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L. Michael Brunt
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Sports Hernia and Athletic Pubalgia

Diagnosis and Treatment

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ISBN 978-1-4899-7420-4 ISBN 978-1-4899-7421-1 (eBook)
DOI 10.1007/978-1-4899-7421-1
Springer New York Heidelberg Dordrecht London

Library of Congress Control Number: 2014932405

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

The editors are pleased to present the first book published on the topic of sports hernia and athletic pubalgia. The culmination of this effort is timely because this increasingly recognized problem affects a significant number of competitive athletes and is often confusing for health care providers of various specialties. It is only fitting that we begin this work by establishing some of the anatomic and pathophysiologic principles underlying this entity and what we should call it. One of the benefits of editing this book is the opportunity to assemble chapters from thought leaders across the world that collectively help to arrive at some common understanding of the etiology and treatment of this condition.

First, we should establish that an athlete with groin pain may have very different and quite possibly inter-related diagnoses. The diagnosis of a sports hernia, as several authors point out in this book, is best applied to the condition in which there is exertional pain at the distal rectus/medial inguinal floor in conjunction with a distinct weakness in the pelvic floor/transversalis fascia and/or tear in the rectus abdominus aponeurosis. The result is not a true hernia in the sense of a protusion of a peritoneal sac, but rather a weakness which creates stress across the distal rectus and inguinal floor. While this understanding is consistent across the different authors, variations in the details are apparent, particularly in regard to the role of involvement of nearby sensory nerves, which may be irritated or compressed as a result of the associated defects. The observation that extremely "tough athletes," accustomed to violent collision sports, are shut down by such a small fascial bulge reflects the significance of this condition. Diagnostic maneuvers that reproduce this pain with Valsalva confirm a sports hernia, and various treatments to correct this weakness in the abdominal wall all appear to be effective. Several chapters outline the technical details of how this can be done, from a general tightening of the soft tissue layers to a selective imbrication under the nerve, to mesh repairs done open or laparoscopically. As you will see in these chapters, all can be successful as they all correct this underlying area of weakness. The benefits of one approach over another have never been directly studied, but the authors here provide a good overview of pros and cons to each method as well as individual results.

Second, athletic pubalgia is best used to refer to a collection of problems associated with the groin region in athletes involving assorted tendinopathies and insertional tendon strains. The differential diagnosis and imaging approach that are essential to selection of athletes for conservative versus surgical management are therefore paramount to arriving at a precise diagnosis. Most commonly, the tendons affected are the rectus femoris or the adductor longus. The strains represent partial tears at the tendinous insertions on the pelvis and result in chronic pain with exertion. Such strains may be associated with a sports hernia type area of weakness or a bulge as well. Repair hinges upon addressing the specific tendon that is injured, with a heavy reliance on MRI for an accurate diagnosis.

Lastly, we are just beginning to understand the strong correlation and interplay between hip impingement problems (femoral acetabular impingement or FAI) and sports hernia type problems. It appears that impingement at the hip can cause altered mechanics in the pelvis, such that the hemipelvis is subject to increased rotation during aggressive athletic motions such as kicking or twisting the torso. The muscles attaching to the pelvis are then subject to increased stresses as they work to stabilize the pelvis. Injury to the tendon attachments or to the transversalis fascia may then occur. However, confirming this theory doesn't prove to be so simple. Not every athlete with radiographic evidence of FAI ends up with a sports hernia, and not every athlete with a sports hernia has FAI radiographically. Even those athletes with both sports hernia and FAI, if only one is fixed surgically, do not necessarily require the other to be addressed. However, this correlation may explain the failures of operative treatment that can occur with any approach to either problem.

Establishing what exactly is injured and what ultimately is repaired is important as we move forward to have any ability to compare outcomes. Any publications should strive to make these issues clear. The contributors to this book were selected for their extensive experience with these problems and to cover the range of etiologies and treatment options for problems in the athletic groin. We feel that we have been successful in covering the landscape well, but recognize that opinions vary on what exactly is going on and how to make it better as illustrated by the differing operative approaches among the various contributors. By providing all of these opinions together, the readers can draw their own conclusions about similar themes that strive to stabilize the posterior inguinal floor and associated structures and to decrease tension across the affected area. Treatment of damaged or inflamed tendon attachments for pain associated with stress on these attachments, whether by conservative or surgical means, is another consideration.

These diagnoses are clearly real. Treatments are effective and athletes do return to compete effectively. We hope this book helps to establish credibility in these areas where there has been doubt and reduce confusion where there have been differences of opinion.

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Sports Hernia—Anatomy: What Is a Sports Hernia?

