The greater trochanter triangle; a pathoanatomic approach to the diagnosis of chronic, proximal, lateral, lower pain in athletes

E C Falvey,1 A Franklyn-Miller,1 P R McCrory2

ABSTRACT
Chronic pain experienced in the proximal, lateral, lower limb may arise from the femoro-acetabular joint, from the muscles and tendons that act upon it, from any of the structures that traverse the area, and from more remote structures such as the lumbar spine.

The aetiology of pathology in this area is not confined to either trauma or overuse. As a result many different sporting activities may have a causal role.

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 makes the diagnostic process problematic.

The paper proposes a novel educational model based on pathoanatomic 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 trochanter triangles) acknowledges this, permitting the clinician to move throughout the region, considering pathologies appropriately.

Proximal lower limb pain is a cause of significant morbidity in athletes.1–4 Trauma to the hip joint and bony structures of the hip may result in direct injury or chronic degenerative change.5 Overload or overuse injury of muscle, tendon, ligament or enthesis/apophysis at or around the femoro-acetabular joint may all result in chronic hip pain.

Pain localised to the lateral thigh may represent pathology within the femoro-acetabular joint,6 or more superficial structures like the iliotibial band7 or trochanteric bursa. Differentiation of joint pathology from that of the structures responsible for its movement may be difficult due to the complexity of movement at the joint. Radicular pain generated in the axial spine may also complicate an already busy area.8

The corollary to this is when pathology arising from the hip joint and structures around it manifests as pain in the groin, buttock and distal leg.4 We must therefore consider these structures when investigating any proximal lower limb pain.

This paper sets out a method based on pathoanatomic principles for a systematic examination of the chronically painful proximal lateral lower limb. This enables the clinician to discriminate more easily between pathological conditions and target their management to specific diagnoses.

THE GREATER TROCHANTER TRIANGLE
The specific anatomical landmarks and borders of the greater trochanter triangle are set out in fig 1.

Figure 1 The greater trochanter triangle: ASIS, anterior superior iliac spine; 3G, the 3G point; G Max, gluteus maximus; G Med, gluteus medius; TFL, tensor fasciae latae; Ilio Ps., iliopeos; RF, rectus femoris; VL, vastus lateralis; VM, vastus medialis.
Within the triangle


Define and Align

Pathology

Listen and Localise

Palpate and Recreate

Alleviate and Investigate

Within the triangle (adult)

Femoro-acetabular impingement
Labral injury
Osteoarthritis
Femoral stress fracture
Neck
Shaft
Inflammatory conditions
Septic arthritis
Avascular necrosis of femoral head
Tumour

Mechanical symptoms, clicking locking.
Insidious onset, night pain.
Groin pain.
Features of systemic inflammation.
Systemic inflammatory response.
Mechanical symptoms more prominent than functional limitation.
Systemic "red flags", absence of appropriate physical stressors.

± Impingement test.
Limited ROM, especially internal rotation.
Hop test.
Fulcrum test.
Systemic manifestations of particular condition.
Inability to weight bear, limited range of motion, ± sepsis.
Limited range of motion.

Plain film x-ray, magnetic resonance imaging ± arthrogram.
Plain film x-ray.
Plain film x-ray, isotope bone scans, magnetic resonance imaging.
Plain film x-ray, ultrasound-guided joint aspiration.
Plain film x-ray, fluoroscopically/ultrasound-guided joint aspiration.
Plain film x-ray, magnetic resonance imaging.

Plain film x-ray, computerised tomography (CT)/ magnetic resonance imaging, biopsy.
Table 2  Pathoanatomic approach; within the greater trochanter triangle (paediatric) (diagnoses appear in order of frequency in an athletic population)

<table>
<thead>
<tr>
<th>Define and Align</th>
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<th>Alleviate and Investigate</th>
<th>Define and Align</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within the triangle (Pediatric)</td>
<td>Acute transient synovitis</td>
<td>Male. Refusal to weight bear. Poorly localised pain. Viral precipitant.</td>
<td>3–6 years</td>
<td>Well, non-toxic, variable range of motion.</td>
<td>Diagnosis of exclusion, to be monitored to exclude septic arthritis.</td>
</tr>
<tr>
<td></td>
<td>Apophysitis/avulsion fracture</td>
<td>Associated injury/event.</td>
<td>&lt;18 years</td>
<td>Point tenderness.</td>
<td>Plain film x-ray, computed tomography (CT).</td>
</tr>
<tr>
<td></td>
<td>Perthes’ disease</td>
<td>Male, associated knee pain.</td>
<td>4–9 years</td>
<td>Decreased range of movement of hip, abduction and internal rotation ↓</td>
<td>Plain film x-ray, antero/ posterior (AP), lateral, and comparative views.</td>
</tr>
<tr>
<td></td>
<td>Slipped capital femoral epiphysis</td>
<td>Overweight, male, 30% cases bilateral.</td>
<td>12–15 years</td>
<td>Decreased range of motion of hip, abduction and internal rotation ↓, Limb shortening, external rotation of hip.</td>
<td>Plain film x-ray, antero/ posterior (AP), lateral, and comparative views.</td>
</tr>
<tr>
<td></td>
<td>Septic arthritis</td>
<td>Refusal to weight bear. Systemically unwell.</td>
<td>All</td>
<td>Unwell, toxic, variable range of motion.</td>
<td>Temp &gt;38.5, CRP &gt;20, ESR &gt;40, refusal to weight bear, leucocytosis &gt;12.</td>
</tr>
<tr>
<td></td>
<td>Congenital dysplasia</td>
<td>Delayed mobilising/limp, walking on tip-toe.</td>
<td>All</td>
<td>Limb length discrepancy, unilateral symptoms, limitation of abduction.</td>
<td>Ultrasound, x-ray.</td>
</tr>
<tr>
<td></td>
<td>Tumour</td>
<td>Night pain, systemic “red flags”, absence of appropriate physical stressors.</td>
<td>All ages</td>
<td>Systemic features, may mimic stress fracture.</td>
<td>Plain film x-ray, magnetic resonance imaging.</td>
</tr>
</tbody>
</table>

