Imaging of Groin Pain

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KEYWORDS

• Groin • MR imaging • Athletic pubalgia
• Tendon • Ligament

Groin pain is typically an overuse injury due to excessive athletic activity, accounting for approximately 2% to 18% of all sports injuries.[1–3] A study of soccer players in 1999 demonstrated that 8% of players had an episode of groin pain over a 1-year period.[4] A report from 1974 found that nearly two-thirds of soccer players had a history of groin injury during their careers.[5] Indeed, any sport that is associated with rapid changes in speed and direction, or kicking activity in particular, has higher rates of groin injury. Such sports include ice hockey, American football, Australian Rules football, fencing, track and field events, and soccer.[6–8]

Even though injuries to the groin are relatively common, it can be a diagnostic challenge to elucidate the etiology. Patients typically complain of pain over the prepubic, inguinal, and proximal adductor regions that may be referred to the scrotum and perineum.[9] Tenderness on physical examination commonly localizes to the pubic symphysis, pubic tubercle, mid-inguinal region, or adductor longus insertion. In addition, there may be pain on resisted adduction of the hips.[10] Although groin injuries may be acute, they typically have an insidious onset over weeks to months.

The underlying processes that lead to a groin injury are complicated, varied, and incompletely understood. The commonest reported potential causes of overuse injuries of the groin are listed in **Box 1**. Perhaps not surprisingly, there are numerous treatment options for patients with groin pain, ranging from conservative to invasive. Due to the difficulty in obtaining an accurate diagnosis, patient management and outcomes have historically been unpredictable.[8,11,12]

In clinical practice, the term ''athletic pubalgia'' is a general term used to describe exertional pubic or groin pain.[13] Most investigators have concluded that the commonest causes of groin pain are adductor longus injury, common adductor-rectus abdominis dysfunction, osteitis pubis, and sportsman's hernia.[9,14–16] This article reviews the anatomy, etiology, and imaging appearances of the commonest causes of athletic pubalgia.

ANATOMY

The pubic symphysis is composed of the paired pubic bones and the intervening fibrocartilaginous articular disc.[17] The medial articular surface of the pubis is grooved and lined by hyaline cartilage. It is thought that the ridged nature of the pubis protects the joint from shear forces.[9] The main function of the fibrocartilaginous disc is to absorb and dissipate axial and shear forces experienced at the pubic symphysis.[18] A thin physiologic cleft (also called the primary cleft) can be located superiorly within the fibrocartilaginous disc (**Fig. 1**).[19] The pubic tubercle arises from the lateral aspect of the pubic crest, a bony projection over the anterior surface of the pubic body. The pubic symphysis does not have a true joint capsule, as the joint does not have a synovial lining.[9,20,21] Surrounding ligaments and tendons provide the majority of the soft tissue support. A thin superior

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Box 1
Common causes of groin pain

- Adductor dysfunction
- Rectus abdominis Injury
- Osteitis pubis
- Sportsman's hernia
- Stress fracture
- Muscle contusion
- Apophysitis
- Nerve entrapment syndromes
- Referred pain
  - from hip
  - from spine (including sacroiliac joint)

pubic ligament bridges the pubic tubercles, which is partly formed from posterior rectus abdominis muscle fascia. The arcuate (inferior pubic) ligament is an important stabilizing structure that forms a strong fibrous arch along the inferior margin of the symphyseal joint. The arcuate ligament blends with the subjacent fibrocartilage disc.[9] A thin anterior pubic ligament also attaches to the underlying articular disc and blends with interconnecting connective tissue anteriorly formed from tendons and ligaments (see **Fig. 1**).

The rectus abdominis muscle acts as a stabilizer of the anterior abdominal wall, originating lateral to the pubic symphysis along the pubic crest. The adductor longus tendon acts to allow thigh adduction and to stabilize the anterior pelvis during the swing phase of the gait.[22] The adductor longus originates just inferior and in line with the rectus abdominis origin along the most anterior aspect of the pubis and just inferior to the pubic crest. The adductor longus tendon is usually entirely tendinous anteriorly, with an accessory muscular origin posterolaterally in 25% of patients.[17,22] The rectus abdominis and adductor longus muscles are antagonists during rotation and extension of the waist. Of note, the origins of the rectus abdominis and the adductor longus tendons merge anterior to the pubis to form a common structure that is firmly adherent to the prepubic surface.[9,23] The adjacent gracilis and adductor brevis tendons are variably fused with each other and adductor longus as they arise from the inferior pubic body, anterior pubic ligament, and arcuate ligament.[24] Further to this, the rectus abdominis muscle and sheath extends across the anterior pubic surface to interdigitate with the tendon fibers that give origin to the adductor muscle compartment, resulting in the formation of a common adductor-rectus abdominis origin. The obturator externus muscle arises from the anterior surface of the pubis and external surface of the obturator membrane, and can act as an adductor of the hip in addition to causing external rotation. This muscle can therefore be reliably distinguished from the other adductor muscles as the structure arising anterior to the obturator foramen and adjacent portions of the pubic bone.

An anatomic reference book from 1904 refers to interlacing fibers anterior to the pubic symphysis composed predominately of the rectus abdominis and external oblique tendons.[25] Reference is also made to how this tissue is composed of tendons from the "superficial adductors of the thigh." There are additional elements contributing to this prepubic tissue. An infolding of the inferior margin of the external oblique aponeurosis forms the inguinal ligament. Recent cadaveric study has demonstrated that, similar to other apes, humans have a continuation of the inguinal ligament into the lateral aspect of this prepubic connective tissue.[26] In addition, the medial aspect of the external oblique aponeurosis splits in two to form the superficial inguinal ring, the medial crus of