1

Matt Lyons and L. Michael Brunt

Introduction

Groin pain is a frequent complaint in competitive athletes with up to 58 % of soccer players reporting a history of symptoms [1]. Acute groin pain is most commonly associated with muscle strains involving the adductor and hip flexor muscle groups and will improve with rest and expectant management. Pain that is chronic in nature and recalcitrant to conservative management can be a source of frustration for high-level athletes, leading to loss of playing time and decreased productivity. Management of chronic groin pain can be challenging from both a diagnostic and therapeutic standpoint due to the multiplicity of causes, subtle physical exam findings, and anatomic complexity of the hip and groin region. Sports hernia represents a frequent diagnosis in this setting, present in over 80 % of athletes with chronic groin pain in separate studies [2, 3].

The initial literature on sports hernia displayed difficulty in distinguishing between sports hernia and a subtle conventional hernia [4]. For instance, the original description defined it as a groin pain complex associated with a small direct inguinal hernia [5]. Only with attempted surgical management was it discovered that the presence of a "true hernia" or palpable protrusion of a hernia sac through a defect in the abdominal wall did not exist in the setting of sports hernia. This review led to the current definition by Swan and Wolcott [4] of a sports hernia as a weakness in the posterior wall of the inguinal canal causing a chronic activity-related pain in the groin and its surrounding structures. Meyers et al. [6] added to this definition with the concept of athletic pubalgia, involving an insertional shearing injury to the muscular attachments to the pubis, resulting from an imbalance of adduction and abduction forces centered on the pubic symphysis. The exact location of the tear or area of weakness remains an area of disagreement. Consequently, for the purposes of this chapter, the terms sports hernia and athletic pubalgia will be used interchangeably. In this chapter, we will attempt to detail the complex anatomy of the abdominal wall and inguinal region, while delineating the proposed etiology and pathophysiology of the sports hernia/athletic pubalgia condition.

Anatomy

The groin region represents a complex confluence of anatomic structures. Prior to discussing the pathologic processes involved in development of a sports hernia, it is imperative to have an

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D.R. Diduch and L.M. Brunt (eds.), *Sports Hernia and Athletic Pubalgia: Diagnosis and Treatment*,
DOI 10.1007/978-1-4899-7421-1_1, © Springer Science+Business Media New York 2014

understanding of the basic anatomy of the abdominal, inguinal, and pelvic region. We will therefore begin with an anatomic overview of the region.

Pubic Symphysis

The symphysis pubis is an amphiarthrodial joint consisting of the corresponding pubic bones with an intervening fibrocartilage disk (Fig. 1.1). The articular surface is oval in shape and lined with a thin layer of hyaline cartilage. Each of the pubic bones contributes to form the anterior aspect of the innominate bone of the pelvis and consists of three segments: the medial body, as well as superior and inferior rami. The symphysis has a large contact area with minimal motion, aiding in pelvic stabilization by protecting against shear force. The disk aids in this function by absorbing and dispersing both axial and shear forces [7]. The pubic rami then spread compressive forces to the remainder of the pelvis. The four supporting ligaments of the pubic symphysis aid in stability, blending intimately with the insertion of the muscles of the abdominal wall. The superior and inferior or arcuate ligaments appear to have a greater role in dissipation of shear force than the anterior and posterior. The superior ligament bridges the pubic tubercles, while the inferior merges with the aponeurosis of the external oblique and adductor longus muscles. The pubic tubercle also serves as an attachment point for the inguinal ligament. Originating from the anterior superior iliac spine, the ligament is formed by the external oblique aponeurosis and forms the inferolateral boundary of Hesselbach's triangle. The anterior symphyseal ligament divides into superficial and deep portions. The superficial becomes contiguous with the aponeurosis of the external oblique and rectus abdominis muscles, while the deep inserts within the cartilaginous disk [8].

Abdominal Wall

Numerous muscles responsible for stabilization of the pelvis have a common attachment point on the pubic symphysis, including the muscles of the abdominal wall. From superficial to deep the structures of the abdominal wall include: skin, fascia, external oblique muscle and fascia, internal oblique muscle and fascia, transversus abdominis muscle and fascia, and transversalis fascia. Deep to this is parietal peritoneum. The rectus abdominis is the principal vertical midline muscle of the abdominal wall, consisting of two strap-like muscle bellies. These bellies are divided by a strong fibrous band formed by the aponeuroses of other abdominal muscles, known as the rectus sheath. The difference between the manner in which the aponeuroses decussate and split the rectus in the superior and inferior aspects of the abdominal wall forms a potential area of vulnerability. In the cranial 3/4th of the wall, the internal oblique aponeurosis splits the rectus, leaving its posterior lamina and the transversus abdominis completely posterior. However, below the level of the semicircular or arcuate line in the caudal 1/4th of the abdomen, the internal oblique and transversus abdominis both pass anterior to the rectus, leaving only peritoneum as the posterior layer. This anatomic feature is hypothesized as a potential contributing factor in the development of hernias [4].

