ANATOMY OF THE HIP JOINT

AND HOW IT IS RELATED TO GROIN PAIN

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INTRODUCTION

Groin pain refers to discomfort in the area where the abdomen ends and the legs begin[1]. Groin pain in athletes constitutes one of the most difficult clinical entities to diagnose and treat in sports medicine[2]. The reasons for this are the amount of differential diagnoses and the complexity of the anatomy of the groin and hip region, where many structures interact. As a consequence, there is often referred pain or a pain pattern that cannot be attributed to a single structure. A precise and early diagnosis of the cause or causes of groin pain is important for timely recovery. For this, close collaboration between all involved in the care of the athelete is essential. To facilitate this, this article describes the anatomy of the hip joint.

Hip joint pathology is one of the causes that can produce groin pain. Among the clinical entities affecting the hip joint that can be responsible for groin pain, we can differentiate between intra-articular and extra-articular causes of pain.

Examples of **intra-articular hip joint pathology** are:
- acetabular labral tears,
- osteonecrosis of the femoral head,
- femoroacetabular impingement,
- Perthes disease,
- oncologic processes,
- osteoarthritis,
- osteochondritis dissecans,
- septic arthritis,
- slipped capital femoral epiphysis,
- synovitis and others.

Examples of **extra-articular hip joint pathology** are:
- apophyseal avulsion fractures,
- lumbar radiculopathy,
- pubic ramus stress fracture,
- muscle strains,
- nerve entrapment,
- osteitis pubis and others[1].

Intra-articular disorders of the hip joint, although relatively uncommon, are a potential career-ending for the elite athlete[3]. Due to the nature of their activities, athletes tend to subject their hips to a significant amount of stress with increased peak axial and torsional forces, which is a potential source of intra-articular disorders of the hip.

Knowledge of hip anatomy is mandatory for diagnosis and treatment of hip pathology. In addition, knowledge of surgical anatomy is necessary in both open and arthroscopic techniques used to treat hip joint pathology.

This article gives a comprehensive review of the complex anatomy of the hip joint, centred in the intra-articular causes of hip pathology and therefore excluding the anatomy of musculature and neurovascular structures.
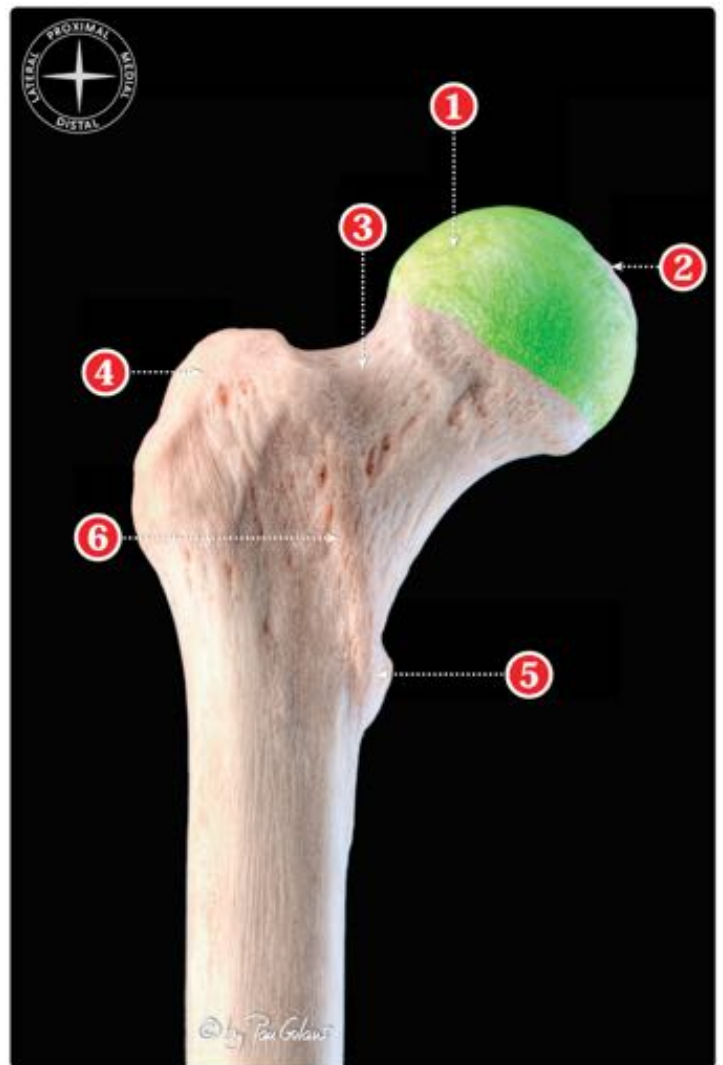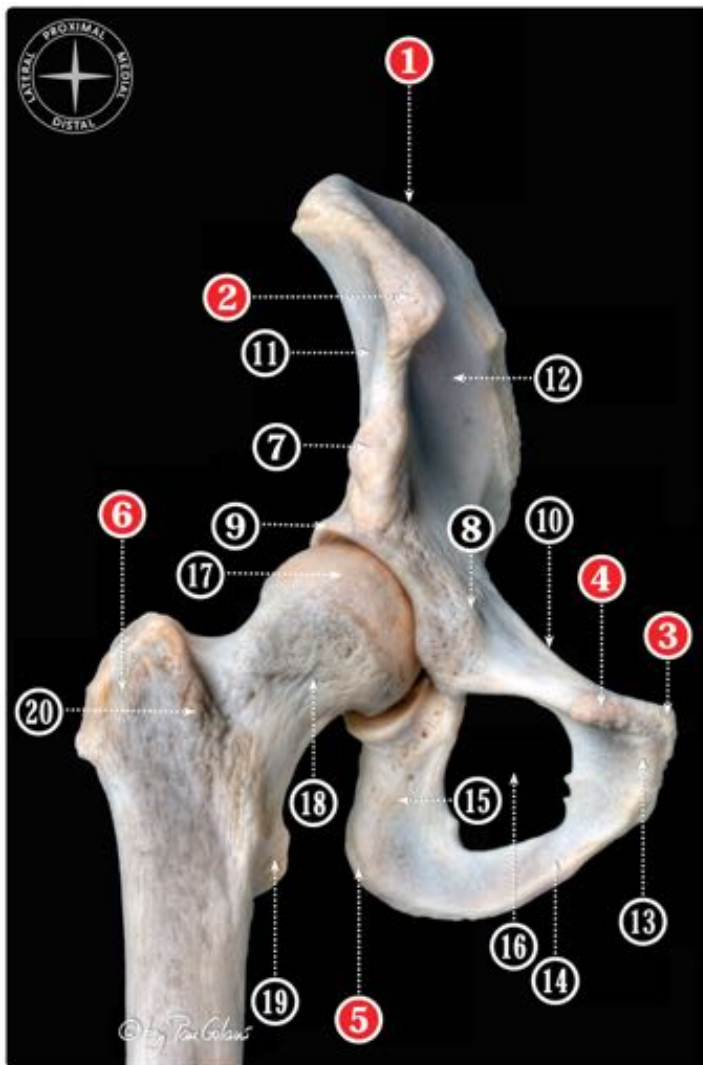
ANATOMY OF THE HIP JOINT