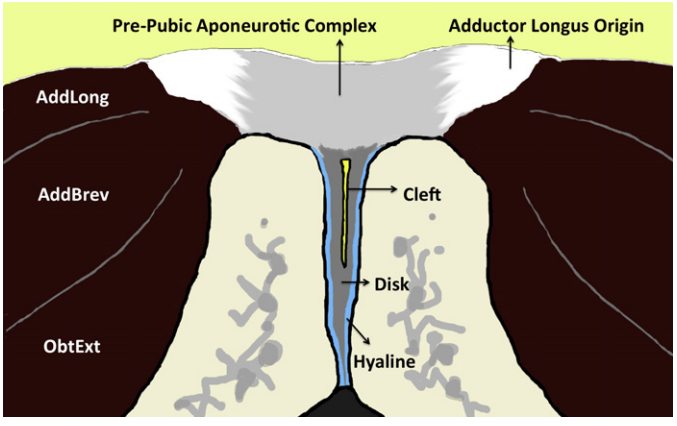

Fig. 1. An axial section through the pubic symphysis below the level of the pubic crest, demonstrating the adductor origin from the prepubic aponeurotic complex (P-PAC). The P-PAC is continuous with the underlying fibrocartilage of the symphysis. AddLong, adductor longus muscle; AddBrev, adductor brevis muscle; ObtExt, obturator externus muscle.

which inserts adjacent to the pubic tubercle and merges with prepubic connective tissue.[25] It has been traditionally taught that the conjoint tendon forms the roof and medial third of the posterior wall of the inguinal canal and inserts onto the pubic crest. Recent research, however, has demonstrated that the concept of a ''conjoint'' tendon is a rare entity during fresh dissection.[27] The internal oblique and transversus abdominis aponeuroses (which form the posterior wall of the inguinal canal) are typically not conjoined as they insert onto the pubis, but are in fact only closely apposed. It is believed that in previous studies using formalin-preserved cadavers, the two aponeuroses dehydrated and resulted in tissue toughening, thereby producing an apparent conjoint tendon.[27] Further to this, during fresh dissection the most common finding is that the internal oblique and transversus abdominis aponeuroses (the so-called conjoint tendon) actually insert onto the anterior sheath of the lateral aspect of the rectus abdominis, above the pubic crest, with an insertion onto the pubic crest being a rare finding. Hence, the structures that compose the posterior wall of the inguinal canal are reliant on the origin of the rectus abdominis for their integrity. The transversus abdominis and internal oblique muscles also contribute to pubic symphysis stability by increasing apposition of the pubic bodies during gait.[28] Sagittal cross-sectional anatomic studies along the axis of the rectus sheath and adductor tendons have demonstrated a condensation of triangular fibrocartilage inferior to the pubic crest, which likely acts as the main anchor point for the overlying connective tissue and its components (the adductor longus in particular). This condensation of fibrocartilaginous tissue is continuous with the underlying periosteum, anterior pubic ligament, and articular disc.[23] Indeed, it is difficult to define and separate the fibrocartilage disc as an entity distinct from the overlying connective tissue.[19]

In summary, the anterior aspect of the pubis acts as a common origin for important muscular structures around the pubic symphysis. Tissue in this prepubic region not only interconnects the adductor tendons and rectus abdominis, but also integrates with the parasymphyseal support ligaments and elements of the inguinal canal. In addition, there appears to be a fibrocartilaginous component to this prepubic tissue continuous with the articular disc. This complex structure acts as a central anchor point, and is formed by interconnecting fibers of the adductors, rectus abdominis, external oblique, inguinal ligament, anterior pubic ligament, arcuate ligament, and fibrocartilaginous disc, and will be referred to as the prepubic aponeurotic complex (P-PAC) (see

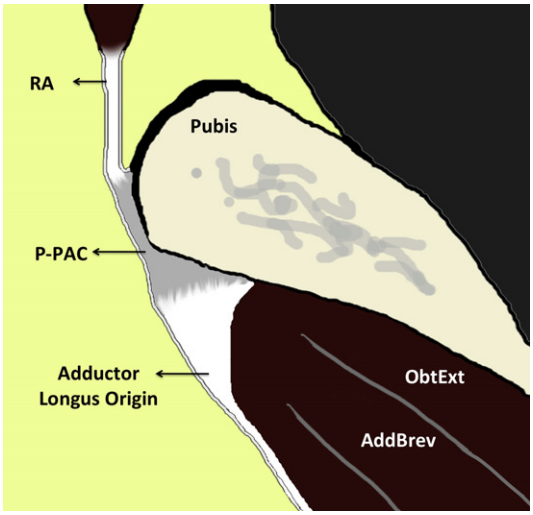

Fig. 2. A sagittal section through the pubis lateral to the symphysis. This schema demonstrates that the rectus abdominis (RA) and adductors are continuous anterior to the pubis through the prepubic aponeurotic complex (P-PAC). AddBrev, adductor brevis muscle; ObtExt, obturator externus muscle.

Figs. 1–3). This complex is crucial to the understanding of the mechanism of groin injuries and thus formulating an accurate diagnosis. For example, proximal adductor tendon injuries involving the P-PAC are an important cause of

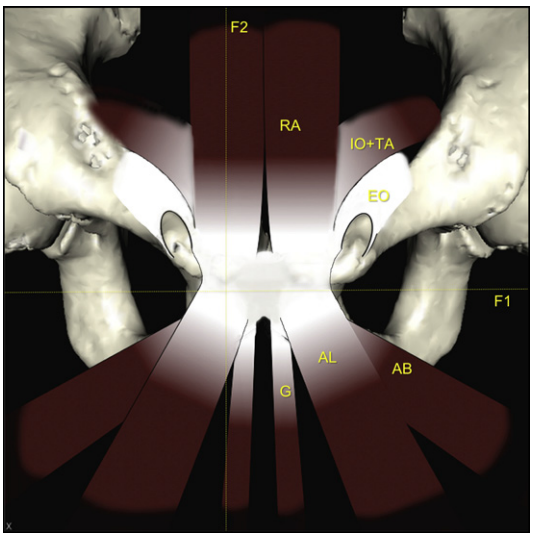

Fig. 3. A coronal view of the anterior pubis. This schema demonstrates the major components of the prepubic aponeurotic complex located over the anterior pubis bilaterally. The dotted lines represent the level of Fig. 1 (F1) and Fig. 2 (F2). RA, rectus abdominis; IO+TA, internal oblique and transversus abdominis; EO, external oblique aponeurosis forming superficial inguinal ring; AL, adductor longus; AB, abductor brevis; G, gracilis.

groin pain. The anatomic relationships suggest that a shear or avulsion injury to the P-PAC could potentially result in chronic microavulsion of the attachment of the inguinal ligament medially, and additionally weaken the common attachment of the transversus abdominis/internal oblique/rectus abdominis at the pubic crest, thus producing symptoms referable to the inguinal region. As this results in pain in the inguinal region (despite the lack of discrete hernia formation), athletes presenting with pain in this region likely represent the clinical entity previously referred to as the ''sportsman's hernia.''