The rectus abdominis originates from the pubic symphysis crest and inserts on the xiphoid process and fifth to seventh costal cartilages. It is innervated by the lower costal and subcostal nerves, which arise from the ventral rami of the caudal six thoracic nerves. It receives the majority of its blood supply from the superior and inferior epigastric arteries, with smaller contributions from the posterior intercostal, subcostal, posterior lumbar, and deep circumflex iliac arteries. The rectus abdominis functions to flex the trunk, and compress and protect the abdominal viscera. The muscle tapers significantly from cranial to caudal with its proximal insertion approximately three times wider than its distal origin. The resulting concentration of force over a smaller area may predispose the distal origin of the muscle to injury [9].

The inguinal canal passes through the caudal extent of the abdominal wall, extending from the deep inguinal ring formed through the transversalis fascia to the superficial inguinal ring formed through external oblique aponeurosis (Fig. 1.2). The deep ring is located approximately midway

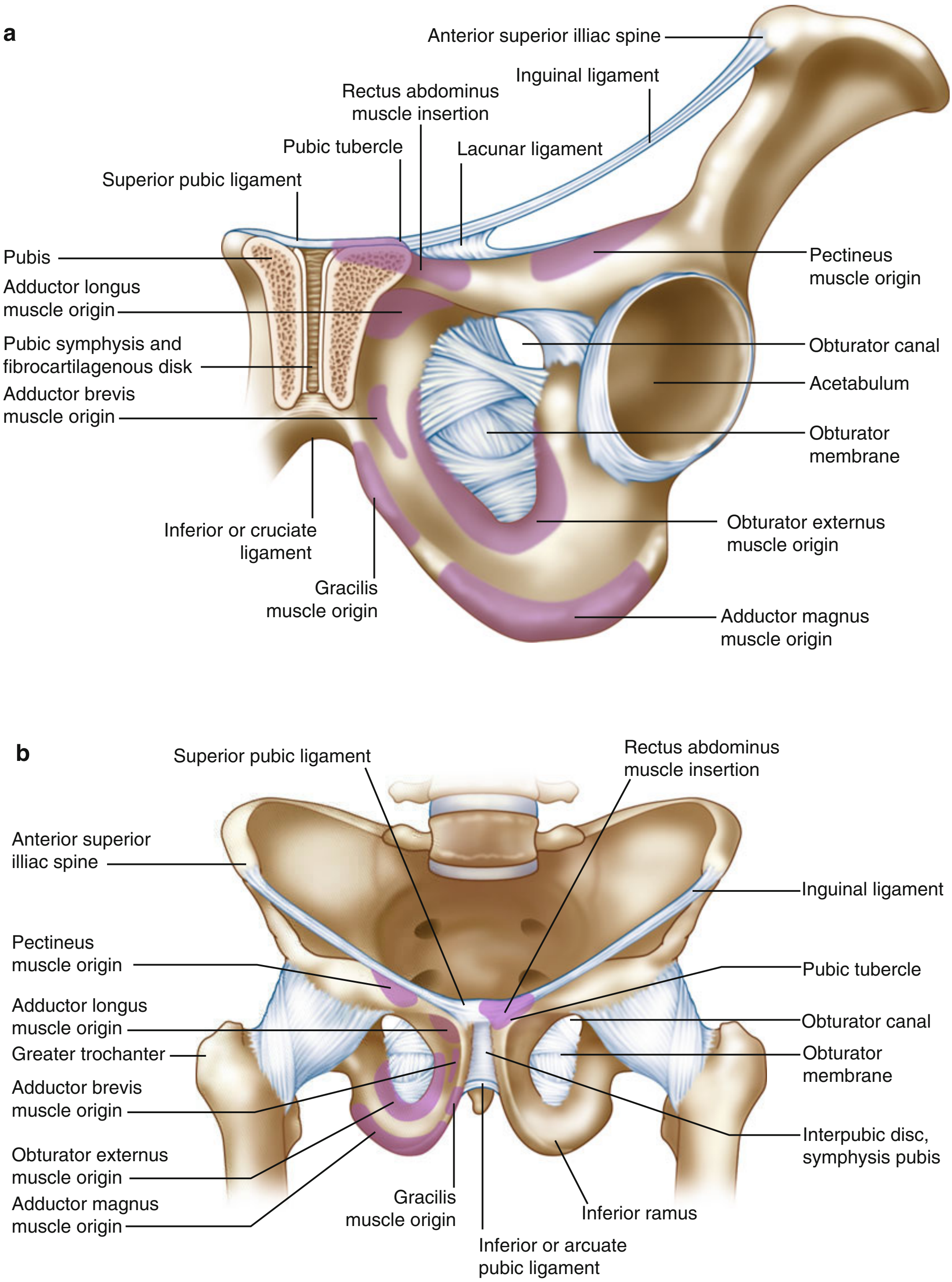
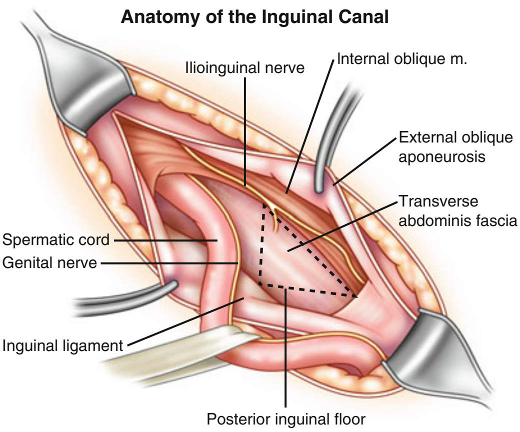