Table 3  Pathoanatomic approach; superior to the greater trochanter triangle (diagnoses appear in order of frequency in an athletic population)

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</tr>
</thead>
<tbody>
<tr>
<td>Superior to the triangle</td>
<td>Myofascial trigger points in gluteus medius and tensae fasciae latae</td>
<td>Gluteal and lateral leg tightness and discomfort ± accompanying lateral knee pain. Weakness in stance phase of walking and/or running, climbing stairs.</td>
<td>Restricted movement/strength in affected muscle. Tender “trigger” points palpable within muscle.</td>
<td>Dry needling effective in relieving trigger points.</td>
</tr>
<tr>
<td></td>
<td>Trochanteric bursitis</td>
<td>Age group (13–25 years), activity load.</td>
<td>Point tenderness, painful Trendelenburg.</td>
<td>Ultrasound, relief of pain by local anaesthetic injection.</td>
</tr>
<tr>
<td></td>
<td>Apophysitis; iliac crest</td>
<td></td>
<td></td>
<td>Plain film x-ray, computed tomography (CT).</td>
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</tbody>
</table>
Pathoanatomic approach; posterior to the triangle (diagnoses appear in order of frequency in an athletic population)

Table 4

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Medial to the triangle</td>
<td>Hamstring tendinopathy</td>
<td>Sudden pain in buttock/posterior thigh. Walking painful.</td>
<td>Tenderness of muscle belly or tendon from common origin.</td>
<td>Magnetic resonance imaging.²⁷ association between proximity of muscle defect to ischial tuberosity and recovery.²⁷</td>
</tr>
<tr>
<td></td>
<td>Referral pain</td>
<td>Diffuse ache, may not have back pain.</td>
<td>“Lasègue” straight leg raise (sensitivity 72–97%, specificity 11–66%).²² Braggard’s sign (94% +ve).²²</td>
<td>Response to lumbar mobilisation.²⁷ guided nerve root injection.²⁷ magnetic resonance imaging.²⁷</td>
</tr>
<tr>
<td>Ischial tuberosity apophysitis</td>
<td>Age group 15–25 years.²¹ Shooting pain following high-energy kick or change of direction.</td>
<td>Pain standing on one leg and Hop test,²⁶ associated deep buttock pain.</td>
<td></td>
<td>Plain film x-ray, magnetic resonance imaging.²⁷</td>
</tr>
<tr>
<td>Piniformis tendinopathy</td>
<td>Hamstring origin pain with gradual rather than sudden onset and/or sciatic referred pain.</td>
<td>Tenderness over sciatic notch and aggravated by flexion, adduction, and internal rotation (Lasègue sign) of the hip²⁶, also FAIR test,²⁶ Pace Test.²⁶</td>
<td></td>
<td>Ultrasound-guided injection.²⁷</td>
</tr>
</tbody>
</table>

Posterior border of the greater trochanter triangle

The posterior border of the triangle is the line from the greater trochanter to the apical point. Structures lying beyond this which require differentiation as casual agents for lateral thigh pain include the small hip rotators such as piriformis, the gemelli, obturator and quadratus femoris, the ischial tuberosity and hamstring origins and referred pain from the lumbar spine. Other major structures encountered in this area include the sciatic nerve; this leaves the pelvis through the greater sciatic foramen, below the piriformis muscle, and descends between the greater trochanter of the femur and the ischial tuberosity. Initially deep to piriformis, it runs inferiorly and laterally posterior to the ischium, crossing over the nerve to quadratus femoris. Inferior to piriformis, it lies deep to gluteus maximus. It passes inferiorly crossing obturator internus, the gemelli and quadratus femoris. The ischial tuberosity gives rise to the hamstring group of muscles, semimembranosus, semitendinosus, and the long head of biceps femoris.

