

Greater trochanteric pain syndrome

Anatomy & Pathophysiology

BONY ANATOMY

- The hip is a multiaxial joint formed by the articulation between the pelvis and femur, connecting the axial skeleton and the lower extremity [8].
- The hemipelvis comprises three bones: the ilium, ischium, and pubis, which unite at the triradiate cartilage within the concave acetabulum [8].
- The acetabulum comprises an articular crescent-moon-shaped lunate surface and a nonarticular central fossa that serves as the attachment point for the ligamentum teres [8].
- The acetabulum is incomplete inferiorly, forming a notch through which vital blood vessels and nerves pass to supply the joint [8].
- The femoral head forms two-thirds of a sphere, with a small depression at its center from which the ligamentum teres extends to connect to the acetabular notch [8].
- The neck-shaft angle of the femur averages 125° [8].
- Normal version, defined as the head-neck angle in the frontal plane, averages 15 to 20° [8].
- At the junction of the neck and shaft are the greater and lesser trochanters, which are connected by the intertrochanteric line anteriorly and the intertrochanteric crest posteriorly [8].
- The acetabulum is normally anteverted 15 degrees and obliquely oriented in the coronal plane 45 degrees caudally [14].
- The posterosuperior articular surface of the acetabulum is thickened to accommodate weight bearing [14].
- The inferior surface of the acetabulum contains the acetabular (cotyloid) notch, which is bound by the transverse acetabular ligament [14].
- The femoral neck is normally anteverted approximately 14 degrees in relation to femoral condyles, with a range of 1–40 degrees [14].
- The femoral neck-shaft angle averages 127 degrees, beginning at 141 degrees in the fetus [14].
- The mean femoral neck-shaft angle in the adult is 130° ± 7° [18].
- The mean anteversion of the femoral neck is 10° ± 7° [18].

- The two prime trabecular groups of the proximal femur are the principal tensile group and the principal compressive group [18].
- Secondary compressive and tensile trabecular groups also exist in the proximal femur [18].
- The weakest area in the femoral neck is located in the Ward triangle [18].
- The calcar femorale is a medial area of dense trabecular bone that transfers stress from the femoral shaft to the inferior portion of the femoral neck [18].

LIGAMENTS AND CAPSULE

- The hip is surrounded by a dense fibrous capsule extending from the periphery of the acetabulum to the intertrochanteric line of the femoral neck [8].
- The capsule enhances joint stability by preventing translation of the femoral head in the acetabulum [8].
- The Y-shaped iliofemoral ligament is the thickest and strongest of the three main ligaments supporting the hip [8].
- The medial portion of the iliofemoral ligament connects the anterior inferior iliac spine to the anterior intertrochanteric line [8].
- The lateral portion of the iliofemoral ligament originates slightly superior to the medial arm and attaches to the anterior greater trochanter [8].
- The iliofemoral ligament functions to limit external rotation [8].
- In isolation, the lateral arm of the iliofemoral ligament limits extension of the joint [8].
- The ischiofemoral ligament extends from the ischial margin of the acetabulum to the greater trochanter of the femur [8].
- The ischiofemoral ligament provides support posteriorly and restricts internal rotation motion [8].
- The pubofemoral ligament extends from the obturator crest of the pubic bone to the femoral neck [8].
- The pubofemoral ligament acts to limit abduction of the joint [8].
- Deep fibers from the iliofemoral, ischiofemoral, and pubofemoral ligaments merge to form the zona orbicularis, which circumvents the femoral neck [8].
- The hip capsule attaches anteriorly and posteriorly along the periphery of the acetabulum outside the labrum [9].
- Inferiorly, the hip capsule is attached to the acetabular labrum [9].
- The capsule is attached to the femur anteriorly along the intertrochanteric crest [9].
- On the posterior side, the capsule attaches only partially, such that the basicervical region of the femoral neck and the intertrochanteric region of the femur are not intracapsular [9].
- The iliofemoral ligament becomes taut in full extension, preventing anterior dislocation and hyperextension of the hip [9].
- The twisted orientation of the hip ligaments provides a screw mechanism for the hip in full extension [9].
- The ligamentum teres originates in the cotyloid fossa and attaches on the fovea of the femoral head [9].

