Groin Pain in Athletes

Leistenschmerz beim Sportler

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Abstract

Groin pain in athletes is one of the most difficult to treat clinical entities in sports medicine. The reasons are the amount of differential diagnoses, complexity of pathophysiologic causes and the long time of limited participation in sport. In order to maximize efficient treatment, thorough diagnostics and a clear therapeutic regimen are crucial. To succeed with this issue, a close cooperation between physicians and radiologists is mandatory. MRI is gold standard in the diagnostic work-up of the principal differential diagnoses, such as muscle tears, avulsion injuries, stress fractures, tears of acetabular labrum, and osteitis pubis. The article gives a comprehensive overview of the special anatomy and biomechanics of the pubic region and of typical MRI findings in athletes with groin pain. The use of dedicated imaging protocols is also discussed.

Key Points:
- Groin pain in competitive sports is frequent (5 – 18 % incidence among professional soccer and tennis players).
- The differential diagnoses are numerous and comprise among others extraarticular (e. g. muscle and tendon injuries, stress fractures), intraarticular causes (e. g. femoroacetabular impingement, labral lesions), and osteitis pubis.
- Sports hernia is a clinical diagnosis, the radiologist should exclude or define other causes such as osteitis pubis.
- A labral tear as cause of groin pain can only be reliably diagnosed using direct MR arthrography.

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Zusammenfassung

Der Leistenschmerz beim Profisport ist eines der am schwierigsten zu behandelnden Krankheitsbilder in der Sportmedizin. Grund hierfür ist die Fülle von Differenzialdiagnosen, die Komplexität der pathophysiologischen Einflussfaktoren und die mitunter lange Ausfallzeit. Um eine maximal effiziente Therapie zu gewährleisten, sind eine differenzierte Diagnostik und ein klares Therapiekonzept entscheidend. Dies gelingt nur, wenn eine enge Zusammenarbeit zwischen betreuenden Ärzten und Radiologen stattfindet. Die MRT ist der Goldstandard zur Aufarbeitung der wichtigsten Differenzialdiagnosen wie Muskelverletzungen, apophysäre Verletzungen und Stressfrakturen, Labrumpathologien des Hüftgelenks und die Osteitis pubis. Der Artikel gibt einen umfassenden Überblick über die spezielle Anatomie und die Biomechanik der Schamgegend und typische MRT-Befunde bei Athleten mit Leistenschmerzen. Die Verwendung eines dezidierten Bildgebungsprotokolls wird ebenso diskutiert.

Introduction

Groin pain in competitive sports is a frequent and complex ailment accounting for 2 – 5 % of all sports-related pain development, with an incidence of 5 – 18 % among professional soccer and tennis players [1–5]. Chronic groin pain frequently leads to extended time lost to injury, despite all therapy [6]. Consequently, in recent years increasing value has been placed on prophylaxis and early detection. Important in this regard is a precise diagnosis of the causes of the complaint; for establishing a correct diagnosis the close collaboration between the attending (team) physician and radiologist is indispensable. Especially in professional sports, which enjoy extensive media coverage, there is great pressure on physicians and therapists, since the athlete's downtime should be minimized, and the prognosis generally cannot be precisely provided to the trainer and athlete. Further, groin pain is likewise an increasing problem in recreational sports, with an incidence of sport-related injuries of 3.1 – 5.6 % [7]. One need only consider the many middle-aged casual athletes, mainly with sedentary occupations, "weekend warriors" who vigorously pursue sports during their free time. The following provides an overview of the epidemiology of groin pain among competitive athletes, identifies frequent differential diagnoses, and describes diagnostics and therapy with a focus on ultrasound and MRI procedures. In particular, this article will discuss muscle injuries in the groin region, apophyseal injuries and stress fractures as well as labral pathology of the hip joint and osteitis pubis.

Epidemiology

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In competitive sports, groin pain represents one of the most frequent complaints and is observed among professional athletes, primarily soccer, hockey or rugby players [8–10]. In addition, groin pain occurs in track and field athletics (e. g. hurdling), volleyball or ski racing [11]. Common to all these sports are recurrent, abruptly flexing and rotational movements in the hip joint and groin with rapid changes of direction and high torqueing [5]. As a consequence, the fascia as well as musculoskeletal structures of the thigh and caudal abdominal musculature are strained. Whereas acute groin pain can be treated with conservative remedies within 4 to 6 weeks, symptoms of chronic groin pain are persistent and frequently result in considerable time lost due to injury [9]. With respect to causes of downtime, inguinal pain is in third place, behind fractures and injuries to the anterior and posterior cruciate ligament [12].

The frequency of groin complaints is steadily increasing among soccer players. As early as 1966, Cabot noted that in the previous 30 years, 0.5 % of Spanish footballers complained of groin pain; in 1980, Renström stated that 5 – 13 % of players presented with groin-related pain within an observation period of 1 – 2 years [13]. In the meantime, approximately 60 % of soccer players report acute or chronic groin pain during their playing years, and every tenth injury-related absence from play is related to groin pain or injury [1, 14]. Causes mentioned include increasing playing and training demands, increased motional speed and the development of footwear with increased traction resulting from changes to the cleats. In a prospective study of 23 European top member teams of the UEFA (Union des Associations Européennes de Football), between 2001 and 2007 an average of 12 – 16 % of all injuries per team were related to groin or hip injuries per season [10]. These numbers concur with those of the German soccer league team, TSG 1899 Hoffenheim, with which we are affiliated.