For a better understanding of the complex anatomy we have subdivided this review in two sections:
1. Bone and articular surfaces anatomy.
2. Capsule and ligaments.

Bone and articular surfaces anatomy

Patients presenting with groin pain will benefit from a comprehensive physical

Figure 1 (left): Anterior view of the osseous components of a right hip joint (red numbers correspond to bone landmarks that can be palpated). 1=iliac crest, 2=anterior superior iliac spine, 3=pubic symphisis, 4=pubic tubercle, 5=ischial tuberosity, 6=greater trochanter, 7=anterior inferior iliac spine, 8=iliopubic eminence, 9=rim of the acetabulum, 10=pectineal line or pecten of pubis, 11=gluteal surface, 12=iliac fossa, 13=body of pubis, 14=ramus of ischium, 15=body of ischium, 16=obturator foramen, 17=head of femur, 18=neck of femur, 19=lesser trochanter, 20=intertrochanteric line (Figure copyright ©Pau Golanó 2014).

Figure 2 (right): Anterior view of the proximal epiphysis of a right femur. 1=head and articular surface (coloured with Adobe® Photoshop® software), 2=fovea capitis, 3=neck, 4=greater trochanter, 5=lesser trochanter, 6=intertrochanteric line (Figure copyright ©Pau Golanó 2014).

examination, in which surface anatomy has an important role. In fact, because the hip is a deep joint, a proper understanding of the surface anatomy is essential for physical examination and treatment in and around the joint.

In the surface anatomy of the hip region, it is possible to palpate different bony landmarks such as the greater trochanter, anterior superior iliac spine, iliac crest, posterior superior iliac spine, pubic symphysis, pubic tubercle and ischial tuberosity. The greater trochanter, one of the main landmarks in hip physical examination, can be seen and palpated as a flattened, depressed area. A line extending caudally and horizontally from the tip of the greater trochanter will intersect the centre of the acetabulum. It is important to remember that depending on the position of the leg the reference provided by the greater trochanter can vary. Thus, it must be repeatedly localised by palpation when the position changes (Figure 1).

The hip is a synovial joint formed by the surface of the acetabulum and the head of the femur. These form a ball-and-socket joint with two highly congruent juxtaposed articular surfaces, lubricated by fluid from the synovial lining and surrounded by a strong capsule and ligament complex. The architecture of the joint provides a nearly exact match between the cup-like acetabulum and spherical femoral head and makes the freely mobile articulation perfectly suited for weight-bearing locomotion. In addition, the configuration of the bony architecture provides inherent stability and limits total range of motion, while allowing multiaxial articulation and minimising the need for soft tissue constraint. Due to these characteristics, the hip joint plays a pivotal role in lower extremity gait advancement and bears up to four times the body weight during walking[4].

The hip joint is the perfect example of a ball-and-socket joint. The ball portion of the hip joint is formed by the femoral head,

which is reciprocally shaped to the acetabular socket. The head is conceptualised as two-thirds of a sphere, but during development becomes more ovoid than spherical. The head is attached at its base to the femoral neck and the neck is attached distally to the femoral shaft. The femoral head is fully encased in articular cartilage, except for the fovea capitis. The thickest portion of cartilage lies anterolaterally, at the site of greatest load bearing. This region corresponds to the superior dome of the acetabulum. In the area posterior and slightly inferior to the true centre of the femoral head there is a small depression corresponding to the femoral insertion site of the ligamentum teres, named the fovea capitis[5]. It is the only area of the femoral head not covered by articular cartilage (Figures 2 and 3).

