Landmarks for the 3G approach: Groin, Gluteal and Greater trochanter triangles - A patho-anatomical method in Sports Medicine

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Summary

Groin, gluteal and hip pain are common presentations in sports medicine. The pathology is varied and can be referred from any of these regions due to the three-dimensional nature of the anatomy.

There is a tendency in modern medical school curricula for less time to be devoted to didactic as well as practical anatomy teaching, possibly to the detriment of students' ability to formulate a differential diagnosis when investigating musculoskeletal conditions. This is particularly important in areas of complex anatomy.

This paper proposes a novel diagnostic system based on the underlying anatomical structures, to form a series of triangles which act as a grid, by which the clinician may narrow the diagnosis in spite of a lesser understanding of the anatomical relations. This acknowledges the problem based approach, where problem solving without this encyclopedic knowledge is attempted.

In dividing the proximal lower limb into triangles, the authors propose a new educational reference point termed '3G'. This point is located in the line of the femur, anteriorly at the midpoint between the anterior superior iliac spine and the superior pole of the patella, and posteriorly, at a point on the femur following the line between the spinous process of L5 lumbar vertebra and the ischial tuberosity. These points were found to correlate and are common to all triangles.

Key words: Anatomy – Lower extremity – Groin – Hip – Problem based learning – Education – Athletic injuries

Introduction

A thorough understanding of anatomy is essential in musculoskeletal and sports medicine in order to make an accurate diagnosis. Anatomy teaching has been in steady decline over recent years in the United Kingdom, United States and Australia.(Dyer and Thorndike, 2000; Patel and Moxham, 2006). Students of today's generation are exposed to significantly less anatomy than their forebears (Older, 2004). There has been some concern from professional colleges over the resultant

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level of anatomical knowledge (Cottam, 1999), although this has resulted in little change in the move towards modern teaching methods(Winkelmann, 2007).

In sports medicine, conditions relating to the proximal lower limb (i.e. acute and chronic groin, gluteal and hip pain) are particularly challenging (Bruckner and Khan, 2007; Walden et al., 2007). Morbidity due to conditions arising at these sites is responsible for much time away from sport (Brooks et al., 2005a, 2005b, 2005c) and the resultant recovery process is slowed and undermined by the biomechanical difficulties.

Chronic injury presents a diagnostic challenge, particularly in the proximal lower limb. In contrast to acute injury, chronic injury will often involve a number of structures. Injury to one structure often leads to overload and overuse injury of an adjacent structure. Biomechanical imbalance of the hip flexors, abductors and rotators may be difficult to pinpoint due to the complexity of the movements involved. Pain is often poorly localised and commonly referred to superficial structures.

Pathological conditions often mimic each other, such as, a gluteal muscle strain presenting with the signs and symptoms of an acute disc prolapsed. Without a clear diagnosis, the subsequent management of any injury is difficult.

The complex, three-dimensional anatomy and biomechanics of this region, coupled with increasingly less time devoted to anatomy teaching, result in potential difficulties when constructing the differential diagnosis. The proximal lower limb or '3G - Groin, Gluteal, Greater Trochanter' region remains a diagnostic conundrum for many clinicians at all levels of experience.

Based upon clinical knowledge of the region, the authors constructed a series of theoretical triangles which divide relevant pathological conditions with their anatomical origin. The intention was to define a novel system based on the Oslerian principles of history and clinical examination, with relevance to the underlying anatomy to form a basis for both understanding the clinical anatomy, but also in differentiating the potential diagnoses to better direct specific investigation.

Following cadaveric dissection, the series of triangles and relationships were confirmed, which form the underlying basis of a clinical diagnostic pathway.

