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REVIEW ARTICLE

Imaging of inguinal-related groin pain in athletes

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ABSTRACT

Inguinal canal-related groin pain is common in athletes and may involve numerous structures such as the conjoint tendon and the transversalis fascia. Ultrasound is the only dynamic tool that shows the passage of preperitoneal fat at the level of the Hesselbach triangle and allows excluding true inguinal hernias. Fascia transversalis bulging and inguinal ring dilatation may also be described. MRI assesses injuries of rectus abdominis and adductor longus enthesis and osteitis symphysis but its accuracy for the diagnosis of inguinal-related groin pain remains debated.

INTRODUCTION

Groin pain is one of the most frequent complain in athletes and is involved in up to 6% of all sports-related pathologies[1] and 4% of injuries in professional soccer players.[2] The terminology used for groin pain in athletes remains unclear and includes «athletic pubalgia», «sportsman's hernia», «posterior wall weakness» and "inguinal related or groin pain".[3,4] Moreover, «sportsman's hernia» is a misleading term, since no hernia is present. The 2014 Doha consensus conference identified four anatomical structures that may be the cause of groin pain: the inguinal wall, the proximal insertion of the adductor muscles, the pubic symphysis, and the iliopsoas muscle.[5] Nevertheless, other causes such as hip internal derangement, rectus abdominis strain, pelvic stress fracture have also been cited.[2,6] Because of the anatomical continuum between the aponeuroses of the different muscles that insert in the pubic bone, these structures are often all involved.[2,7–10] In athletes with inguinal canal-related groin pain, surgical studies usually differentiate lesions of the posterior wall, including the conjoint tendon and the transversalis fascia from those of the anterior wall, including the rectus abdominis muscle, the inguinal ligament and the external oblique aponeurosis.[3,11,12] The term «Sportsman's hernia» does not seem accurate because it may still be confused with true inguinoscrotal hernia or wall weakness in young athletes.[9]

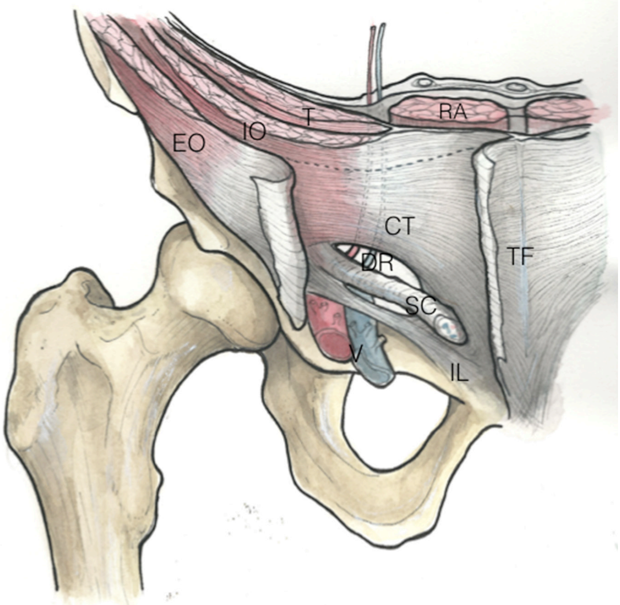
The role of imaging has not been fully clarified:[4] the definition and the diagnostic criteria for the 2012 Manchester conference and updated at the 2014 Doha conference do not include imaging.[3] Although several studies on the diagnosis and management of athletes with inguinal canal-related groin pain have been recently published,[6,11,12] data on imaging features remain scarce. A recent study reported the excellent diagnostic value of dynamic ultrasound for the diagnosis,[11] and, although MRI remains the reference technique for the investigation of groin pain in athletes,[13–15] its role in the management of this pathology has not been fully defined.[4] MRI is the gold-standard for the assessment of symphysis, adductor-related groin pain and the evaluation of rectus abdominis muscle.[16] However, the role of MRI for the diagnosis of inguinal canal-related groin pain is less well-defined. Nevertheless, imaging plays a significant role in the diagnosis of this entity, and can help improve patient management by avoiding unnecessary surgery and limiting costs.

The aim of this article is to review the role of imaging in inguinal canal-related groin pain based on anatomical, pathogenic and clinical features.