Fig. 1.1 Schematic anatomy of the pubic symphysis. (**a**) Partially rotated view (**b**) anterior view

a



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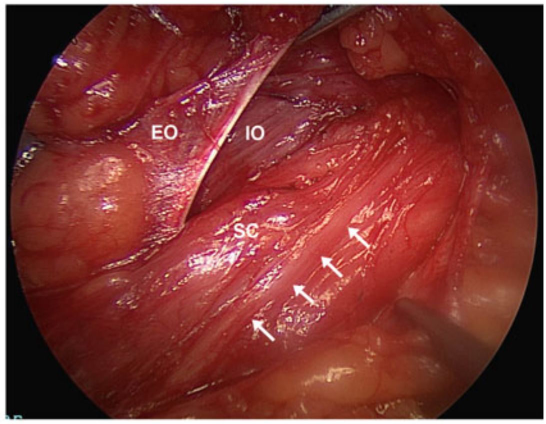

Fig. 1.2 (**a**) Schematic depiction of inguinal floor/canal anatomy; (**b**) operative photograph of normal inguinal anatomy—(left side)—*EO* external oblique aponeurosis, *IO* internal oblique, *SC* spermatic cord, *arrows* point to the ilioinguinal nerve

between the anterior superior iliac spine and pubic tubercle, while the superficial ring is directly superolateral to the pubic tubercle. The spermatic cord in males and round ligament in females pass through it. The canal has both anterior and posterior walls, as well as a roof and floor. The anterior wall is formed by the aponeurosis of the external oblique muscle, while the transversalis fascia forms the posterior wall. In only 5 % of cases or less is the transversalis fascia joined by fibers from the internal oblique, forming the so-called conjoined tendon. The roof of the inguinal canal is composed of fibers of the internal oblique and transversus abdominis muscles and the inguinal ligament and lacunar ligament form the inferolateral boundary [9].

Two nerves of the abdominal wall, the ilioinguinal nerve and genital branch of the genitofemoral nerve, are often implicated in the pathologic process though to be responsible for chronic groin pain [10]. The ilioinguinal nerve is a branch of the lumbar plexus, originating from the L1 nerve root. It emerges from the lateral edge of the psoas muscle, piercing the transversus abdominis near the iliac crest and the internal oblique prior to entering the superficial inguinal ring. It does not enter the deep inguinal ring. Along its course, it provides branches to both the transversus abdominis and internal oblique before eventually providing sensation to the scrotum or labia majora and medial aspect of the thigh. The genitofemoral nerve emerges from the L1 and L2 nerve roots of the lumbar plexus before dividing into two branches. The femoral branch provides sensation to the skin of the anterior thigh in the area of the femoral triangle. The genital branch passes anterior to the psoas muscle and either perforates the transversalis fascia or passes directly into the deep inguinal ring. It travels within the spermatic cord to the scrotum, providing innervation to the cremaster and dartos muscles, as well as some fibers to the skin of the scrotum [9].

Adductor Muscle Group

The adductor muscles also have a common origin on the pubis. They not only provide adduction of the thigh but also function in concert with the hip flexors and external rotators to stabilize the pelvis through the swing phase of gait [8]. The muscles of the adductor group make up the medial compartment of the thigh (Fig. 1.3). They include the adductor longus, adductor magnus, adductor brevis, gracilis, and pectineus. The anatomic appearance and relationships on imaging are seen in Fig. 1.4.