Materials and Methods

Twenty adult, formalin-fixed cadavers were examined. Cadavers were preserved with standard formalin embalming fluid under routine process. All material was supplied by the Department of Anatomy and Cell Biology, University of Melbourne, Australia. Information on age, gender, and cause of death was provided in accordance with the University of Melbourne Human Ethics Committee approval of applied and clinical investigation using cadaver tissues. Information regarding occupational history or previous physical activity levels was not available. Medical students had dissected the cadavers superficially, as part of their gross anatomy teaching. Cadavers which had sustained significant destruction to the anatomy of muscular, vascular or neural structures were not included. Limb alignment was assessed by measuring the Q angle at the knee with an angle of <13° (male) and <18° (female) confirming a normal classification (Peeler et al., 2005). Further examination was carried out by placing the cadaver in the prone position; remaining skin and superficial fat were removed exposing the gluteal and hamstring musculature. Important landmarks were identified and relationships described. A series of landmarks were selected which divided the pathology of the area and anthropometric measurements were made between selected landmarks using digital vernier callipers (Torquata Engineering) with a measuring range of 0-300 millimetres (mm) and to the nearest 0.5mm. Each measurement was recorded three times. The gluteus maximus was divided and reflected to expose the underlying anatomy. Important relationships were described with reference to the proposed triangles. The cadaver was then placed in the supine position and the remaining skin and superficial fat were removed exposing the inguinal ligament and anterior compartment musculature. Important relationships were described and landmarks identified as above. Finally, the relationships of the greater trochanter were examined and landmarks of the lateral triangle were measured using the same technique and the relationships noted.

Results

Twenty cadavers were examined. Eight limbs were excluded due to previous dissection damage leaving a total of 32 limbs (14 male and 10 female, 10 left and 14 right) (ages 59-98yrs; mean 80 yrs). Limb alignment and joint position were recorded and a further 8 limbs were excluded due to the Q angle being unacceptable. The anthropometric measurements of the triangles are shown in Table 1.

Table 1. Anthropometric measurements of triangles.

Triangle	Anthropometric measurements	Distance (mm) (mean) SD
Groin	PT to ASIS	128-250 (156.5) 31.1
	ASIS to SPP	339-512 (431.3) 38.0
	ASIS to 3G	169.5-256 (216.1) 19.6
	3G to PT	123-326.5 (172.4) 39.5
Gluteal	L5SP to GT	259.5-385 (298.9) 15.2
	L5SP to IT	142.5-215 (162.3) 22.5
	L5SP to 3G	190-362 (303.7) 42.6
	GT to 3G (pos)	125-204 (159.8) 22.2
Greater trochanter	GT to 3G (ant)	134-194 (163.2) 17.3
	ASIS to GT	94-163 (137.8) 15.2
	3G to ASIS	169.5-256 (216.1) 38.0

PT – Pubic tubercle, ASIS – Anterior superior iliac spine, 3G – Triangle apical point, L5SP – 5th Lumbar vertebrae spinous process, GT – Greater trochanter, ant – anterior, pos – posterior

The 3G Point

From the anthropometric measurements, the authors were able to define an apical point common to all three triangles. 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 ASIS and the superior pole of the patella, and in the posterior coronal plane, double the distance from the spinous process of L5 lumbar vertebra to the ischial tuberosity. This point was determined during the examinations and, as shown in Table 1, the correlation between the 3G point to the greater trochanter in both anterior and posterior planes was within 4mm. The authors were able to confirm that this point was common to all three subsequent triangles, and the landmarks were selected with a view to dividing the common pathological diagnosis evenly within each region to simplify the approach for the clinician.

It is recognised that a potential limitation is the age and condition of the cadavers when making these anthropometric measurements. It is clear that that the muscular bulk of a 24 year old athlete is different to that of a 70 year old chair-bound former athlete. What remains common, however, is the position of bony landmarks and these were used to construct the triangles.

The Groin Triangle

The anatomical reference points of anterior superior iliac spine (ASIS), pubic tubercle and the reference point of 3G were selected to comprise the groin triangle.