ANATOMY

The inguinal area corresponds to the inferior and anterolateral part of the abdominal wall. The anatomic arrangement of the bones and the muscular and fascial layers of this area make it a site of potential weakness, mainly because of the passage of the inguinal canal in males. Indeed, the inguinal canal has an oblique shape,[17] which is lateral to the rectus

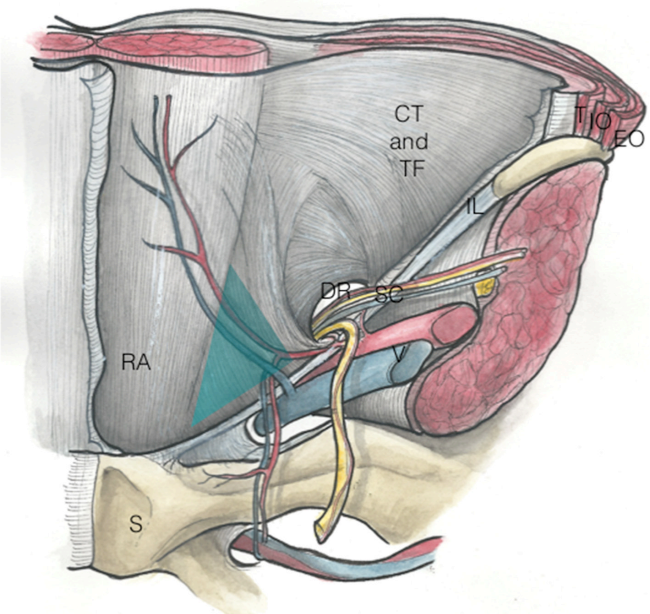
Figure 1. Schematic drawing from an anterior view of the inguinal canal. The internal deep ring is superior, and located at the middle of the inguinal ligament. It is inferior and medi-olateral to the conjoint tendon, and lateral to the inferior epigastric vessels. The external superficial ring is a triangular opening in the external oblique aponeurosis. The inferior epigastric artery (a) and vein (v) originate from the external iliac artery and vein and lie medial to the internal inguinal ring. CT, conjoint tendon; EO, external oblique muscle; EOA, external oblique aponeurosis; IL, inguinal ligament; IO, interne oblique muscle; RA, rectus abdominis; SC, spermatic cord; T, transverse muscle; TF, transversalis fascia; DR, deep ring.



abdominis muscle and medial to the inferior epigastric vessels. The inguinal canal can be described as a cylinder surrounded by four walls and two rings:

(1) the superior wall, formed by the conjoint tendon (previously called the inguinal aponeurotic falx) of the internal oblique abdominal and the transverse abdominal muscles. Both muscles become aponeurotic before merging with the sheath of the rectus abdominis muscle[18] (Figure 1).
(2) he inferior wall (floor), including the cranial ramus of the pubic bone, and the inguinal ligament
(3) the posterior wall, with the transversalis fascia and conjoint tendon;
(4) the anterior wall, with the aponeurosis of external oblique and the fleshy part of the internal oblique muscle;
(5) the superficial ring, subcutaneous and inferior, lateral and cranial to the pubic tubercle. This corresponds to a "window" between the lateral and medal pillars of the aponeurosis of the external oblique muscles.
(6) he deep ring, superior, and located at the middle of the inguinal ligament. It is inferior to the conjoint tendon, and lateral to the inferior epigastric vessels. Medial to this deep ring, the Hesselbach triangle is medial to the inferior epigastric vessels, lateral to the rectus abdominis muscles and cranial to the inguinal ligament. The deep ring and the Hesselbach triangle are the weak spots of the posterior wall, where sportsman's hernia and true hernias may occur (Figure 2). Finally, this area is covered by preperitoneal fat and by the peritoneum.[17]

Figure 2. Schematic drawing from a posterior view of the Hesselbach triangle. Medial to this deep ring, the Hesselbach triangle is medial to the inferior epigastric vessels, lateral to the rectus abdominis muscles and cranial to the inguinal ligament. CT, conjoint tendon; TF, transversalis fascia; IL, inguinal ligament; RA, rectus abdominis; DR, deep ring; S, symphysis; SC, spermatic cord; T, transverse muscle; O, interne oblique muscle; E, external oblique muscle.