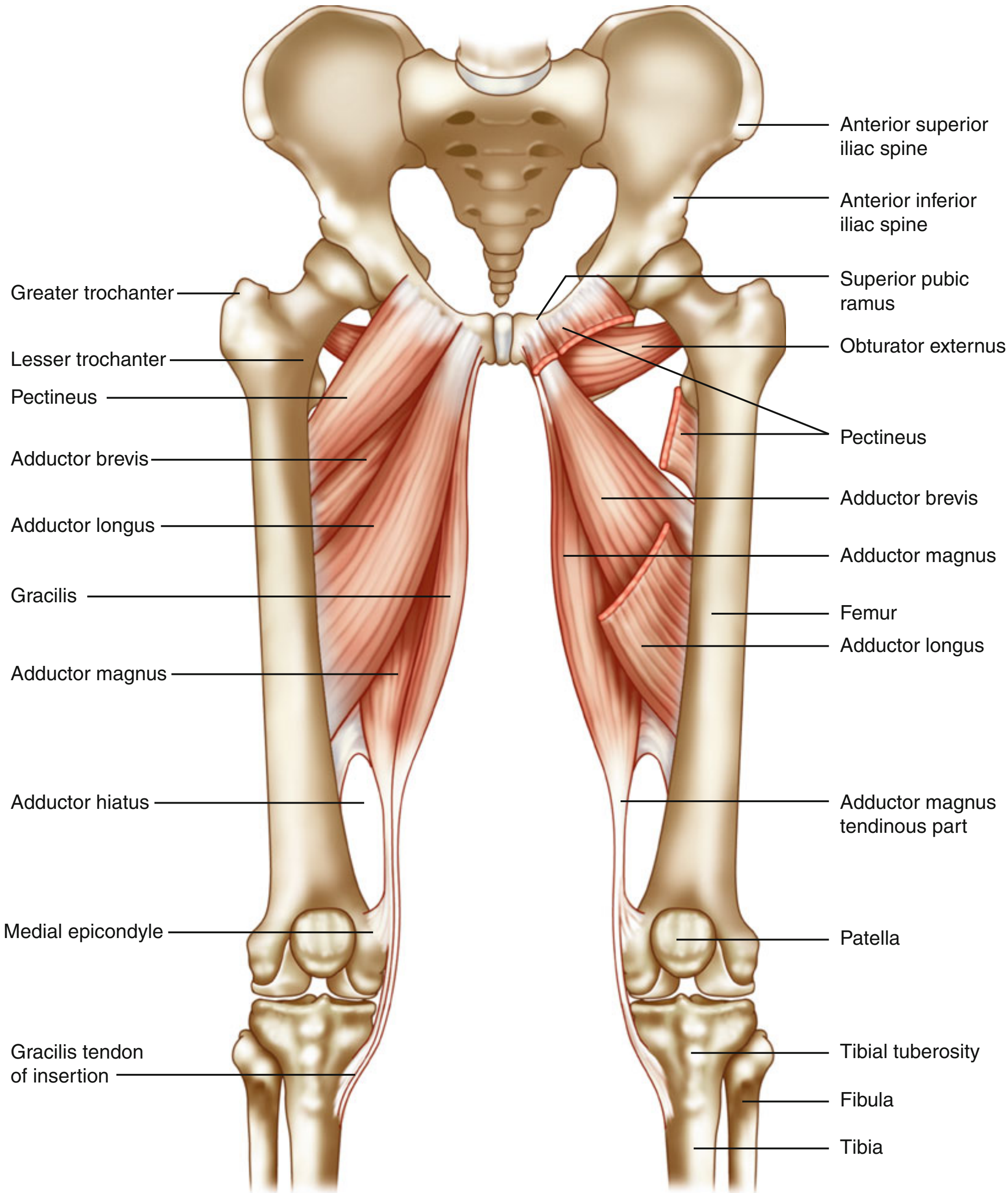

Fig. 1.3 Schematic anatomy of adductor muscle group

The adductor longus is the most anterior of the three adductor muscles, lying medial to the pectineus. Originating from the anterior margin of the pubis, it has a large triangle-shaped muscle belly that broadens significantly prior to its insertion on the linea aspera of the mid-femur [8]. The proximal musculotendinous junction is the most common site of injury, with a predominance of the tears involving the anterior aspect of the tendon. This has been attributed to both the more highly