The important anatomical structures located relative to each border of the triangle are noted, allowing for the differentiation of the potential diagnoses to be narrowed considerably by the use of the accompanying tables. The triangle provides a means to visualize the relationship between anatomy and pathology; it does not attempt to enlighten the reader as regards the origins or insertions, innervations or vascular supply but to stimulate further reading if this is required. The anatomical structures are highlighted to coordinate the teaching and orientation of the potential diagnoses. The accompanying table (Table 2) highlights the anatomically significant structures responsible for the pathology associated with signs detectable on clinical examination in that corresponding area. This area has been covered in greater depth using the 4 step approach (Franklyn-Miller et al., 2007) and a covering examination and investigation by the authors (Falvey et al., 2008b).

The Gluteal Triangle

From a posterior approach, the anatomical reference points of the spinous process of the L5 lumbar vertebra, the lateral border of greater trochanter and again the 3G point were used. As shown in Figure 2.

The accompanying table highlights the important structures encountered relevant to pathology (Table 3). This area has been covered in greater depth in a covering examination and investigation by the authors (Franklyn-Miller et al., 2008).

The Greater trochanter Triangle

Laterally, the anatomical reference points of the greater trochanter of the femur, the anterior superior iliac spine and again the 3G point were selected to form the lateral triangle. Here the most significant structure is the femoral acetabular joint and much of the pathology relates here; further relationships are described in the accompanying table (Table 4). A more detailed expansion of investigations and examination techniques by the authors is available (Falvey et al., 2008a).

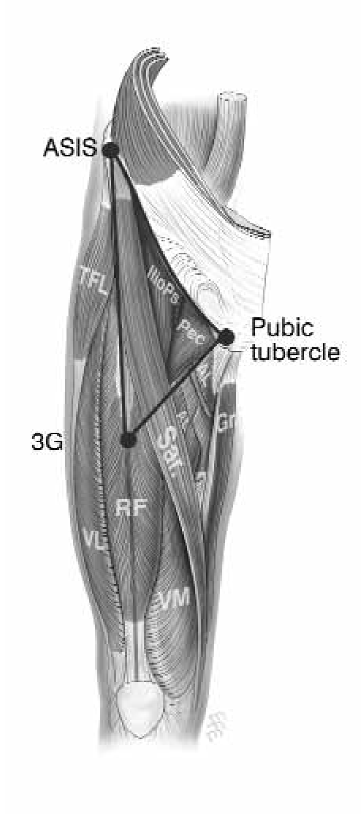

Fig. 1. The Groin triangle. TFL= tensor fasciae latae, IlioPs= iliopsoas, Pec= pectinius, AL= adductor longus, Sar.= sartorius, Gr= gracilis, RF= rectus femoris, VL= vastus lateralis, VM= vastus medialis, ASIS= anterior superior iliac spine, 3G= the 3G point.