Of note, as each ligamentous or tendinous component is connected with each other on the same and contralateral side through the P-PAC, injury of one of its components may cause pubic symphysis instability and also difficulty in localizing symptoms, hence causing diagnostic confusion from a clinical perspective. The complex interrelated anatomy of this anatomic area has led to the use of confusing diagnoses and terminology when describing the causes of groin pain, which are almost certain to be linked pathophysiologically.

ETIOLOGY OF GROIN PAIN

A catch-all term for all the causes of groin pain is ''athletic pubalgia.''[9] This term is the preferred label referring to a spectrum of musculoskeletal injuries that occur in and around the pubic symphysis and that share similar mechanisms of injury and common clinical manifestations.[9] The literature supports that the commonest causes of athletic pubalgia originate from the muscles and tendons of the adductor group and rectus abdominis, pubic symphysis (osteitis pubis), and inguinal wall.[1,9,17]

Groin pain in athletes can be acute (secondary to a single event), chronic (secondary to altered biomechanical load and repetitive microtrauma), or a combination of the two. It can be postulated that an injury to a structure inserting into the P-PAC (typically adductor longus or rectus abdominis) may secondarily affect the remaining structures that rely on the aponeurotic complex for their integrity.

COMMON ADDUCTOR-RECTUS ABDOMINIS INJURY

Although there are many causes of athletic pubalgia described, most investigators conclude that the commonest cause of groin pain in athletes is adductor dysfunction, as this is the strongest muscle group acting on the pubic symphysis.[29,30] Although the exact frequency of injury to specific structures around the pubic symphysis will be sport specific, injury to the adductor longus is consistently the commonest, especially in soccer players.[29] The prevalence of adductor dysfunction ranges from 44% to 60% in published series.[8,31,32] There are several risk factors for adductor injury, including a history of strain and low levels of sport-specific preseason training.[33] The hip adductors include the adductor longus, adductor brevis, adductor magnus, pectineus, and the gracilis (the obturator externus is occasionally included in this group). The pectineus muscle arises from the

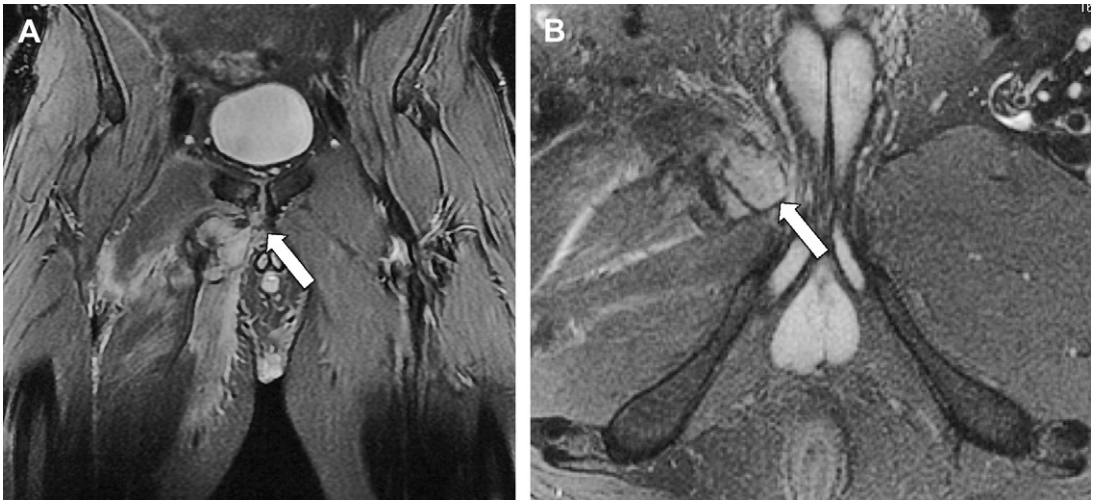

Fig. 4. (*A*) Coronal fat-saturated T2-weighted MR image. Large acute proximal right adductor longus origin tear with hematoma formation, edema, and distal retraction of the tendon (*arrow*). This condition is potentially disruptive for the prepubic aponeurotic complex. (*B*) Axial fat-saturated T2 MR image demonstrating a hematoma and retracted adductor longus tendon (*arrow*).