Differential Diagnoses

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The groin and hip region is made up of a number of different structures that interact: pubic bones, pubic symphysis, musculature, tendons, aponeuroses, ligaments, inguinal canal, hip joint. Consequently there is frequently reference pain or a pain pattern that cannot be uniquely assigned to a single structure [1, 3]. In addition, there are a multitude of various nerves responsible for providing sensation and which support movement. Compression of these nerves (entrapment syndrome), such as a result of laxness of muscle fascia, can likewise lead to significant stress-related pain [1, 5]. Therefore a knowledge of the complex anatomy of the groin and pelvic region, interaction of the affected structures and a detailed clinical investigation, as well as dedicated image-based diagnostics are prerequisites for a definitive diagnosis with respect to the numerous differential diagnostic-related causes [5, 6]. Further, close interdisciplinary collaboration among orthopedists and trauma surgeons with focus on sports medicine together with radiologists is required to establish appropriate imaging protocols. **Table 1** provides a summary of possible differential diagnoses, whereby a distinction must be made between extra-articular causes (e. g. muscle and tendon injuries) and intra-articular sources (e. g. femoroacetabular impingement, labral lesions) [1, 5, 6, 15–18]. The following sections present the most frequent causes in detail.

Muscular Injuries in the Groin Region and Apophyseal Injuries

Muscular injuries of the adductors, the iliopsoas muscle and abdominal musculature are the most frequent sources for the occurrence of acute groin pain; among 23 UEFA top teams, adductor injuries (n = 399/628) were most frequent, followed by injuries to the iliopsoas muscle (n = 52/628) [10]. Depending on the age of the athlete, muscular weak points include unfused apophysis among the young, degenerative tendons among more mature and older athletes. Among most competitive athletes between the ages of 20 and 30, the myotendinous junction is the predilection site for muscle tears [15, 19]. When the immature skeletal struc-

Table 1 Frequent causes of groin pain in competitive athletics, modified according to [15]

acute onset	
	muscle injury (strain, muscle fiber rupture, fascicle rupture etc.)
	avulsion and apophyseal injury
	fracture
gradual onset	
	adductor inflammation, insertional tendinosis
	osteitis pubis, symphysitis
	weak groin, inguinal hernia
	pathology of the hip joint (labral lesions, femoroacetabular impingement (FAI))
	snapping hip (coxa saltans)
spinal column disorders	
	disc prolapse with nerve root inflammation
	blockage in the lumbar spine region
	spondylolisthesis
ilioinguinal nerve entrapment syndrome	
functional impairment of the pelvis	
	blockage of the iliosacral joints
	pelvic torsion
imbalance in the muscle strings	

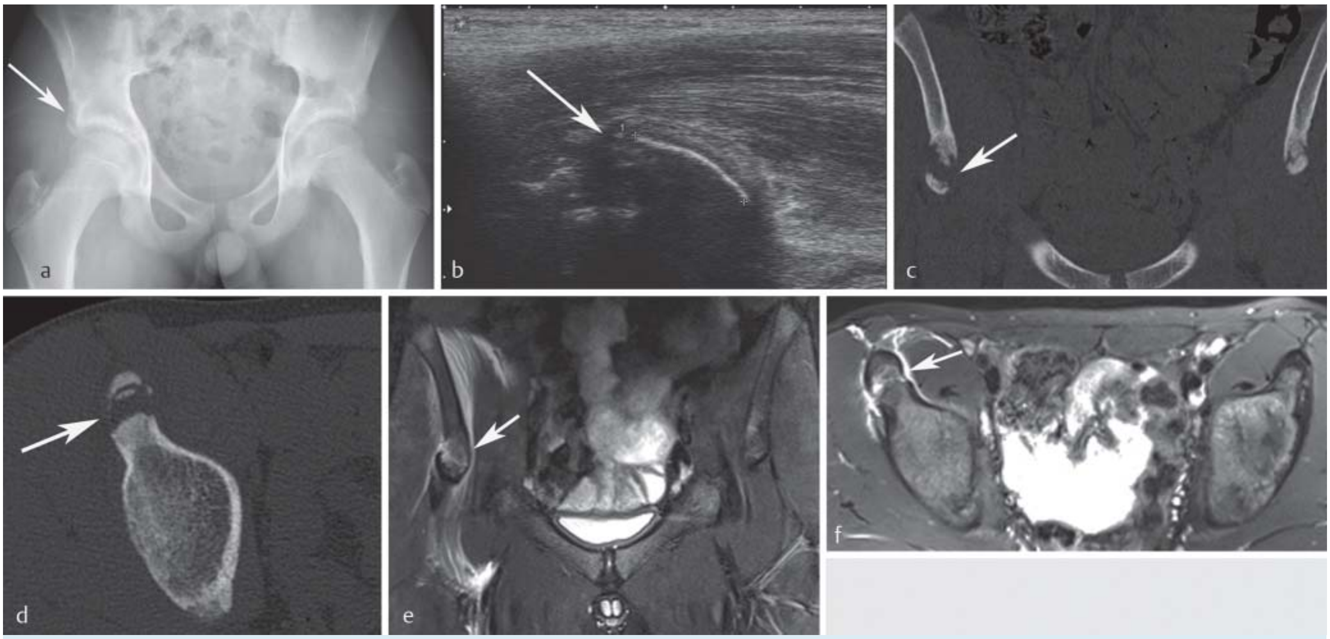

Fig. 1 Apophyseal muscle detachment. 13-year-old youth soccer player with apophyseal detachment of the rectus femoris muscle on the right anterior inferior iliac spine (arrows). Pelvic overview image **a**, ultrasound **b**, CT in coronal **c** and axial reformation **d**, 3-Tesla MRI: coronal STIR sequence **e**, axial, T2-weighted fat-suppressed sequence **f**.

ture is overstressed, injuries to the apophysis can occur at all large muscle attachments [15] (**Fig. 1**). In mature skeletal structures, avulsions occur practically only among high-performance athletes.

