

Imaging of Groin Pain: Magnetic Resonance and Ultrasound Imaging Features

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Context: Evaluation of groin pain in athletes may be challenging as pain is typically poorly localized and the pubic symphyseal region comprises closely approximated tendons and muscles. As such, magnetic resonance imaging (MRI) and ultrasound (US) may help determine the etiology of groin pain.

Evidence Acquisition: A PubMed search was performed using the following search terms: *ultrasound, magnetic resonance imaging, sports hernia, athletic pubalgia, and groin pain*. Date restrictions were not placed on the literature search.

Study Design: Clinical review.

Level of Evidence: Level 4.

Results: MRI is sensitive in diagnosing pathology in groin pain. Not only can MRI be used to image rectus abdominis/adductor longus aponeurosis and pubic bone pathology, but it can also evaluate other pathology within the hip and pelvis. MRI is especially helpful when groin pain is poorly localized. Real-time capability makes ultrasound useful in evaluating the pubic symphyseal region, as it can be used for evaluation and treatment.

Conclusion: MRI and US are valuable in diagnosing pathology in athletes with groin pain, with the added utility of treatment using US-guided intervention.

Strength-of Recommendation Taxonomy: C

Keywords: core injury; athletic pubalgia; sports hernia; magnetic resonance imaging; musculoskeletal ultrasound

Groin pain in athletes accounts for 5% to 23% of all sports injuries^{8,10,11,18,28} and is attributable to kicking or twisting mechanisms. These injuries are most common in soccer players and can occur either as a single acute episode or as a culmination of repetitive microtrauma.²³ Injuries to the groin may have severe consequences for an athlete's career, resulting in loss of playing time or early career termination.^{17,19} Evaluation of groin pain in the athlete can prove challenging as pain may not be well localized and patients may present with overlapping symptoms or coexisting injuries. The complex anatomy of the pubic symphysis further confounds clinical diagnosis as the muscles and tendons of this region are close in proximity.

Different terminologies describe the etiology of groin pain, including core injury, sports hernia, athletic pubalgia, and

osteitis pubis. The interchangeable general terms "sports hernia" and "athletic pubalgia" can confound the evaluation of groin pain and the reporting of abnormalities on magnetic resonance imaging (MRI) and ultrasound (US). "Athletic pubalgia" is more of a clinical term for groin pain in athletes rather than a specific diagnosis. "Sports hernia" initially denoted a posterior inguinal wall deficiency due to disruption of the transversalis fascia or external oblique, internal oblique, and transverse abdominis muscles^{12,14}; however, because the location of weakness is disputed, it was often used as a more general term for inguinal pain.²³ Because these different terminologies create confusion, the Doha agreement²⁹ was formulated to promote a standard characterization of groin pain etiology, composed of adductor-, iliopsoas-, inguinal-, and pubic-related groin pain in addition to hip or other causes of groin pain.

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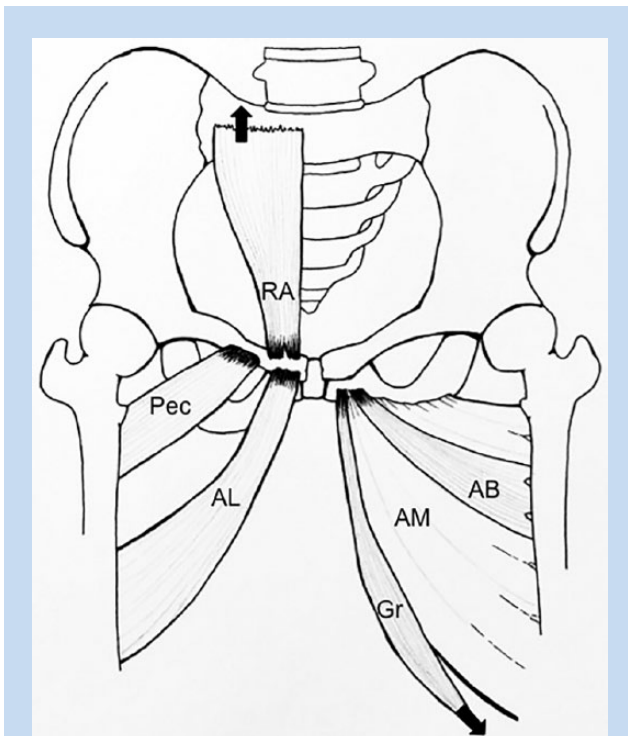


