The groin triangle: a patho-anatomical approach to the diagnosis of chronic groin pain in athletes

E C Falvey, A Franklyn-Miller, P R McCrory

ABSTRACT
Chronic groin pain is a common presentation in sports medicine. It is most often a problem in those sports that involve kicking and twisting movements while running. The morbidity of groin pain should not be underestimated, ranking behind only fracture and anterior cruciate ligament reconstruction in terms of time out of training and play. Due to the insidious onset and course of pathology in the groin region it commonly presents with well-established pathology. Without a clear clinical/pathological diagnosis, the subsequent management of chronic groin pain is difficult. The combination of complex anatomy, variability of presentation and the non-specific nature of the signs and symptoms make the diagnostic process problematical. This paper proposes a novel educational model based on patho-anatomical concepts. Anatomical reference points were selected to form a triangle, which provides the discriminative power to restrict the differential diagnosis and form the basis of ensuing investigation. This paper forms part of a series addressing the three-dimensional nature of proximal lower limb pathology. The 3G approach (groin, gluteal and greater trochanteric regions) acknowledges this, permitting the clinician to move throughout the region, considering pathologies appropriately.

THE GROIN TRIANGLE
The specific anatomical landmarks and borders of the groin triangle are set out in fig 1.

APEX POINTS OF THE GROIN TRIANGLE
The anatomical apex points of the triangle are as follows: the anterior superior iliac spine (ASIS); the pubic tubercle and the 3G (groin, gluteal and greater trochanteric triangles) point.

The 3G point
From anthropometric measurements, the authors defined a new reference point at the apex of the triangle. This point was termed the “3G point” in reference to the three-dimensional pathology and the groin, gluteal and greater trochanteric regions. The relationship of this point in the anterior coronal plane was the mid-distance point between the ASIS and the superior pole of the patella, and in the posterior coronal plane double the distance from the spinous process of the L5 lumbar vertebrae to the ischial tuberosity in the line of the femur.

ANATOMICAL RELATIONS OF THE BORDERS OF THE GROIN TRIANGLE
Superior border of the groin triangle
The line between the pubic tubercle and the ASIS forms the superior border of the triangle. This corresponds to the anatomical position of the inguinal ligament, a thickening of the aponeurosis of the external oblique muscle. Superior to this line, working from the pubic tubercle medially to the ASIS laterally the following structures will be encountered: the rectus abdominis and rectus abdominis sheath insertions; internal oblique, external oblique and transversus abdominis insertions and aponeuroses; inguinal canal, medially the superficial inguinal ring and conjoint tendon, more laterally the canal and further laterally the deep inguinal ring; the ilioinguinal, iliohypogastric and genital branch of the genitofemoral nerve; the conjoint tendon of ilio-psoas as it passes under the lateral third of the inguinal ligament; the visceral contents of the abdomen and pelvis.

The insertion of the rectus abdominis and its sheath are intimately related to the aponeuroses of the obliques and transversus abdominis. The junction of where these structures converge at the pubic bone revolves around the inguinal canal. The internal inguinal ring is located at a point between the mid-inguinal point (situated midway between the anterior superior iliac spine and the pubic symphysis) and the midpoint of the inguinal ligament. The transversus fascia and the conjoint tendon, a confluence of internal oblique and transversalis fasciae, form the posterior wall of the canal. The superficial inguinal ring, the opening in the external oblique aponeurosis is situated a
centimetre above and lateral to the pubic tubercle. The anatomy of the ilioinguinal and iliohypogastric and genital branch of the genitofemoral nerves is extremely variable, between them they supply the skin of the lower abdomen, medial thigh and scrotum.7

Medial border of the groin triangle

The line from the pubic tubercle to the 3G point inferiorly forms the medial border of the triangle. Although neither the medial or lateral borders of the triangle comprise a muscular line, in both instances they work to separate the clinically important “groups” of structures that lie on either side of them. Medial to the border lie the adductor muscles, from superficial to deep—adductor longus, gracilis, adductor brevis, adductor magnus.