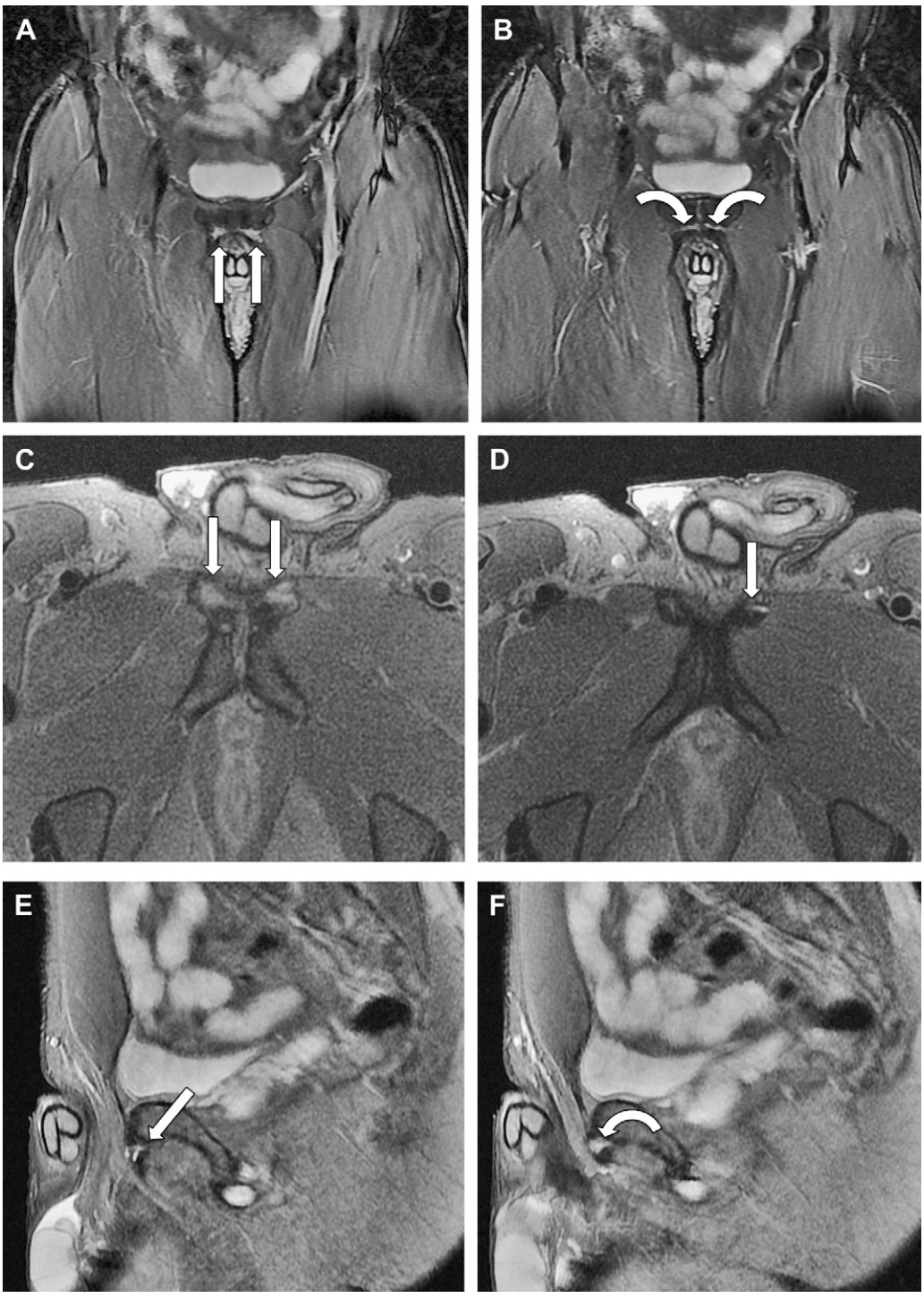

Fig. 5. (*A*) Coronal fat-saturated T2-weighted MR image. Bilateral severe adductor longus origin tendinosis (*arrows*). (*B*) Coronal fat-saturated T2-weighted MR image. Bilateral secondary clefts extending from the pubic symphysis into the adductor attachments, indicating some disruption of the prepubic aponeurotic complex tissue (*curved arrows*). (*C*) Axial fat-saturated T2-weighted MR image demonstrating bilateral adductor longus tendinosis (*arrows*). (*D*) 3D Axial fat-saturated T2-weighted MR image. Small tear of the left adductor longus tendon (*arrow*). (*E*) Sagittal fat-saturated T2-weighted MR image. Small tears of the origin of the left adductor longus tendon (*arrow*) (*F*) Sagittal fat-saturated T2-weighted MR image. This image demonstrates more severe adductor longus tendinosis that involves the prepubic aponeurotic complex (*curved arrow*).

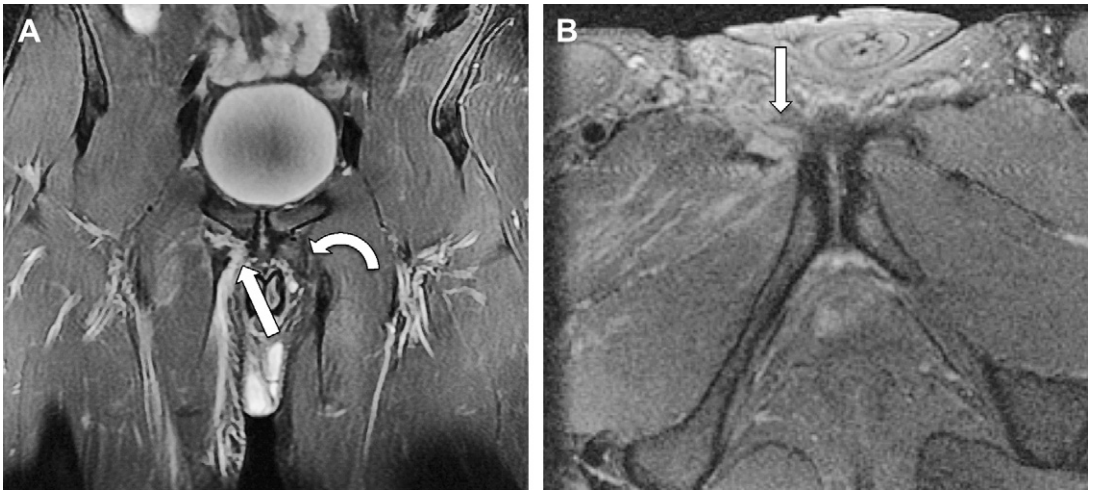

Fig. 6. (*A*) Coronal fat-saturated T2-weighted MR image. Hyperintense signal abnormality at the origin of the right adductor longus tendon (*straight arrow*) consistent with an acute tear. Chronic tear of left adductor longus as evidenced by thickening and hypointensity with retraction of the tendon and healing with scar formation (*curved arrow*). (*B*) Axial fat-saturated T2-weighted MR image demonstrating acute right adductor longus tear (*arrow*).

superior pubic ramus just lateral to the pubic tubercle. The adductor magnus arises from the inferior pubic ramus and ischial tuberosity. The remainder (gracilis, adductor longus, and adductor brevis) arise from a small area of the anterior aspect of the pubis (see **Fig. 3**). The adductor muscles insert on the posteromedial aspect of the femur (linea aspera), with the adductor magnus having the largest area of insertion.

