Because cutaneous atrophy and depigmentation are believed to be more common with particulate corticosteroids, the subcutaneous injection of these medications should be avoided.

Viscosupplements.—Hyaluronic acid (HA) is a high-molecular-weight polymer molecule that is present naturally in cartilage and synovial fluid (6). In normal joints, it serves as a lubricant and regulator of cellular activities (6). As osteoarthritis progresses, endogenous HA becomes depolymerized, and this process reduces its useful mechanical and viscoelastic properties in the synovial fluid (6). Recognition of this process has led to the clinical injection of exogenous HA directly into osteoarthritic joints for symptom relief. Injected HA has been shown to have beneficial effects, facilitating the maintenance of joint lubrication and providing anti-inflammatory, analgesic, and chondroprotective effects (6).

Although many different preparations of locally injectable HA are available and differ primarily in the molecular weight of HA, study

results (6) have shown that there is no significant difference in the associated long-term outcome among these preparations. The intra-articular injection of HA is safe; however, acute transient worsening, or flaring, of joint pain in the form of a pseudoseptic reaction after injection has been documented and noted to be more common with use of high-molecular-weight, cross-linked formulations of HA (7).

Platelet-rich Plasma.—The use of platelet-rich plasma (PRP) for treatment of various musculoskeletal conditions has been gaining in popularity. Although platelets are better known for their key role in the coagulation cascade, they also have an essential role in tissue healing (8). After a tissue injury is sustained, platelets concentrate at the site of the injury and activate healing by releasing growth factors (8). The principal component of using PRP effectively is the injection of a high concentration of platelets at the site of injury to maximize the local presence of growth factors to promote healing in relatively low-vascularity structures such as the tendon (8). Therefore, unlike corticosteroids, which usually provide only short-term symptom relief, PRP may be used to promote healing and more long-term relief.

Platelet-rich plasma is defined as a platelet concentration above the physiologic concentration found in normal whole blood. Some authors (8) have specified that the platelet concentration must be at least five times that of whole blood (usually $1 \times 10^6/\mu L$) to be considered PRP. To achieve this high concentration, the patient's venous blood is drawn and placed in a tabletop centrifuge system so that the blood sample can be spinned down and separated into three components: platelet-poor plasma, PRP, and packed red blood cells (8). Once the PRP is separated from the other blood components, 3–5 mL of PRP is collected into a syringe and injected at the site of injury. Clinical studies (8) to investigate the effectiveness of PRP for treatment of a myriad of conditions, including tendinopathies, plantar fasciitis, acute ligament injuries, and acute muscle injuries, have revealed promising results.

US-guided Injections

Safety.—US-guided procedures are associated with minimal risk. However, there is a steep learning curve, involving visualization of the needle and needle tip, for performing these procedures. Operators often hold the transducer in one hand while advancing the needle by using the other hand. Other institutions may use a team approach, having the sonographer hold the transducer and locate the target while the operator advances the needle with guidance from the sonographer. Regardless of the technique used, the most important safety tip is to always visualize the needle tip before advancing it toward the target. Real-time knowledge of the needle tip location will prevent unintended consequences of neurovascular injury.

Equipment.—The US-guided injection process begins with selection of the appropriate transducer. Most musculoskeletal injections are targeted at superficial structures, which are best imaged with a high-frequency (eg, 6–15-MHz) linear transducer. However, injections around the hip often are targeted at deeper structures, which may be better visualized with use of a lower-frequency (eg, 5–12-MHz) curved transducer. For US-guided injections, the operator is required to use a sterile transducer cover and sterile gel with a standard sterile technique.

Twenty-five–gauge to 30-gauge needles are used to initially deliver local anesthetic to the skin surface and deeper subcutaneous tissues, to a depth of about 1.5 inches. When administering particulate corticosteroid agents, 22-gauge needles are recommended to prevent needle clogging. Standard 22-gauge 3.5-inch spinal needles are commonly used, but longer needles may be required, depending on the patient's body habitus.

Medication Selection.—One percent lidocaine hydrochloride (10 mg/mL) without epinephrine is the primary medication used to induce local anesthesia before the corticosteroid injection. To reduce the pain associated with the injection, the lidocaine should be buffered with 8.4% sodium bicarbonate in a 9:1 ratio (9). One or more local anesthetic agents (usually lidocaine hydrochloride or ropivacaine hydrochloride) are usually mixed with the corticosteroid before the injection, and care must be taken to ensure that they are free of preservatives.

With regard to corticosteroid selection, a nonparticulate corticosteroid such as dexamethasone sodium phosphate is used for peripheral nerve blocks. Particulate corticosteroids such as triamcinolone acetonide and methylprednisolone acetate are used for the remaining injections described in this review. The suggested doses of corticosteroids and local anesthetic agents used for the injections described in this review are listed in Table 2. Triamcinolone acetonide and methylprednisolone acetate are essentially interchangeable with respect to the dose of corticosteroid used. In addition, it should be noted that the volumes and doses of medications that we suggest for the various injections are based on the guidelines used at our institution and thus may differ slightly from those used at other institutions.

Table 2: Suggested Target Site–based Corticosteroid–Local Anesthetic Mixtures

Target Site	10 mg/mL Preservative-free Lidocaine HCL 1%	5 mg/mL Ropivacaine HCL 0.5%	40 mg/mL Triamcinalone Acetonide	10 mg/mL Dexamethasone Sodium Phosphate	Total Volume Injected
Anterior hip					
Hip joint	2 mL (20 mg)	2 mL (10 mg)	1 mL (40 mg)	…	5 mL
Iliopsoas bursa	2 mL (20 mg)	2 mL (10 mg)	1 mL (40 mg)	…	5 mL
Ilioinguinal nerve	3 mL (30 mg)	…	…	1 mL (10 mg)	4 mL
LFCN	3 mL (30 mg)	…	…	1 mL (10 mg)	4 mL
Lateral hip					
Trochanteric bursa	…	2 mL (10 mg)	1 mL (40 mg)	…	3 mL
ITB	…	2 mL (10 mg)	1 mL (40 mg)	…	3 mL
Posterior hip					
Ischiogluteal bursa	…	4 mL (20 mg)	1 mL (40 mg)	…	5 mL
Piriformis	…	2 mL (10 mg)	1 mL (40 mg)	…	3 mL
IFS	1 mL (10 mg)	1 mL (5 mg)	1 mL (40 mg)	…	3 mL

Note.—HCL = hydrochloride, IFS = ischiofemoral space, ITB = iliotibial band, LFCN = lateral femoral cutaneous nerve.

Procedural Risks.—The risks associated with any injection, including pain, infection, bleeding, and an allergic reaction to the administered medications, should be explained to the patient. The aforementioned risks specific to corticosteroid administration also should be disclosed. It should be emphasized that most of the common adverse events related to corticosteroid injection are self-limiting and resolve within 1–2 days, and serious side effects are rare.

Contraindications.—Therapeutic injections are elective and are typically deferred in cases of active infection owing to the risk of seeding the targeted structure in the patient. Patients are advised to reschedule their procedure for a time either after their symptoms have resolved or at least 1 week after they have stopped antibiotic therapy. Because the risk of bleeding is low, patients usually are not asked to hold off undergoing anticoagulation therapy before their procedure. Patients should always disclose any allergies to medication and/or contraindications to corticosteroid use before proceeding with the injection.

Expected Results and Aftercare.—Informed patient consent includes a discussion with the patient regarding the expected course following the procedure. Immediate pain relief may occur owing to the administration of anesthetic medication, and patients are instructed not to exert the affected limb for the remainder of the day. The injection site should be kept clean and dry and not be submerged in water for 24 hours. The effect of corticosteroids is gradual, and symptom relief may not begin until 3–5 days after the procedure. Patients must be made aware that corticosteroids do not correct or heal the underlying insult that leads to the pain and that the therapeutic benefit typically lasts an average of 4–6 weeks.

With regard to PRP, specific pre- and post-procedural guidelines should be clearly explained to the patient. These guidelines include avoiding the use of nonsteroidal anti-inflammatory drugs and corticosteroids for 2 weeks before and 2 weeks after the injection, as these medications can adversely affect the effectiveness of PRP. The recommended activity after PRP injection therapy also should be clearly outlined: Following PRP treatment, immobilization for the first 24–72 hours is advised, with the goal being capability for an early range of motion as soon as the patient's pain level allows. Strict guidelines regarding the gradual increase in activity should be followed, with a return to activity, as tolerated, at 2 months (Table 3). The guidelines for activity after PRP injection are further detailed in an online document from the University of Wisconsin Sports Medicine website (10).

Anterior Hip

Hip Joint

Anatomy.—The hip joint is a ball-and-socket synovial joint that consists of the osseous acetabulum and proximal femur, as well as the fibrocartilaginous labrum, which serves to deepen the joint space and decrease the risk of instability (11). The joint capsule surrounds the hip joint and

Table 3: Instructions for Activity after PRP Treatment

Immobilization for 24–72 hours after the procedure, with early range of motion allowed according to pain level
Resume physical therapy within 1–2 weeks
Gradual increase in activity at 4–6 weeks
Activity, as tolerated, at 2 months

extends from a few millimeters above the labrum down to the intertrochanteric line of the femur.