The adductor longus and gracilis tendons are the most commonly affected and lie in an almost continuous site of origin along the body of the pubis. The other adductor muscles (brevis and magnus) arise more posterolaterally along the inferior pubic ramus. The ramus forms a direct continuum between the pubic body and the ischial tuberosity. The obturator nerve divides in the obturator canal (2–3 cm long canal situated in the anterosuperior aspect of the obturator foramen containing the obturator nerve, artery and vein) to anterior and posterior divisions. The anterior branch innervates the adductor longus, brevis, gracilis and, occasionally, the pectineus; it supplies sensory innervation to the skin and fascia of the inner distal thirds of the medial thigh.8

Lateral border of triangle

The line from the ASIS superiorly to the 3G point forms the lateral border of the triangle: femoro-acetabular joint; trochanteric bursa; tensor fasciae latae and iliotibial band.

Although the surface marking of the femora-acetabular joint lies within the triangle, the pathology of the joint is usually referred to as the greater trochanter, as such it is considered in this section. Gluteal bursae underlie the gluteus maximus and
Medial to triangle Adductor/gracilis enthesopathy Insidious onset, warms up with exercise Guarding on passive abduction,1 extraordinary weakness.19 Pubic “clock”: 6–8 Magnetic resonance imaging1
Rectus abdominis enthesopathy Well localised to insertion, acute or insidious onset Pain from resisted sit-up.16 Pubic “clock”: 12 Bone tenderness predominates12 13 Diagnosis of exclusion Magnetic resonance imaging12
Pubic bone stress injury Non-specific diminished athletic performance, loss of propulsive power Bone tenderness predominates12 13 Diagnosis of exclusion Magnetic resonance imaging12
Degenerative pubic symphysis Central pain, associated with stress through symphysis—stair climbing Tender over symphysis. Pubic “clock”: 3 Plain film,13 magnetic resonance imaging1 Magnetic resonance imaging12
Incipient hernia; conjoint tendon tear Insidious onset, diminished performance, warms up Pain on resisted “torsion” of trunk ipsilateral direction.10 “Pubic “clock”: 11 Plain film, stress view,14 magnetic resonance imaging1 Ultrasound12
Incipient hernia; external oblique aponeurosis tear Acute onset, related to sport-specific movement eg. “slap shot”.22 Pain on resisted “torsion” of trunk contralateral direction.”.16 Tenderness and dilation of superficial inguinal ring on invagination of scrotum.23 Pubic “clock”: 12–1 Magnetic resonance imaging18 Confirmation by direct vision at arthroscopy22
Nerve entrapment; ilioinguinal nerve Altered skin sensation Superficial pain with or without hype/ dysaesthesia to skin over pubis.26 Absence of muscular component26 Relief of pain by ultrasound-guided local anaesthetic infiltration15 Nerve conduction studies1
Genitofemoral nerve (genital branch) Post inguinal surgery26 over the hip joint is facilitated by the iliopsoas bursa, which is in some cases in direct communication with the hip joint. The rectus femoris arises via a direct head from the anterior inferior iliac spine and a reflected head arising from the superior acetabular rim and joint capsule. The femoral ring is the base of the femoral canal. Its surface marking is medial to the femoral artery, palpable at the mid-inguinal point. The femoral ring is bounded in front by the inguinal ligament, behind by the pectineus, medially by the crescentic base of the lacunar ligament and laterally by the fibrous septum on the medial side of the femoral vein.