Whereas the ischiocrural muscles (hamstrings) are most frequently affected, and such injuries generally occur during running, in the case of adductors, injuries arise as a result of abrupt rotational motions or trauma during abduction or adduction rotation [19]. An early diagnosis established using imaging is critical for proper treatment since prompt and intensive treatment as well as complete healing of these injuries is crucial in avoiding development into a potentially chronic inflammation of the muscle insertion. Ultrasonography is the initial imaging modality in the case of simple superficial injuries. Advantages include high local resolution, rapid access, dynamic examination in real time and cost-effectiveness. The disadvantages, however, include dependence on the examiner's experience, poor reproducibility, less longitudinal coverage than MRI, limitation with respect to deep lesions or those close to the pubic bone [6]. On the other hand, MRI is the procedure of choice for complex injuries and for prognostication, in particular with respect to high-performance sports [6], since these injuries require exact assessment of the length of the muscle tear, and is reproducible when evaluating progress. A muscular edema verified by MRI can last longer than the actual pain, and can indicate increased vulnerability of the muscle [20]. In addition to the presence of a hematoma, the longitudinal extension of a muscle tear is a decisive predictor of lost playing time ($r = 0.58$; $p < 0.0001$) [21]; this downtime can be underestimated by ultrasonography [22]. The assessing radiologist should indicate the degree of the muscle tear, as this is important for the type of therapy to be selected as well as useful for estimating the downtime and risk of recurrence. In German-speaking areas, the Müller-Wohlfahrt classification of Grades I-IV is common [23]; internationally, classification uses Grade 1 (feathery edema), Grade 2 (partial tear) and Grade 3 (complete tear with a fluid-filled gap) [19, 24, 25] (**Table 2**, **Fig. 2**; Overview and consensus recommendation [26]).

Table 2: Overview of common graduations of muscle injury.

Müller-Wohlfahrt 2010 [23]:	Peetrons 2002 [24]:	Rybak 2003 [19]:
	(ultrasound-based)	*(MRI-based)*
grade I: muscle hardening	grade 0: no changes visible in imaging	
grade II: so-called "muscle strain" (neuromuscular strain)		
grade IIIa: muscle fiber rupture (≤ 5 mm transverse extension)	grade 1: muscular edema. Discontinuity < 5 % of muscle fiber. Perifascial fluid collection. Possibly minimal hematoma, no function deficit.	
grade IIIb: muscle bundle tear (≥ 5 mm transverse extension; *exceptional form: intramuscular tendon rupture*)	grade 2: partial rupture > 5 % discontinuity. Hematoma, functional limitation. Indicate proportional transverse and longitudinal extension.	
grade IV: muscle tear/tendinous muscle detachment	grade 3: complete rupture. Muscle gap, avulsed muscle and tendon origins. Almost always hematoma. Significant functional limitations, OP if needed.	

Stress fractures

Stress responses should additionally be considered as a cause of groin pain; in athletes these occur mainly in the lower pubic branch, the pubic symphysis and proximal femur [5, 6, 17, 18]. Stress fractures are generally observed in female runners; to avoid them, the training distance should not be increased by more than 10 % per week [15]. It is important to consider that the conventional X-ray image frequently yields negative results; MRI is the most sensitive examination method [5, 6] (**Fig. 3**). A radionuclide scan to