Related Pathologic Entities.—Many pathologic processes can affect the hip joint (12) and lead to symptoms that include pain, stiffness, and joint locking. These symptoms can occur in the groin or thigh and may radiate to the buttocks or down to the knee. Osteoarthritis is the most common form of arthritis and one of the most important causes of pain and disability in adults (13). On radiographs, osteoarthritis is often readily apparent and seen as nonuniform joint space narrowing. This narrowing usually is most pronounced along the superior weight-bearing aspect of the joint, with osteophytes, subchondral cysts, and sclerosis (12).

Early joint changes associated with primary osteoarthritis, such as subtle chondrosis and marrow edema, are better appreciated on MR images. A worrisome cause of hip pain is septic arthritis, which manifests as synovial enhancement, perisynovial edema, and joint effusion at MRI (14). Septic arthritis must always be excluded before injecting corticosteroids into a joint. Labral tears are another potential cause of hip pain and are best assessed with MR arthrography (15). Inflammatory arthritides, such as rheumatoid arthritis, usually lead to more uniform joint space narrowing, with erosive changes seen on radiographs and synovial hypertrophy seen on MR images (12). Avascular necrosis of the femoral head is another potential cause of hip pain. It can be bilateral and has many potential underlying causes (12,16).

Injection Technique.—Although fluoroscopy is often the modality of choice for many clinicians performing imaging-guided hip joint injections, US-guided hip joint injections represent a safe and useful alternative approach (3). The patient is placed in a supine position, and the ipsilateral leg is internally rotated. The transducer is placed anterior and parallel to the femoral neck so that the anterior aspect of the rounded femoral head and concave femoral neck can be identified (Fig 1a). With real-time US guidance, a 22-gauge spinal needle is advanced from the inferolateral to superomedial aspect until the tip of the needle contacts the deepest concavity of the femoral head-neck junction within the anterior recess (Fig 1b). A small volume of 1% lidocaine is then injected to distend the joint capsule and confirm that the needle tip is appropriately positioned (Fig 1c). This process is followed by the injection of a premixed solution of corticosteroid and local anesthetic agent. Viscosupplements can be injected by using an identical technique.

Iliopsoas Bursa

Anatomy.—The iliopsoas musculotendinous unit is composed of three muscles: the psoas major, psoas minor, and iliacus (17,18). The iliacus is a flat fan-shaped muscle that arises from the iliac wing and tapers distally, inserting into the lateral side of the psoas tendon and lesser trochanter of the femur. The psoas major originates from the T12 to L5 vertebrae, passing deep to the arcuate ligament of the diaphragm and along the retroperitoneum, merging with the iliacus muscle at the level of the L5–S2 vertebrae under the inguinal ligament, forming the iliopsoas muscle, and inserting onto the lesser trochanter.

The iliopsoas bursa is the largest synovial bursa in the human body (17). It lies deep to the iliopsoas muscle and tendon, separating them from the hip joint capsule and pubis bone. Occasionally, it extends proximally into the pelvis or distally to the lesser trochanter. It has been shown to communicate with the hip joint in approximately 15% of adults (17).

Related Pathologic Entities.—Iliopsoas tendinopathy and bursitis have been reported in athletes who engage in sports that primarily involve kicking activities with repetitive hip flexor motion, such as soccer and hockey (19). The MRI appearance of tendinopathy includes tendon thickening and/or increased intrasubstance signal intensity. Accompanying fluid distention of the iliopsoas bursa and peritendinous edema also can be seen (19).

Snapping hip syndrome is commonly seen in young patients and is characterized by hip pain and audible or perceived snapping of the hip with movement (20). The causes can be categorized as external, internal, and intra-articular. Internal snapping hip syndrome is often due to snapping of the iliopsoas tendon at the level of the iliopectineal eminence. Dynamic US has been shown to depict in real time the snapping as the leg is moved from an abducted and externally rotated leg position back to a neutral position (21). Results of a study performed by Blankenbaker et al (20) showed that US-guided corticosteroid injection in the iliopsoas bursa has diagnostic

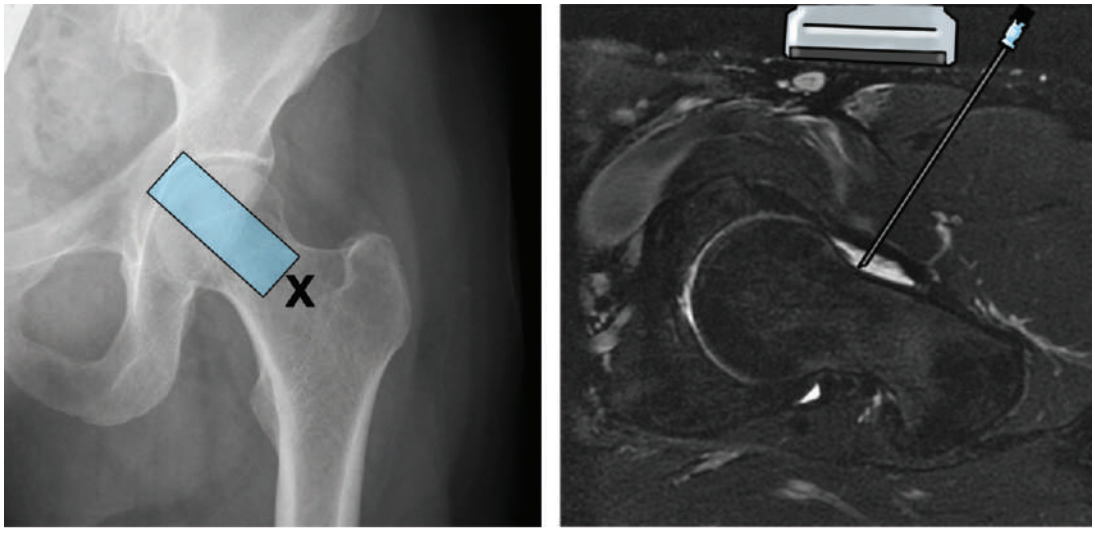


Figure 1. US-guided hip joint injection. **(a)** Anteroposterior hip radiograph with overlying drawing shows the appropriate positioning of the ultrasound probe (rectangle) parallel to the long axis of the femoral neck. *X* denotes the skin entry site of the needle. **(b)** Axial oblique MR arthrogram with overlying drawing shows the probe positioning and needle approach, with the needle tip contacting the deepest concavity of the anterior femoral head-neck junction. **(c)** US image oriented parallel to the long axis of the femoral neck shows a needle (arrowheads) at the junction of the femoral head *(FH)* and femoral neck *(FN).* The joint has been distended with 1% lidocaine, which appears as anechoic fluid (*), confirming the intra-articular position of the needle tip before injection of the corticosteroid.

and therapeutic benefits for patients with groin pain and clinically suspected snapping iliopsoas tendon, even if the snapping cannot be demonstrated sonographically. A positive response to corticosteroid injection is a predictor of a good surgical outcome after the surgical release of the iliopsoas tendon (20).

Iliopsoas impingement syndrome is an infrequent but increasingly recognized cause of postoperative groin pain following total hip arthroplasty. Impingement is most commonly due to anterior protrusion of the acetabular cup, with the resulting friction on the overlying iliopsoas tendon leading to tendonitis and bursitis (17). Additional causes of impingement include cement debris anterior to the cup and protruding fixation screws or bone graft material (17). As the associated clinical findings are often nonspecific, imaging can be helpful in making the diagnosis. CT enables measurement of the extent of overhang of the acetabular cup, whereas US can be used to identify tendonitis, bursitis, and snapping of the tendon over the margin of the acetabular cup (17). Corticosteroid injection into the iliopsoas bursa can serve both a diagnostic role and a therapeutic role, as a positive response will confirm the source of postoperative pain while simultaneously providing symptomatic relief (17).

Injection Technique.—With the patient placed in the supine position, the ultrasound probe is positioned transversely over the femoral head and then shifted superiorly and angled parallel to the inguinal ligament (Fig 2a). The iliopsoas musculotendinous complex is then identified on the short axis traversing the acetabular brim, with care taken to position the transducer above the level of the hip joint. A 22-gauge spinal needle is advanced from the lateral to medial aspect, oriented parallel to the imaging plane of the transducer, until the tip of the needle contacts the ilium immediately lateral and deep to the iliopsoas tendon (Fig 2b, 2c) at the expected location of the bursa. It should be noted that the native iliopsoas bursa itself often is neither distended nor visualized. A small volume of 1% lidocaine is then injected to distend the bursa. This usually results in the iliopsoas tendon being lifted off the acetabular brim of the ilium (Fig 2d), confirming the appropriate placement of the needle tip. This process is followed by an injection of a premixed solution of corticosteroid and local anesthetic agent.