Within the triangle
Within the triangle the following structures are encountered: conjoint tendon of the iliopsoas muscle; rectus femoris muscle; femoral canal. The psoas arises as a series of slips, each of which arise from the adjacent margins of the vertebral bodies and the intervening discs from the lower border of T12 to the upper border of L5. The iliacus arises from the upper two-thirds of the concavity of the iliac fossa and the inner lip of the iliac crest, as well as the ventral sacro-iliac and iliolumbar ligaments and the upper surface of the lateral part of the sacrum. The two muscles converge and pass downwards and medially beneath the inguinal ligament over the hip joint and into the lesser trochanter of the femur. The passage of this conjoined tendon

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Table 1  Patho-anatomical approach: pubic tubercle region (diagnoses appear in order of frequency in an athletic population)

<table>
<thead>
<tr>
<th>Define and align</th>
<th>Pathology</th>
<th>Listen and localise</th>
<th>Palpate and re-create</th>
<th>Alleviate and investigate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pubic tubercle</td>
<td>Adductor tendon enthesopathy</td>
<td>Insidious onset, warms up with exercise</td>
<td>Guarding on passive abduction,1</td>
<td>Magnetic resonance imaging1</td>
</tr>
<tr>
<td></td>
<td>Rectus abdominis enthesopathy</td>
<td>Well localised to insertion, acute or insidious onset</td>
<td>Pain from resisted sit-up.16 Pubic “clock”: 12</td>
<td>Magnetic resonance imaging1</td>
</tr>
<tr>
<td></td>
<td>Pubic bone stress injury</td>
<td>Non-specific diminished athletic performance, loss of propulsive power</td>
<td>Bone tenderness predominates12 13 Diagnosis of exclusion</td>
<td>Magnetic resonance imaging12</td>
</tr>
<tr>
<td></td>
<td>Degenerative pubic symphysis</td>
<td>Central pain, associated with stress through symphysis—stair climbing</td>
<td>Tender over symphysis. Pubic “clock”: 3 Plain film,13 magnetic resonance imaging1</td>
<td>Magnetic resonance imaging12</td>
</tr>
<tr>
<td></td>
<td>Incipient hernia; conjoint tendon tear</td>
<td>Insidious onset, diminished performance, warms up</td>
<td>Pain on resisted “torsion” of trunk ipsilateral direction.10 “Pubic “clock”: 11 Plain film, stress view,14 magnetic resonance imaging1</td>
<td>Ultrasound12</td>
</tr>
<tr>
<td></td>
<td>Incipient hernia; external oblique aponeurosis tear</td>
<td>Acute onset, related to sport-specific movement eg. “slap shot”.22</td>
<td>Pain on resisted “torsion” of trunk contralateral direction.”.16 Tenderness and dilation of superficial inguinal ring on invagination of scrotum.23 Pubic “clock”: 12–1 Magnetic resonance imaging18 Confirmation by direct vision at arthroscopy22</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nerve entrapment; ilioinguinal nerve</td>
<td>Altered skin sensation</td>
<td>Superficial pain with or without hype/ dysaesthesia to skin over pubis.26 Absence of muscular component26 Relief of pain by ultrasound-guided local anaesthetic infiltration15 Nerve conduction studies1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Genitofemoral nerve (genital branch)</td>
<td>Post inguinal surgery26</td>
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</tr>
</tbody>
</table>

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Table 2  Patho-anatomical approach: medial to the groin triangle (diagnoses appear in order of frequency in an athletic population)