Patients with adductor origin injury typically present with groin pain, exacerbated by exercise and kicking. Clinical examination may reveal local muscle tenderness or tenderness over the pubic symphysis, exacerbated by resisted adduction of the thighs. As the adductor longus muscle is the most frequently injured muscle, inflammatory change in the parasymphyseal bone (osteitis pubis) may coexist. Radiographs are generally normal; however, enthesopathy, ill definition of cortical bone at the tendon origin, sometimes is visible. Ongoing healing with repeated injury can lead to a mixed sclerotic-lytic appearance in severe cases (which is separate to osteitis pubis, discussed later). Sonography can also be used to diagnose tendinosis of the adductor longus distal to its origin. Tendinosis manifest as hypoechogenicity to the tendon, with tendon expansion seen in more severe injuries. With careful sonographic examination, a partial-thickness or full-thickness tear can be visualized.[34] A rectus abdominis injury at its origin from the pubic symphysis is also described as a source of pubic pain in athletes, with similar clinical and physical findings seen in adductor origin injury.[30] As Gibbon[31] described in 1999, a common adductor-rectus abdominis (CA-RA) origin exists as an anatomic and functional unit anterior to the pubis. This unit has been referred to as an aponeurosis by many investigators[9,23,29] and is the main contributor to the P-PAC described.

Magnetic resonance (MR) imaging is the modality of choice in the depiction of adductor tendon, rectus abdominis tendon, and aponeurotic complex injuries (**Fig. 4**). Fat-saturated fluid-sensitive MR sequences in the axial oblique plain will best demonstrate acute or chronic adductor muscle injuries and coronal sequences are ideal for the detection of the ''secondary cleft'' sign adjacent to the pubic symphysis (**Fig. 5**). The secondary cleft sign is manifest as extension of fluid-bright signal external to the pubic symphysis to one or both sides (the side of extension has been shown to correlate with symptoms) and is continuous with the primary intra-articular cleft.[18] The exact anatomy of this sign has yet to be formally elucidated, but it likely represents a tear or partial avulsion of the adductor longus origin where it gains origin from the P-PAC. The aponeurotic injury likely extends into the underlying fibrocartilage disc, disrupting the integrity of the anterior aspect of the physiologic cleft (if present). In this circumstance, symphyseal cleft injection can demonstrate extension of contrast from the physiologic cleft into the secondary cleft.[18] Tendinosis manifests as ill-defined increased signal on T2-weighted imaging, with partial thickness tears manifesting as focal areas of T2 hyperintensity similar to fluid signal. Gadolinium enhancement, if used, has been shown to correlate with the symptomatic side.[35] Muscular strains most