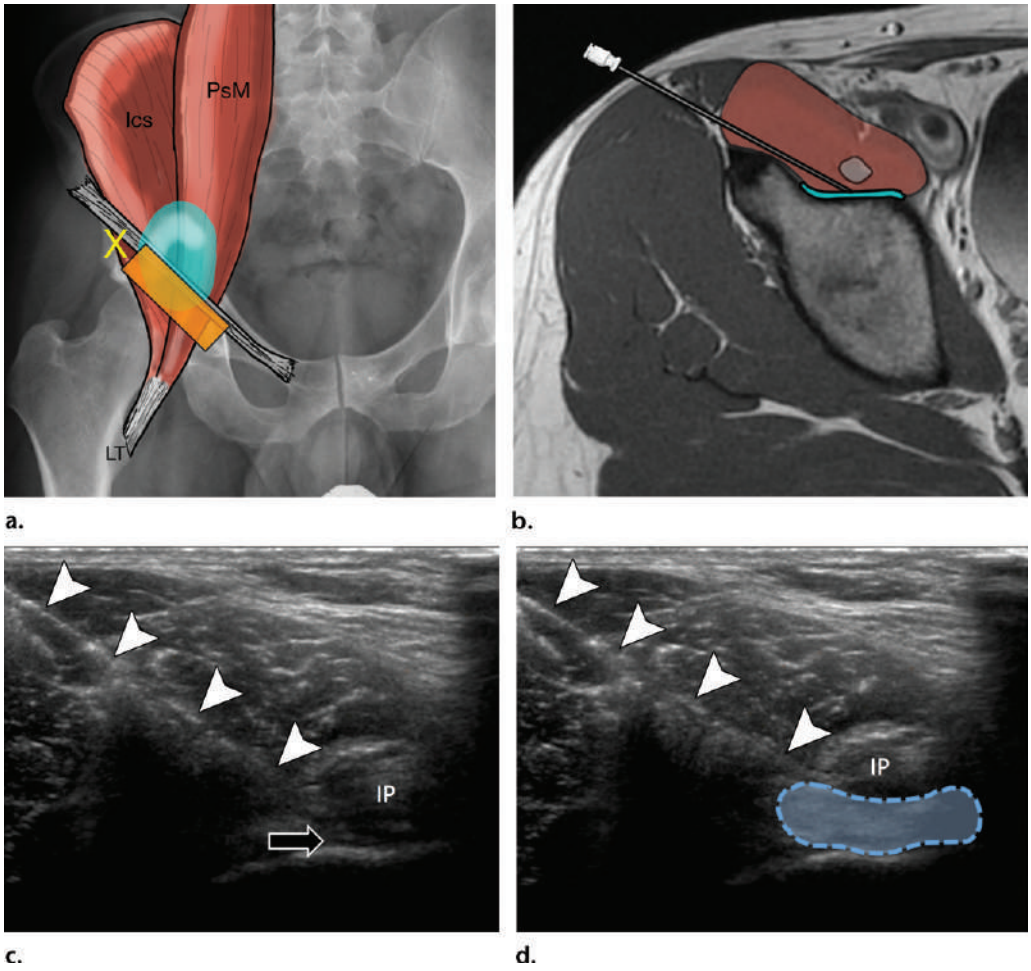
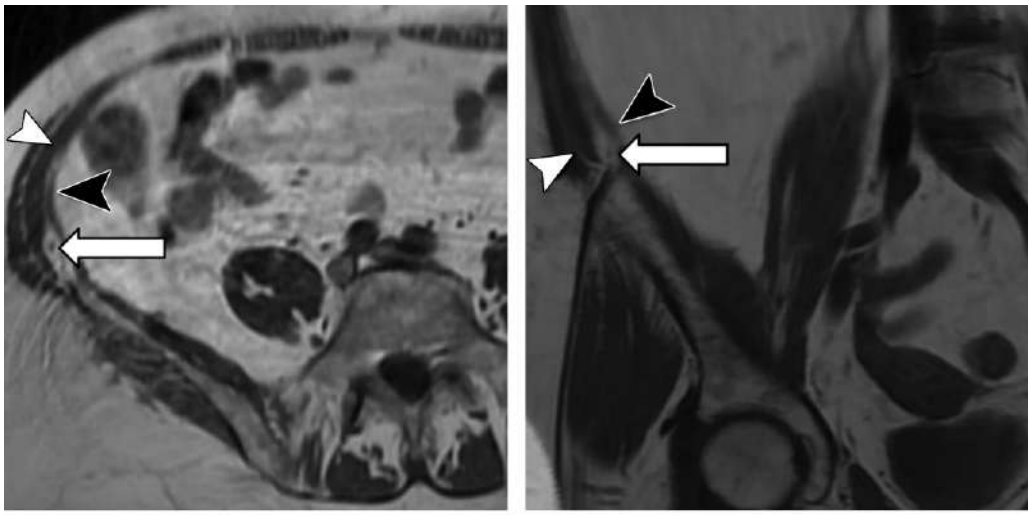


Figure 2. Iliopsoas bursa injection. **(a)** Drawing overlaid on an anteroposterior radiograph depicts the psoas major *(PsM)* and iliacus *(Ics)* muscles, which form the iliopsoas musculotendinous unit and traverse deep to the inguinal ligament to form a common distal tendon that inserts onto the lesser femoral trochanter *(LT)*. The iliopsoas bursa (shaded turquoise) is deep to the iliopsoas musculotendinous unit. For identification of the relevant structures on the US image, the probe (rectangle) is positioned parallel to the inguinal ligament, just above the level of the hip joint. The skin entry site *(X)* for the needle is immediately lateral to the probe. **(b)** Drawing overlaid on an axial T1-weighted MR image shows the desired trajectory of the needle from the lateral to medial aspect. **(c)** US image oriented transversely relative to the iliopsoas tendon (seen on the short axis) shows the needle (arrowheads) in the proper position, with its tip (arrow) just lateral and deep to the iliopsoas tendon *(IP)* and abutting the underlying ilium. **(d)** US image in **c** with the iliopsoas bursa outlined shows that during instillation of the injectate, the iliopsoas bursa often becomes distended and lifts the iliopsoas tendon *(IP)* off the ilium. Arrowheads point to the needle.

Ilioinguinal Nerve

Anatomy.—The ilioinguinal nerve arises, along with the iliohypogastric nerve, from the anterior ramus of the L1 nerve root as a component of the lumbar plexus (22). This nerve courses over the quadratus lumborum muscle, subsequently piercing the lateral abdominal wall and traversing anteriorly and medially between the lateral abdominal wall muscles (Fig 3a, 3b) (22). At the level of the anterior aspect of the iliac crest, the nerve pierces the transversus abdominis and internal oblique muscles to enter the inguinal canal, eventually exiting at the superficial inguinal ring to become subcutaneous (23). The ilioinguinal nerve cutaneously innervates the pubic symphysis, superior and medial aspects of the femoral triangle, root of the penis and anterior scrotum in men, and the mons pubis and labia majora in women (22).

Related Pathologic Entities.—Owing to the anatomic course of the ilioinguinal nerve, the risk of injury to this nerve during various pelvic surgeries, including inguinal herniorrhaphy, open appendectomy, and major gynecologic surgery, is well documented (24). Patients usually describe a burning or radiating pain in the groin and proximal medial region of the thigh (25). Identification of an abnormal distal ilioinguinal nerve is very challenging at MRI, and because this nerve has only a sensory function, there will be no associated denervation of the downstream



a. b.

Figure 3. Ilioinguinal nerve anatomy. Axial **(a)** and coronal **(b)** T1-weighted MR images show the course of the ilioinguinal nerve (arrow) between the internal oblique (white arrowhead) and transversus abdominus (black arrowhead) muscles in the anterolateral abdominal wall.

muscles to serve as a clue to the diagnosis at imaging. As such, the diagnosis of ilioinguinal nerve injury is largely based on the appropriate clinical history and symptoms, with support from electrodiagnostic methods (24). An anesthetic injection in the nerve, with or without corticosteroids, may relieve pain temporarily and guide the selection of further definitive treatment alternatives.

Injection Technique.—The ilioinguinal nerve is targeted at the level of the anterior-superior iliac spine as it courses along the lower anterior abdominal wall. The nerve is identified approximately 2 cm medial and 2 cm superior to the anterior-superior iliac spine (Fig 4a), where it travels between the transversus abdominis and internal oblique muscles, and courses with the deep circumflex iliac artery.

The transducer is placed at the target site in an oblique plane, with the medial end of the transducer directed cranially toward the umbilicus for visualization of the ilioinguinal nerve in the short-axis plane (Fig 4b). Once the ilioinguinal nerve is identified, a 22-gauge spinal needle is advanced into the plane, with the needle tip placed deep to the nerve in a perineural location, carefully avoiding the deep circumflex iliac artery (Fig 4c). Hydrodissection of the plane between the transversus abdominis and internal oblique muscles, with use of an anesthetic, can aid in visualizing the needle tip. Once the needle tip is in the appropriate position, a premixed solution of nonparticulate corticosteroid and local anesthetic agent is injected, flooding the perineural space with medication.

Microwave Ablation.—A more durable alternative for pain relief is microwave ablation of the ilioinguinal nerve (25). After a positive diagnostic response to the US-guided injection of combined corticosteroid and anesthetic agent in the nerve, US-guided microwave ablation can be performed with placement of a 17-gauge, 15-cm antenna probe (Neuwave PR Antenna Probe; Ethicon/Johnson and Johnson Medical Devices, Somerville, NJ). Similar to the technique used to perform a diagnostic nerve block, but with the patient in conscious sedation, the probe is placed just underneath the short axis of the ilioinguinal nerve at the level of the anterior-superior iliac spine. After needle placement, the ablation is performed in three cycles of 30 W at 30 seconds each, with 1-minute rest intervals. Immediately after the procedure, the patient is closely followed up as an outpatient, with a follow-up clinic visit at 2 weeks.