<table>
<thead>
<tr>
<th>Define and align</th>
<th>Pathology</th>
<th>Listen and localise</th>
<th>Palpate and re-create</th>
<th>Alleviate and investigate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medial to triangle</td>
<td>Adductor/gracilis enthesopathy</td>
<td>Insidious onset, diminished performance, warms up</td>
<td>Guarding, weakness1 18</td>
<td>Magnetic resonance imaging1</td>
</tr>
<tr>
<td></td>
<td>Adductor longus pathology at musculotendinous junction</td>
<td>Acute onset, worse during exercise</td>
<td>Pain in proximal adductor2 (2–4 cm distal to enthesis), guarding, weakness1 18</td>
<td>Magnetic resonance imaging1</td>
</tr>
<tr>
<td></td>
<td>Pubic bone stress injury</td>
<td>Pain primarily at pubis radiating to proximal thigh</td>
<td>Bone tenderness, lack of point muscular tenderness</td>
<td>Magnetic resonance imaging12 13</td>
</tr>
<tr>
<td></td>
<td>Stress fracture inferior pubic ramus pain</td>
<td>Insidious onset, heavy training load pain</td>
<td>Hop test,19 associated deep buttock pain</td>
<td>Plain x ray, magnetic resonance imaging16</td>
</tr>
<tr>
<td></td>
<td>Nerve entrapment</td>
<td>Claudiant-type pain of medial thigh, which settles on resting19</td>
<td>Exercise-related adductor weakness, superficial dysesthesia of mid-medial thigh19</td>
<td>Electromyography of adductor longus20 Guided local anaesthetic injection to obturator foramen7</td>
</tr>
<tr>
<td>I. Obturator nerve</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II. Ilioinguinal nerve</td>
<td>Altered skin sensation</td>
<td></td>
<td>Dyseaesthesia/hyperaesthesia over area of skin supplied by nerve in question19 20</td>
<td>Relief of pain by ultrasound-guided local anaesthetic infiltration15 Nerve conduction studies1</td>
</tr>
<tr>
<td>III. Genitofemoral nerve (genital branch)</td>
<td>Post inguinal surgery?</td>
<td></td>
<td>Exercise-related lower limb weakness, exercise-altered bruit and ankle/brachial index18</td>
<td>Doppler ultrasound39 Angiography40</td>
</tr>
<tr>
<td>External iliac artery endofibrosis</td>
<td>Thigh discomfort post high-intensity exercise mainly in cyclists</td>
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<td></td>
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</tbody>
</table>
**Table 3** Patho-anatomical approach: superior to the groin triangle (diagnoses appear in order of frequency in an athletic population)

<table>
<thead>
<tr>
<th>Define and align</th>
<th>Pathology</th>
<th>Listen and localise</th>
<th>Palpate and re-create</th>
<th>Alleviate and investigate</th>
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</thead>
<tbody>
<tr>
<td>Superior to base</td>
<td>Rectus abdominis tendinopathy</td>
<td>Well localised to insertion, acute or insidious onset</td>
<td>Pain from resisted sit-up,(^{20,21}) Pubic &quot;clock&quot;: 12</td>
<td>Magnetic resonance imaging(^{19})</td>
</tr>
<tr>
<td></td>
<td>Incipient hemia; conjoint tendon tear</td>
<td>Insidious onset, diminished performance, warms up</td>
<td>Pain on resisted &quot;torsion&quot; of trunk &quot;ipsilateral direction&quot;; Pubic &quot;clock&quot;: 11</td>
<td>Ultrasound(^{17})</td>
</tr>
<tr>
<td></td>
<td>Incipient hemia; external oblique aponeurosis tear</td>
<td>Acute onset, related to sport-specific movement, eg, &quot;slap shot&quot;(^{22})</td>
<td>Pain on resisted &quot;torsion&quot; of trunk &quot;contralateral direction&quot;(^{14})</td>
<td>Magnetic resonance imaging(^{18})</td>
</tr>
<tr>
<td></td>
<td>Inguinal hernia</td>
<td>Pain on valsala manoeuvre</td>
<td>Tenderness and dilation of superficial inguinal ring on invagination of scrotum(^{19})</td>
<td>Confirmation by direct vision at arthroscopy(^{19,21})</td>
</tr>
<tr>
<td></td>
<td>Nerve entrapment</td>
<td>Altered skin sensation</td>
<td>Pubic &quot;clock&quot;: 12–1</td>
<td>Ultrasound(^{20})</td>
</tr>
<tr>
<td></td>
<td>Iliohypogastric nerve</td>
<td></td>
<td></td>
<td>Hemiography,(^{22}) laparoscopy</td>
</tr>
<tr>
<td></td>
<td>Iliohypogastric nerve</td>
<td></td>
<td></td>
<td>Relief of pain by ultrasound-guided local anaesthetic infiltration(^{21})</td>
</tr>
<tr>
<td></td>
<td>Iliopsoas nerve</td>
<td></td>
<td></td>
<td>Nerve conduction studies(^{1})</td>
</tr>
<tr>
<td></td>
<td>Genitofemoral nerve (genital branch)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lateral femoral cutaneous nerve</td>
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</tbody>
</table>

**A PATHO-ANATOMICAL APPROACH USING THE GROIN TRIANGLE**

The diagnostic process of history and examination is often abbreviated. There is a growing tendency to rely on investigational studies as the initial diagnostic step (eg, proceeding to magnetic resonance imaging of a painful groin in the absence of a clear differential diagnosis). The authors propose a four-step approach to the diagnostic process emphasising history and examination and limiting investigation to the final step as follows.