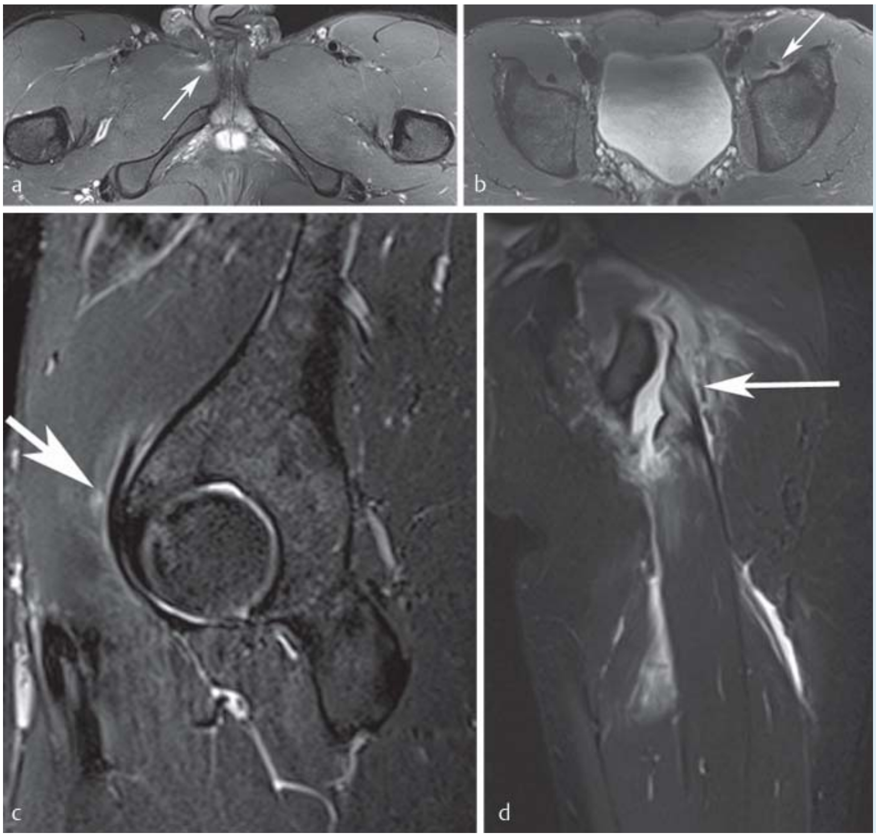

Fig. 2 Overview of muscle tears with varying degrees of severity in the vicinity of the pelvis. **a** The axial fat-suppressed T2-weighting shows a grade 1 tear according to [19] of the right adductor magnus muscle (arrow) in a 20-year-old professional soccer player. **b, c** Grade 1 tear according to [19] of the left iliopsoas muscle on the myotendinous junction (arrow) in a 30-year-old professional soccer player (**b**, axial fat-suppressed T2-weighted; **c**, sagittal STIR sequence). **d** Grade 3 muscle injury according to [19] after a split during a dance performance of a 15-year-old girl with detachment of the biceps femoris muscle on the ischial tuberosity. The arrow on the coronal STIR sequence points to the detached tendon end and the hematoma.

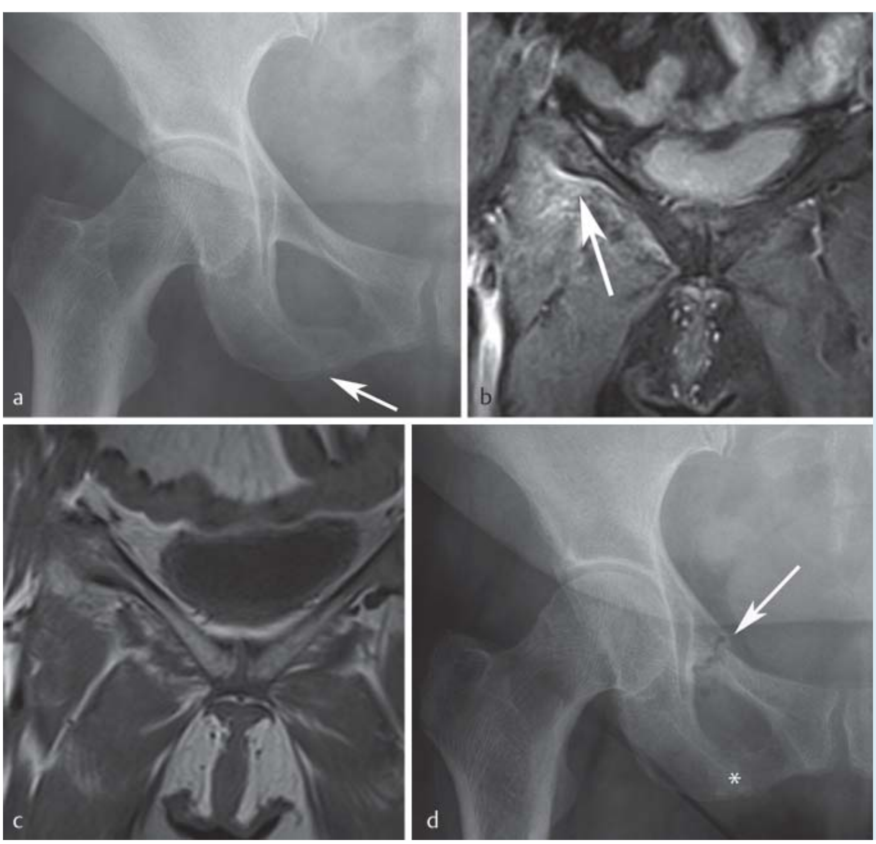

Fig. 3 Stress fractures. The conventional X-ray image **a** exhibits no stress fracture on the upper pubic branch, but rather a fracture line through the lower pubic branch (arrow). The 3-Tesla MRI (**b**, coronal STIR; **c**, coronal T1-weighting) can verify the periostal accentuated osseous edema as an indication of the stress reaction of the right superior pubic ramus, and the edema of the surrounding muscles and soft tissues (arrow) (grade 3 stress fracture according to Kiuru [6]). Despite an interruption of sports activity, two months later the woman experienced a stress fracture of the upper pubic branch (arrow in **d**); there is callus formation around the stress fracture of the lower pubic branch (asterisk in **d**).

demonstrate a stress fracture is obsolete [5, 6] and is only used in individual cases when MRI is contraindicated and CT findings are inconclusive.

Osteitis Pubis or Symphysitis

Both of these diagnoses concern one of the most frequent causes of chronic groin pain among soccer and rugby players, American football players as well as runners and swimmers (primarily among competitive athletes performing kicking motions, rapid acceleration and deceleration movements as well as abrupt changes in direction) [27]; in our experience, hardly any professional soccer players exhibit a completely unremarkable symphysis in dedicated imaging procedures. The cause is chronic insertional tendinosis of the adductors resulting from repetitive trauma reinforced by an imbalance between the adductors and the rectus abdominis muscle. As this progresses, the pubic symphysis becomes more instable with consecutive stress reactions of this joint and adjacent pubic bone branches [5, 6]. The result is a vicious circle of symphysitis, joint instability and muscular imbalance of the originating muscles. Medial pelvic pain, particularly tenderness of the pubic symphysis and pubic bones are usually present as well as generally positive adductor signs; the pain can, however, project into the abdomen, either perineally or in the direction of the scrotum [27]. The related therapy is difficult, frequently long-term, and requires a complete spectrum ranging from physiotherapy, pain medication, local injections (corticoides [28], local anesthesia [28], autologous conditioned plasma [29]), through hyperbaric oxygen therapy in a pressure chamber [30], and potentially, denervation or fusion operations [6, 27]. An extended absence from sports activity is generally unavoidable. Downtime is frequently 3 months or longer [5, 6].