Figure 1. The adductor longus (AL) tendon arises at the inferior margin of the superior ramus and forms a fibrous aponeurotic plate with the rectus abdominis (RA). The pectineus (Pec) attaches superolateral to the adductor longus. The adductor brevis (AB) and adductor magnus (AM) attach posterior to the adductor longus, with the adductor magnus extending posterolaterally while the gracilis (Gr) has a posteromedial attachment.

In more recent years, the label of “core injury” has arisen as an inclusive term for musculoskeletal injuries involving the anterior pelvis, or more specifically, the pubic symphysis and its muscular attachments.⁶ This spectrum includes isolated adductor tendon tears, injury to the pubic plate or common aponeurosis of the rectus abdominis and adductor longus tendon, and osteitis pubis—all of which can be diagnosed using MRI.^{4,13} Injury can also extend into the pectineus or adductor brevis tendons.²³ The anatomy of the pubic symphyseal region will be reviewed with imaging protocols as well as the imaging features of various etiologies of groin pain on MRI and US.

THE PUBIC SYMPHYSIS: NORMAL ANATOMY

The pubic symphysis is an amphiarthrodial articulation (a joint that possesses a limited range of motion) with a fibrocartilage articular disc located between the 2 pubic bones, of which the articular surfaces are covered in hyaline cartilage.^{2,31} Numerous muscles and tendons attach onto the pubic symphysis, including the rectus abdominis, transversus abdominis, internal and external obliques, and adductors (adductor longus, adductor

brevis, adductor magnus, pectineus, and gracilis).¹³ The anteriorly paired rectus abdominis muscles and bilateral adductor longus tendons blend and attach to a fibrous aponeurotic plate that extends across the midline of the pubic symphysis, extending from the pubic tubercles to the anteroinferior pubic bodies, thus stabilizing the anterior pelvis.²³ The arcuate ligament, located at the inferior margin of the pubic symphysis, also contributes to the aponeurotic plate, as does the anterior pubic periosteum.²⁵

The adductor longus and pectineus have the most anterior attachments to the pubic symphysis, with the pectineus attaching superolateral to the pubic tubercle at the pubic crest (Figure 1). The remaining adductor muscles have their attachments at the pubic bones slightly more inferior and posterior to the rectus abdominis–adductor longus aponeurotic plate. The adductor brevis originates immediately posterior to the adductor longus, while the adductor magnus and gracilis originate more posterolaterally and posteromedially, respectively.⁶ Lateral and cephalad to the rectus abdominis–adductor longus aponeurosis, the external oblique muscle blends with the rectus abdominis. While multiple tendinous attachments contribute to anterior pelvic stability, the most important are the rectus abdominis and adductor longus attachments,²¹ with injury to the aponeurotic plate most commonly seen in core injuries.²⁵

MAGNETIC RESONANCE IMAGING

Falvey et al investigated the value of MRI in evaluating groin pain, demonstrating that MRI improved diagnostic posttest probability.⁹ A study by Serner et al²⁶ concluded that MRI showed good inter- and intrarater reproducibility. Not only can MRI evaluate groin pain, but it can also serve to identify pathology arising from the hip or lumbar spine, as patients often poorly localize pain.

A dedicated sports hernia MR protocol is utilized for evaluation of groin pain (Table 1). The patient is imaged supine, with initial large field of view sequences of the pelvis using the body coil. Coronal inversion recovery (IR) and axial fast spin echo (FSE) sequences are obtained to evaluate for fractures and marrow edema pattern and to assess for symmetry, respectively. A surface coil is then placed with a smaller field of view centered at the pubic symphyseal and rectus abdominis/adductor region for dedicated higher resolution imaging in the axial, sagittal, and oblique coronal planes using proton density (PD) sequences. Note the plane selection for oblique coronal imaging is parallel to the pubic bone, from the pubic crest to the ischiopubic ramus, as seen on the sagittal plane (Figure 2).