The inguinal canal contains:

(1) in male: the spermatic cord, and its coverings and the ilioinguinal nerve. The spermatic cord normally contains three arteries (the artery to the vas deferens, the testicular artery and the cremasteric artery), three fascial layers (the external spermatic, cremasteric, and internal spermatic fascia); the pampiniform plexus, the vas deferens (ductus deferens), testicular lymphatics, and three nerves (genital branch of the genitofemoral nerve, sympathetic and visceral afferent fibres, ilioinguinal nerve)
(2) in female: the round ligament of the uterus, the ilioinguinal nerve and the genital branch of the genitofemoral nerve.[19]

PATHOPHYSIOLOGY

The origin of inguinal canal-related groin pain is functional.[20] Physiologically, during muscular contraction of the abdominal wall, the conjoint tendon lowers and closes the deep inguinal ring like "a curtain" decreasing its diameter. Thus, the inguinal canal becomes more oblique and longer, and the deep ring of the inguinal canal moves upwards and outwards. Functionally, the "sealing" of the inguinal canal depends upon the contraction of the flat muscles, mainly the internal oblique muscle as well as the morphology of the conjoint tendon.[19]

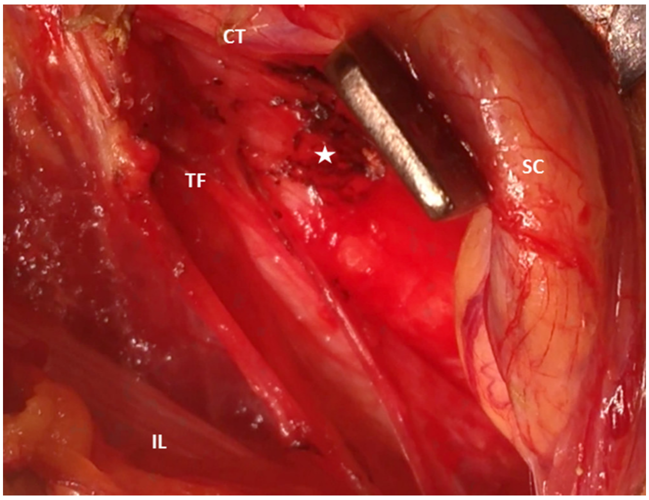
Thus, in the presence of the conjoint tendon, the internal oblique muscle compresses by contracting the inguinal canal, acting as a "sphincter" and preventing the development of a hernia.[17,21] According to our experience, conjoint tendon abnormalities play a role in the defective covering of the deep ring during muscle contraction, weakening the posterior wall. When this is combined with repetitive microtraumatic muscular lesions, parietal weakness can develop.

The lowering of the conjoint tendon towards the inguinal ligament, the upwards and outwards movement of the deep inguinal ring, the closing of the pillars of the external oblique muscle resulting in narrowing of the superficial inguinal ring, the retraction of the cremaster and the ascent of the cord are all anatomic factors that limit the opening of the canal. Inguinal wall weakness may involve one or more of the parietal components of the anterior or posterior walls.[7]

Posterior wall deficiency is due to degeneration of the transversis abdominis and internal oblique muscles resulting in weakness of the posterior inguinal wall, which become lax and can protrude into the inguinal canal causing a mass effect during straining. With ongoing injury, this can potentially in turn lead to complete disruption of the posterior wall resulting in a direct inguinal hernia. The conjoint tendon and/or the fascia transversalis are most frequently involved according to recent surgical descriptions[3,11] (Figure 3) . At the posterior wall, protrusion of the pre-peritoneal fat in the spermatic cord contributes to the progressive widening of the deep inguinal ring helping maintain the degeneration of the posterior wall, resulting in:

(1) Compression of the genital branch of the genitofemoral nerve or the ilioinguinal nerve, leading to the development of a neuroma called the "hockey groin syndrome" in the literature;[13]
(2) Functional imbalance between the abdominal wall and adductor muscles due to the anatomic relationships of those structures and the deficiency of the conjoint tendon and fascia transversalis.[1,7]

Figure 3. Anterior laparoscopic view of the inguinal canal during Shouldice procedure shows dehiscence of the TF and protrusion of pre-peritoneal fat (star). CT, conjoint tendon; IL, inguinal ligament; SC, Spermatic cord; TF, transversalis fascia.