Familiarity with the following special anatomical characteristics is crucial for understanding the origin of osteitis pubis. The two pubic bones are separated by hyaline cartilage and a central fibrocartilaginous pubic disc, which in adult physiology exhibits a fluid-filled gap, the symphyseal cavity [2, 31]. In the region of the pubic symphysis are important muscle groups such as the adductors (especially adductor longus) and the rectus abdominis muscles as well as elements of the inguinal canal that are bound to the pubic symphysis (**Fig. 4a–c**) [17, 18, 32]. The rectus abdominis muscle stabilizes the distal abdominal wall, and its insertions join with the sources of the adductor longus muscle ventrally and on the anterior aspect of the pubic symphysis [33, 34]. These connective tissues and insertions form the prepubic aponeurotic complex [3], called also the rectus abdominis-adductor aponeurosis and inserts on the pubic tubercle [5, 17]. Likewise, the inguinal ligament, an important element of the inguinal canal, moves in that direction, and these structures are associated with the periosteum

Fig. 4 Schematic illustrations of the anatomy of the symphysis region. **a** Axial sectional view through the symphysis and **b** sagittal sectional view 1 – 2 cm lateral to the symphysis center modified according to [3]. **c** The drawing illustrates the narrow position of the outer inguinal ring lateral to the rectus abdominis-adductor aponeurosis. The rectus and adductor longus muscles function antagonistically on the symphysis during rotation and extension; the open arrows illustrate the force vectors [5]. Targeted MRI orientation in the case of osteitis pubis. Methods of choice are a sagittal, fat-suppressed T2-weighting or proton density (PD)-weighting to demonstrate the rectus abdominis-adductor aponeurosis **d** and a T2-weighted sequence parallel to the arcuate line of the ilium, i. e. axial oblique **e**. Asterisks: rectus abdominis-muscle adductor aponeurosis, 1: adductor longus muscle, 2: adductor brevis muscle, 3: obturator externus muscle, 4: pubic bone, 5: symphyseal cavity in the interpubic disc, 6: hyaline cartilage, 7: adductor longus muscle insertion, 8: rectus abdominis muscle, 9: outer inguinal ring, 10: inguinal ligament, 11: obturator internus muscle.

of the pubic bone, the ligaments and disc of the pubic symphysis (Fig. 4a–c) [3, 5, 6, 33, 34]. The outer inguinal ring lies less than 5 mm laterally to this aponeurosis [5, 32]. The anatomical features imply that injuries to the adductor longus muscle and rectus abdominis muscle involving the prepubic aponeurosis can affect the inguinal canal [5, 17]. Detachment of the prepubic aponeurotic complex, either partial or complete, is an injury frequently designated as sportsman's hernia [3, 35] – probably because of the accompanying involvement of the inguinal canal [3]. However, the radiologist should avoid this term in favor of the more proper osteitis pubis [3]. Imbalance between abdominal and adductor muscles interfere with the force equilibrium on the pubic symphysis [6]. An injury to one of these components thus creates instability of the symphyseal region [3, 17]. In addition, injuries to the adductor insert regularly lead to involvement of the insertion of the rectus abdominis muscle at the pubic symphysis [5, 18].
An important element in the MR diagnostic workup of suspected osteitis pubis is the representation of the pubic symphysis by means of an optimized sequence protocol (Table 3) using axially oblique orientation parallel to the arcuate line of the ilium [5] as well as sequences with a large field of view combined with high-resolution sequences (Fig. 4 d, e). Coronal sequences can be used to optimally assess the rectus abdominis muscle insertion and originating point of the adductor; sagittal proton density or T2-weighted fat-saturated sequences above the symphysis best represent the rectus abdominis-adductor aponeurosis with its periosteal attachments to the anterior and anterior-inferior pubic bone (Fig. 4 d) [3, 5, 17]. Image findings of osteitis pubis in acute cases reveal juxta-articulate bone marrow edema in the adjacent pubic bone (Fig. 5), an irregular symphyseal cavity and frequently accompanying edema in all or individual adductor brevis, adductor longus and rectus abdominis muscles [6, 17]. As mentioned above, a lesion of these stabilizing muscles initially results in destabilization of the symphysis [5], thus setting the stage for osteitis pubis. Lesions of the rectus abdominis-adductor aponeurosis can range from minimal detachment to complete ruptures with retraction of the

Table 3 MRI protocol for diagnosing symphyseal / groin pain in competitive athletics

sequence	orientation	FOV (cm)	slice thickness [mm]
STIR	coronal	28 – 38	3 – 4
T1w	coronal	28 – 38	3 – 4
T2w fat-suppressed	axial	28 – 36	3 – 4
T2w	axial oblique	20	2 – 3
PD fat-suppressed	sagittal	20 – 24	2 – 3
T2w fat-suppressed	axial oblique	20	2 – 3
T1w	axial oblique	20	2 – 3
Optional			
T2w fat-suppressed	*sagittal*	*20 – 24*	*2 – 3*
T1w after CM	*axial oblique*	*20*	*2 – 3*

FOV: Field-of-view, STIR: Short tau inversion recovery, T1w: T1-weighted sequence, T2w: T2-weighted sequence, PD: Proton density. Axial oblique: oblique layer parallel to the arcuate line of the ilium. A supplementary injection of contrast medium (CM) is necessary only in cases of suspected septic arthritis and is superfluous in the standard diagnosis of osteitis pubis. MR arthrography of the hip should be performed if a labral lesion is suspected.