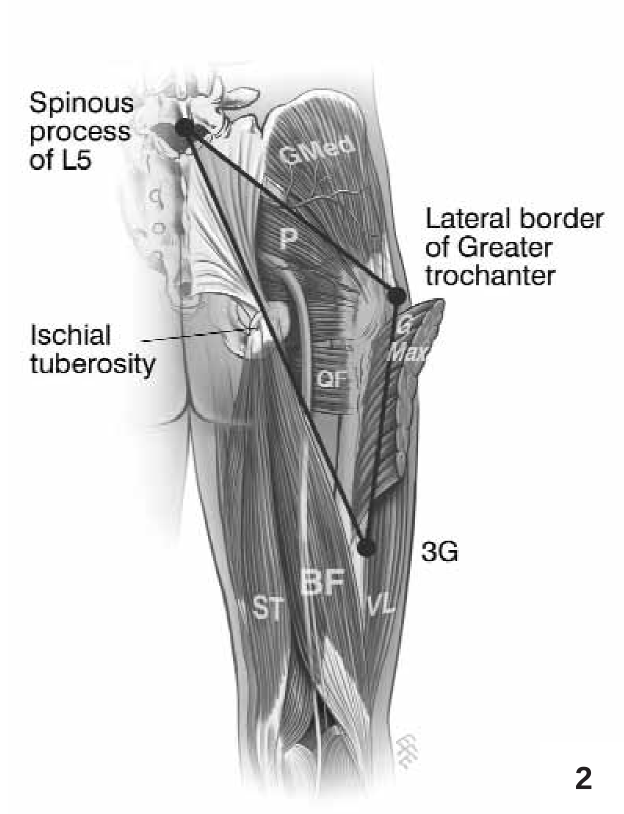

Fig. 2. The Gluteal triangle. G Max= gluteus maximus, G Med.= gluteus medius, P= piriformis, QF= quadratus femoris, ST= semitendinosus, BF= biceps femoris, VL= Vastus lateralis.

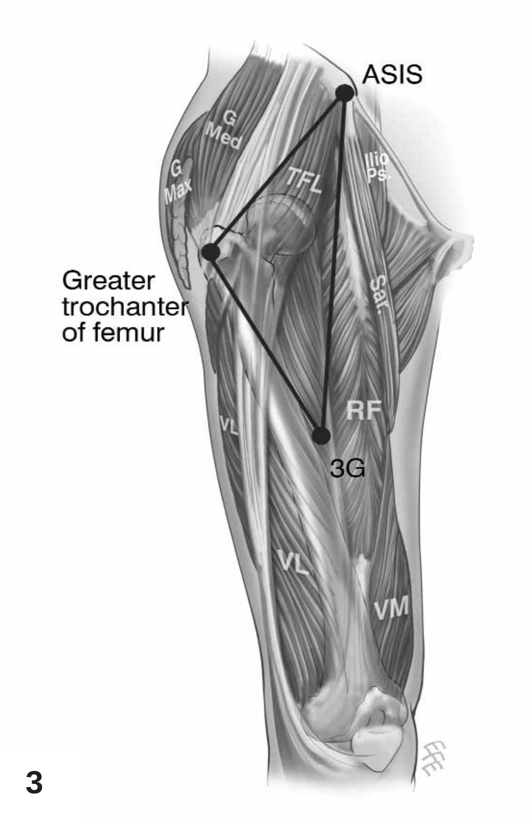

Fig. 3. The Greater trochanter triangle. ASIS= Anterior superior iliac spine, 3G= the 3G point, GMax= gluteus maximus, G Med= gluteus medius, TFL= tensor fasciae latae, Ilio Ps.= Iliopsoas, RF=rectus femoris, VL= vastus lateralis, VM= vastus medialis.