Lateral Femoral Cutaneous Nerve

Anatomy.—The LFCN is a sensory nerve arising from the posterior divisions of the L2 and L3 nerve roots of the lumbar plexus, which are responsible for sensory innervation to the anterior and lateral regions of the thigh (22,26). The LFCN pierces the lateral side of the psoas major muscle and courses obliquely along the anterior surface of the iliacus, toward the anterior-superior iliac spine. This nerve then has a variable exit from the pelvis, coursing deep to, superficial to, or through the inguinal ligament and over the sartorius muscle, approximately 1 cm medial to the anterior-superior iliac spine (22,26). In the proximal region of the thigh, it travels in a superfi-

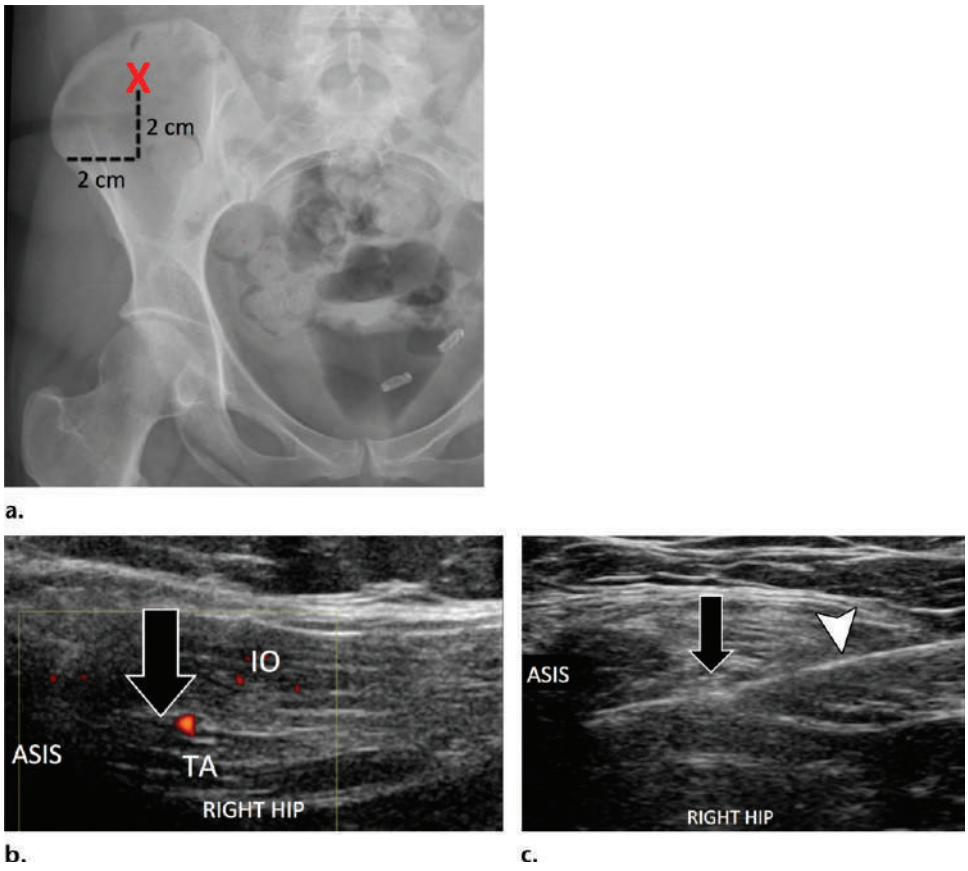


Figure 4. Ilioinguinal nerve block. **(a)** Anteroposterior hip radiograph shows the target site of injection in the ilioinguinal nerve, 2 cm medial and 2 cm superior to the anterior-superior iliac spine *(X).* **(b)** Color Doppler US image obtained with the probe oriented in an oblique transverse plane and the medial end of the transducer directed cranially toward the umbilicus shows the ilioinguinal nerve (arrow) immediately adjacent to the deep circumflex iliac artery, with the nerve and artery traveling in the fascial plane between the internal oblique *(IO)* and transversus abdominus *(TA)* muscles, just cranial to the anterior-superior iliac spine *(ASIS).* **(c)** US image obtained in the same orientation as **b** shows a microwave ablation probe (arrowhead) immediately deep to the ilioinguinal nerve (arrow). For an ilioinguinal nerve block, the trajectory of the needle would be identical; however, the tip of the needle would be positioned immediately deep to the ilioinguinal nerve before injection of the corticosteroid–anesthetic agent mixture. *ASIS* = anterior-superior iliac spine.

cial fascial plane between the sartorius and tensor fascia lata muscles, which serve as useful landmarks for the injection.

Related Pathologic Entity.—Altered sensation in the anterolateral thigh due to neuropathy of the LFCN has been termed *meralgia paresthetica* (26). The LFCN is most commonly injured at the level of the inguinal ligament owing to mechanical compression (Fig 5). This compression can be external, caused—for example—by tight clothing, tool belts, or seat belts (26). The compression could also have an internal cause such as a protuberant abdomen, as seen in obese and pregnant individuals. Compression by the sartorius muscle during turn-out rotation of the leg also has been described in ballet dancers (26).

Injection Technique.—With the patient in a supine position, the ultrasound transducer is placed transversely at the level of the femoral neck. The sartorius and tensor fascia lata muscles are identified and serve as imaging landmarks (Fig 6a). The fascial space between these two muscles contains fat and the anterior branch of the LFCN. With real-time US guidance, a 22-gauge needle is advanced into the transducer plane from a lateral to medial approach. Once the needle tip is subjacent to the nerve in the fascial plane (Fig 6b), with care taken to avoid piercing the nerve itself, a premixed solution of corticosteroid and local anesthetic agent is injected to flood the perineural space with medication.

Lateral Hip

Greater Trochanteric Bursa

Anatomy.—The greater trochanter of the femur serves as the bone landmark for the greater

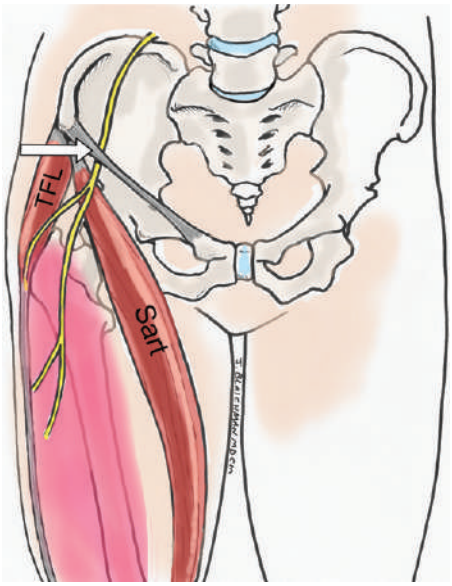


Figure 5. Drawing depicts the course of the LFCN in the anterior region of the hip in the setting of meralgia paresthetica. The LFCN (yellow) typically passes deep to the lateral inguinal ligament (arrow), the most common site of impingement, after which it continues caudally between and superficial to the sartorius *(Sart)* and tensor fascia lata *(TFL)* muscles in the upper anterior thigh and divides into the anterior and posterior branches. Irritation or injury of this nerve can lead to sensory deficits and paresthesias in the distribution of the anterolateral thigh (pink region), which characterize a condition that has been termed *meralgia paresthetica*.

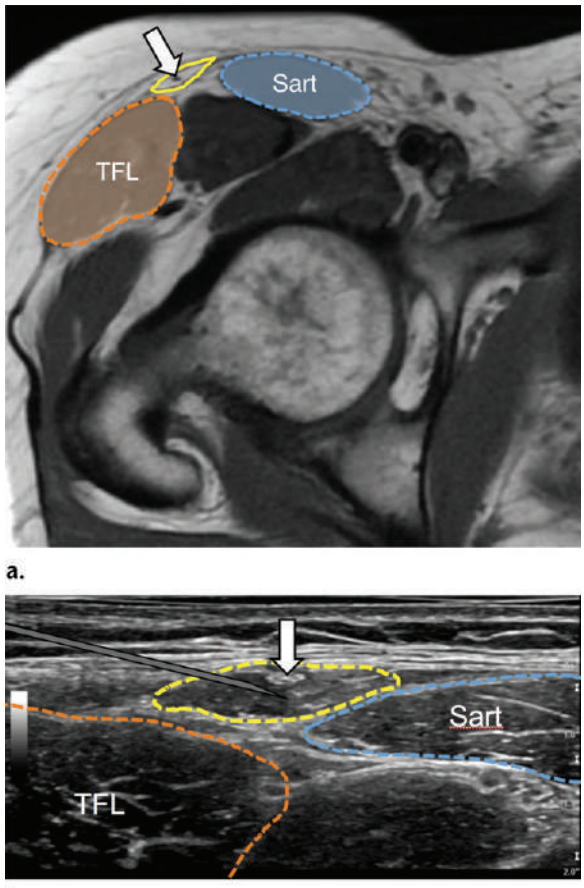


Figure 6. LFCN block. **(a)** Axial T1-weighted MR image shows the location of the LFCN (arrow), which is surrounded by fat within a superficial fascial space (yellow outline), medial and superficial to the tensor fascia lata muscle *(TFL)* (orange outline) and lateral and superficial to the sartorius muscle *(Sart)* (blue outline). **(b)** Corresponding US image obtained with the transducer oriented transverse to the thigh shows the structures in **a** and the desired trajectory of the needle, with the tip immediately deep to the LFCN (arrow) within the fascial space (yellow outline). *Sart* = sartorius muscle, *TFL* = tensor fascia lata muscle.

trochanteric bursa. The greater trochanter of the femur has four facets: the anterior, lateral, posterior, and posterosuperior facets (27). The gluteus minimus attaches to the anterior facet, and the gluteus medius attaches to the lateral and posterosuperior facets. The greater trochanteric bursa directly covers the posterior facet and extends anteriorly to cover the lateral aspect of the gluteus medius muscle (Fig 7a). It lies deep to the gluteus maximus muscle and iliotibial tract. It is lined by small layers of fat along its deep and superficial surfaces.