Osteitis pubis is a degenerative process of the pubic symphysis and occurs secondary to repetitive biomechanical stresses, which include repetitive shear forces and distraction injuries. It involves the pubic bones of the pubic symphysis, with findings ranging from acute to more chronic changes. Acutely, subchondral marrow edema pattern is the most salient finding on MRI and should encompass the entirety of the

Table 1. MRI protocol for athletic pubalgia

Plane/Sequence	FOV, cm	Matrix, Frequency × Phase	Slice Thickness, mm	TE, ms	TR, ms	TI, ms	Bandwidth, kHz	NEX/ETL
3 plane localizer (SS FSE)	45	320 × 160	8	80	min	—	83	—
Coronal IR FSE (pelvis)	38	256 × 192	5	17	4500	150	31	2/9-12
Axial PD FSE-XL (pelvis)	32	512 × 320	4	30	5000	—	31	2/9-12
Coronal PD FSE-XL	26	512 × 384	2	30	4000	—	31	2/9-12
Sagittal PD FSE-XL	26	512 × 352	3.5	30	4000	—	31	2/9-12
Oblique coronal PD FSE-XL	26	512 × 384	2	30	5000	—	31	2/9-12

ETL, echo train length; FOV, field of view; FSE, fast spin echo; FSE-XL, enhanced fast spin echo; IR, inversion recovery; MRI, magnetic resonance imaging; NEX, number of excitations; PD, proton density; SS FSE, single-shot fast spin echo; TE, time to echo; TI, inversion time; TR, time to repetition.



Figure 2. Plane selection for our coronal oblique image is parallel to the pubic bone in the sagittal plane.

anterior to posterior dimension of the symphysis (Figure 3a).²¹ The marrow edema should be bilateral but may be asymmetric.^{6,30} Once bone marrow edema is identified on the fat-suppressed pulse sequences, the surface coil PD sequences must be evaluated carefully to exclude other causes of symphyseal marrow edema, such as acute fractures, inflammatory arthritides, including septic arthritis, and neoplasm. Evidence of a more long-standing osteitis pubis (>6 months) includes subchondral irregularity and sclerosis along with osteophytes and resorption (Figure 3b).^{15,23} Osteitis pubis is not typically seen in isolation; other adductor or hip

pathology may be seen in conjunction.³⁰ Cunningham et al suggested that osteitis pubis is usually associated with a microtear of the adductor longus tendon attachment at the pubis.⁷ Symphyseal steroid injection under US guidance may be performed for treatment purposes; symptom relief may only be temporary, especially if the osteitis is due to instability at the joint.

The adductor tendons are frequently involved in core injuries.²⁷ Adductor longus tendinosis is a result of chronic repetitive overuse and occurs immediately distal to the rectus abdominis–adductor longus aponeurosis. MRI findings include thickening with or without hyperintense signal, particularly on the fluid-sensitive sequence, distal to the rectus abdominis–adductor longus aponeurosis and with or without hypointense foci of calcification (Figure 4). Acute injury to the adductor longus tendon can vary from a strain at the myotendinous junction to a partial-thickness or complete tear of the proximal tendon. A strain may manifest as high signal within the tendon with associated soft tissue edema. Partial-thickness tear would be identified as a focal or linear defect of the tendon filled with fluid. Acute adductor longus injury can also present as a complete tear, typically occurring immediately distal to the rectus abdominis–adductor longus aponeurosis, which often results in distal retraction of the avulsed tendon (Figure 5).

Injury to the aponeurotic plate is the most commonly identified core injury on MRI.²⁵ Tear of the aponeurotic plate manifests as a fluid-signal cleft lifting up the anterior periosteum at the pubis with additional fluid signal abnormality disrupting the tendinous insertion of either 1 or both tendons. Recently, Murphy et al²² described a “superior cleft,” which is a linear signal abnormality extending from the symphyseal cleft parallel to the inferior margin of the superior pubic ramus (Figure 6), to be representative of a tear at the rectus abdominis aponeurotic