**Step 1: define and align**
Define the anatomical points and borders of the triangle on the patient (ASIS, pubic tubercle and 3G point).

**Step 2: listen and localise**
Listen to the patient’s history and obtain as many localising factors as possible, then pinpoint the pain in relation to the groin triangle.

**Step 3: palpate and re-create**
Carefully palpate the identified area and determine which anatomical structures are painful. The use of provocative manoeuvres/examinations (eg, exercise) to re-create the patient’s pain can be a critical diagnostic step. To describe all of the manoeuvres in detail is beyond the scope of this text; readers are referred to reviews on this topic.\(^{32,45}\)

**Step 4: alleviate and investigate**
When a number of anatomical structures are in close proximity, clinical presentations can be very similar. The manner in which pain can be removed may be very helpful. A decrease in pain following abstinence from aggravating activity is revealing. If a distinct structure can be identified, the elimination of symptoms following guided injection of local anaesthetic into the structure is invaluable. The authors recognise that a number of conditions discussed in this text may only be diagnosed definitively following radiological investigation; in these instances the most discriminative, evidence-based investigation is recommended.

**SPECIFIC SCENARIOS USING A PROBLEM-ORIENTED APPROACH**

The diagnostic stepwise approach using the groin triangle is summarised in tables 1–5. The triangle is used to localise the pathology to a particular area. We refer the reader to the specific table relating to that border of the triangle. This provides a differential diagnosis and clarifies the most discriminative evidence-based tests.

**Table 4** Patho-anatomical approach: lateral to the groin triangle (diagnoses appear in order of frequency in an athletic population)

<table>
<thead>
<tr>
<th>Define and align</th>
<th>Pathology</th>
<th>Listen and localise</th>
<th>Palpate and re-create</th>
<th>Alleviate and investigate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral to triangle</td>
<td>Impingement/labral pathology, femoro-acetabular joint</td>
<td>Mechanical signs, clicking in joint and/or catching</td>
<td>Impingement test(^{16})</td>
<td>Magnetic resonance imaging, arthrogram(^{17})</td>
</tr>
<tr>
<td></td>
<td>Osteoarthritis/chondral damage, femoro-acetabular joint</td>
<td>History of traumatic/congenital insult, older age group</td>
<td>Limited range of movement,(^{46}) pain on weight bearing</td>
<td>Plain film x ray, magnetic resonance imaging(^{47})</td>
</tr>
<tr>
<td></td>
<td>Iliotibial band friction syndrome</td>
<td>Persistent lateral hip pain worse on lying on affected side</td>
<td>Pain on transition between lying/standing(^{57})</td>
<td>Ultrasound(^{48})</td>
</tr>
<tr>
<td></td>
<td>Stress fracture neck of femur</td>
<td>External &quot;snapping&quot; and/or lateral knee pain</td>
<td>Re-create snapping(^{19})</td>
<td>Relief of pain by ultrasound-guided local anaesthetic injection</td>
</tr>
<tr>
<td></td>
<td>Nerve entrapment; lateral cutaneous femoral nerve/meralgia paraesthetica</td>
<td>Heavy training load, biomechanical/gait abnormality</td>
<td>Ober’s test(^{16})</td>
<td>Ultrasound(^{15})</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Exercise induced, obesity(^{42})</td>
<td>Hop test,(^{46}) fulcrum test(^{14})</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reproduction of symptoms on pressure inferior to anterior superior iliac spine(^{42})</td>
<td></td>
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</tr>
</tbody>
</table>