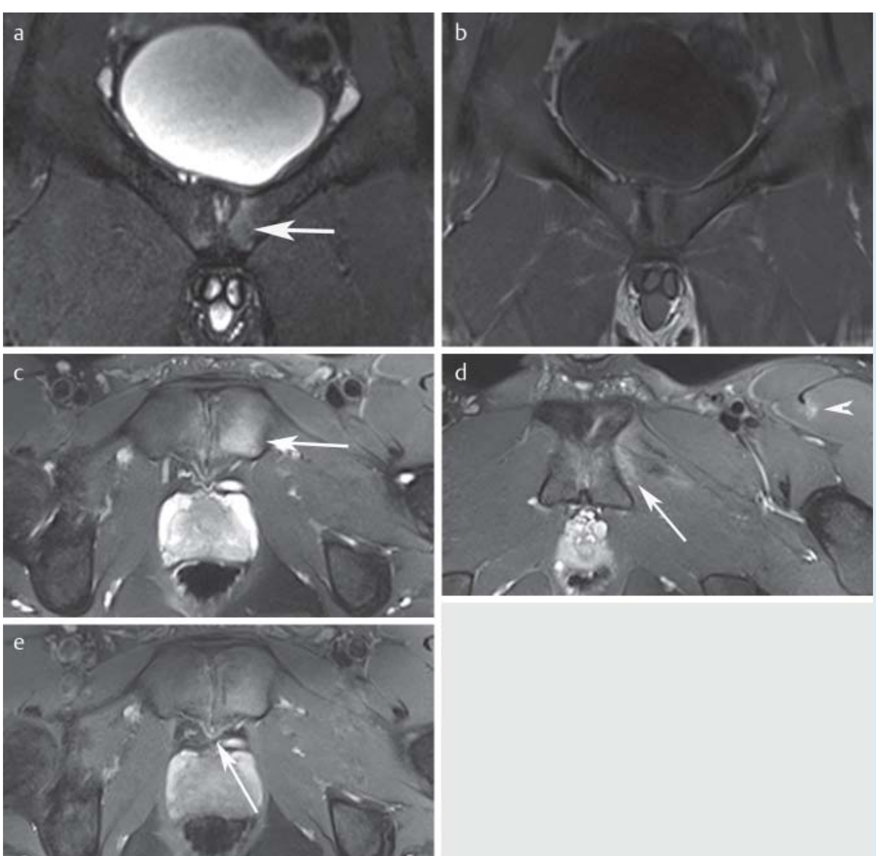

Fig. 5 Acute osteitis pubis. 17-year-old youth soccer player with acute osteitis pubis and bilateral subchondral, mainly left-sided parasymphyseal bone marrow edema (arrow), coronal STIR **a** and coronal T1-weighting **b**. The maximum or side of the edema frequently correlates to the pain site. **c, d** Axial, fat-suppressed T2-weighted 3-Tesla MRI of a 20-year-old professional soccer player. Left-side parasymphyseal bone marrow edema (arrow) and edema in the left adductor brevis muscle insertion (arrow), both typical in acute cases. In addition, there is a grade 1 muscle tear according to [19] in the rectus femoris muscle (tip of arrow). A supplementary injection of contrast medium **e** is necessary only in cases of suspected septic arthritis and provided no additional utility in this case. Further, a posterior herniation of the symphyseal disc (arrow) is present, frequently encountered in competitive athletes, and which can be asymptomatic [6]. It is unclear whether this herniation predisposes to osteitis pubis [2].

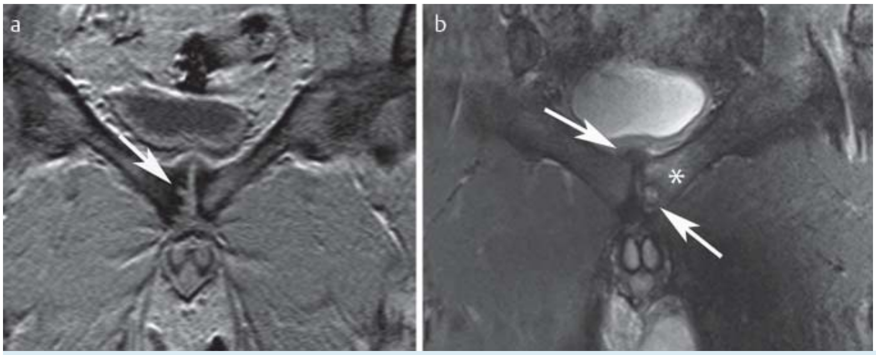

Fig. 6 Chronic osteitis pubis. 56-year-old male with chronic osteitis pubis. **a** The coronal T1-weighting demonstrates an irregular margin of the symphyseal cavity with erosions (arrow). **b** Active chronic osteitis pubis in a 30-year-old professional soccer player. The coronal STIR sequence shows left parasymphyseal bone marrow edema (asterisk). This bone marrow edema is an indicator of active involvement. The protrusion of the cranial symphysis (arrow) by osteophytes and hypertrophy of the capsule and superior pubic ligament as well as the irregular joint margin with subchondral cysts indicate a chronic process.

insertions of the adductor longus and rectus abdominis muscles from the pubic symphysis and pubic tubercle. Milder lesions (micro-ruptures on the adductor origin) can manifest themselves as secondary cleft formation (primary cleft = symphyseal cavity) which can be delineated on coronal MRI images as T2w-hyperintense on the inferolateral edge of the pubic symphysis [2, 5, 31]. Some patients present with only isolated lesions of the adductor compartment, which in the MRI are displayed as minor injuries to the myotendinous junction ranging from a feathery T2w-hyperintense edema through chronic tendinosis of the adductor junction with enlarged hypointense tendon [3, 5]. In the MRI, myotendinous injuries and muscle tears in the adductor compartment should be graded like other muscle tears (see above) [17, 32].