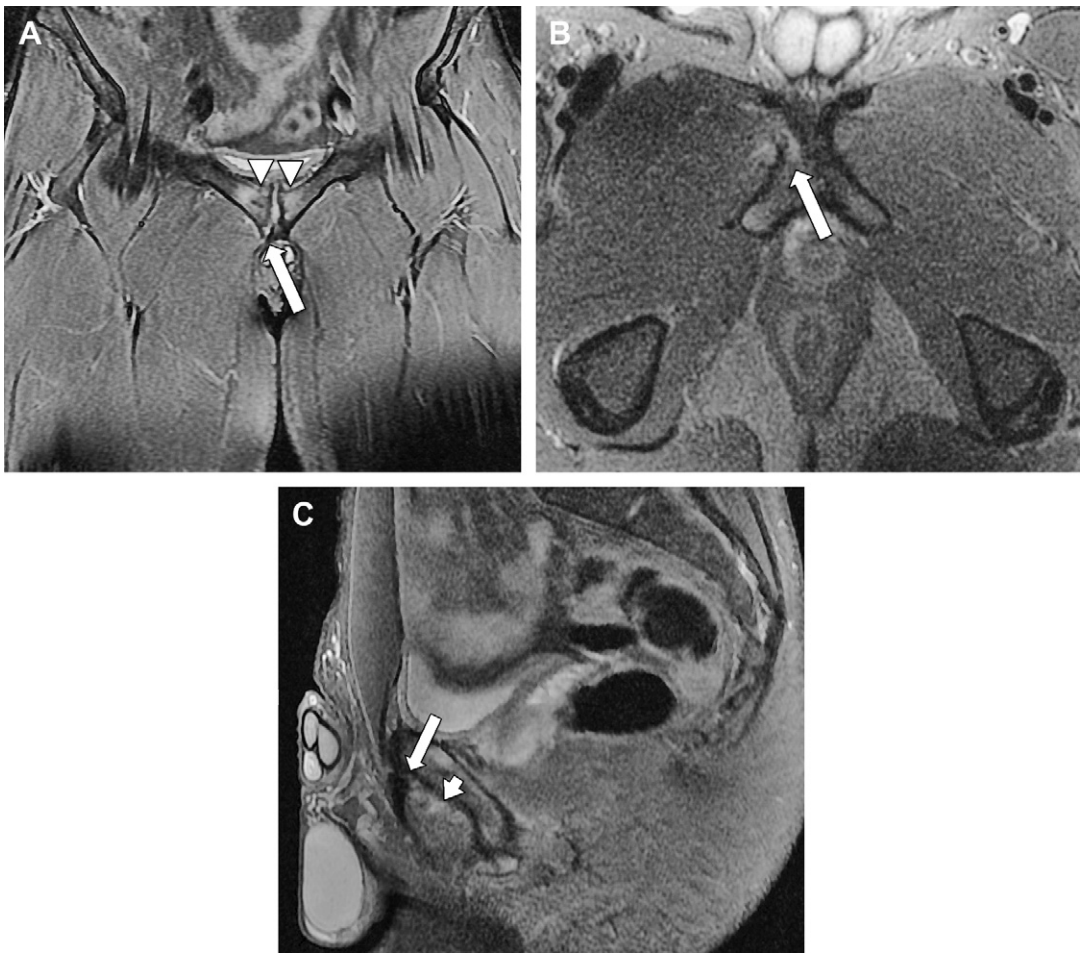

Fig. 7. (*A*) Coronal fat-saturated T2-weighted MR image. Bilateral osteitis pubis, right worse than left, characterized by bone marrow hyperintensity (*arrowheads*),with microtearing along the medial right obturator externus attachment and disruption of the prepubic aponeurotic complex causing secondary cleft formation (*straight arrow*). (*B*) Axial fat-saturated T2-weighted MR image demonstrating microtearing of the right obturator externus attachment posterior to adductor longus with secondary bony stress reaction (*arrow*). (*C*) Sagittal fat-saturated T2-weighted MR image. Edema and microtearing of the origin of the obturator externus (*short arrow*) posterior to adductor longus and brevis, extending posterior to the adductor longus origin from the prepubic aponeurotic complex (*long arrow*).

commonly occur at the musculotendinous junction of the adductor longus, normally anteriorly. In severe injury, a retracted tendon secondary to a full-thickness tear can be visualized on MR imaging (**Fig. 6**).

As the P-PAC is essentially a common origin for the adductors and the rectus abdominis, significant injury at the adductor origin, with disruption of the aponeurotic complex, frequently extends to the origin of the rectus abdominis that may be apparent on imaging. The reverse is also possible, with a primary rectus abdominis injury causing disruption of the complex.[30] In addition, it can be seen how injury to the complex can affect adjacent structures causing symptoms to be referred to the inguinal region.

Nonoperative management is the rule in adductor strain, with surgical intervention used in the acute setting for reattachment of full-thickness avulsion injuries. In the context of chronic groin pain, adductor tenotomy can be performed, with surgical excision of granulation tissue.[6,36]

OSTEITIS PUBIS

Osteitis pubis is a painful condition affecting the pubic symphysis that likely represents an inflammatory response, secondary to altered biomechanics, and loading at the symphysis. Osteitis pubis is most frequently seen in athletes involved in kicking sports, such as soccer and Australian Rules football. Osteitis pubis can occur in isolation;

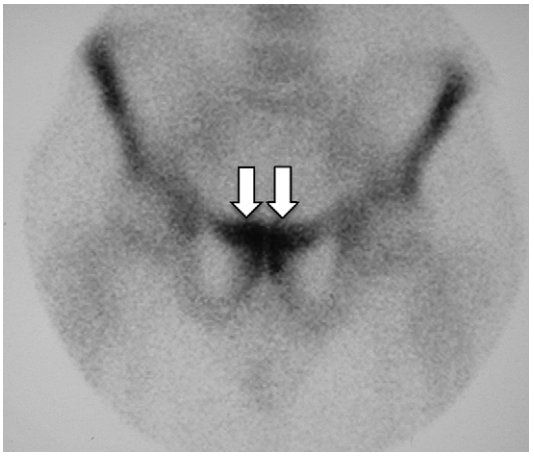

Fig. 8. Isotope bone scan shows concentration of radiotracer activity at the symphysis pubis in a patient with increased marginal osteoblastic activity in a 27-year-old soccer player with osteitis pubis (*arrows*).

however, it is commonly associated with other pathologic entities around the pubic symphysis such as adductor and rectus abdominis injuries (**Fig. 7**).[18,29,30] Patients typically complain of pain localized to the symphysis, radiating to the medial thigh, lower abdomen, and perineum. The pain is exacerbated by exercise, kicking, and running.

Imaging appearances were first described on plain radiography as irregularity of the subchondral bone, erosions, and fragmentation with areas of mixed sclerosis and lysis. If very severe there may be widening of the symphysis. A craniocaudal discrepancy of inferior pubic margins on stress radiography is diagnostic of symphyseal instability. Radioisotope bone scans show increased uptake of radiotracer about the pubic symphysis (**Fig. 8**).[37] Hyperintense signal change on fluid-sensitive sequences in the bone marrow adjacent to the symphysis on MR imaging are presumed to represent bone marrow edema and the earliest manifestation of osteitis pubis. As has been mentioned, the pubic symphysis is intimately connected with the prepubic aponeurotic complex that acts as the origin for many structures around the symphysis. Chronic repetitive injury of a component of the aponeurotic complex may lead to instability at the pubic symphysis and a stress response, with resultant edema in the parasymphyseal subchondral bone. If the bone edema is preferentially unilateral, this likely reflects direct traction effects from a more focal injury. Of note, osteitis pubis with bone marrow edema is usually seen in symptomatic patients and predicts preseason training restriction.[16,29]

MR imaging reveals parasymphyseal hyperintensity on fluid-sensitive sequences, presumably reflecting edema due to increased stress response and areas of trabecular microtrauma.[38] Histologic sampling of these T2 hyperintense parasymphyseal regions has demonstrated new woven bone formation consistent with a bone stress response.[39] T1-weighted images can show widening of the symphyseal cleft in chronic cases. If stress fractures are also present, these are often manifest as vertically oriented subchondral areas of T1 hypointensity adjacent to the pubic symphysis. Nonsurgical management includes rest, oral anti-inflammatory medications, physical rehabilitation, and image-guided injection of corticosteroid and local anesthetic directly into the joint.[40,41] Surgical management includes curettage, and in the setting of instability arthrodesis may be performed to stabilize the pelvis. Wedge resection of the pubic symphysis is rarely performed in cases that are refractory to nonoperative measures, as this can be eventually complicated by pelvic instability.