The acetabulum is a confluence of the ilium, superiorly, the ischium, laterally and inferiorly and the pubis, medially. These three bones fuse at the triradiate cartilage during growth and development to form the coxal bone. The acetabulum is hemispheric in shape and is partially covered at the weight-bearing surface by articular cartilage, creating a lunate-shaped cartilage configuration, the lunate articular surface, with a non-articular portion in the centre and inferior regions. This lunate-shaped cartilage is thickest at its most superior portion owing to the load it bears during ambulation. At the anteroinferior region of the acetabulum, there is a focal bone indentation, the acetabular notch, which is spanned by the transverse acetabular 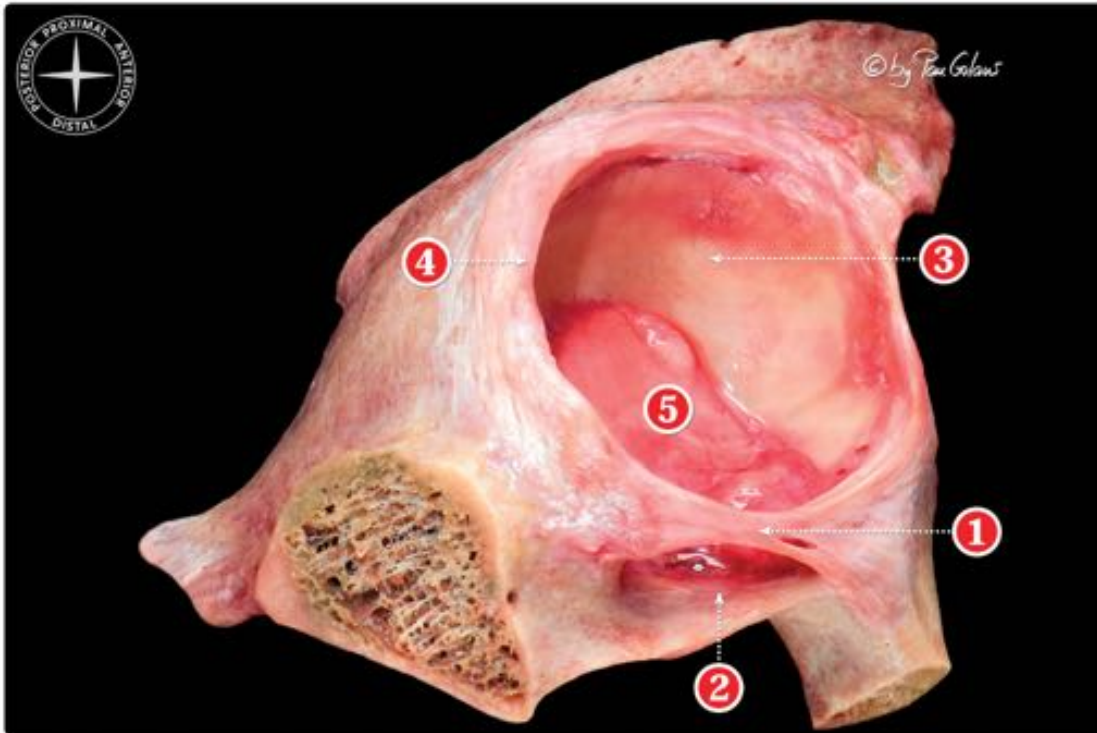ligament. The transverse acetabular ligament acts like a bridge across the acetabular notch, being the basis of the acebabular labrum in this zone and supporting important tensile strains during physiological activities such as walking[6]. The central, non-articular cavity or acetabular fossa, often referred to as the cotyloid fossa, contains the pulvinar and ligamentum teres. The bony acetabulum has a fibrocartilaginous rim, the labrum, which increases the depth and extension of the cotyloid fossa (Figures 4 - 6).

In order to describe intra-articular lesions of the acetabulum and femoral head, Ilizaliturri et al have described a six-zone method that allows description of the topography and location of the lesions, thus helping to define the particular pathological processes[7].
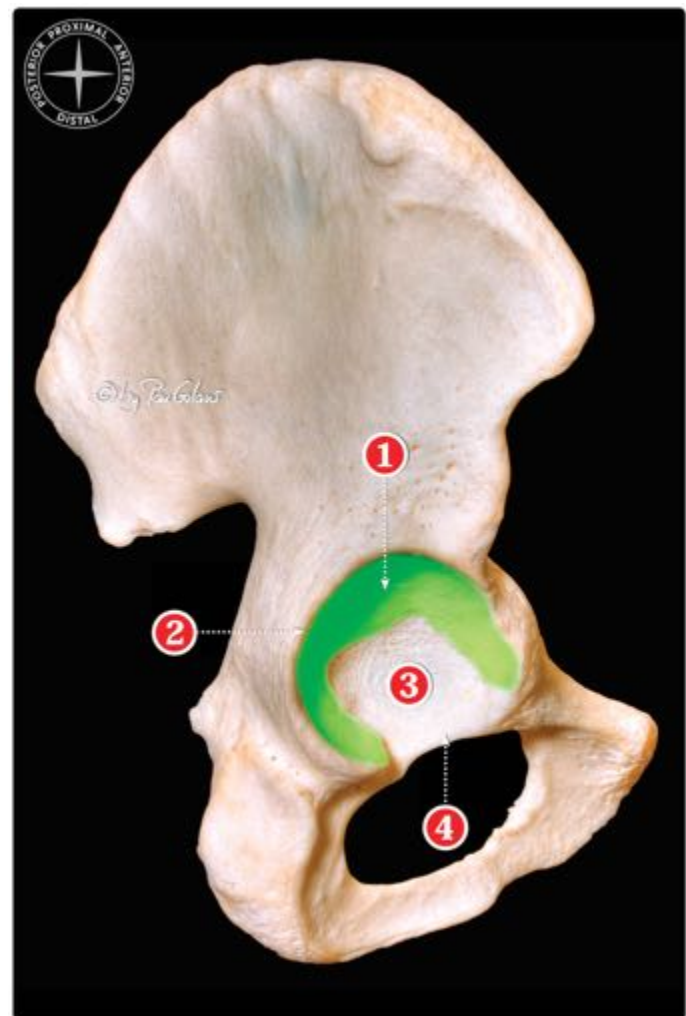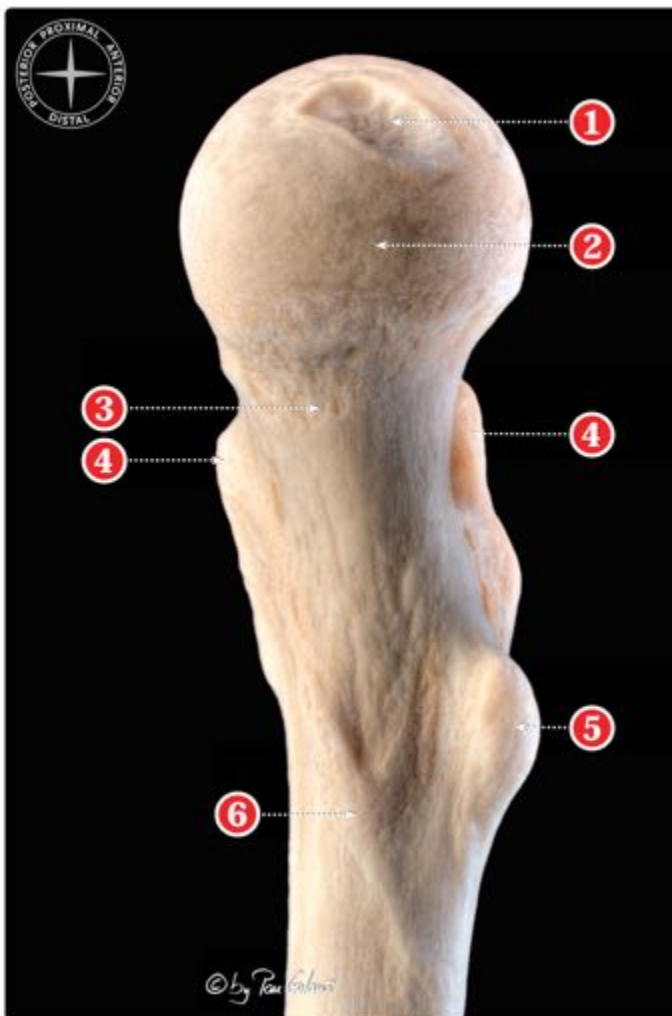