Chronic progression with symptoms lasting more than 6 months, for example in the case of chronic instability of the pubic symphysis resulting from repetitive microtrauma, exhibit typical indicators of arthrosis such as joint space narrowing, subchondral sclerosis and cysts as well as productive changes such as bony spurs and enthesiopathy of the adductors [6, 32], whereas active chronic pubic osteitis exhibits appositional bone marrow edema (**Fig. 6**). On the pubic symphysis this process is frequently bilateral, although asymmetrical, and the side with the greatest MRI change is generally the side with the most pain [2, 17].

The differential diagnosis must take into account that ruptures of the hip flexors such as the sartorius, iliacus and iliopsoas muscles can clinically mimic an injury to the rectus abdominis-adductor aponeurosis complex [5, 6]. In this instance, MRI permits clear differentiation and reliably identifies accompanying pathologies. A radionuclide scan to demonstrate an osteitis pubis is obsolete [6] and is only used in individual cases to assess activity when MRI is contraindicated.

Genuine Hernia, Sports Hernia and Weak Groin

During diagnostic workup of groin pain, additional extra-articular pathologies must be considered during the differential diagnosis. These include hernias (abdominal wall, inguinal as well as femoral hernia [36], or especially in the case of women, the rare obturator hernia [37] (**Fig. 7**). Although genuine hernias are rare among athletes with groin pain (n = 2/102 patients [18]), MRI sequences with large field of view should nevertheless be checked for hernia, e. g. during a hip MRI [5]. Such hernias can be ascertained using the same sensitivity using ultrasound (always in comparison to the opposite side) as well as MRI [38]; however, ultrasonography permits dynamic examination at a higher time resolution.

A sports hernia is usually not an inguinal hernia, and the term "sports hernia" is not uniformly applied in the literature and is subject to debate [1, 5, 17, 18]. The most frequent injuries clinically designated as sports hernia are musculoskeletal in nature and affect the pubic symphysis and the insertions of the muscles and tendons (see above); these are easily diagnosed using MRI [5, 17]. Other authors define a weak groin or sports hernia, which generally exhibits pain radiating into the genital region during coughing and sneezing, as a disruption of the rear wall of the inguinal canal, leading to nerve inflammation (genital branch of the genitofemoral nerve) and pain in the region of the tendon insertion on the pubic bone [1, 6, 39]. The fascia transversalis expands at its weakest point, thus resulting in a widening of the inguinal triangle. This consists of the rectus abdominis muscle, inguinal canal and epigastric vessels with consecutive cranial and medial displacement of the rectus abdominis muscle and increased tension on the pubic bone [39]. Dynamic ultrasonography can ascertain a protrusion of the rear abdominal wall (transverse fascia) under pressure (Valsalva maneuver) [1, 6], whereas a static MRI will be unremarkable. Among soccer players, extreme rotational and flexion motions in this region will provide above-average disclosure of a weak groin. This explanation is supported by an 80 – 90 % success rate of microsurgery providing stabilization by overlapping layers of the transverse fascia [1]. Absence of pain has been reported after 14 days on average [39]. We draw the following conclusion: sports hernia is a clinical diagnosis [3, 6, 28, 38]; the radiologist should employ MRI to exclude other causes or define for instance osteitis pubis as a correlate of a diagnosis of sports hernia.

Labral Pathology of the Hip Joint

The above-mentioned causes of groin pain must be distinguished from pain arising from other sources being projected into the groin. The most frequent cause is acetabular lab-

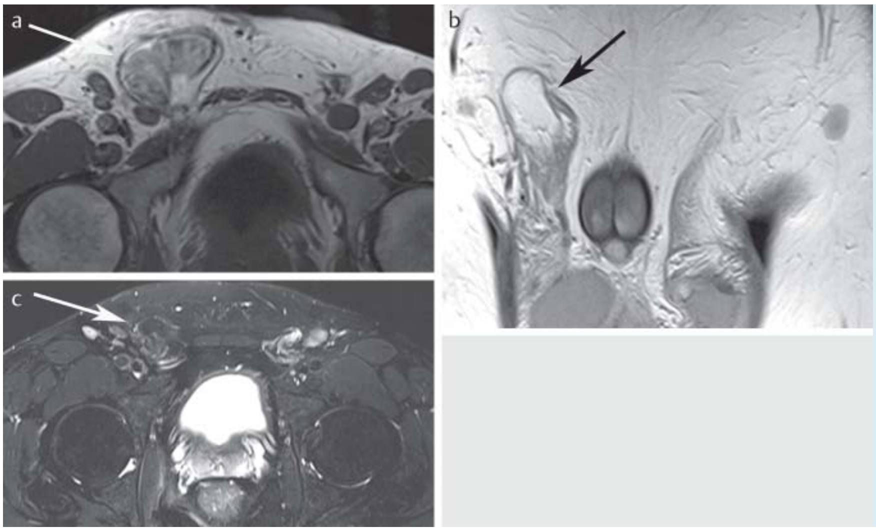

Fig. 7 Unsuspected hernia in MRI. The axial **a** and coronal **b** T1-weighted sequence of this 40-year-old athletic male with uncharacteristic groin pain demonstrates inguinal hernia (arrows). There is no fluid in the axial fat-suppressed T2-weighting around the herniated intestinal loop as an indicator of incarceration **c**. The latter image illustrates the value of sequences without fat suppression, since solely using fat-suppressed images makes it difficult to delineate the hernias.