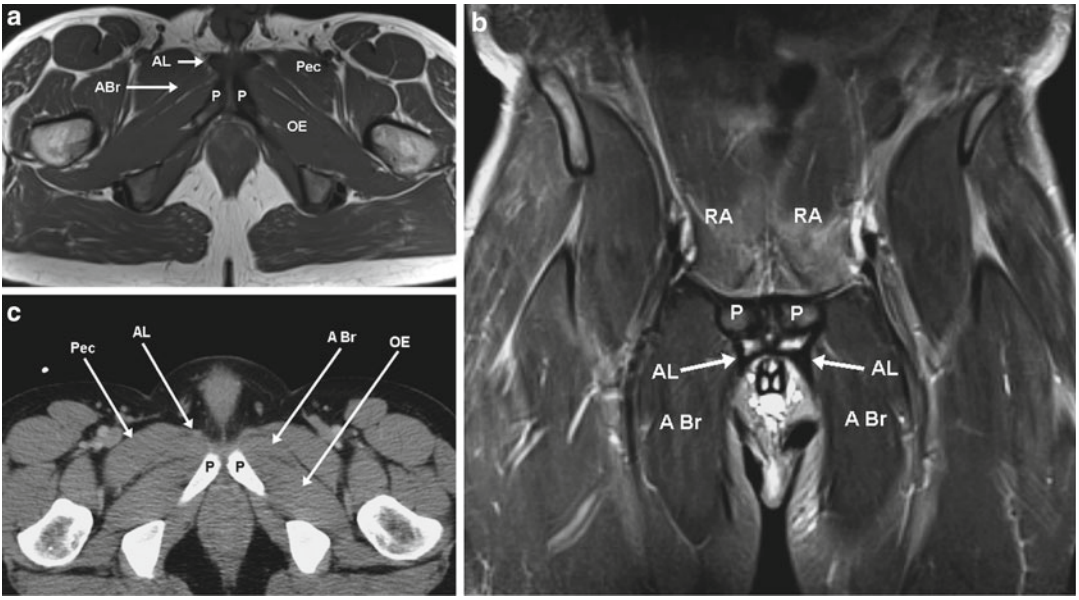

Fig. 1.4 Imaging of adductor group and relationships to pubis (**a**) axial MRI sequences; the adductor longus tendon is the dark triangular area just below the pubis; (**b**) coronal MRI. In this case, there is detachment of the adductor longus tendon from the pubis as evidenced by the area of bright signal just below the pubis; (**c**) CT cross-sectional appearance. *AL* adductor longus, *ABr* adductor brevis, *Pec* pectineus, *P* pubis, *OE* obturator externus, *RA* rectus abdominus

developed nature of the anterior compared to the posterior junction, where the muscle fibers attach direct to bone, as well as the relatively poor blood supply of the junction, which may decrease both the ability to resist force and repair injury [8]. The blood supply is predominately from a branch of the deep femoral artery known as the artery of the adductors. The muscle is innervated by an anterior branch of the obturator nerve via the L2–4 nerve roots [9].

Moving from anterior to posterior, the adductor brevis and adductor magnus are located posterior to the adductor longus. The adductor brevis originates from the anterior pubic body and inserts on the proximal linea aspera. Similar to the adductor longus, it receives its blood supply from the artery of the adductors and innervation from the anterior branch of the obturator nerve (L2–4 nerve roots). As its name implies, the triangular-shaped adductor magnus is the largest muscle of the group. It is composed of two distinct segments. The adductor segment arises from the inferior pubic ramus and inserts on the linea aspera distal to the adductor brevis. It acts to adduct the thigh, with its innervation provided by the posterior branch obturator nerve (L2–4 nerve roots). The muscle also contains a hamstring segment, which originates from the ischial tuberosity and attaches distally to the adductor tubercle of the femur. Functioning as a thigh extensor, it gains its innervation from the tibial division of the sciatic nerve (L4 nerve root). Given the muscle's extensive size, the blood supply originates from multiple arteries. The majority of blood flow is provided by the deep femoral artery with smaller contributions from the medial circumflex and popliteal arteries [9].

The gracilis and pectineus muscles complete the adductor group. The most medial adductor muscle, the gracilis, is a strap-like muscle which attaches proximally to the pubic body and inferior ramus. It inserts distally on the pes anserine, acting to adduct the thigh and to flex and internally rotate the hip and flex the knee. In accordance with the other adductor muscles, it garners its blood supply from the artery of the adductors and innervation from the obturator nerve (L2–3 nerve roots) [9]. The pectineus muscle is located anterior to the adductor longus and is often classified as a muscle of the anterior, rather than medial compartment. It acts similar to the other adductor muscles, functioning to adduct the thigh and flex and internally rotate the hip, but through a different blood supply and innervation. The medial circumflex artery predominately supplies its blood supply, while the femoral nerve (L2–3 nerve roots) and accessory obturator nerve provides its innervation [8].

Etiology

Within the literature, there is a lack of agreement on the etiology of sports hernias. The incidence in professional athletes has been estimated between 0.5 and 6.2 % [10]. Published studies have identified sports that involve use of the proximal thigh and lower abdominal muscles for kicking, cutting, or pivoting as risk factors for development of the condition [4]. The most commonly implicated sports include soccer, ice hockey, rugby, or Australian rules football, American football, skiing, and running [11]. Men are much more commonly affected than women, and the condition is typically insidious in nature, with few athletes able to describe an acute event [4]. Symptoms are most commonly unilateral but can affect both sides [8].

Overuse, abdominal and adductor muscle strength mismatch, reduced hip range of motion, and congenital inguinal wall weakness have all been implicated in the development of chronic groin pain [10]. Imbalances in strength, coordination, endurance, or range of motion which lead to overload and eventual failure of muscle attachments and/or non-contractile tissues represent key factors in all proposed etiologies. The pubic symphysis can be viewed as a central point linking the posterior pelvis, abdominal wall, and lumbosacral spine with the hips and lower extremities. The concept of the "pubic joint" was first proposed by Meyers et al. [12] to help understand these complex relationships. In this model, the central pubis acts as a large complex rotational joint or central fulcrum for the powerful abdominal and thigh muscles. Imbalances in forces or motion would, therefore, place increased shear stress across the pubis and result in eventual excessive load and failure of the opposing muscles or aponeurotic attachments. Some authors have speculated that off-season training programs may accentuate the imbalance between strong adductor muscles and weak abdominals. This view is supported by studies which demonstrated that adductor strains were 20 times more likely in hockey training camps than during the regular season [10].