Figure 3 (left): Medial view of the proximal epiphysis of a right femur. 1=fovea capitis, 2=head, 3=neck, 4=greater trochanter, 5=lesser trochanter, 6=pectineal line or spiral line (Figure copyright ©Pau Golanó 2014).

Figure 4 (right): Lateral view of a right coxal bone. 1=lunate articular surface (coloured with Adobe® Photoshop® software), 2=rim of the acetabulum, 3=acetabular or cotyloid fossa, 4=acetabular notch (Figure copyright ©Pau Golanó 2014).

Figure 5: Posterior inferior view of an osteoarticular dissection of the acetabular area. 1=transverse acetabular ligament, 2=acetabular notch, 3=lunate articular surface, 4=acetabular labrum, 5=acetabular or cotyloid fossa with the pulvinar (the ligamentum teres has been resected) (Figure copyright ©Pau Golanó 2014).
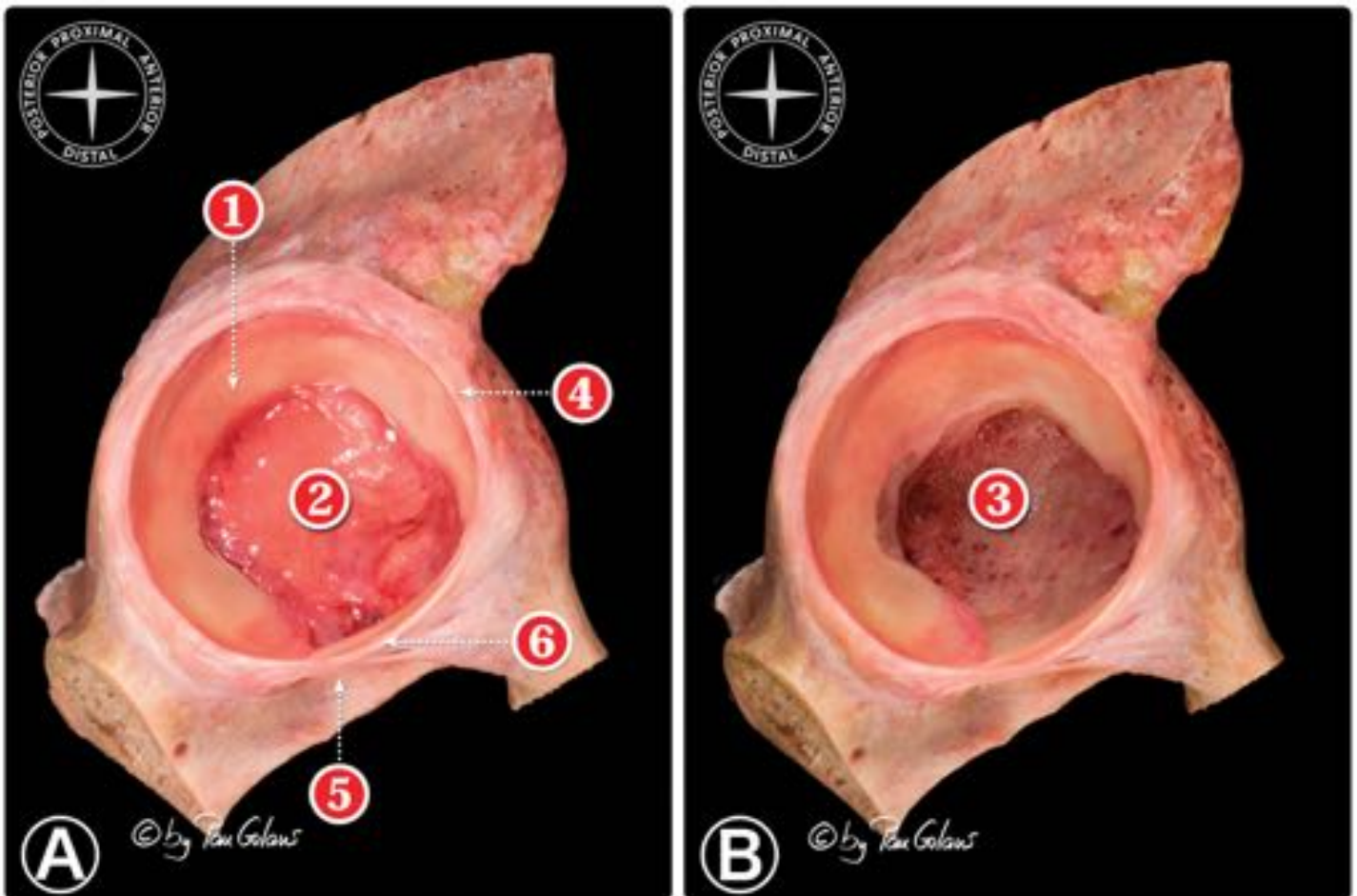
Figure 6: Anterior view of an osteoarticular dissection of the acetabular area. A) acetabular fossa with the pulvinar, B) acetabular fossa with the pulvinar removed. 1=lunate articular surface, 2=pulvinar, 3=acetabular or cotyloid fossa, 4=acetabular labrum, 5=acetabular notch, 6=transverse acetabular ligament (Figure copyright ©Pau Golanó 2014).