Related Pathologic Entity.—Greater trochanteric pain syndrome (GTPS) is a clinical diagnosis characterized by pain and tenderness over the lateral aspect of the greater trochanter (typically with the patient in an ipsilateral lateral decubitus position) that can be reproduced with resisted abduction (28–30). GTPS is common, with a reported prevalence of nearly 18% (28). The symptoms of GTPS can be caused by bursitis but also related to gluteal tendinopathy, enthesopathy, and tendon tears. The results of a study by McEvoy et al (31) indicated that corticosteroid injections into the greater trochanteric bursa may be more effective than injections into the subgluteus medius bursa for treatment of GTPS.

Injection Technique.—The patient is placed in a lateral decubitus position, with the target hip facing upward. The ultrasound probe is placed over the greater trochanter and oriented along its short axis, with visualization of the anterior, lateral, and posterior facets (Fig 7b). A 22-gauge spinal needle is advanced in plane with the transducer from the posterior to anterior aspect into the greater trochanteric bursa overlying the lateral aspect of the gluteus medius tendon insertion onto the lateral facet. The bursa is distended with a small volume of 1% lidocaine, confirming the appropriate position of the

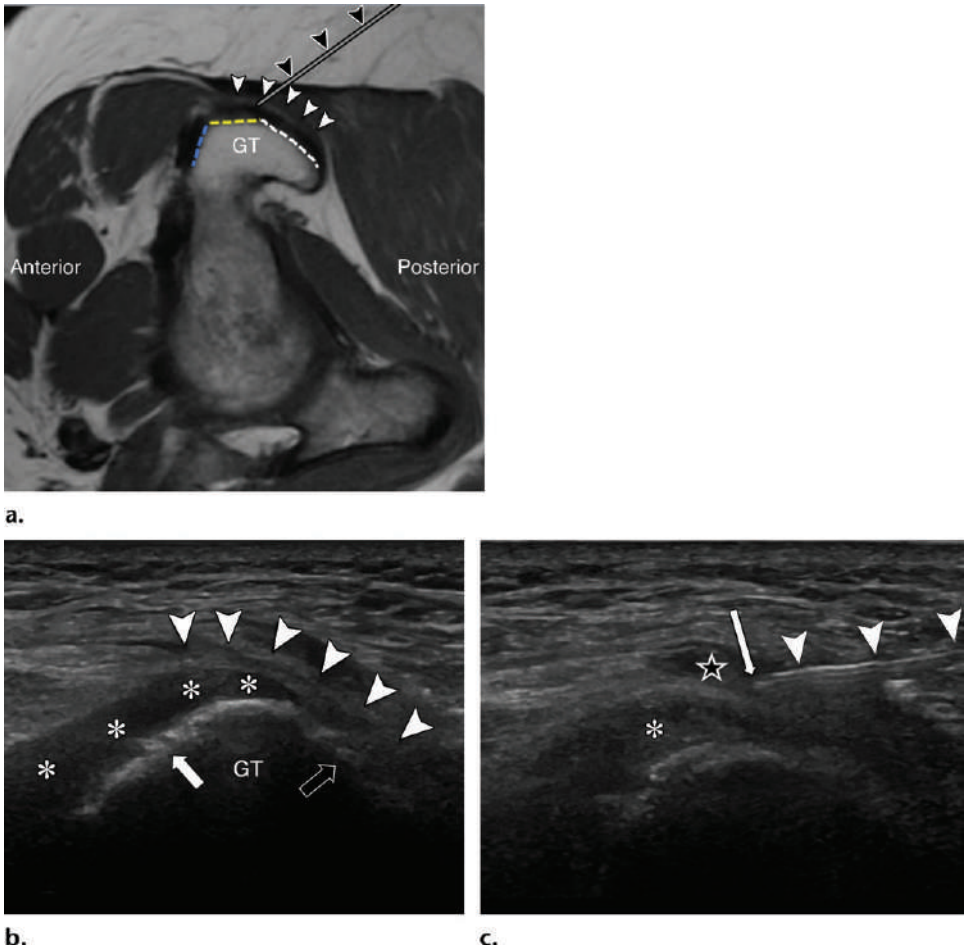


Figure 7. Greater trochanteric bursa injection. **(a)** Axial T1-weighted MR image of the left hip, which is oriented with the patient in the right lateral decubitus position, shows the anterior (blue dashed line), lateral (yellow dashed line), and posterior (white dashed line) facets of the greater femoral trochanter *(GT)* and the typical location of the greater trochanteric bursa (white arrowheads), which lies over the posterior aspect of the gluteus medius tendon insertion of the lateral facet and directly over the posterior facet. The desired trajectory of the needle from the posterior to anterior aspect (black arrowheads) also is shown. **(b)** Transverse US image shows the lateral (white arrow) and posterior (black arrow) facets of the greater femoral trochanter *(GT),* which serve as osseous landmarks during injection; the distal insertion of the gluteus medius tendon (∗) on the lateral facet; and the location of the greater trochanteric bursa (arrowheads) overlying these structures. **(c)** Transverse US image shows a needle (arrowheads), with its tip (arrow) in the greater trochanteric bursa overlying the distal gluteus medius tendon (∗). The bursa is now distended by anechoic injectate (☆).

needle tip (Fig 7c). This process is followed by the injection of a premixed solution of corticosteroid and local anesthetic agent.

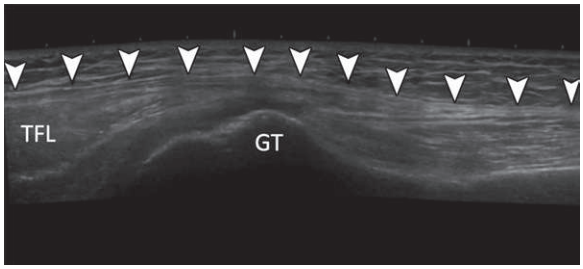
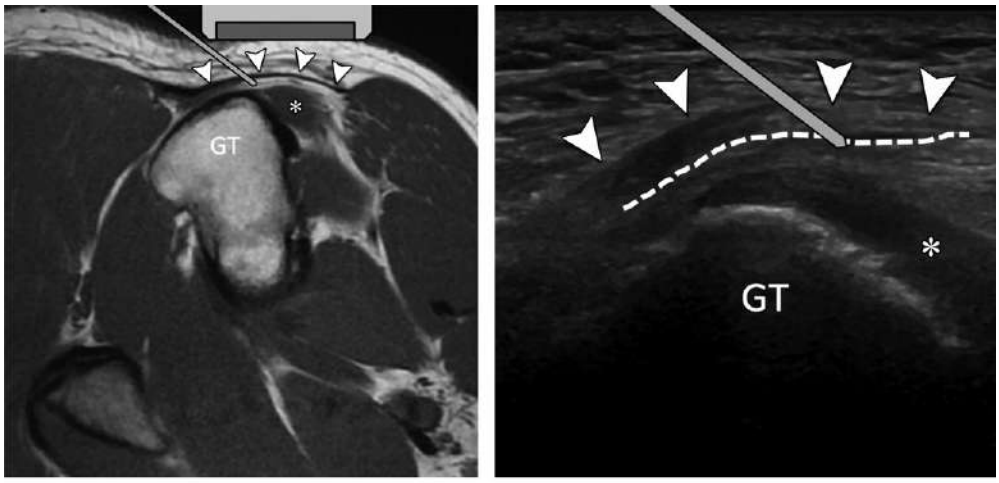


Figure 8. ITB anatomy. Extended longitudinal US image shows the relationship of the proximal ITB (arrowheads) with the tensor fascia lata muscle *(TFL)* and greater femoral trochanter *(GT),* which the ITB passes over.

Iliotibial Band

Anatomy.—The fascia lata refers to a deep fascia that invests the thigh musculature. The ITB is a thickened portion of the fascia lata along the upper lateral thigh. The anatomy of the ITB is complex and consists of superficial, intermediate, and deep layers, which fuse in the region of the greater femoral trochanter (Fig 8) (32). The ITB is reinforced posteriorly by tendinous fibers arising from the gluteus maximus muscle; it also receives contributions from the gluteal aponeurotic fascia, which covers the gluteus medius muscle, before extending caudally and inserting onto the Gerdy tubercle along the anterolateral proximal tibia.



a. b.

Figure 9. ITB injection. **(a)** Axial T1-weighted MR image obtained with the patient in a left lateral decubitus position shows the proper needle trajectory from the posterior to anterior aspect at the site of maximal pain, with the needle tip in the fat plane immediately deep to the ITB (arrowheads) and superficial to the greater femoral trochanter *(GT)* and gluteus medius muscle (*). **(b)** Corresponding US image oriented transversely over the greater femoral trochanter *(GT)* shows the proper needle tip position. The injected medication should spread evenly along the deep surface (dashed line) of the ITB (arrowheads). * = gluteus medius muscle.