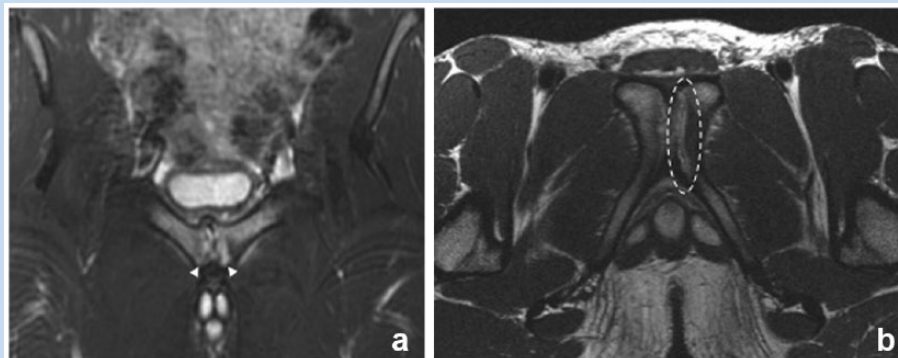


Figure 3. A 16-year-old male soccer player with left groin pain for 1 year. (a) Coronal inversion recovery image demonstrates increased signal in the left greater than right pubic bodies (arrowheads), which encompassed the entire anterior-to-posterior dimension of the symphysis, consistent with osteitis pubis. (b) Coronal oblique proton density image delineates the subchondral irregularity and subchondral bony resorption (left greater than right).

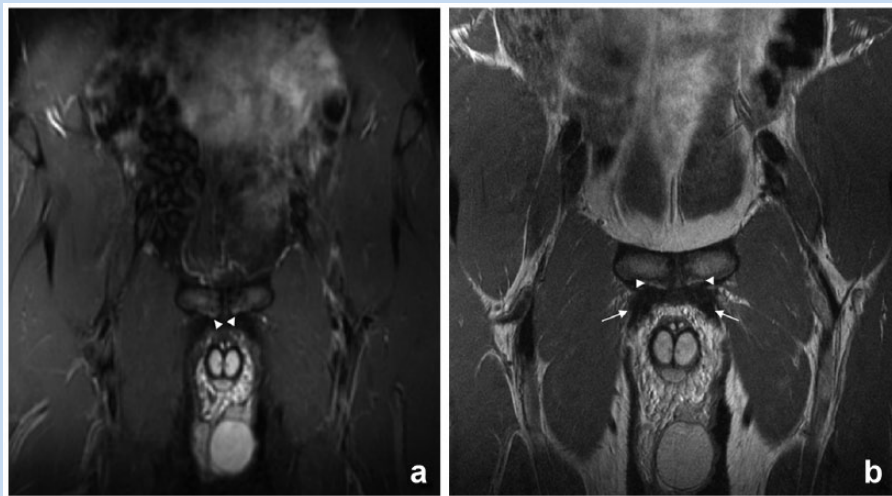


Figure 4. A 32-year-old male basketball player. (a) Coronal inversion recovery image demonstrates mild marrow edema of the pubic bones bilaterally, which, on sequential images, was noted to encompass the entire anterior-to-posterior dimension of the symphysis, consistent with osteitis pubis. (b) Coronal proton density image demonstrates thickening of and increased signal within the adductor longus tendons (arrows) and bony irregularity at the inferior aspects of both pubic bones (arrowheads), representing adductor longus tendinosis.

plate. They report that the “secondary cleft,” first described by Brennan et al,³ in which linear fluid signal extended inferiorly from the symphysis parallel to the inferior margin of the inferior pubic ramus (Figure 7),^{5,22} represents a tear of the posterior-inferior adductors, including the gracilis and adductor brevis, rather than the rectus abdominis–adductor longus aponeurotic plate. The “superior cleft” and “secondary cleft” are different from the developmental cleft that may be seen in the posterosuperior central portion of the pubic symphyseal disc³; approximately 10% of adults have this “primary cleft,” identifiable as a midline, fluid-filled cleft.²³

ULTRASOUND IMAGING

High-resolution imaging of the pubic symphysis and its attachments can be accomplished using a 12.5-MHz linear array transducer. The rectus abdominis–adductor longus aponeurosis is imaged from an anterior approach with the patient supine and the hips abducted and externally rotated. The pubic symphysis and the rectus abdominis muscles and their attachments to the pubic tubercle are imaged in both the transverse (or axial) and longitudinal (or sagittal) planes (Figures 8-10). Because the adductor longus contribution has a



Figure 5. A 45-year-old man who suffered a hockey injury 1 week prior. (a) Coronal inversion recovery and (b) proton density images demonstrate acute avulsion of the left adductor longus and brevis origins, with the tendon retracted distally (arrow) and surrounding high-signal intensity soft tissue edema.