A more recent link has been made between femoroacetabular impingement (FAI) and the development of sports hernia. FAI and sports hernia occur in similar sports and share common symptoms. Soccer players in particular have a high prevalence of radiographic hip abnormalities with one study demonstrating cam lesions in 68 % and pincer lesions in 27 % of male players. It has been suggested that the presence of hip alignment abnormalities and the resultant abnormal pelvic mechanics may not only accompany but also play a causative role in the development of sports hernia [4, 10, 11, 13, 14].

Pathophysiology

Similar to etiology, there exists no consensus within the literature for the pathophysiologic process(es) that lead to symptomatic athletic pubalgia. Studies reporting operative findings have identified a multitude of injured structures, including the transversalis fascia (posterior inguinal wall), conjoined tendon, rectus abdominis, adductor longus aponeurosis, internal oblique muscles at the pubic tubercle, external oblique muscle and aponeurosis, ilioinguinal nerve entrapment secondary to external oblique tear, as well as isolated entrapment of the ilioinguinal and/or genitofemoral nerves [10].

The different proposed areas of injury can be divided into three general categories:

1. Injury to the distal rectus abdominis and adductor tendon complex at the pubis.
2. A weakened or deficient posterior inguinal wall.
3. Nerve entrapment involving the ilioinguinal nerve or genital branch of the genitofemoral nerve.

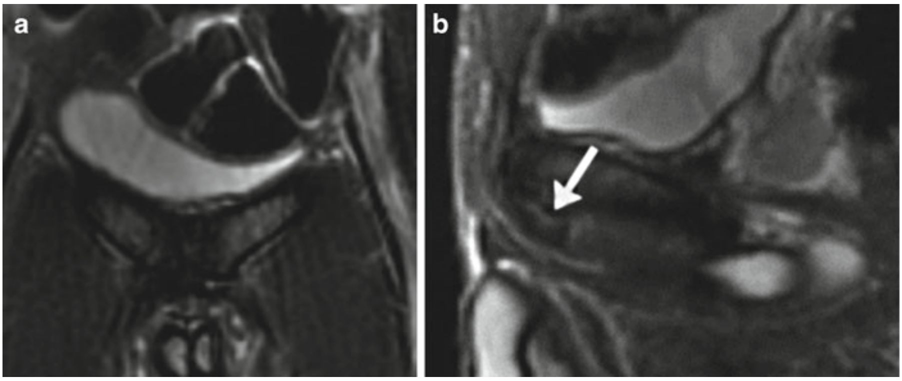

Fig. 1.5 MRI rectus tendon injury on the left side. (**a**) Axial view; (**b**) sagittal view. *Arrows* point to the site of the tear/separation

Introduced by Meyers and based on his intraoperative and MRI findings, the first proposed pathology focuses on the antagonistic relationship action of the rectus abdominis and adductor longus muscles on the pubic symphysis [15, 16]. Each muscle's origin coalesces to form a common aponeurosis on the anterior pubic body. The primary action of the rectus is to rotate the pelvis up, while adductor longus contraction results in a downward force. Cutting and planting sports, which require repetitive, forceful thigh adduction and trunk hyperflexion, can result in injury to either of the muscle tendons (Fig. 1.5). In fact, single leg stance planting in sports such as soccer, requires simultaneous co-contraction of the abdominal wall and adductors to maintain neutral pelvic alignment [10]. Resulting asymmetric biomechanics places the other tendon at risk for injury, leading to instability of the pubic symphysis and further injury to the surrounding muscle attachments. Hernia-type symptoms are attributed to the close proximity of the external ring of the inguinal canal to the lateral border of the rectus-adductor aponeurosis [8]. Meyers et al. [12] have described 17 distinct anatomic variants of athletic pubalgia, the most common of which are listed in Table 1.1; most of these involve injury to the distal rectus tendon, adductor tendon, or a combination of the two. His group has reported excellent results with direct repair of the rectus injury, with 95 % of 5,218 total patients returning to play within 3 months [15].