LABRUM

- The acetabular labrum is a fibrocartilaginous ring attached to the rim of the acetabulum that extends the articulating surface area and increases femoral head coverage [8].
- The labrum is triangular in cross section [8].
- Only the external one-third of the labrum contains blood vessels, leaving the majority of the structure avascular [8].
- The avascular nature of the majority of the labrum limits its healing ability following injury [8].
- The labrum is highly innervated, with the presence of both mechanoreceptors and nociceptors [8].
- The labrum is absent in the area of the inferior acetabular notch, where the transverse acetabular ligament serves as the continuation of the labrum [8].
- The fibrocartilaginous labrum deepens the acetabulum, enhancing stability [5].
- Labral functions include load transmission, maintenance of vacuum seal, regulation of synovial fluid hydrodynamics, and joint lubrication [5].

MUSCULAR ANATOMY

- The abductors of the hip are predominantly the gluteus medius and minimus muscles [16].
- The gluteus medius has three different components: anterior, middle, and posterior [16].
- The gluteus medius and minimus muscles function together to maintain and abduct the femur during the stance phase of gait [16].
- A Trendelenburg lurch is an attempt by the body to compensate for abductor weakness by bringing the center of gravity closer to the hip center, forcing the patient to lean toward the affected side [16].
- The piriformis muscle originates from the greater sciatic foramen and inserts onto the greater trochanter [16].
- The superior gluteal nerve and artery exit the pelvis above the piriformis muscle [16].
- The pudendal nerve, internal pudendal artery, nerve to the obturator internus, posterior femoral cutaneous nerve, sciatic nerve, inferior gluteal nerve, inferior gluteal artery, and nerve to the quadratus femoris all exit the pelvis below the piriformis [16].
- In 10% of cases, the common peroneal component of the sciatic nerve can pass through the division in the piriformis [16].
- The tensor fasciae latae muscle originates laterally on the anterolateral edge of the iliac crest [16].
- The action of the tensor fasciae latae is to flex, abduct, and rotate the hip [16].

NEUROVASCULAR ANATOMY

- The medial femoral circumflex artery is the main blood supply to the femoral head [18].
- The lateral femoral circumflex artery gives rise to the anterior aspect of the extracapsular arterial ring [18].
- The superior and inferior gluteal arteries also contribute branches to the extracapsular arterial ring [18].

- The ascending cervical arteries originate from the extracapsular arterial ring and are divided into four distinct groups: lateral, medial, posterior, and anterior [18].
- The lateral group of ascending branches is the main blood supply to the femoral head [18].
- The lateral epiphyseal artery penetrates the femoral head and is believed to be the dominant blood supply to the femoral head from this system [18].
- Fractures that disrupt the ascending blood flow to the lateral epiphyseal vessel have an increased risk of osteonecrosis [18].
- The artery of the ligamentum teres arises from either the obturator or medial femoral circumflex artery [18].
- The artery of the ligamentum teres does not provide sufficient blood supply to maintain the viability of the femoral head [18].
- In adulthood, the major blood supply to the femoral head is from the medial femoral circumflex and lateral epiphyseal arteries [21].
- The common femoral artery passes anterior and medial to the hip capsule [21].
- The common femoral vessels are the most commonly reported extrapelvic vascular structures that are injured during total hip arthroplasty [21].
- The most common mechanism of injury to the common femoral vessels is errant retractor placement anterior to the acetabulum [21].
- The superior gluteal vessels are branches of the posterior division of the internal iliac artery [21].
- Superior gluteal artery injury can occur with the placement of screws in the region of the sciatic notch [21].
- The inferior gluteal vessels and internal vessels are branches of the anterior division of the internal iliac artery [21].
- The inferior gluteal vessels exit the pelvis between the piriformis and coccygeus muscles [21].

PATHOPHYSIOLOGY OF GREATER TROCHANTERIC PAIN SYNDROME

- Greater trochanteric pain syndrome (GTPS) is a conglomerate of conditions including snapping hip, trochanteric bursitis, and gluteal tendinopathy [20].
- Lateral-sided hip pain associated with GTPS has been reported to be as debilitating as end-stage degenerative joint disease [20].
- In patients between 50 and 79 years of age, GTPS was found in 15% of women and 6.6% of men in one hip [20].
- Lateral hip anatomy includes three to four bursae surrounding the side of the hips [20].
- The largest bursa is found between the gluteus maximus muscle and the gluteus medius tendon, which is located directly lateral to the greater trochanter [20].
- The muscular sheaths and tendinous attachments of the gluteus maximus, iliotibial band, tensor fascia lata, gluteus medius, and gluteus minimus contribute to a complex local environment susceptible to overuse injuries, direct trauma, and gait alterations [20].