Related Pathologic Entity.—External snapping hip syndrome is an extra-articular form of snapping hip. This syndrome is characterized by abrupt forward translation of the proximal ITB, or less commonly the gluteus maximus muscle, over the greater trochanter during hip flexion (33,34). Repetitive rubbing during physical activity can lead to painful tendinopathy or bursitis that often affects athletes and ballet dancers (35). This pain can also extend to the knee. External snapping hip syndrome is best assessed dynamically at US, with the transducer placed in the transverse plane over the greater trochanter. With the patient in a supine or upright position, hip flexion or external rotation is performed to assess for sudden motion of the ITB, which is often accompanied by reproduction of the patient's pain or an audible or palpable snap (36).

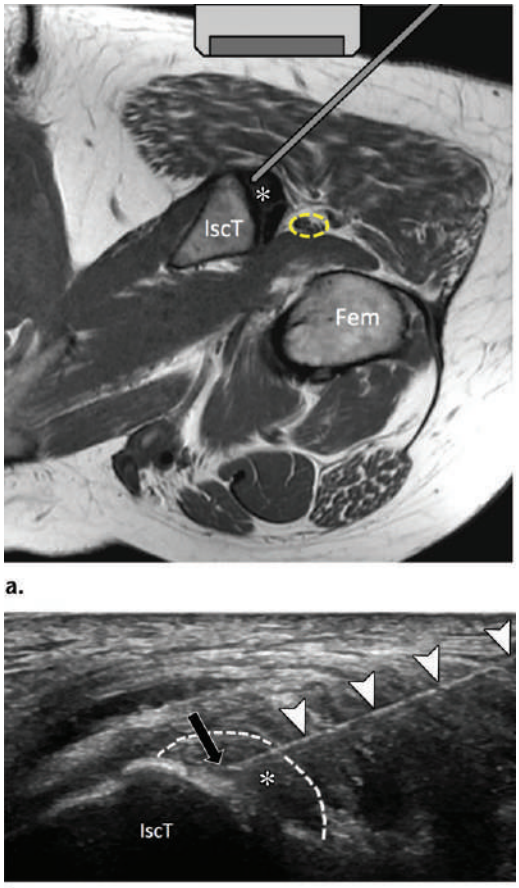
Injection Technique.—The patient is placed in the lateral decubitus position, with the affected side up. The ultrasound transducer is placed over the lateral hip in the transverse plane, and the ITB is visualized as a curvilinear hyperechogenic band superficial to the greater trochanter and the gluteus medius tendon (Fig 9a). The ITB should be targeted at the patient's site of maximal tenderness. A 22-gauge spinal needle is advanced in plane to the transducer from the posterior to anterior aspect. The needle tip is positioned immediately deep to the ITB. Then, a small volume of 1% lidocaine is injected and should spread along the deep aspect of the ITB, confirming the appropriate positioning of the needle (Fig 9b). This process is followed by the injection of a premixed solution of corticosteroid and local anesthetic agent.

Posterior Hip

Hamstring Tendon Origin

Anatomy.—The hamstring muscle complex, consisting of the hamstrings and their tendons, is the primary muscle group in the posterior region of the thigh (37,38). This complex extends across the hip and knee joints, from the ischial tuberosity to the proximal tibia and fibula, and consists of three muscles: the biceps femoris, semimembranosus muscle, and semitendinosus muscle. The proximal biceps femoris and semitendinosus muscles form a conjoint tendon, which originates from the transverse facet of the ischial tuberosity. The semimembranosus muscle originates on the superolateral aspect of the ischial tuberosity, lateral to the conjoint tendon.

Related Pathologic Entity.—*Tendinopathy* refers to chronic overuse injury at the origin of the hamstrings, which can result in soreness and discomfort in the buttock region overlying the ischial tuberosity when the individual runs or sits (37). MRI findings that are consistent with tendinopathy include increased signal intensity within and around the tendon origin, with tendon thickening, with fluid-sensitive sequences and occasional marrow edema involving the underlying ischial tuberosity (37). On US images, the tendon origin appears thickened and



a.

b.

Figure 10. PRP injection into the hamstring tendon origin. **(a)** Axial T1-weighted MR image of the hip with the patient in the prone position, with overlying drawing, shows the proper needle trajectory from the lateral to medial aspect into the hamstring tendon origin (*). The ischial tuberosity *(IscT)* serves as an osseous backstop for the needle. The sciatic nerve (yellow outline) travels in close proximity to the hamstring tendon origin and must be visualized and avoided during the injection procedure. *Fem* = proximal femur. **(b)** Transverse US image shows the needle (arrowheads) with its tip (arrow) within the hamstring tendon origin (*, dashed outline) and the ischial tuberosity *(IscT)* serving as an osseous backstop. The hamstring tendon can be gently fenestrated before injection of the prepared PRP.

hypoechoic, and power Doppler US may depict hyperemia in the tendon (37).

Injection Technique.—PRP can be used to treat hamstring tendinopathy and injuries (39,40). Before the PRP injection, the patient's blood is drawn and centrifuged to yield 3–5 mL of PRP, which is collected into a syringe in a sterile manner.

After the patient is placed in the prone position, the ultrasound transducer is positioned in a transverse orientation at the ischial tuberosity–hamstring tendon origin (Fig 10a). The ischial tuberosity can be identified in the gluteal region as a triangular, echogenic, posteriorly shadowing structure. The common hamstring tendon origin appears as a round hypoechoic structure arising from the inferolateral surface of the ischial tuberosity. A 22-gauge spinal needle is then guided in plane with the transducer from the lateral to medial aspect until the needle tip is within the tendon origin, with the ischial tuberosity serving as an osseous needle backstop (Fig 10b). The syringe containing the collected PRP is then connected to the needle, and the full volume of PRP is injected into the tendon by using a fan-shaped approach so that different portions of the diseased tendon can be filled. Immediately before injecting the PRP, five to 10 passes of gentle tendon fenestration can be achieved by repeatedly moving the needle in and out of the tendon to disrupt the scar tissue and prepare the tendon bed for the PRP. The most hypoechoic and hyperemic parts of the tendon origin, including the region of enthesis itself, are targeted. Following the procedure, the patient is advised to follow a recommended return-to-activity protocol (10).

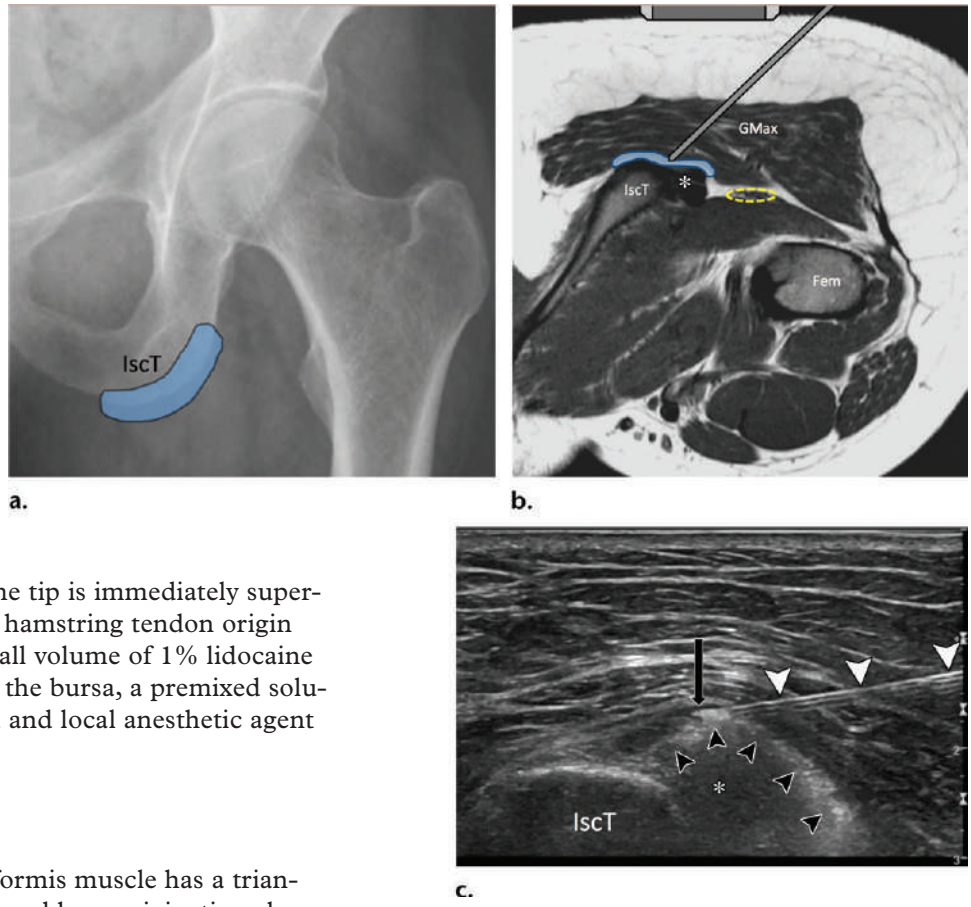
Ischiogluteal Bursa

Anatomy.—The ischiogluteal bursa is located posterior and inferior to the ischial tuberosity and deep to the inferior portion of the gluteus maximus muscle (Fig 11a) (41). In the absence of disease, it is barely perceptible at imaging.