Acetabular labrum

The acetabular labrum is found on the rim of the bony acetabulum, increasing the depth and coverage of the acetabulum and forming slightly more than a hemisphere. The labrum is able to exert a high tensile force on the rim of the acetabulum and thus plays a very important role in the stability of the hip joint. It also has an important role in joint lubrication.

The labrum is formed from fibrocartilage with a triangular cross section and has three surfaces:

1. The base or adherent surface is the part that inserts onto the rim of the acetabulum.
2. The internal or articular surface is continuous with the articular surface of the acetabulum.
3. The external surface inserts onto the joint capsule, leaving a free border.

The size of the labrum varies; it is thicker superiorly and posteriorly than it is inferiorly and anteriorly[8,9] (Figures 5 and 6). Classic anatomical studies observed variations of between 6 and 10 mm in the height of the labrum. In the superior area there is a small separation between the insertion of the capsule and the acetabular rim, creating a space between the labrum and the capsule known as the paralabral sulcus, labrum-capsular sulcus or perilabral recess[9,10].

From an arthroscopic point of view, Dorfmann and Boyer[11] divided the hip into two compartments separated by the acetabular labrum: the central compartment and the peripheral compartment. The central compartment includes the acetabular fossa, ligamentum teres, lunate cartilage and articular surface of the femoral head

Figure 7: Anterior view of the osseous components of a right hip joint. The acetabular labrum divides the hip into two compartments: the central compartment (red area) and the peripheral compartment (blue area) (compartments have been coloured with Adobe® Photoshop® software) (Figure copyright ©Pau Golanó 2014).

> **Groin pain in athletes constitutes one of the most difficult clinical entities to diagnose and treat in sports medicine**

in the weight-bearing area. The peripheral compartment is formed of the non-weight-bearing cartilage of the femoral head, the femoral neck with its synovial folds and the joint capsule (Figure 7).

Tears and detachment of the labrum have been recognised as a cause of hip pain and clicking and can thus be a cause for groin pain. On the inner lip of the acetabulum lies the cartilage-labrum junction, which is the most common site for labral pathology. However, it must be remembered that a partial separation of the labrum may be observed at the superior part of the acetabulum as an anatomic variant[12]. This separation is called the sublabral sulcus and should not be confused with a labral lesion. In vivo observation during hip arthroscopy shows the most common site for labral injury to be the anterior and anterosuperior regions[12–14]. Lesions of the posterior labrum are less common and are due to an axial impact with the hip flexed, as occurs in

trauma suffered by the driver in a car accident hitting the dashboard[12]. However, the distinction between the sublabral sulcus and a labral lesion is not always clear; a labral lesion should be considered when there are compatible symptoms or when there is an associated image of labral haemorrhage in acute disorders or granulation tissue indicating attempted healing in chronic disorders[12].

The innervation of the labrum arises from a branch of the nerve to the quadratus femoris muscle and from the obturator nerve. The labrum is a relatively avascular structure, with only the peripheral zone having vascular support, derived from the capsule[15].

Femoroacetabular impingement

Some anatomical variants of the shape of the femoral head and of the acetabulum are mentioned here specifically. The presence of these morphological variations do not

suppose a disease per se, but are rather a predisposing factor by which the hip can fail, constituting a pathological entity named femoroacetabular impingement, one of the causes of intra-articular hip pain[16]. It is considered that femoracetabular impingement is related to an early development of osteoarthritis of the hip and that this condition can cause groin pain in adolescents and active adults[16,17].

Depending on whether the bony abnormality affects the femoral head or the acetabulum, two different types of impingement have been described:

1. **Cam impingement:** In these cases, the femoral head is not completely spherical, due to a bony prominence at the head-neck junction[18]. This results in microtrauma of the altered femoral head abutting against the acetabular rim and leading to acetabular cartilage delamination and minor labral tearing[17].