Anterior wall deficiency arises as a consequence of degeneration and tear of the external oblique muscle and aponeurosis resulting in a dehiscence between the inguinal ligament and leading to dilatation of the superficial inguinal ring. Positive imaging findings are rarely seen in this group and therefore this is primarily a clinical diagnosis.

CLINICAL PRESENTATION

Inguinal-related groin pain is relatively frequent and represents up to 18% of consultations in sports medical departments, with a ratio of 9 males/1 female.[8,9] It is associated with sports with increased intra-abdominal pressure involving kicks, rapid changes in direction and rapid twist starts, which are found in sports such as football, rugby, hockey or running.[1,9] The pain is inguinal near the pubic tubercle. It usually occurs gradually and is frequently unilateral, ranging from simple discomfort to severe pain sometimes extending to the pelvis, perineum, thigh root and lumbar region. It is generally worsened by stress and relieved by rest. The pain is worsened by contraction contraresistance of the abdominal muscles during Valsalva maneuvers, coughing or sneezing. Initially, the pain disappears when sports are no longer practiced, then may gradually become permanent and may prevent the practice of sports altogether.[3] The 2014 Doha Consensus Conference clearly redefined the clinical diagnosis of inguinal-related groin pain as the presence of least three of the following five signs:[5]

(1) pain with palpation of the pubic tubercle at the insertion of the conjoint tendon;
(2) pain with palpation of the deep inguinal ring;
(3) pain or dilatation of the superficial inguinal ring without hernia;
(4) pain at the origin of the tendon of the long adductor; and/or
(5) diffuse inguinal pain radiating to the perineum, thigh or contralateral level.

However, recent studies[22,23] suggested sportsman's hernia is often associated with other causes of groin pain in the athlete (Table 1).

IMAGING

Conventional radiographs

Conventional radiographs are essential to evaluate the pubic symphysis, and to eliminate congenital abnormalities such as femoroacetabular impingement, developmental dysplasia of the hip as well as degenerative conditions of hip and sacroiliac joints. Furthermore, they may also indicate erosions, sclerosis and symphysis widening in cases of osteitis pubis.[24] In adolescent athletes, signs of pubic apophysitis can be seen at secondary ossification centers.[25] Indeed, Sailly et al[26] identified another cause of groin pain due to a pubic apophysitis at the secondary ossification centre located along the anteromedial corner of pubis beneath the insertions of symphysial joint capsule and adductor longus tendon.

Table 1. Differential diagnosis of inguinal-related groin pain in the athlete

Structures	Types of lesions
Symphysis pubis	Osteitis pubis
Adductor longus tendon	Enthesitis/tendinitis/tear
Rectus abdominis muscle	Muscle strain/fatty infiltration
Iliopsoas muscle	Muscle strain
	Snapping
Hip joint	Osteoarthritis
	Femoroacetabular impingement
	Labral tears
Pelvic bones	Stress fractures
Nerves	Lumbar nerves referred pain

Ultrasound

Technique

An ultrasound examination should be performed with the patient resting in the supine position and should include Valsalva maneuvers in the supine and standing position. A bilateral and comparative examination should be performed[8,27,28] with a high-frequency probe (linear 12- to 18 MHz transducer). First, in the axial position, the Hesselbach triangle is located between the ostium of the lower epigastric arteries on the external iliac artery and the lateral edge of the rectus abdominis muscle. The deep inguinal ring is located lateral to the lower epigastric artery. Then, the posterior wall of the inguinal canal is assessed for bulging at rest and with Valsava maneuvers. Still in axial position, the transducer is moved down to the level of the medial attachment of the inguinal ligament crossing the superficial inguinal ring, by following the spermatic cord to the pubic tubercle. Once the spermatic cord is visualized, anterior motion of the pre-peritoneal fat is observed while repeating the Valsava maneuver. The sagittal assessment is performed from the ostium of the lower epigastric artery sliding the transducer medially and laterally. At this level, the inguinal ligament may be identified in its short axis at the lower edge of the deep inguinal ring.