Related Pathologic Entity.—Ischiogluteal bursitis can be acute or chronic, with causes that include direct trauma to the ischial tuberosity; abnormal friction between the ischial tuberosity, hamstring origin, and overlying gluteus maximus; and underlying hamstring tendinopathy (37). Ischiogluteal bursitis appears as a T2-hyperintense fluid collection deep to the inferior portion of the gluteus maximus muscle and posteroinferior to the ischial tuberosity on sagittal MR images, and medial to the common hamstring tendon origin, abutting the inferomedial surface of the ischial tuberosity, on axial and coronal MR images (41). Occasionally, bursitis related to abnormal friction or tendinopathy is entirely interposed between the proximal hamstring tendons and the ischial tuberosity (37). US images show an anechoic or hypoechoic fluid collection overlying the ischial tuberosity (37).

Injection Technique.—The patient is placed in the prone position. The ultrasound transducer is placed transversely over the ischial tuberosity, in the same location used for PRP treatment of the hamstring origin (Fig 11b). With real-time US guidance, a 22-gauge spinal needle is guided in plane with the transducer from the lateral to

Figure 11. Ischiogluteal bursa injection. **(a)** Anteroposterior radiograph of the left hip shows the anatomic location of the ischiogluteal bursa (shaded blue), which overlies the ischial tuberosity *(IscT).* **(b)** Axial T1-weighted MR image of the hip with the patient in the prone position shows the desired trajectory of the needle from the lateral to medial aspect into the ischiogluteal bursa (shaded blue), which is immediately superficial to the ischial tuberosity *(IscT)* and hamstring tendon origin (*) and deep to the gluteus maximus muscle *(GMax).* The sciatic nerve (yellow outline) travels close to the ischial tuberosity and must be visualized and avoided during the injection procedure. *Fem* = femur. **(c)** Transverse US image shows the needle (white arrowheads) with its tip (arrow) in the ischiogluteal bursa, which overlies the ischial tuberosity *(IscT)* and hamstring tendon origin (*). A small amount of gas injected with the medication causes posterior acoustic shadowing along the ischiogluteal bursa (black arrowheads), making it easier to identify.



medial aspect until the tip is immediately superficial to the common hamstring tendon origin (Fig 11c). After a small volume of 1% lidocaine is injected to distend the bursa, a premixed solution of corticosteroid and local anesthetic agent is injected.

Piriformis Muscle

Anatomy.—The piriformis muscle has a triangular shape, with a broad base originating along the ventral surface of the sacrum at the level of the second and third sacral foramina (42). The muscle exits the pelvic cavity through the greater sciatic notch above the sacrospinous ligament, extending inferolaterally across the gluteal region to insert onto the superior border of the greater trochanter of the femur (42). In the gluteal region, the piriformis muscle is positioned deep to the gluteus maximus muscle and superficial to the obturator internus and gemellus muscles (42). The piriformis muscle serves as an abductor and lateral rotator of the hip (43).

The sciatic nerve is the largest nerve in the body and is formed by the L4–S3 nerve roots (26). This nerve exits the pelvis by way of the infrapiriformis portion of the greater sciatic foramen. The sciatic nerve typically travels immediately anterior and inferior to the piriformis muscle in the gluteal region (44), although it can also travel above or through the piriformis muscle. This close anatomic relationship between the sciatic nerve and piriformis muscle can predispose an individual to piriformis syndrome. More distally, the nerve continues down the thigh, posterior to the adductor magnus muscle and anterior to the gluteus maximus muscle (26).

Related Pathologic Entity.—Piriformis syndrome is a controversial entity referring to sciatic nerve entrapment by an abnormal piriformis muscle at the level of the greater sciatic notch. This entrapment results in physical irritation of the sciatic nerve as it passes between the piriformis and obturator internus muscles (42–45). It is a rare cause of low back–buttock pain and sciatica, having been shown to potentially be responsible for these symptoms in 6%

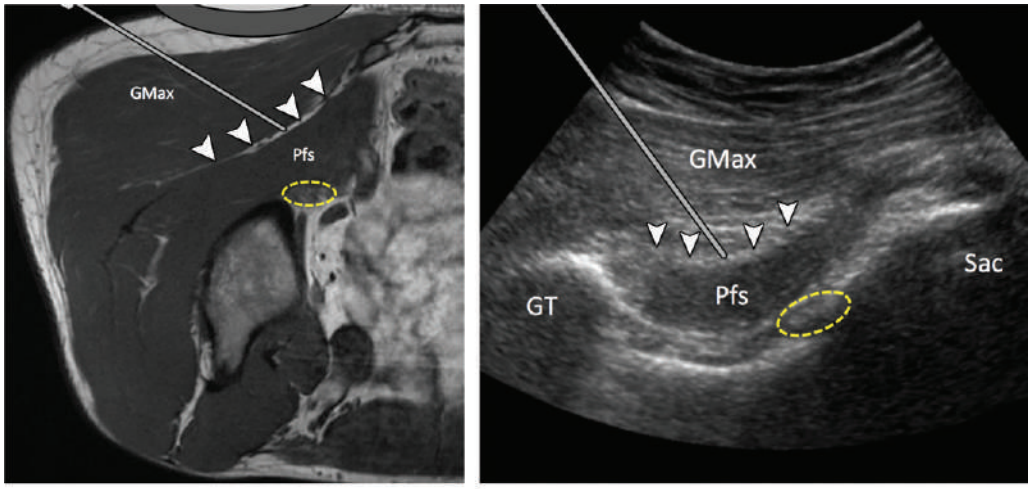


Figure 12. Piriformis muscle injection. **(a)** Axial T1-weighted MR image obtained with the patient in the prone position shows the desired trajectory of the needle from the lateral to medial aspect into the fascial plane (arrowheads) immediately deep to the gluteus maximus muscle *(GMax)* and superficial to the piriformis muscle *(Pfs).* The sciatic nerve (yellow outline) travels immediately deep to the piriformis muscle, so care should be taken to ensure that the needle remains superficial to the piriformis muscle to avoid inadvertently injuring the sciatic nerve by advancing the needle too deep. **(b)** Corresponding transverse US image shows the sacrum *(Sac)* and greater femoral trochanter *(GT),* which are osseous landmarks. Again, the needle is advanced into the fascial plane (arrowheads) between the gluteus maximus *(GMax)* and piriformis *(Pfs)* muscles. Advancing the needle too far could lead to injury of the sciatic nerve (yellow outline) immediately deep to the piriformis muscle.

of cases seen in general practice (45). Piriformis hypertrophy, spasm, contracture, trauma, inflammation, and neoplastic infiltration are processes that potentially can result in irritation of the sciatic nerve (26,44). Rarely, anatomic variants of the piriformis muscle also can result in piriformis syndrome (44).

Diagnosing piriformis syndrome is challenging. Historically, it has been a diagnosis of exclusion based on clinical findings and the exclusion of spinal disease as a source of the sciatica (44,46). The challenges of diagnosing this syndrome are multifactorial and include nonspecific symptoms, technical difficulty performing electromyography owing to the deep location of the sciatic nerve, and lack of reproducible and reliable imaging criteria for the diagnosis (26,44,46). With regard to imaging, asymmetric piriformis muscle size commonly can be seen in asymptomatic patients (47), and muscle size asymmetry alone has been shown to have poor sensitivity and specificity at MR neurography (48).

Injection Technique.—The patient is placed in the prone position. The ultrasound transducer is placed in a transverse orientation in the gluteal region to identify the piriformis, which traverses deep to the gluteus maximus muscle (Fig 12a). To see the piriformis in larger patients, a lower-frequency curvilinear probe may need to be used (49). The piriformis is identified extending from the sacrum, superficial to the ilium, toward the greater femoral trochanter. One can confirm the identification of the piriformis by bending the patient's ipsilateral knee and internally and externally rotating the ipsilateral hip. This should result in passive movement at dynamic imaging. Once the piriformis is positively identified, the sciatic nerve should be visualized as the transducer is moved distally toward the ischial tuberosity. Although the course of the sciatic nerve is variable, in most cases, it is deep to the medial aspect of the piriformis and immediately superficial to the underlying quadratus femoris muscle (49).

Once the probe is in the appropriate position, a 22-gauge spinal needle is advanced from the lateral to medial aspect under real-time US guidance until the needle tip is in the fascial plane immediately superficial to the piriformis muscle (Fig 12b). A small volume of 1% lidocaine is injected and should spread smoothly along the fascial plane, confirming the appropriate position of the needle. Following this process, a premixed solution of corticosteroid and local anesthetic agent is injected.