\(\text{Note:} \) All references are from the given text, and the numbers indicate the corresponding sections or pages within the text.
PUBLIC TUBERCLE

Because many potentially anatomical structures converge at this point, we propose a marking of the structure in similar fashion to a clock face (fig 3, table 1). This schematic representation of the anatomy of the area serves as a guide to what may be palpable following invagination of the scrotum. The examining clinician can therefore “walk their finger” around the tubercle assigning each part of the clock face to the relevant attachment as highlighted in fig 3. The authors recognise the variability of structures in this area, having based diagrams on cadaveric studies performed prior to this paper.55 We have employed the term “pubic bone stress injury” for what is often in the literature called “osteitis pubis”. We feel this is a better reflection of the clinical picture in the absence of any evidence of an inflammatory process.

The topic of incipient hernia is included as disorders of the posterior and anterior inguinal walls. These are diagnoses of exclusion and, outside of the most experienced hands, probably inseparable. These may represent different ends of a spectrum of pathology in the area as a result of differing sporting activity.3 19 22 25 56

MEDIAL TO THE TRIANGLE

Adductor longus pathology is the most common cause of pain in this area; differentiation of enthesis-related problems from those at the musculotendinous junction is important. The abnormal mechanics that arise as a result of adductor dysfunction play a critical role in the generation of a chronic pain/dysfunction cycle in the area (fig 4, table 2).

SUPERIOR TO THE TRIANGLE

Rectus abdominis pathology tends to be well localised to its insertion at the pubic tubercle, often making it the most clearcut diagnosis in this area. This may arise as a primary diagnosis, or develop secondary to pubic overload originating from adductor or iliopsoas pathology (fig 5, table 3).

LATERAL TO THE TRIANGLE

As a cause of recalcitrant groin pain, pathology of the femoroacetabular joint should not be underestimated. The joint is prone to degenerative, inflammatory and infective processes. The long-term contribution of acute or repetitive trauma to the
development of degenerative conditions such as osteoarthritis is of particular concern in the sports setting (fig 6, table 4).

WITHIN THE TRIANGLE
Pathology of the iliopsoas muscle may cause pain that is referred in the area superior to the triangle, but the conjoint tendon is the most palpable structure within the triangle when the hip is flexed. This is a common, although underdiagnosed, cause of groin pain. It is particularly prone to irritation when over-loaded secondary to dysfunction of other muscular structures around the groin, such as the adductors (fig 7, table 5).

INTRA-ABDOMINAL PATHOLOGY
Discussion of this topic is beyond the scope of this paper; gastrointestinal and genitourinary pathology may mask as groin discomfort or pain. Key discriminating symptoms may be signs of systemic illness, systemic inflammatory response and no
This paper outlines a novel educational approach to the categorisation of pathologies in the groin area in an athlete. Pain-generating structures are categorised according to their anatomical position, around a triangle based on easily located anatomical landmarks. This categorisation, with accompanying high-quality diagrams, focuses the diagnostic process. Discriminative questioning and evidence-based examination presented in tabular form facilitate accurate differential diagnosis.

Experience and a thorough knowledge of the anatomy of the region remain vital in any complete understanding of groin pain. By providing a means of focusing the differential diagnosis in a structured manner, practitioners who lack expertise may approach this problem with more confidence.

Competing interests: None.

REFERENCES

CONCLUSION
This paper presents a method of teaching the causes of chronic groin pain. By offering a systematic means of limiting the differential diagnosis through history examination, diagnostic manoeuvres and, when necessary, directed investigation, this method may help the less experienced clinician with the diagnostic process.

The groin triangle is one section of the “3G” approach to teaching the causes of chronic pain in the proximal lower limb. This paper should therefore be read in conjunction with the gluteal greater trochanter triangle papers to address the three-dimensional nature of the region fully.

Figure 7 Within the triangle.

correlation between exercise and symptoms or signs. Any or all of the above in conjunction with a negative musculoskeletal examination serve to alert the examining physician to focus their examinations beyond the musculoskeletal system.