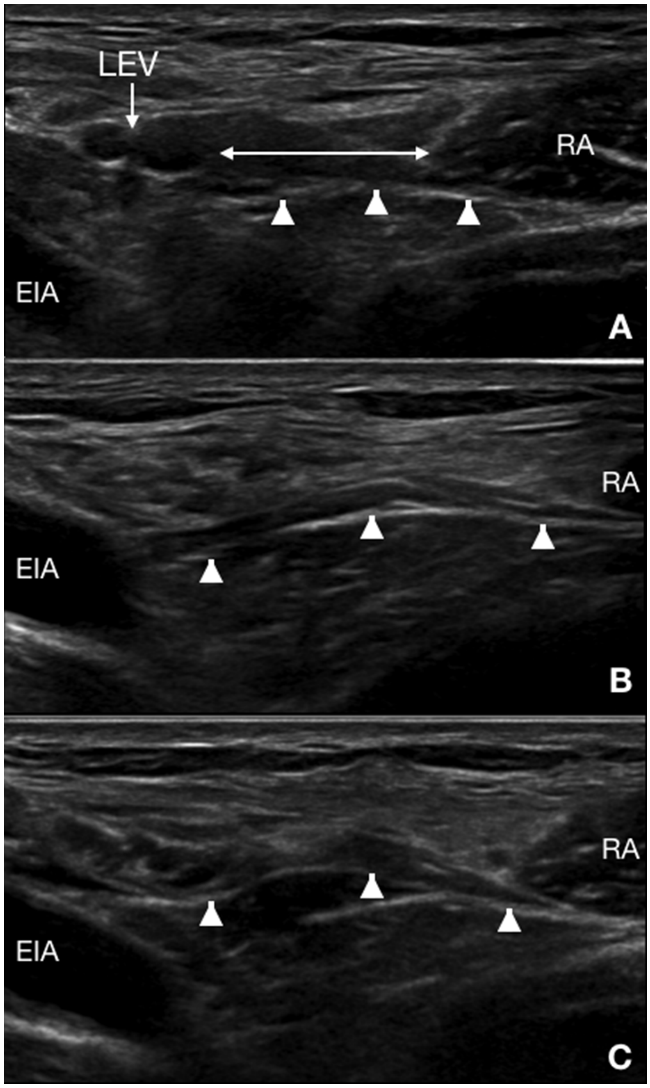
Normal features

In young athletic subjects, there should be no prominence of the pre-peritoneal fat through the deep inguinal ring or the Hesselbach triangle when the examination at rest is compared to that with abdominal pressure (Figure 4).[28] On the axial plane, the distance between the lateral edge of the rectus abdominis and the ostium of the lower epigastric artery is usually less than 2 cm.[13]

Pathological features

Several studies[8,11,29] have described a posterior wall bulge or protrusion of pre-peritoneal fat through the Hesselbach triangle or the deep ring during abdominal thrusts[11] (Figure 5). In a study of 573 patients who underwent surgery, Santilli et al[11] showed that ultrasound had a sensitivity of 95% and a specificity of 100% compared with the findings of laparoscopy with positive and negative predictive values close to 100%. Others features