Quadratus Femoris Muscle

Anatomy.—The quadratus femoris muscle serves as a strong external rotator and weak

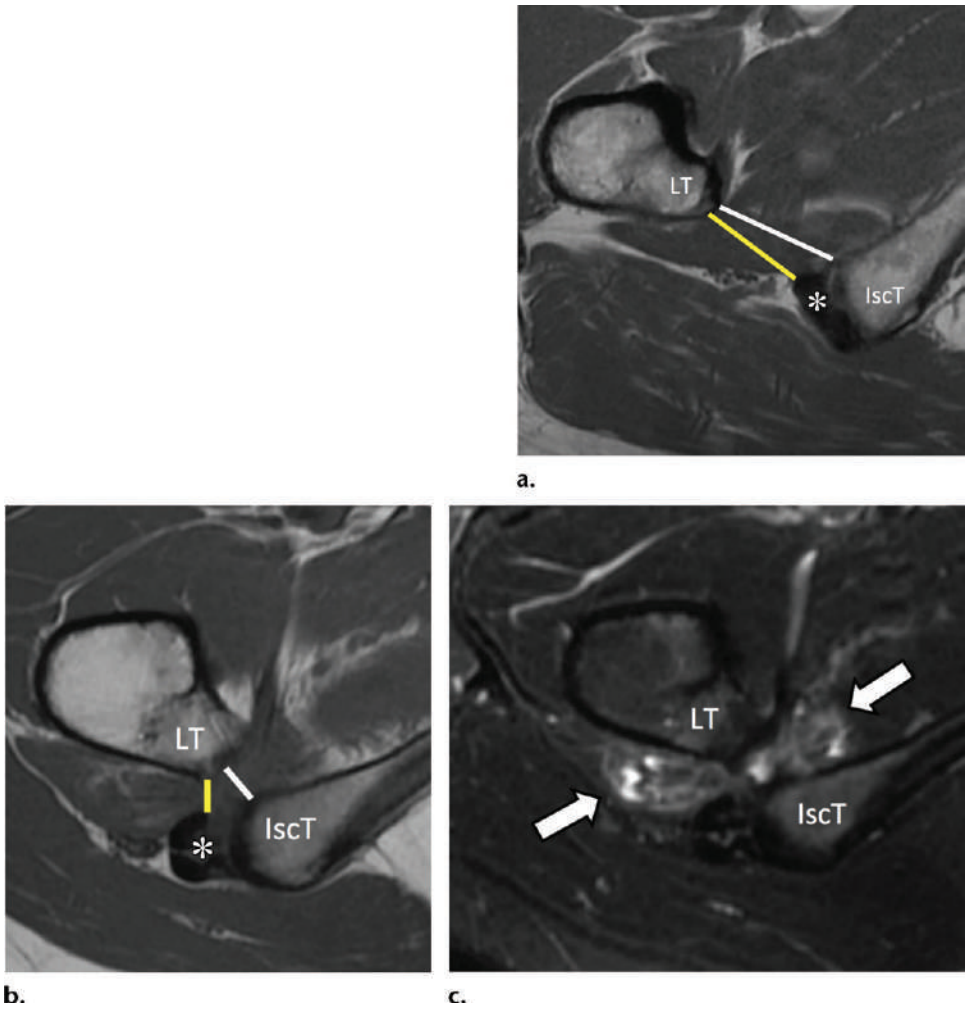


Figure 13. Ischiofemoral impingement. **(a, b)** Axial T1-weighted MR images of the hip show normal **(a)** and abnormally narrowed **(b)** IFS and QFS. The IFS (white line) is measured at the narrowest point between the lesser femoral trochanter *(LT)* and ischial tuberosity *(IscT),* whereas the QFS (yellow line) is measured at the narrowest point between the lesser femoral trochanter and hamstring tendon origin (∗). **(c)** Axial fat-saturated T2-weighted MR image in the patient in **b** shows compression of the quadratus femoris muscle (arrows), with resultant intramuscular edema and degenerative cystic changes, confirming the diagnosis of ischiofemoral impingement. *IscT* = ischial tuberosity, *LT* = lesser femoral trochanter.

adductor of the hip. It is a flat quadrangular muscle located along the posterior aspect of the hip joint (50). It originates from the inferolateral margin of the anterior ischial tuberosity, just anterior to the hamstring tendon origins, and inserts at the posteromedial aspect of the proximal femur along the quadrate tubercle of the posterior intertrochanteric ridge (50).

Along its course, the quadratus femoris muscle is located between the ischium and common hamstring tendon origin medially and the lesser femoral trochanter laterally (51). Two relevant spaces have been defined at MRI: the IFS and quadratus femoris space (QFS) (Fig 13a, 13b). The IFS is the smallest distance between the lateral cortex of the ischial tuberosity and medial cortex of the lesser trochanter on axial MR images (51). The QFS is the smallest distance between the superolateral surface of the hamstring tendons and the posteromedial surface of the iliopsoas tendon or lesser trochanter on axial MR images (51).

Related Pathologic Entity.—*Ischiofemoral impingement* is defined as narrowing of the distance between the ischial tuberosity and the lesser femoral trochanter, which results in compression and symptomatic impingement of the quadratus femoris muscle, leading to irritation and eventual atrophy of the muscle (52). The narrowing can be positional, congenital, or acquired (52). Clinically, ischiofemoral impingement syndrome is a potential cause of hip, gluteal, and atypical groin pain (53). It is mainly seen in middle-aged to elderly women but can also be identified in pediatric patients (52,54). Affected persons may also experience sciatica owing to irritation of the adjacent sciatic nerve (55).

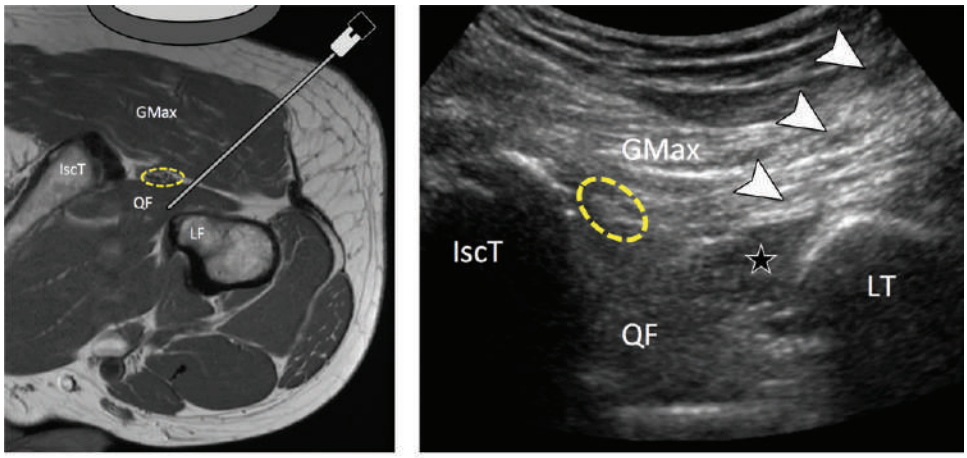


Figure 14. Quadratus femoris injection. Axial T1-weighted MR image with the patient prone **(a)** and corresponding transverse US image **(b)** show the placement of the ultrasound transducer and the trajectory of the needle (arrowheads in **b**) advanced into the quadratus femoris muscle *(QF).* The ischial tuberosity *(IscT)* and lesser femoral trochanter (*LF* in **a**, *LT* in **b**) serve as osseous landmarks. Because the sciatic nerve (yellow outline) is immediately superficial to the medial aspect of the quadratus femoris, the operator is advised to advance the needle into the quadratus femoris immediately medial to the lesser trochanter. The sciatic nerve must be visualized at all times during needle placement to ensure that the needle remains lateral and deep to the nerve until it enters the quadratus femoris. *GMax* = gluteus maximus muscle. In **b**, the arrowheads indicate the needle trajectory, and ☆ indicates the appropriate location of the needle tip.

MRI features of ischiofemoral impingement include edema, atrophy, and/or cystic changes of the quadratus femoris muscle and narrowing of the IFS or QFS (Fig 13c). Torriani et al (51) found that the IFS and QFS were markedly narrower in affected patients (mean IFS width, 13 mm ± 5 [standard deviation]; mean QFS width, 7 mm ± 3) than in control subjects (mean IFS width, 23 mm ± 8; mean QFS width, 12 mm ± 4). Similar findings were seen in a subsequent larger study by Tosun et al (55). It is important to avoid imaging the hip in external rotation, as this can lead to an overestimation of the degree of IFS and QFS narrowing (51). Torriani et al (51) suggested using cutoff widths of 17 mm or less for the IFS and 8 mm or less for the QFS to define narrowing of these spaces.

Study results (52,56) have demonstrated transient but significant relief of the symptoms of ischiofemoral impingement syndrome with use of US-guided corticosteroid injections. These injections may also have a role in determining a patient's suitability for surgical management of ischiofemoral impingement syndrome—for example, with arthroscopic iliopsoas tenotomy or lesser femoral trochanter resection (56).

Injection Technique.—The patient is placed in the prone position. A lower-frequency curvilinear ultrasound transducer is placed in a transverse plane on the affected side. The ischial tuberosity and hamstring origin are identified as bone landmarks. The transducer is then shifted laterally until the lesser trochanter is identified. At this point, the quadratus femoris should be identified between the ischial tuberosity and lesser femoral trochanter, deep to the gluteus maximus muscle (Fig 14a). The sciatic nerve also must be identified, as it is superficial to the quadratus femoris muscle and thus could be unintentionally injured by the needle if care is not taken to avoid it. The sciatic nerve is typically located at the medial aspect of the quadratus femoris, just lateral to the hamstring tendon origin.

Under real-time US guidance, a 22-gauge spinal needle is advanced in plane with the transducer from a lateral to medial approach into the quadratus femoris muscle, with the needle tip remaining deep and lateral to the sciatic nerve, which should be closely visualized until the needle is appropriately positioned within the muscle (Fig 14b). Once the needle is in position, a premixed solution of corticosteroid and local anesthetic agent is injected.

Conclusion

Hip pain is a debilitating condition with many potential causes, and identifying the source of disease can be a conundrum for clinicians. The radiologist can have a key role in the diagnostic examination and therapeutic management of patients with hip pain by aiding in the percutaneous intervention. US is an ideal modality for imaging guidance, and familiarity with the various US-guided interventions in and around the hip can

enable the radiologist to confidently and safely assist in the management of hip pain.

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