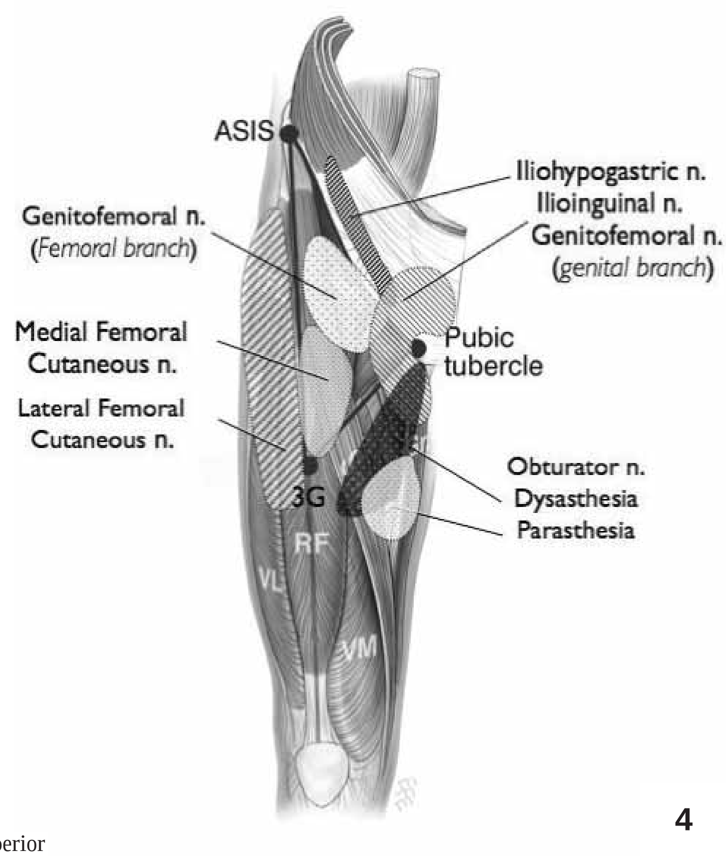

Fig. 4. Cutaneous distribution and associated nerve entrapments.

Table 2. Clinical and anatomical relationships of the Groin triangle.

Relationship to Triangle	Significant anatomical structures	Clinical pathology
Superior	Rectus abdominis Inguinal Canal T12-L3, Nerve Roots & their branches	Rectus abdominis tendonopathy Inguinal hernia Incipient hernia complex Ilio-inguinal nerve entrapment Ilio-hypogastric nerve entrapment Genito-femoral nerve (genital branch) entrapment
Medial	Adductor Magnus/Gracilis Pubic bone T12-L3, nerve roots & their branches External iliac artery	Adductor Magnus/Gracilis Enthesopathy Osteitis pubis Stress fracture of inferior pubic rami Obturator nerve entrapment Ilio-inguinal nerve entrapment Genito-femoral nerve (genital branch) entrapment External iliac artery entrapment
Lateral	Femoro-acetabular joint Tensor fasciae latae/ Ilio tibial band Femur Lateral femoral cutaneous nerve	Impingement/tear of acetabular labrum Osteoarthritis/Chondral injury of femoro-acetabular joint Iliotibial band syndrome Stress fracture neck of femur Lateral femoral cutaneous nerve entrapment
Within	Iliacus Psoas Rectus femoris Femoral canal Genito-femoral nerve Femoral cutaneous nerve	Iliopsoas syndrome Tendonopathy/Apophysitis of Rectus femoris Femoral hernia Genito-femoral nerve (femoral branch) entrapment Medial femoral cutaneous nerve entrapment
Pubic Tubercle	Adductor compartment/Gracilis Rectus abdominis Pubic bone Pubic symphysis Inguinal canal T12-L3, nerve roots & their branches	Adductor compartment/Gracilis enthesopathy Rectus abdominis enthesopathy Osteitis pubis Degenerative pubic symphysis Conjoint tendon Superficial inguinal ring External oblique aponeuroses Ilio-inguinal nerve entrapment Genito-femoral nerve (genital branch) entrapment

Table 3. Clinical and anatomical relationships of the Gluteal triangle.

Relationship to Triangle	Significant anatomical structures	Clinical pathology
Superior	Gluteus maximus Gluteus medius Gluteus minimus Iliolumbar ligament and fascia	Myofascial disorder Gluteus medius tendonopathy Ilio-lumbar ligament dysfunction/fascial trigger points
Medial	L5 lumbar vertebra Gluteus maximus origin Sacroiliac joint Sacrotuberous ligament Ischial tuberosity Semimembranosus origin Obturator nerve Superior gluteal artery	Sacro-iliac dysfunction Spondyloarthropathy Stress fracture; Sacrum, Lumbar vertebrae Obturator nerve entrapment Posterior compartment syndrome Superior gluteal artery entrapment
Lateral	Tensor fasciae latae (TFL) Ilio tibial band (ITB) Vastus lateralis Biceps femoris Trochanter bursae Femoro acetabular joint	Trochanteric bursitis TFL/ITB syndrome Femoral acetabular pathology Stress fracture neck of femur Lateral cutaneous nerve entrapment
Within	Gluteus maximus Piriformis Sciatic nerve	Acute disc prolapse Piriformis tendonopathy Pelvic floor dysfunction Circumflex femoral vein thrombosis
Ischial tuberosity	Common hamstring origin Sacrotuberous ligament	Hamstring origin tendonopathy Hamstring tear Ischial bursitis Ischial tuberosity apophysitis/avulsion fracture Stress fracture pubic ramus

Table 4. Clinical and anatomical relationships of Greater trochanter triangle.