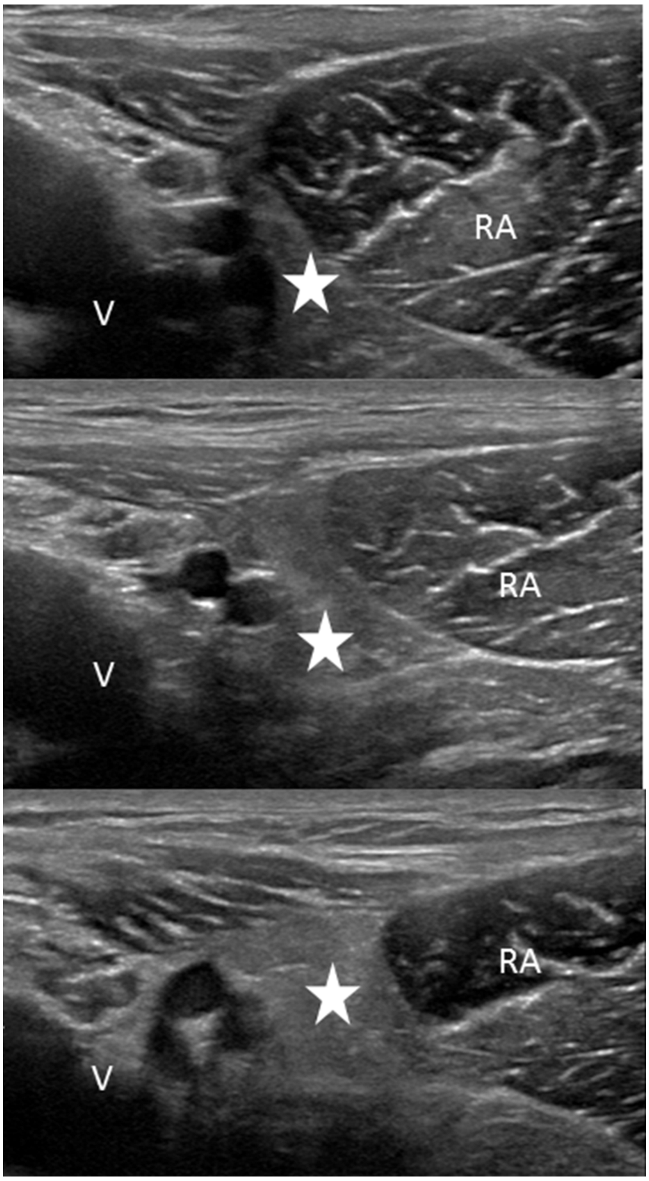
Figure 4. Ultrasound of an asymptomatic male athlete. Dynamic ultrasound in the axial plane at rest (A) and at the beginning (B) and end (C) of Valsalva's maneuvers shows the location of the Hesselbach triangle (double arrows) at the level of the LEV. Additionally, there is a slight convexity of the fascia transversalis (arrowheads) without protrusion of pre-peritoneal fat. LEV, lower epigastric vessels; RA, rectus abdominis.



have been described such as a convex and painful bulge of the transversalis fascia[30] or inguinal dilatation of more than 2 cm on dynamic ultrasound.[31]

Ultrasound helps to exclude the main differential diagnosis of inguinal hernia, which corresponds to the passage of peritoneal fat and the peritoneum with or without digestive contents, medial to the inferior epigastric vessels in the Hesselbach triangle (direct inguinal hernia) or lateral to the inferior epigastric vessels through the deep inguinal ring (indirect inguinal hernia).[32] In these cases, the presence of hyperechoic fat tissue in the Hesselbach triangle between the ostium of the lower epigastric artery and the rectus abdominis is abnormal both at rest and during effort.[28] Parietal weakness may be asymptomatic and is

Figure 5. Ultrasound of a 27-year-old male soccer player with bilateral groin pain. Dynamic ultrasound at the level of Hesselbach's triangle of the right deep inguinal ring in the transverse planes shows progressive bulging of the preperitoneal fat during Valsalva's maneuvers (white arrow). V, vessels; RA, rectus abdominis.



more frequent in elderly patients.[28] Anatomical variants of the conjoint tendon or abnormalities of the transversalis fascia are not directly visible on ultrasound.[11] Very few ultrasound features have been described for the superficial inguinal ring. The presence of a neuroma of the genitofemoral nerve is an interesting indirect sign of anterior wall weakness.[33] In our experience, the ultrasound features of lesions of the aponeurosis of the external oblique muscle remain unknown.

MRI

A few recent studies have assessed the role of MRI in inguinal related groin pain.[4,6,13,15,16,34,35]

Imaging protocols

Several authors[6,15,35] described a MRI protocol tailored to clinical athletic pubalgia including coronal short tau inversion-recovery (STIR) and T_1 weighted spin echo sequences with a large field of view (ranging from 28 to 36 cm) to exclude remote pathologies. Then, sequences should be acquired with a surface coil, placed over the anterior pelvis centered at the pubic symphysis. Our protocol includes sagittal and axial T_2 weighted fat spin echo (FSE) fat-suppressed sequences as well as proton density FSE-weighted and T_2 weighted FSE fat-suppressed axial oblique sequence angled with the anterior border of the ileum.[15,35] Although the goal of T_1 weighted images is to identify the anatomical structures, fat-saturated T_2 weighted images allow visualizing signal abnormalities in tendinous and bony structures. Three-dimensional T_1 weighted acquisitions may be helpful when using reformatted images in the plane of the conjoint tendon, the inguinal ligament or the aponeurosis of the external oblique muscle[19,34] (Table 2). Valsalva maneuver can improve the performance of the MRI but is not performed in a routine protocol.[35] In a recent study, Omar et al[36] performed dynamic T_1 weighted sequence in order to assess anterior motion of the posterior wall to detect lipoma within the inguinal canal. Gadolinium-chelate is mainly used in patients with a previous history of surgery.[19,34]