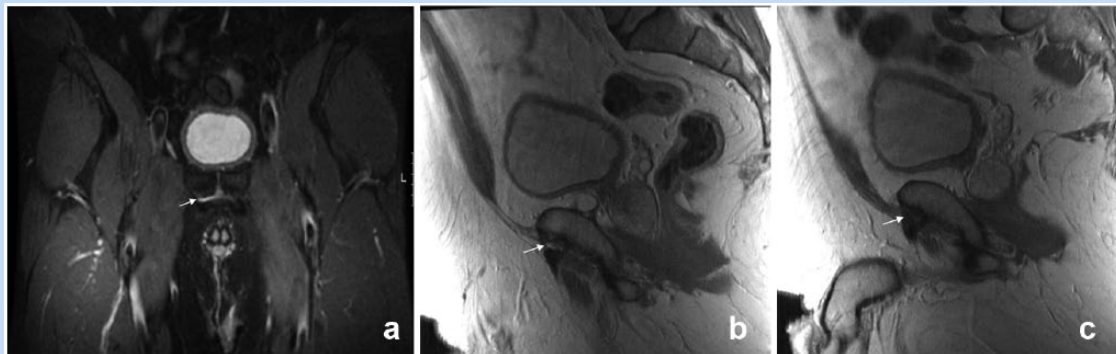


Figure 6. A 57-year-old man presenting with right groin pain. (a) Coronal inversion recovery demonstrates horizontal high signal at the inferior margin of the superior pubic ramus on the right, which extends slightly to the left of midline, consistent with a superior cleft. Sagittal proton density images to the (b) right and (c) left of midline. (b) Note the anterior location of the superior cleft (arrow) along the right superior pubic body. (c) On the comparison image of the left side, there is adductor longus tendinosis (arrow) without tearing.

more oblique orientation, the transducer is then placed in a sagittal oblique position at the inferior pubic body with the distal end of the transducer directed toward the femur (Figure 11). This orientation will produce an image of the adductor longus in the longitudinal plane; to evaluate the adductor tendon in the transverse dimension, the transducer is turned 90 degrees to the longitudinal plane. Dynamic sonographic assessment can be accomplished using the Valsalva maneuver to look for bulging of the posterior wall of the inguinal canal, as this may be associated with athletic pubalgia.^{1,24}

Findings of tendinopathy include thickening or hypoechoogenicity of the tendon as well as loss of the normal fibrillar architecture. Partial- or full-thickness discontinuity of the

tendon may be seen in cases of tendon tear and is evident when an anechoic defect is visualized.^{16,20} Figure 12 demonstrates a tear of the right adductor longus tendon with comparison to the left normal tendon. Note that as anisotropy can create the false appearance of tendinosis or tear when the tendon curves and changes fiber orientation (as can be seen at the adductor insertion onto the pubis), the “heel-toe” maneuver should be used. This maneuver involves placing pressure on the end of the transducer overlying the region of the tendon diving deep to the skin surface, thus reorienting the US beam perpendicular to the tendon area of interest and eliminating anisotropy.¹⁶ Additional sonographic findings to support a core injury include irregularity and spurring of the pubic body, pubic