ral injury (in up to 22 % of professional athletes with groin pain [40]) manifesting as pain radiating into the groin during hip movements [5, 17], particularly during rotational motions in the hip. Labral lesions are fostered by athletic actions (repetitive microtrauma) or isolated trauma during sports and femoroacetabular impingement arising from a poorly formed junction of the femoral head and acetabulum [40]. In the hip there is a distinction between pincer impingement when the femoral head is covered by a defective overhang of the acetabulum, and cam impingement, when the form-fit of the femoral head/neck juncture is reduced [41–43]. Most frequently exhibited (70 %) are combined forms and the antero-superior form of impingement with pain provocation, in particular during hip flexion and forced inner rotation and adduction [40, 41]. A labral tear can only be reliably diagnosed using direct MR arthrography (**Fig. 8**) [40, 44–47], although dedicated radially-arranged MR slices of the femoral head allow a more exact spatial relationship, since the labrum and cartilage are largely represented orthogonally [41]. Likewise, direct MR arthrography can distinguish between a labral tear and the more common detachment of the labrum caused by joint distension [45, 46]. MR arthrography achieves sensitivities/specificities of 90 – 95 %/ 91 – 100 % compared to 30 – 65 %/36 % when conventional MR imaging is used, since in the case of labral lesions, there is frequently no joint swelling leading to joint distension, which would make the tear more visible. In addition, a healthy labrum can exhibit heterogeneous signal intensity [40, 44, 46]. However, a normal labrum typically is triangular, and the signal intensity homogeneously ranges from none to low (Czerny stage 0) [44, 46]. In cases of coagulation disorder or if the patient refuses joint puncture, indirect MR arthrography is an alternative to direct MR arthrography. The patient is brought to the MRI unit after administration of e. g. 0.2 ml/kg gadolinium-DTPA and 15 minutes of joint movement. Sensitivities of 88 – 100 % have been described for labral tears. However, there was no improvement in the demonstration of cartilage compared to native MRI [48, 49]. CT arthrography is significantly inferior to MR arthrography in the detection of labral tears (MR sensitivity/specificity: 100 %/50 % vs. CT: 15 %/13 %) [50]; therefore it should be used only in specific cases of MR contraindications and under consideration of weighing radiation exposure against potential information to be gained from patients who are generally young.

Imaging Protocol and Uncommon Differential Diagnoses

Based upon the multiple above-described causes of groin pain, a two-stage MRI protocol (**Table 3**) can be used, consisting of overview images and targeted sequences [5]. Important in this regard are a coronal STIR sequence and an axial fat-suppressed T2-weighted turbo spin echo sequence of the entire pelvic region as search sequences which should demonstrate the anterior superior iliac spine, the ischial tuberosity, the pubic symphysis, the sacrum and the coccyx [17, 18]. In addition, a non-fat suppressed, T1-weighted sequence to assess bone marrow should be integrated into the imaging protocol in order to diagnose myeloproliferative bone marrow changes or bone marrow metastasis, which, although unlikely, cannot be in general excluded as a cause of groin pain, due to increasing sports activity extending into old age. With respect to women, additional gynecological-related pathologies such as endometriosis must be considered when making differential diagnoses [1, 17, 18]. Following these scan sequences with a large field of view, the protocol should be supplemented by targeted sequences with a small field of view, high resolution and slice thicknesses ≤ 3 mm, e. g. to identify labral pathology or pubic symphysitis [5, 17].

Summary and Critical Assessment

There are numerous differential diagnostic causes of groin pain in competitive athletes. Targeted MRI diagnostics play a key role in accurate diagnosis of, and therapy planning for, patients with recurring groin pain associated with sports. Close dialog between the radiologist and the sports medicine physician aids in concentrating the imaging procedure in order to rapidly provide the patient with a sufficiently focused radiological examination which can be assessed within a narrow clinical context. Since musculoskeletal injuries are frequently the source of groin pain among athletes, the MRI protocol should include imaging these regions in two planes,

Fig. 8 Femoroacetabular impingement. **a** Joint puncture under fluoroscopy, test injection of 1 – 2 ml iodine-based contrast medium to verify correct position, then injection of 10 – 20 ml thinned gadolinium chelate, e. g. 0.0025 mmol/ml gadoteric acid. Pain provoked by joint distension is an indicator of labral lesion; likewise, pain reduction via intra-articular injection of e. g. 0.5 % bupivacaine suggests that the source of the pain is in the joint [45, 46]. MR arthrogram with axial fat-suppressed T1-weighting **b** and radial proton density (PD)-weighting **c** of a 22-year-old athletic woman with cam-type impingement due to an epi/metaphyseal bump (asterisk) and mucoid degenerative labral lesion (arrows). The radial MR sequence precisely illustrates the detachment and degeneration of the labrum. **d** MR arthrogram of 36-year-old athletic male with T1-weighted fat-suppressed axial sequence indicating iliopsoas bursitis (asterisk) with communication (arrow) between the iliopsoas bursa and joint (with 10 – 15 % population [46]). The arrow tip points to the epi/metaphyseal bump with cam-type impingement (α-angle according to Nötzli: 75°, normal ≤ 55° [42]). **e** Demonstration of the labral tear in the coronal PD-weighted fat-suppressed sequence (arrow).

whereby knowledge of specific localization and injury patterns will assist in diagnosing such pain reliably.

Finally it should be noted that although adductor problems and osteitis pubis are the most frequent reasons for interrupting training, in most cases these should be considered symptoms and not the cause of the injury. Therefore, in addition to these entities with a pathoanatomical/morphological correlate, the large group of muscular balance disturbances, impaired motions in muscle strings and blockages of various joints must be recognized as a source of groin pain. Radiologists thus have the important task of excluding morphologically identifiable causes described above when forming a diagnosis.

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