Similarly, proponents of the second theory believe that an injury to the posterior inguinal wall can result from an imbalance in forces with the stronger, more powerful adductor and thigh musculature placing stress across the pubis and onto the relatively weaker abdominal muscles. This process leads to weakening of the external oblique (Fig. 1.6) and transversalis fascia (Fig. 1.7) and widening of inguinal canal. Surgical intervention, therefore, focuses on repair of the posterior wall deficiency and external oblique injury if present. Studies report return to play rates greater than 90 %, similar to those seen with previously described approach [13, 15, 17]. These findings were originally described in 1980 by Gilmore in soccer players, in which he found a combination of a torn external oblique aponeurosis, torn conjoined tendon, and dehiscence between the conjoined tendon and the inguinal ligament in the absence of a true inguinal hernia [11, 18]. However, this model fails to consider the possibility of a rectus aponeurotic tear, although this specific combination may coexist with the other.

Muschawek and Berger [19] have theorized that a weakness in the posterior inguinal floor results in widening of the groin canal and retraction of the rectus abdominus medially and cranially. As a result, there is increased tension at the pubic insertion and resultant peri-pubic pain. The posterior abdominal wall deficiency may also explain why some authors have reported with the

Table 1.1 Common variations in athletic groin pain syndromes

Athletic pubalgia syndromes and variants	Clinical presentation	Notes
1. Classic sports hernia/ athletic pubalgia	Chronic lower lateral rectus or medial inguinal floor exertional pain	May be associated with parasymphaseal edema and/or distal rectus aponeurotic tear on MRI
2. Adductor longus variant	Principal symptoms and findings are in adductor longus compartment	Adductor aponeurotic tear or adductor tendinopathy on imaging
3. Combined athletic pubalgia and adductor longus syndrome	Abdominal and adductor components coexist in a significant percent of cases	May require partial adductor release in addition to repair of inguinal floor
4. Osteitis pubis variant	Pain is more centrally located in midline pubis area, thought to be overuse related and/or due to abnormal pubis biomechanics	May coexist with athletic pubalgia and not resolve until the latter is treated surgically
5. Iliopsoas variant	Pain occurs at psoas tendon insertion site on lesser trochanter	Weak rectus abdominus may contribute to instability and development of psoas bursitis
6. Snapping hip syndrome	May be internal due to iliotibial band or gluteus maximus snapping over greater trochanter or iliopsoas snapping over iliopectineal bursa. Pain often associated with an audible hip snap on exam	More common in runners or females
7. Spigelian variant	Pain at lateral rectus/oblique junction but cephalad to the inguinal canal in area of arcuate line or above	Pathology is similar to classic athletic pubalgia in terms of musculo-fascial injury

Modified from Meyers WC. Anatomic basis for evaluation of abdominal and groin pain in athletes. Oper Tech Sports Med 2005;13:55–61 with kind permission from Elsevier Limited

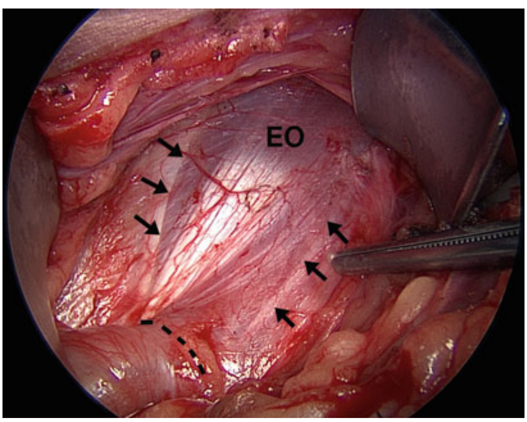

Fig. 1.6 Attenuated external oblique aponeurosis in an athlete with sports hernia pubalgia. *EO* external oblique; *arrows* point to two separate areas of attenuation and thinning of the external oblique aponeurosis

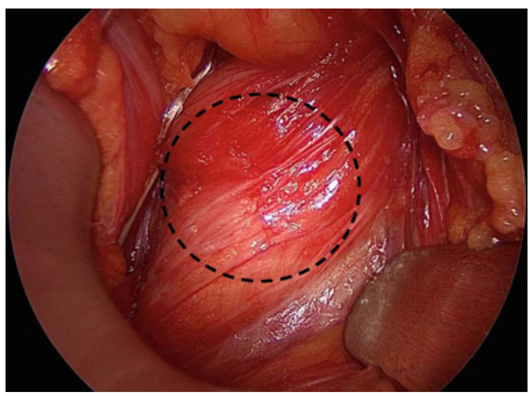

Fig. 1.7 Posterior inguinal floor deficiency as seen from the open anterior approach. *Dashed circle* is primary area of weakness. Also seen is some mild bugling of the entire floor in this area

laparoscopic approach findings of a "direct inguinal hernia" at operation [3, 20].

Finally, nerve entrapment as either an isolated entity or in the setting of a posterior wall defect has been implicated by some authors as the causative factor in the development of pain [21, 22]. The ilioinguinal nerve and genital branch of the genitofemoral nerve are the most commonly implicated and are intimately associated with the inguinal canal (Fig. 1.8) [1]. The true incidence of nerve entrapment has not been substantiated in the literature. Muschaweck has postulated that