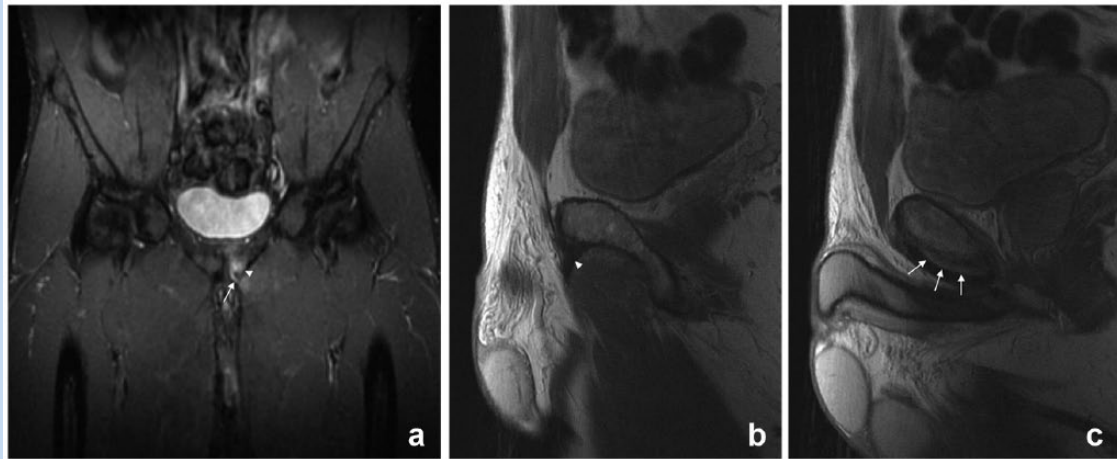


Figure 7. A 37-year-old man with left-sided groin pain 3 weeks after a lacrosse injury. (a) Secondary cleft sign (white arrow) is seen on the left, with adjacent marrow edema at the pubic tubercle (arrowhead). (b and c) Sagittal proton density images slightly lateral to midline. (b) Mild adductor longus tendinosis is evident at the aponeurotic plate (arrowhead) without tearing. (c) Note that the position of the secondary cleft (arrows) is posterior and inferior relative to where the superior cleft occurs, thus involving the adductor brevis and gracilis rather than the adductor longus.

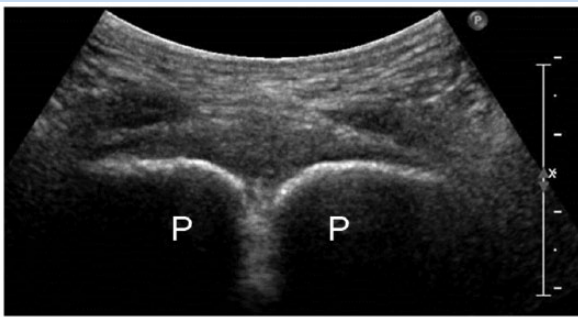


Figure 8. Ultrasound of the normal pubic symphysis in short axis, with the right and left pubic bones (P).

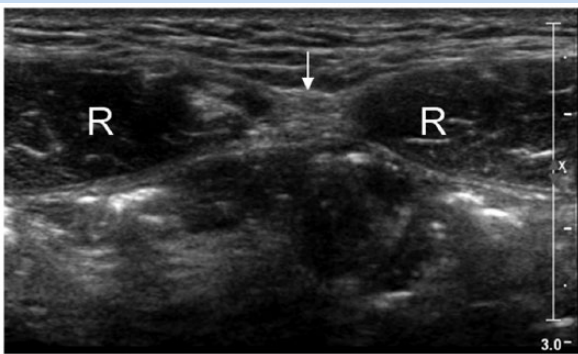


Figure 9. Ultrasound of the normal rectus abdominis muscles in short axis, with the muscle belly (R) surrounded by the rectus sheath, with the linea alba seen at the midline (arrow). The transversalis fascia runs along the posterior aspect of the rectus abdominis muscles.

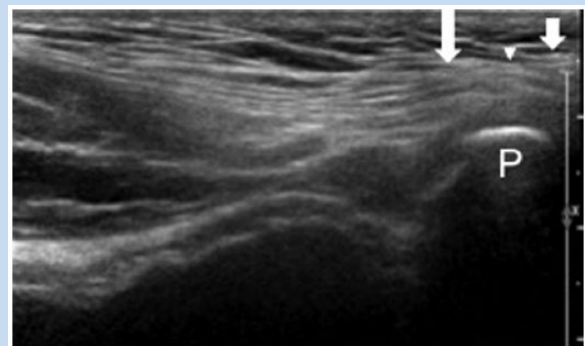


Figure 10. Ultrasound of the normal rectus abdominis attachment (arrow) to the pubis (P) in the long axis. Note the change in direction of the fibers at the aponeurotic plate (arrowhead) transition to the adductor tendon attachment (short arrow).

symphyseal effusion, or periarticular hyperemia on color Doppler.²⁰

An advantage of US over MRI is “sonopalpation”; in patients with symptoms related to a tear at the rectus abdominis–adductor longus aponeurotic plate or proximal adductors, pressure with the ultrasound transducer often reproduces the patient’s pain, thus confirming the site of injury.