Posterior wall

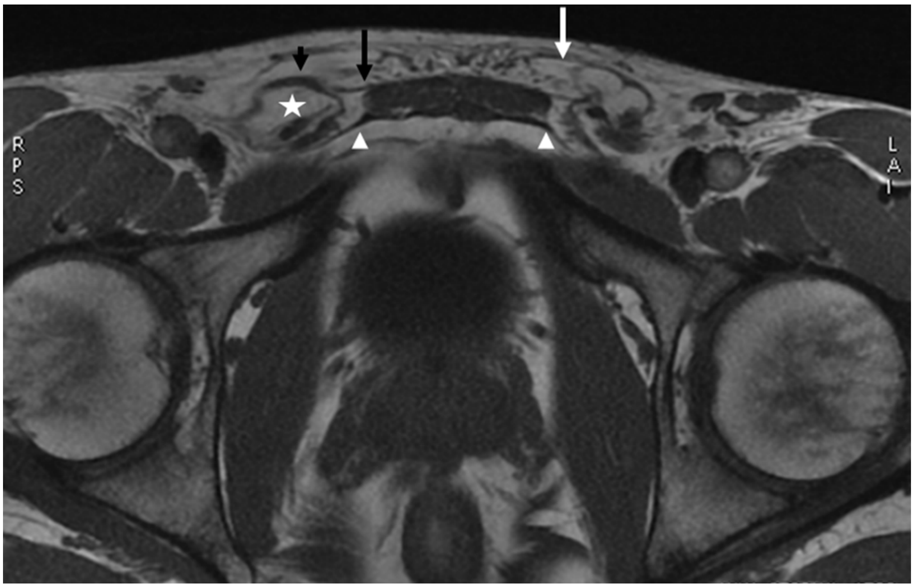
Some articles[13,14,16] have described the MRI features of posterior wall weakness as a bulging or convex appearance of the deep inguinal ring and/or the Hesselbach triangle[13] (Figure 6). The limits of the Hesselbach triangle are difficult to visualize on MRI. In our experience, axial T_1 weighted images can help identify the aponeurosis of the external oblique muscle and

Table 2. MRI protocol

Plan	Sequence	TE (ms)	TR (ms)	Thickness (mm)/gap	FOV (cm)	Matrix
Coronal	T1	Min	572	3,5/0,4	36	448 × 320
Oblique axial	T1	Min	572	3,5/0,4	24	512 × 320
Oblique axiale	PD/FS	45	3241	3.5/0.4	24	512 × 320
Axial	STIR	42	4968	4/1	38	352 × 256
Sagittal	DP/FS	45	3241	3/0,4	24	512 × 320

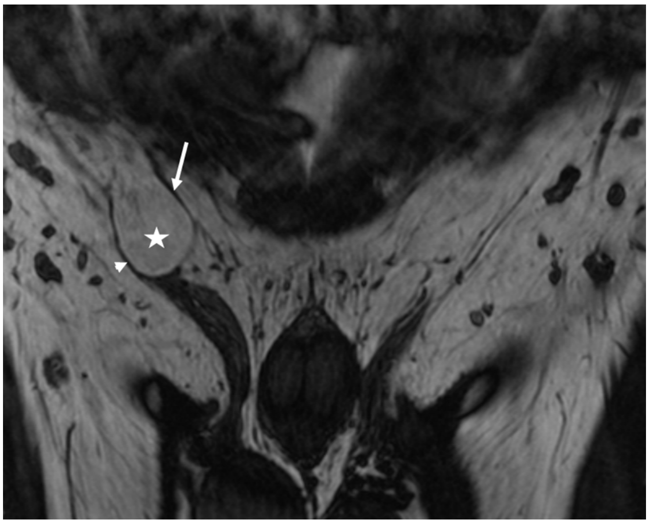
FOV, field of view; FS, fat saturation; PD, proton density; STIR, short tau inversion-recovery; TE, echo time; TR, repetition time.