SPORTSMAN'S HERNIA

This condition has confusing clinical findings and historically varying terminology. Sportsman's hernia is interchangeably referred to as a sportsman's hernia, prehernia complex, conjoint tendon tear, Gilmore groin, external oblique tear, and inguinal wall deficiency.[1,17,18,30] The symptoms of a sportsman's hernia can generally be described as pain referable to the medial inguinal area without evidence of a typical hernia on physical examination, usually experienced by athletes.[42,43] The P-PAC is possibly a unifying

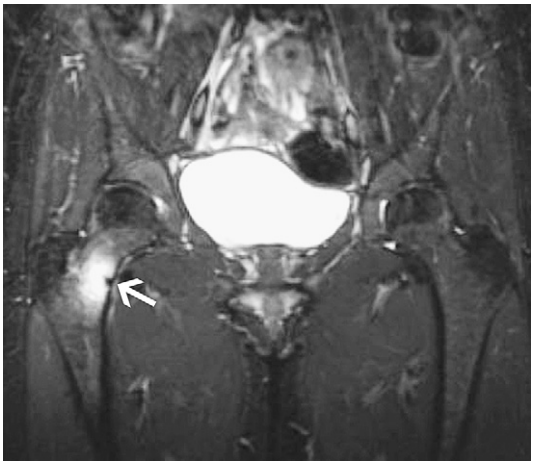

Fig. 9. Coronal fat-saturated T2-weighted image in a 30-year-old female runner shows bone marrow hyperintensity consistent with edema, which surrounds a hypointense line at the inferior aspect of the right femoral neck (*arrow*) compatible with a stress fracture.

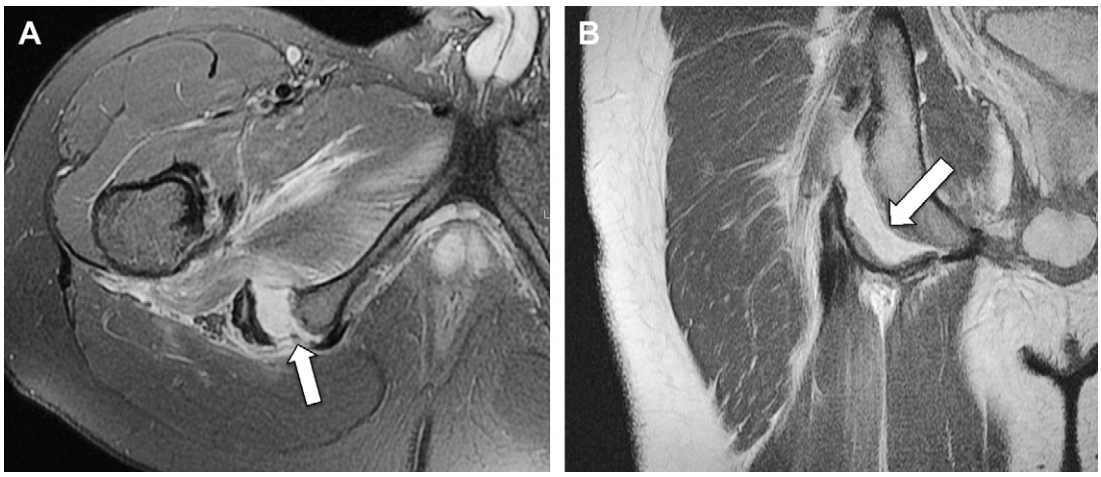

Fig. 10. (*A*) Axial fat-saturated T2-weighted MR image of a 12-year-old patient shows an avulsion at the attachment of the hamstring to the ischial apophysis on the right (*arrow*). (*B*) Coronal T1-weighted image of same patient demonstrating the hamstring avulsion injury (*arrow*).

structure to explain many presentations of this condition, as it is a common anchor for the structures of the posteromedial inguinal canal (internal oblique and transversus abdominis via the rectus sheath); for the medial crus of the superficial inguinal ring; for the most medial aspect of the inguinal ligament itself; and for the main stressors around the pubis (adductors and rectus abdominis) (see **Fig. 3**). An adductor longus or rectus abdominis injury involving the aponeurotic complex may thus affect the structures of the inguinal canal. Depending on the anatomic component and the severity of the injury (from strain to tear), symptoms may range from mild tenderness without palpable protrusion of the inguinal wall, to severe tenderness and palpable protrusion with possible discrete hernia formation.

Gilmore groin is classically described as tenderness over the superficial inguinal ring, with evidence of dilation of the superficial inguinal ring on clinical examination.[44] The pathologic process thus likely relates to the medial attachments of the external abdominis aponeurosis, which is a component of the P-PAC. Whereas the majority of patients cannot localize their symptoms precisely, approximately 40% of patients are found to have concomitant tenderness in the adductor region.[45] Of note, patients can respond to a hernia repair but others experience little or no improvement in their groin pain or develop recurrent symptoms at follow-up.[9,46] Another specific entity in the sportsman's hernia group is posterior inguinal wall deficiency, which has been attributed to an injury of the conjoint tendon. As described earlier, the classic description of the conjoint tendon is not a common finding at cadaveric dissection. The tendon actually merges with the anterolateral aspect of the rectus abdominis sheath as opposed to inserting onto the pubic crest. This entity of posterior inguinal wall deficiency thus likely relates to an injury at the lateral attachment of the rectus abdominis, possibly secondary to disruption of the P-PAC, which weakens the internal oblique and transversus abdominis components of the inguinal canal. Incompetence of the posterior inguinal canal can be diagnosed with dynamic sonography by demonstrating anterior bulging of the posterior wall on straining.[47]

The sportsman hernia is thus a nonspecific entity that can have variable symptoms and signs. Though this term may be used by clinicians interchangeably with other terms such as athletic pubalgia, it is the authors' opinion that this term not be used as a diagnosis when formulating a radiological report. As MR imaging can reliably identified precisely where an injury has occurred, it is best that the site and extent of injury is

Fig. 11. Axial post contrast computed tomography image shows a distended iliopsoas bursa on the left (*arrow*), anterior to the left hip.