2. **Pincer impingement:** In pincer impingement the acetabulum is usually in a position of retroversion, producing an anterior overcoverage that results in contact between the acetabular rim and the head-neck junction. An anterior osteophyte can produce the same problem[17]. Pincer impingement produces more aggressive damage in the labrum than cam impingement[16].

Another cause of groin pain where the femoral head plays an important role is internal snapping hip syndrome. This syndrome is caused by the iliopsoas tendon slipping either over the femoral head or the iliopectineal eminence, during extension of the hip from a flexed position[19].

Capsule and ligaments

The capsule of the hip joint is the most important stabiliser of the joint. It encases the hip joint from the acetabulum to the base of the femoral neck. It is intimately related to the intrinsic ligaments and together with them forms a strong capsuloligamentous complex, that can reach a thickness of 0.5 cm in some parts. Anatomically, the posterior capsular insertion on the femur is more proximal than the anterior insertion.

Despite the stability provided by the osseous anatomy, the soft tissues surrounding the hip joint are important for stability. There are four ligaments surrounding and reinforcing the capsule joint. There is a difficulty in defining the exact structure and function of the hip ligaments and therefore controversy and discrepancy surround the current structural descriptions and functional theories. Classic descriptions establish that there is one ligament for each component of the coxal bone (iliac, ischial and pubic bones) that connects it to the femur and another ligament called the zona orbicularis. The
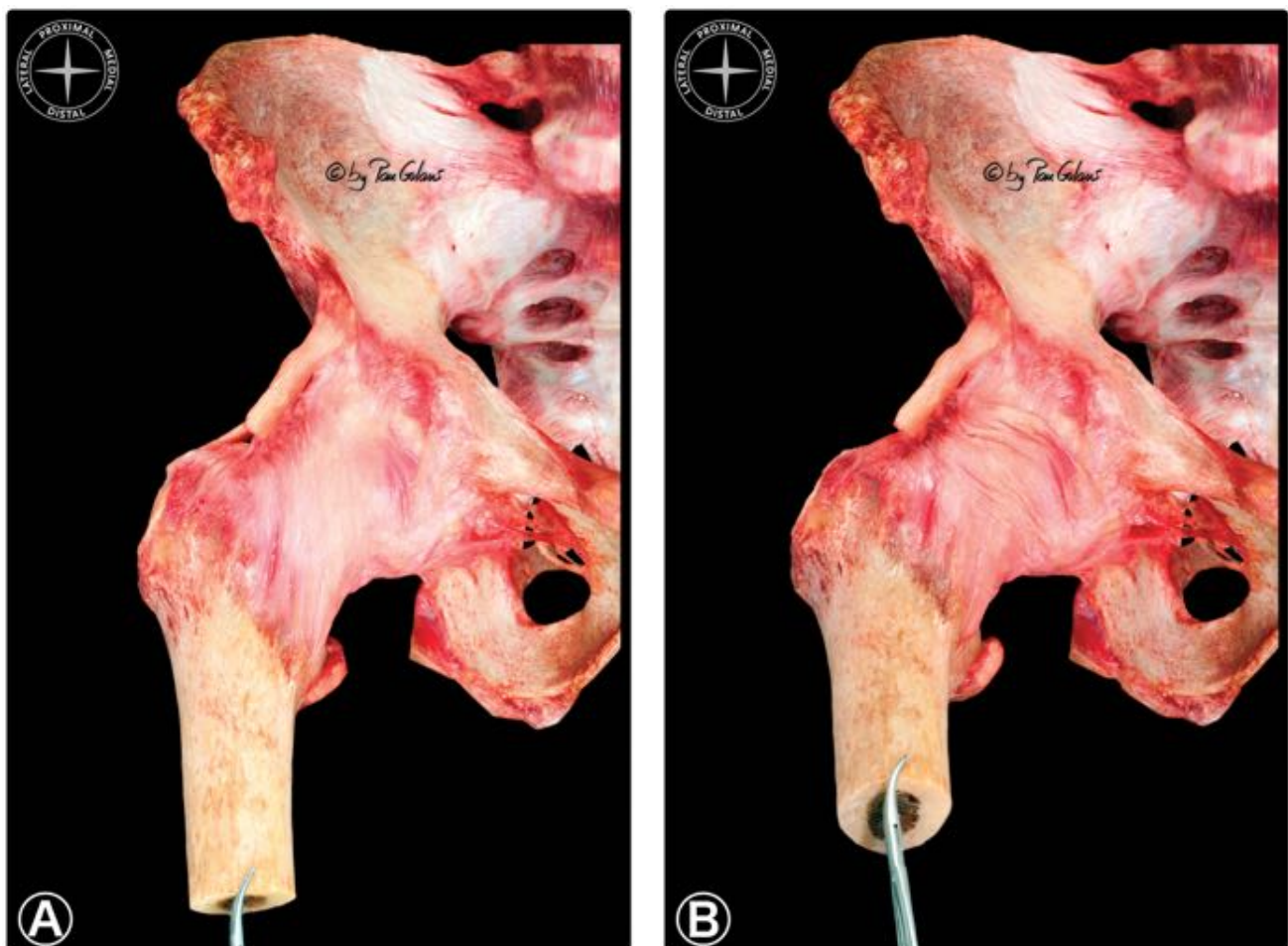
Figure 8: Anterior view of an osteoarticular dissection showing osteoarticular complex of the hip joint. A) Hip in anatomical position, B) hip flexed. Relaxation of the anterior ligaments facilitates access to the hip joint during arthroscopy of the peripheral compartments, creating an anterior working area (Figure copyright ©Pau Golanó 2014).

iliofemoral and pubofemoral ligaments and the zona orbicularis are found in the anterior region of the hip joint, whereas the ischiofemoral ligament is located in the posterior region. Furthermore, the hip contains an intra-articular ligament, the ligamentum teres.