ULTRASOUND-GUIDED INTERVENTION

Real-time capability and lack of radiation renders US an ideal modality for image-guided interventions. Pubic symphyseal intra-articular injection and adductor longus peritendinous

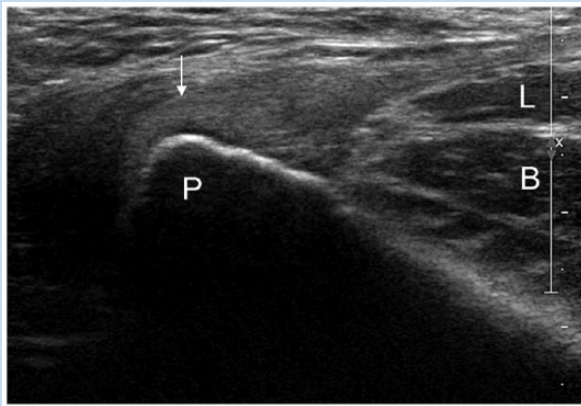


Figure 11. Ultrasound of the normal adductor tendon (arrow) insertion onto the pubic tubercle (P) in the long axis. Note the muscle bellies of the adductor longus (L) and brevis (B).

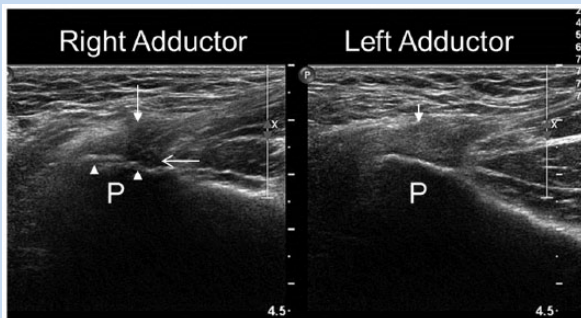


Figure 12. Long axis view of the adductor tendon insertion onto the pubic tubercle (P) in a 51-year-old man with right groin pain. Abnormal hypoechoic thickening of the right adductor tendon origin (long arrow) and focal low-grade deep surface tear (thin arrow) are evident, compared with the normal left adductor tendon insertion (short arrow). Additionally, there is osseous proliferation of the right pubis (arrowhead).

injection are the most commonly performed interventions for patients with intractable athletic pubalgia.

Pubic symphyseal injection is usually performed for osteitis pubis (Figure 13). The US probe, either a high-frequency linear transducer such as a 12-MHz probe or a “hockey stick” probe, is placed immediately cephalad to the base of the penis (in men) and the needle is advanced either in-plane (Figure 14a) or out-of-plane (Figure 14b) to the probe. A 1.5-inch, 25-gauge needle usually suffices in reaching the symphysis, and a combination of anesthetic and cortisone is injected into the symphysis. If the fibrocartilaginous articular disc is relatively intact, one may not be able to inject any volume of medication; even in those with a degenerated articular disc, one can

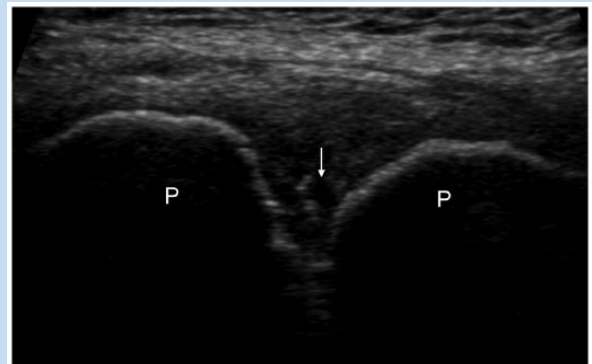


Figure 13. Ultrasound image of the pubic symphysis in short axis in a 37-year-old woman before pubic symphysis injection shows a focal linear hypoechoic cleft slightly to the left of midline (arrow) representing an ultrasound-correlate of a primary cleft sign. P, pubic bones.