Relationship to Triangle	Significant anatomical structures	Clinical pathology
Superior	Tensor fasciae latae (TFL) Gluteus maximus Gluteus medius Gluteus minimus Trochanteric bursae	Myofascial disorder I. Gluteus medius II. TFL Trochanteric bursitis Apophysitis at Iliac crest
Posterior	Common hamstring origin (Biceps femoris and Semimembranosus) Piriformis Semitendinosus Sciatic nerve	Hamstring origin tendonopathy Hamstring belly tear Piriformis syndrome Radicular pain Ischial tuberosity apophysitis
Anterior	Iliotibial band (ITB) Iliopsoas Vastus lateralis Rectus femoris	Iliotibial band syndrome Iliopsoas syndrome Rectus femoris tendonopathy Lateral femoral cutaneous nerve entrapment
Within	Femoro acetabular joint	Femoral neck stress fracture Femoro-acetabular impingement Labral injury Osteoarthritis Inflammatory conditions Septic arthritis Avascular necrosis of femoral head Tumor

The innervations of muscle are not only responsible for direct pathologies, but also secondary pain in the form of entrapment phenomena, and nerve roots and cutaneous distributions are important in understanding the potential pathology. The cutaneous distribution is highlighted in Figure 4.

Discussion

In considering an educational approach to the complex pathology, the authors have described a new reference point along the shaft of the femur, critical in defining the 3G triangles. This point serves to link all three triangles and encourages a three dimensional approach. It has no strict anatomical purpose other than to provide this common reference point when making a clinical assessment of this region. The triangles provide for the differentiation between clinical presentation and diagnosis by the working clinician and serve as a basis for discriminatory investigation.

Practice-based learning is now widely integrated within medical school curricula across the world (Bligh, 1995) and being considered in others (Gukas, 2007). It has been widely adopted for a number of reasons including promoting self-directed learning skills (Barrows and Tamblyn, 1980), promoting interdepartmental collaboration (Norman and Schmidt, 1992), and improved examination success (McParland et al., 2004). There have been detractors who claim there is no evidence that PBL results in improvement in problem-solving skills (Bernstein et al., 1995; Brown et al., 2007) but this has not slowed the advance of this method of learning.

Increasingly, with the advent of more advanced web and pc based learning systems (Jastrow and Vollrath, 2003), such as www.anatomy.tv and www.anatomedia.com, educators are looking for increasingly innovative ways to deliver the content in a more accessible format (James et al., 2004).

Surprisingly, there has been less use of PBL in anatomy delivery. Hinduja et al. (2005) suggest that there are significant shortcomings of anatomical knowledge in PBL-taught students. However, in actuality, most teaching called PBL is far from what McMaster described and this poses difficulties in assessing is applicability.

One area in which PBL has been criticized is that case-based learning narrows the necessarily broad differential diagnosis required in real life. It follows that the risk of PBL anatomy teaching is that the overall understanding is narrowed to provide a case-based solution.

Rather than a case-based approach the authors propose a region-based approach, modular to cover all differential diagnoses within that region. In delivering this method, the emphasis using a 4 step-method

(Franklyn-Miller et al., 2007) of history and examination is important.

By approaching the region using this method, it is clear that the differential diagnosis and their relevant features and anatomical basis are demonstrated and it is an inclusive means of teaching the subject.

It is intended that this system of determining a differential diagnosis from the underlying anatomy will stimulate students to return to basic principles, whether that is the way they were taught as undergraduates or not. The authors propose that the patho-anatomical or 'Oslerian' approach may be a valid consideration in the future of medical education.

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