The iliofemoral ligament is the largest and thickest of the three capsular ligaments and one of the strongest ligaments in the human body. It is comprised of two bands of fibres, one medial and one lateral. In a detailed anatomic study, Fuss and Bacher[20] reported a third band, which has not been observed by other authors in more recent studies[21], nor have we encountered this band in our anatomic dissections. The medial band originates between the anterior inferior iliac spine and the iliac portion of the acetabular rim. It runs distally in a nearly vertical course and inserts in a protuberance in the distal intertrochanteric line of the femur. The lateral band originates proximal to the anterior inferior iliac spine. This band has a more horizontal course than the medial band and inserts in the anterior region of the crest of the greater trochanter. The configuration of these two bands is classically described as an inverted Y. The medial band tightens in external rotation and extension, whereas the lateral band tightens in external rotation and flexion or in internal and external rotation during extension of the hip[21]. Relaxation of this ligament facilitates access to the hip joint during arthoscopy of the peripheral compartments, creating an anterior working area (Figure 8).

The pubofemoral ligament is comprised of a single band of fibres that originate from the superior pubic ramus and inserts on the distal region of the intertrochanteric line of the femur, blending with the medial band of the iliofemoral ligament. Although the pubofemoral ligament tightens in external rotation and extension of the hip, it has a less important limiting role in the joint and acts more as a reinforcing element of the anteroinferior joint capsule[21].

The zona orbicularis is a thick bundle of fibres, circularly arranged in the medial, deep region of the capsule that forms a reinforcing ring around the femoral neck[22]. This structure is thought to act as another 'check rein' to aid in maintaining the head within the acetabulum. A portion of the orbicular fibres are derived from

deep tendons of the gluteal region and the reflected head of the rectus femoris muscle. The zona orbicularis of the anterior capsule is easily seen in the arthroscopic view of the peripheral compartment of the hip joint and should not be confused with the acetabular labrum[23]. The inner surface of the capsule and the intra-articular femoral neck are covered by the synovium. This synovial tissue forms a series of folds that descend along the neck of the femur.

The ischiofemoral ligament is located at the posterior part of the hip joint capsule and consists of an upper and lower band. These bands have a common origin at the ischial part of the acetabular rim. The upper band inserts at a site medial to the anterosuperior base of the greater trochanter. The lower band inserts at a posteromedial site at the base of the greater trochanter, at the posterior intertrochanteric crest. Internal rotation of the hip in flexion and extension tightens both bands of the ischiofemoral ligament[21].

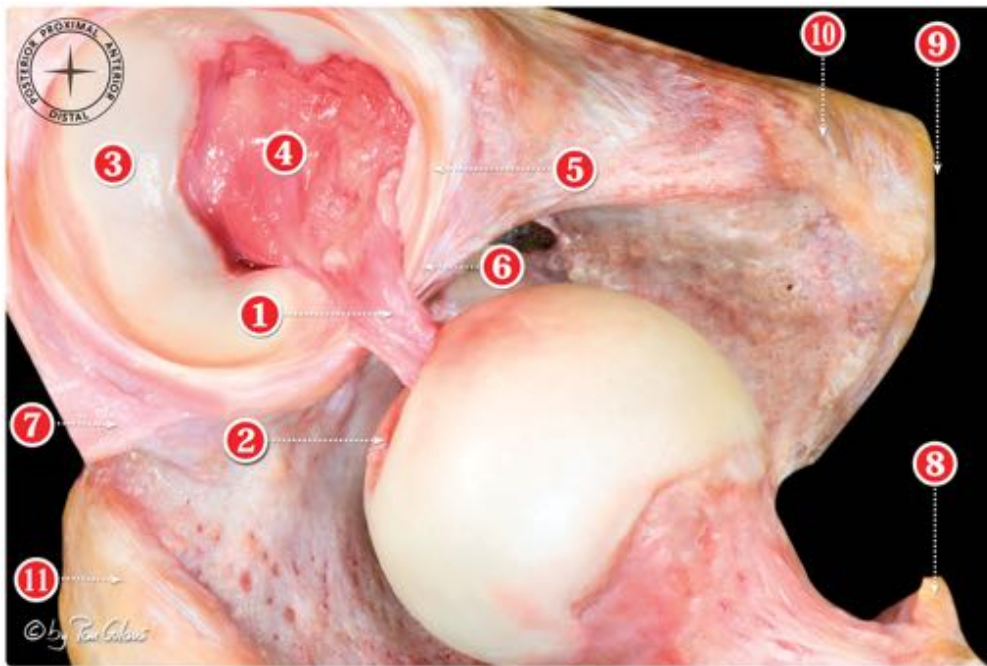The ligamentum teres or ligamentum capitis femoris[24] is an intra-articular ligament that attaches the femoral head to the acetabulum. It arises in the inferior part of the acetabular fossa and runs inferiorly and anteriorly across the joint space to insert into the fovea capitis of the head of the femur.

The ligamentum teres is trapezoid; its base, which is thickened into two bands, inserts onto the border of the acetabular notch and onto the transverse acetabular ligament. As it runs towards the femoral head, it becomes progressively round or ovoid in shape before inserting into the fovea capitis at a site slightly posterior and inferior to the true centre of the head. It is important to remember that the ligamentum teres inserts in the anterosuperior area of the fovea capitis, a fact that allows the fovea capitis to accommodate the proximal part of the ligament when it is tensed[25] (Figures 9 and 10).