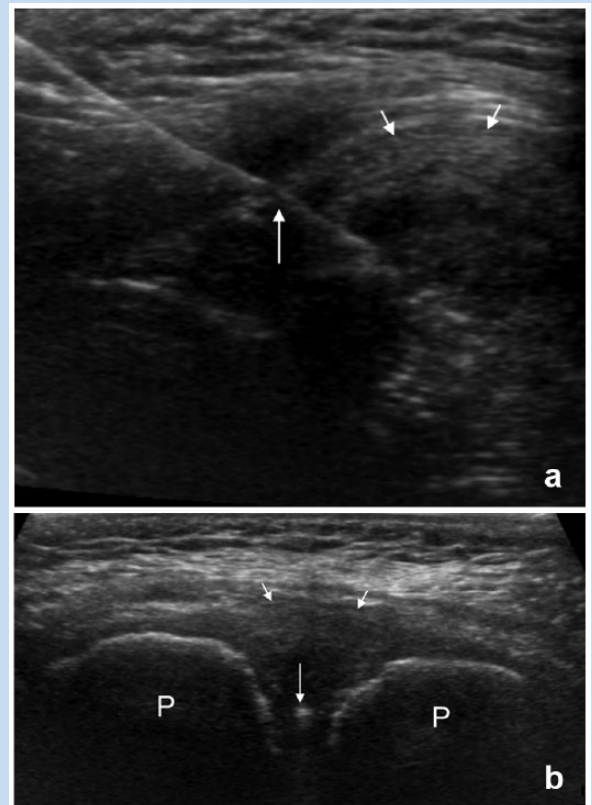


Figure 14. Ultrasound images of a 37-year-old woman during pubic symphysis injection (a) long axis and (b) short axis to the trajectory of the needle (long arrows) at the level of the articular disc. The needle is being advanced from cranial to caudal, with the tip in the symphysis between the 2 pubic bones (P). The anterior public ligament (short arrows) is clearly demonstrated anteriorly.

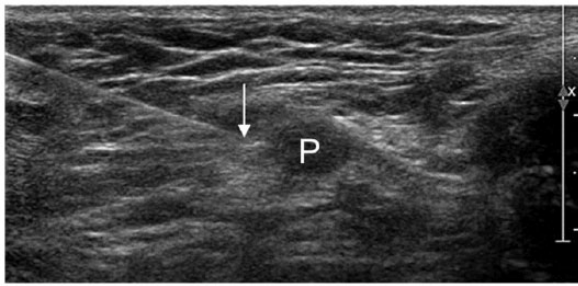


Figure 15. A 35-year-old man with right groin pain during ultrasound-guided injection of the right adductor tendon origin. The needle is advanced from the lateral to medial direction. The needle tip (arrow) is along the superficial edge of the adductor longus tendon insertion seen in short axis at the pubic tubercle (P).

typically only inject a small volume of medication (<0.5 mL) before the patient begins to feel discomfort.

For a peritendinous adductor injection, a sagittal oblique positioning of the transducer is used to image the adductor tendon in longitudinal axis (Figure 15). The target for the peritendinous injection depends on the location of the pathology but is typically at the origin off the pubic tubercle. Alternatively, if sonographic evaluation detects a more distal site of tendon pathology, this area can be targeted. Via this approach, the long-axis of the needle can be visualized in-plane with the transducer and the adductor tendon. Neurovascular structures should be identified and avoided, with color Doppler aiding in the visualization of vascular structures.

CONCLUSION

MRI and US are valuable in diagnosing pathology in athletes presenting with groin pain. MRI is sensitive in diagnosing pathology in groin pain, with injuries to the adductor tendon attachment to the pubic tubercle most commonly identified. Not only can MRI be used to image rectus abdominis/adductor longus aponeurosis and pubic bone pathology, it can also identify hip or inguinal canal abnormalities. Real-time capability of US makes it useful in evaluating the pubic symphyseal region, with the added utility of interventional treatment under US guidance.

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