Within the greater trochanter triangle

Within the triangle the main focus of our attention is the femoro-acetabular joint. This ball and socket joint sacrifices range of movement for stability. When considering pathology of the joint we must consider not only the articular surfaces but also the underlying bone, soft tissue structures such as the synovium and acetabular labrum, and surrounding structures such as the capsule, bursae and muscles. The acetabular labrum acts to provide secondary stability to the bony constrained hip joint.²² Though the morphology of the labrum varies, it is from 2 to 3 mm thick and extends the same distance beyond the acetabular socket.

A pathoanatomic approach using the greater trochanter 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 (e.g. a MR scan to check for an ACL rupture). 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 points of the triangle on the patient: ASIS, greater trochanter, and 3G points. If needs be mark these on the skin, align these points to visualise the borders.

Step 2: Listen and localise

Listen to the patient’s history and obtain as many discriminanting factors as possible. Localise the pain in relation to the triangle. From patient symptoms and careful palpation, assigning the pain to a location on the triangle is a large step towards making a pathoanatomic diagnosis. We must now proceed to differentiate between the different causal possibilities for the pain according to its position on the triangle.

Table 5

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</tr>
</thead>
<tbody>
<tr>
<td>Anterior to the triangle</td>
<td>Iliopsoas syndrome</td>
<td>Pain on forced hip extension, unrelated to knee position. Pain above and below inguinal ligament.</td>
<td>Thomas test.²⁷</td>
<td>Ultrasound guided local anaesthetic injection.²⁷ Magnetic resonance imaging.²⁷</td>
</tr>
<tr>
<td></td>
<td>Iliotibial band friction syndrome</td>
<td>Associated snapping at hip joint, lateral knee pain.</td>
<td>Ober’s test,²⁷ reproduce snap.</td>
<td>Ultrasound, dynamic view.²⁷ Magnetic resonance imaging.²⁷</td>
</tr>
<tr>
<td></td>
<td>Rectus femoris tendinopathy</td>
<td>Pain hip flexion worse with knee flexion.</td>
<td>Flexion contracture test.²⁷</td>
<td>Local anaesthetic infiltration to anterior iliac superior spine. Nerve conduction studies.²⁷</td>
</tr>
<tr>
<td></td>
<td>Neuropathy, lateral femoral cutaneous nerve</td>
<td>Altered skin sensation.</td>
<td>Parasthesia/dysesthesia over superficial area of lateral thigh.</td>
<td></td>
</tr>
</tbody>
</table>
Step 3: Palpate and recreate
Palpate the identified area; a careful examination is of course mandatory. Recreate where possible the patient’s pain. Though not always popular, this has many valuable implementations. The different manoeuvres/examinations employed to generate this pain can be very helpful; we must never forget that, in an athletic population, exercise is one of the most powerful of these tools. To describe individual manoeuvres in detail is beyond the scope of this text so we have limited our descriptions to those manoeuvres not well described in the literature.

Step 4: Alleviate and investigate
Where 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 greater 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.

Internal (within the triangle)
Pathology of the hip joint often defies clinical distinction. The distance of the joint from the surface, the close proximity of the structures involved, and different conditions representing different stages in a clinical spectrum, help explain why. In this section discriminative signs are quite limited, so history and clinical may be even more important than normal.

Dividing them according to an adult and paediatric population facilitates further stratification of the pathologies encountered within the triangle. The hip, be it adult or paediatric, is prone to inflammatory infective and degenerative processes, the latter in particular due to the large compressive loads transmitted during ambulation, through its articular surfaces.

Irregular morphology of the acetabulum, or the femoral head/neck, may disrupt the labrum, resulting in pain, functional limitation, and ultimately joint degeneration.

The presence of the femoral epiphysis and the numerous secondary ossification centres in and around the hip make the diagnosis and treatment of the paediatric and adolescent hip dissimilar to that of the adult. A slipped upper femoral epiphysis, if untreated, has a high probability of being problematic later on in life; the limping child or adolescent must be fully investigated.

Superior
Superior to the line drawn between GT and ASIS lies the iliac crest and the muscles and fascia, which attach therefrom. The most common presentation of pain in this region is that of myofascial trigger points. These are amenable to dry needling or transverse friction myotherapy; it should be acknowledged that this may be the result of a problem elsewhere. The trigger points may lie superficially in gluteus maximus or tensor fasciae latae, or deeper in gluteus medius and gluteus minimus.

Posterior
Beyond the posterior border of the triangle lies an area where poorly differentiated pain is common. The complex anatomy around the greater trochanter, the most superior point of this region, highlights the complexity of the area. The confluence of the small muscles of the gluteal area, piriiformis, the gemelli and obturator internus, all insert here and due to their depth below the gluteal muscles differentiation between them is problematic.

Figure 3
Within the greater trochanter triangle; adult and paediatric.

Figure 4
Superior to the greater trochanter triangle.
The greater trochanter 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 and groin triangle papers to fully address the three-dimensional nature of the region.

We recognise that experience, expertise and a thorough knowledge of the anatomy of an area cannot be supplanted in any complete understanding of the pathologies there encountered. This educational tool provides a means of differentiating the pathologies encountered, by virtue of their anatomical position, in the proximal lower lateral limb.

**Competing interests:** None.

**REFERENCES**

Occasional piece