In cross section, the ligamentum teres is pyramidal, with a fascicular appearance formed by an anterior and a posterior bundle; it follows a spiral course from its acetabular attachment to its femoral insertion.
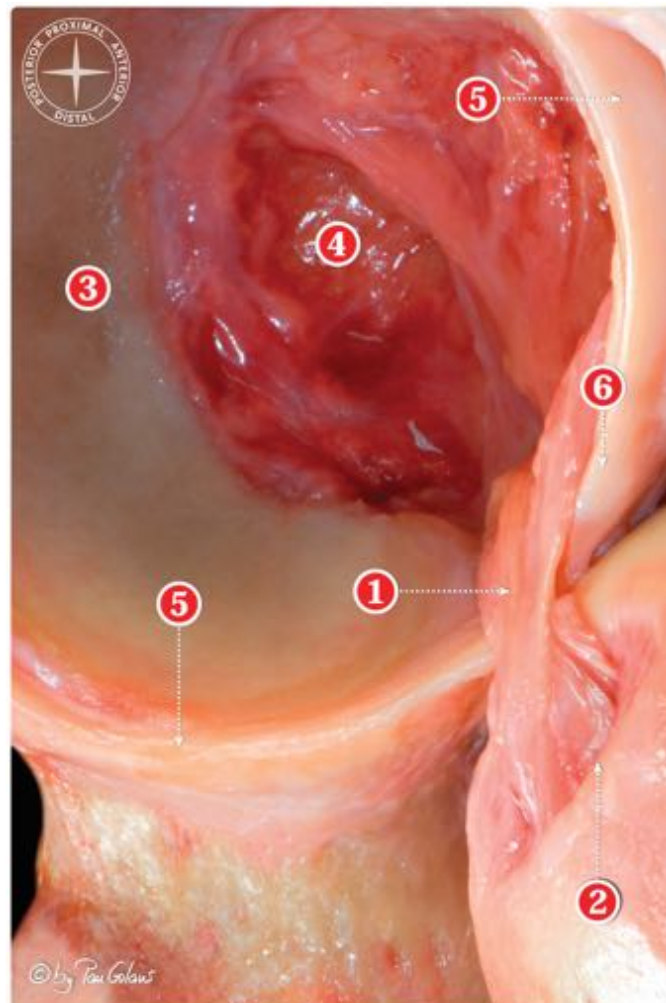
Figure 9: Photo-macrography of a lateral view showing in detail the anatomy of the ligamentum teres. 1=ligamentum teres, 2=fovea capitis, 3=lunate articular surface, 4=acetabular or cotyloid fossa with the pulvinar, 5=acetabular labrum, 6=transverse acetabular ligament (Figure copyright ©Pau Golanó 2014).

Figure 10: Lateral view of a osteoarticular dissection of a dislocated right hip joint showing the anatomy of the ligamentum teres. 1=ligamentum teres, 2=fovea capitis, 3=lunate articular surface, 4=acetabular or cotyloid fossa with pulvinar, 5=acetabular labrum, 6=transverse acetabular ligament, 7=acetabular capsule insertion (cut), 8=femoral capsule insertion (cut), 9=pubic symphysis, 10=pubic tubercle, 11=ischial tuberosity (Figure copyright ©Pau Golanó 2014).

Due to their spiral configuration, the leash-like fibres of the zona orbicularis and anterior capsular ligaments tighten in a screw mechanism during terminal extension and external rotation, further stabilising the joint. As the hip moves into flexion, the fibres unwind and loosen, rendering the joint less stable[26].

Dynamic hip examination shows that the ligament becomes tense during external rotation of the hip and relaxed on internal rotation. A recent arthroscopic study of high level athletes revealed hypertrophic changes of the ligamentum teres, suggesting a relationship with chronic instability of the hip[27]. The ligamentum teres may have a function similar to that of the anterior cruciate ligament in the knee[28].

Although rarely reported, damage to the ligamentum teres is a cause of hip pain. Its rupture occurs usually with dislocation of the hip joint, although rupture may also occur in a twisting injury[29]. A relationship between microinstability of the hip and abnormalities of the ligamentum teres can exist, which represents another cause to consider in the differential diagnosis of hip pain[30].

The synovial folds

As the neck of the femur is intra-articular, it is covered by synovial membrane. This synovial tissue forms a series of folds that descend along the femoral neck, from the border of the cartilage of the femoral head to the insertion of the joint capsule on the femur. These folds, that vary in number and size, can be responsible for hip pain and should be considered when diagnosing groin pain. During surgical procedures it is important to distinguish them from possible adhesions. Synovial folds, which may be large, are usually observed medially and laterally; an anterior fold is less common. The medial fold is an important reference for initial orientation during surgery.

The medial fold can be affected by an impingement disorder called pectineofoveal impingement[31]. Clinically, these patients refer mechanical pain in the hip with movements of flexion and rotation; this can force them to reduce or stop sporting activities. Additional investigations are usually normal and the diagnosis can be made by arthroscopy, which reveals trapping of this synovial fold with the medial soft tissues (zona orbicularis and psoas muscle tendon). In consequence, the synovial fold becomes hypertrophic, rubbing against the femoral neck during the sporting activity. Treatment consists of excision of the thickened synovial fold.

The lateral fold indicates the site of entry of the perforating arterioles, which are important for vascularization of the femoral head[32].

CONCLUSION

The hip is a joint that can be affected by high number of pathologies, either intra-articular or extra-articular. In addition, the fact that hip pathology can produce groin pain adds more difficulty in the diagnosis of hip or groin related pain. Hip pathology must be taken in account as one of the causes of groin pain.

References
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