Fig. 12. Direct MRA of the right hip in a 24-year-old gymnast with hip pain. This coronal image shows direct contrast imbibement (*arrow*), into a surgically confirmed hip labral tear.

described, as well as whether any other structures are involved. As groin injuries are commonly secondary to injury of the main muscular attachments at the pubis, these injuries may variably extend to affect the medial inguinal canal components through the P-PAC.

OTHER CAUSES OF GROIN PAIN

As can be seen from **Box 1**, there are several potential causes that may be attributable to an overuse injury to the groin. Stress fractures in athletes mostly occur about the pubic symphysis and proximal femur (**Fig. 9**). Stress fractures are either fatigue (occurring as a result of abnormal stress on normal bone) or insufficiency (as a result of normal stress on abnormal bone). In general, the term stress fracture is used to describe fatigue fractures rather than insufficiency, and although they occur as a result of chronic stress, they often present as an acute fracture to a site previously weakened over time. There are several pubic region apophyses that can be injured by repetitive muscular contractions in a skeletally immature individual, typically between the ages of 12 and 22 years. Apophysitis may cause athletic pubalgia symptoms (**Fig. 10**).[48] Other conditions that should be considered include muscle contusions and nerve entrapment syndromes. Entrapment of any of the numerous nerves that innervate the groin region can cause a nerve entrapment syndrome (obturator, femoral, genitofemoral, and ilioinguinal nerves). For example, patients with obturator nerve entrapment can present with pain near the adductor origin. Entrapment of the ilioinguinal nerve can cause symptoms similar to athletic pubalgia if it is compressed in the inguinal canal. Findings of muscle denervation-related edema may suggest the diagnosis on MR imaging.[9] Iliopsoas bursitis is an inflammatory condition seen in athletes, secondary to overuse with repetitive hip flexion and extension.[49] The condition causes groin pain in gymnasts, dancers, and runners. On rare occasions patients will present with a groin mass secondary to gross bursal distension (**Fig. 11**). Iliopsoas bursitis can also be seen in association with inflammatory arthropathies, and concomitant exclusion of these conditions may be warranted. MR imaging is the investigation of choice for this condition, as it will more accurately define the size and extent of the distended bursa and also allows

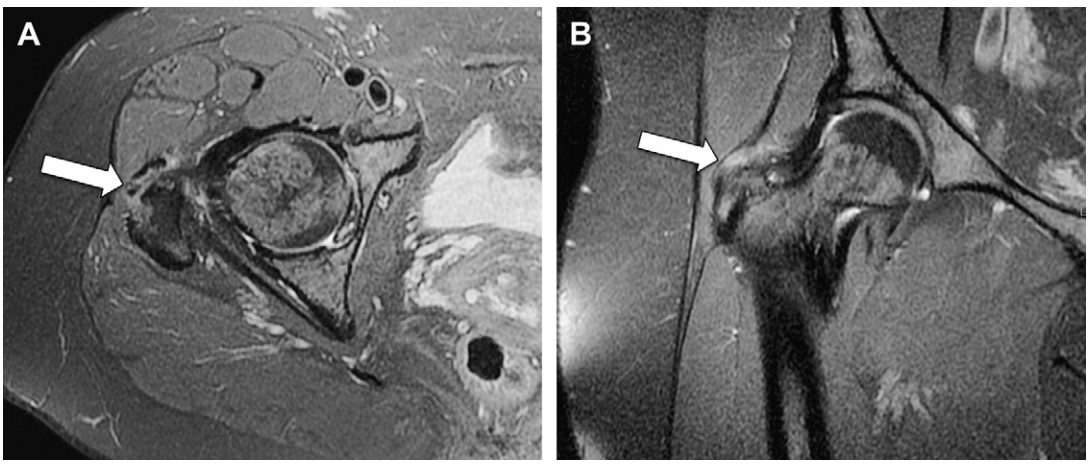

Fig. 13. (*A*) Axial fat-saturated T2-weighted image demonstrating gluteus minimus tendinosis at its insertion on the anterior border of the greater trochanter (*arrow*). (*B*) Coronal fat-saturated T2-weighted image in same patient, demonstrating the abnormal high signal of gluteus minimus tendinosis (*arrow*).

for evaluation of associated hip pathology.[50,51] Fat-saturated fluid sensitive sequences typically show a rounded high signal fluid collection posteromedial to the iliopsoas muscle. Athletic pubalgia also includes pain referred from nearby structures, in particular from hip or spine pathology. An acetabular labral tear in the hip can occur following significant injury, especially after posterior hip subluxation or dislocation. Acute traumatic labral tears are more common in patients who play sports that involve extreme hip rotation and flexion. Patients with preexisting hip dysplasia and with femoroacetabular impingement are more prone to labral tears secondary to altered biomechanics. The pain can be poorly localized, radiating to the groin, where it may be the only area of reported symptoms. Direct magnetic resonance arthrography (MRA) is the gold-standard imaging technique for assessment of the hip labrum (**Fig. 12**).[52] Direct signs of a labral tear on MRA include altered morphology of the labrum and direct contrast imbibition into the labral tear.[53,54] Trochanteric bursitis is also a potential cause of groin and hip pain in the athlete.[55] Trochanteric bursitis typically occurs in athletes who are involved with repeated flexion at the hip joint. It is thought that excess friction between the tensor fascia lata and its underlying bursa gives rise to bursitis. Patients will typically complain of lateral groin and hip pain, exacerbated by adduction and external rotation of the hip. Gluteus minimus tendinosis can cause similar symptoms (**Fig. 13**). Lumbar spondylosis can result in patients presenting with radicular groin pain. In these patients dedicated MR imaging of the lumbar spine may reveal a disc herniation, foraminal stenosis, facet arthropathy, or central canal narrowing. Developmental osseous abnormalities such as transitional anatomy at the lumbosacral junction and spondylolysis may lead to presentation with groin and pelvic pain. Sacroiliitis can also present with groin pain in the athlete. If this is suspected, dedicated MR imaging of the sacroiliac joints should be performed. Full rheumatologic workup of these patients is recommended to evaluate for the potential presence of an underlying inflammatory arthropathy.

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