Figure 6. MRI of a 25-year-old male rugby player with bilateral groin pain. 3D-GE T_1 weighted sequence in the axial plane shows fat within the right spermatic cord (white star), anterior wall bulging and thickening of the right external oblique aponeurosis (black arrowhead), normal distal insertion of the CT (white arrowheads) and tear of the left external oblique (white arrow). 3D, threedimensional.



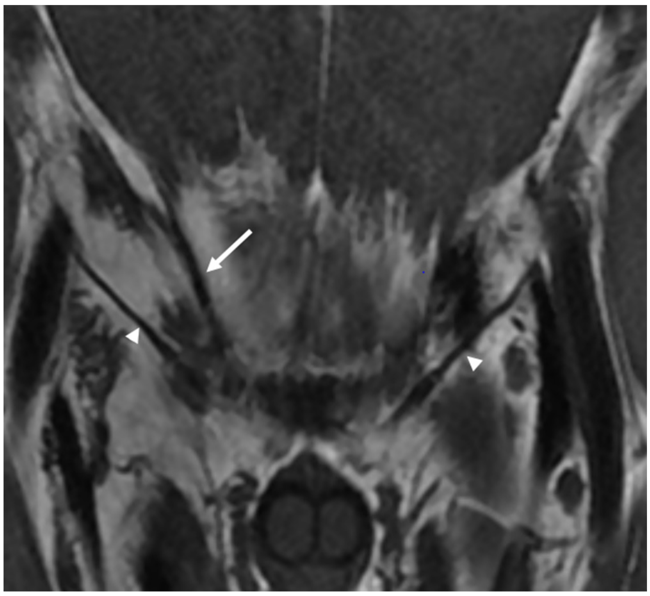
the transversalis fascia on the axial plane, and the conjoint tendon on coronal plane (Figure 7). Read et al[34] described the conjoint tendon on oblique coronal T_1 and T_2 weighted images as a hypointense structure stretching from the underside of the oblique internal and transverse muscles to the inguinal ligament. Cherian et al[37] identified the conjoint tendon in a coronal plane CT scan. If the conjoint tendon and the inguinal ligament are far apart, this may be a risk factor for inguinal related groin pain.[34] However, this feature is difficult to assess because there is no accepted reference distance. The presence of pre-peritoneal fat without a hernial sac can be visualized in the spermatic

Figure 7. MRI of a 27-year-old male soccer player with right groin pain. 3D-GE T_1 weighted sequence in the coronal plane shows thinning thickening of the inguinal ligament (arrowhead) and conjoint tendon (arrow). 3D, three-dimensional.



cord and has been previously described in the literature as a lipoma[38] (Figure 8). Another indirect feature of posterior wall weakness is the anterior displacement of the vas deferens.[13,34] A German study[13] described signal abnormalities of the deep ring with significant dilatation of more than 2 cm. Inguinal ligament abnormalities such as abnormal insertion, thickening or thinning, traumatic lesions and/or tearing have also been

Figure 8. MRI of a 23-year-old male soccer player with right groin pain. 3D-GE T_1 weighted sequence in the coronal plane shows fat within the right spermatic cord (white star), thinning and stretching of the inguinal ligament (arrowhead) and thinned conjoint tendon (white arrow).



reported.[12] Maquirriain et al[39] have also described associated insertions as well as morphological and signal abnormalities of the rectus abdominis and flat muscles.

Anterior wall

Because the aponeurosis of the external oblique muscle is so thin, there are very few reports of the MRI features of anterior wall lesions. Hyperintense signal of the superficial ring has been described on T_2 weighted images and may be a sign of injury.[13] Iliohypogastric and ilioinguinal neuroma or impingement is difficult to visualize due to the limited spatial resolution of MRI.[33]

CONCLUSION

Inguinal-related groin pain was redefined by the Doha conference in 2014 and was chosen as the preferred term to describe weakness of the posterior wall of the inguinal canal with projection of pre-peritoneal fat through the weakness area (Hesselbach triangle or deep inguinal ring) without true hernia. Ultrasound examination shows the fat protrusion medial to the lower epigastric vessels during Valsalva maneuvers. MRI may confirm bulging of the anterior and posterior walls, and/or the presence of fat within the cord. The conjoint tendon may also be visualized. Thus, thorough knowledge of imaging techniques and the features of this entity can help confirm the diagnosis and optimize patient management.

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