- Trochanteric bursitis is often related to the other conditions of GTPS and not true inflammation of the local bursa [20].
- GTPS encompasses various etiologies of pain at the greater trochanter of the femur, including trochanteric bursitis, gluteus medius or gluteus minimus tendon tears, and friction of the iliotibial band over the greater trochanter [32].
- External snapping hip is the result of the iliotibial band snapping over the greater trochanter of the femur [32].

Investigations

CLINICAL EXAMINATION AND HISTORY

- A thorough understanding of normal anatomy and biomechanics is necessary to identify pathology and determine the appropriate course of treatment for hip pain [1].
- A comprehensive clinical examination is required to determine a differential diagnosis because many hip conditions present with similar symptoms [1].
- A thorough history is essential to differentiating between common causes of hip pain [1].
- Clinical examination tests and imaging findings should be used to confirm a suspected clinical diagnosis [1].

RADIOGRAPHY

- Conventional radiographs remain critical in the initial imaging evaluation of the hip [2].
- Conventional radiographs can be used to diagnose fractures, developmental dysplasia of the hip (DDH), femoroacetabular impingement (FAI), and osteoarthritis [2].
- A complete hip series usually consists of an anterior-posterior (AP) pelvis, a centered AP hip, a lateral view (frog-leg, cross-table, Dunn 45° or 90°), and a false-profile (Lequesne) view [2].
- Standard AP radiographs of the hip and pelvis are obtained to examine bony architecture, check for evidence of joint space narrowing or changes to bone quality, and quantify femoral head coverage [25].
- The Dunn view and frog leg view are appropriate to measure the alpha angle to determine the presence of impingement [25].
- Acetabular morphology is assessed on AP pelvis radiographs for acetabular overcoverage and undercoverage [2].
- The femoral head-neck junction morphology is often assessed using the alpha angle [2].
- Some studies have shown that radiographs, in particular the Dunn 45° view, may be more accurate for determining the alpha angle measurement than CT or MRI [2].
- Osteoarthritis of the hip can be categorized using the Kellgren-Lawrence or Tönnis classifications [2].
- The Kellgren-Lawrence classification is a 4-point grading system classified into doubtful, mild, moderate, and severe [2].
- The Tönnis classification is a 3-point grading system categorized into mild, moderate, and severe [2].

- Radiographic and clinical severity do not necessarily correlate, particularly if the radiographs are non-weight-bearing or if false-profile views are not included [2].
- The femoral head extrusion index is defined by the length of the femoral head that lies beyond the acetabulum as a percentage of the total horizontal width of the femoral head [2].
- Femoral head extrusion index values greater than 25% are considered abnormal [2].
- The Tönnis angle is defined by the angle of the acetabular sourcil and a line parallel to the transverse pelvis axis [2].
- Tönnis angles between 0° and 10° are considered normal [2].
- The lateral center-edge angle, or center-edge angle of Wiberg, is the angle between a line from the center of the femoral head perpendicular to the transverse pelvis axis and a second line from the center of the femoral head to the superolateral most point of the acetabulum [2].
- Center-edge angles of 20°-40° are considered normal, while angles from 20° to 25° are considered borderline [2].
- An optimal AP pelvis image is required for assessing the “crossover” sign, as pelvic tilt or rotation may lead to false-positive and false-negative results [2].
- For neutral pelvic tilt on an AP pelvis radiograph, the sacrococcygeal joint should be between 3 and 5 cm above the superior border of the symphysis pubis [2].
- Radiographs remain integral to the assessment of fractures and can be supplemented with CT to further investigate suspected occult fractures, define fracture morphology, and assist in preoperative planning [2].
- Radiographs can serially assess hardware positioning and evaluate symptomatic hardware related to open reduction and internal fixation and total hip arthroplasty [2].

MAGNETIC RESONANCE IMAGING (MRI)

- MRI is the modality of choice for patients suspected of soft tissue or intra-articular pathology, given its superior sensitivity and specificity [25].
- Conventional MRI is effective at identifying osteochondral injuries, musculotendinous pathologies, and inflammation [25].
- Magnetic resonance arthrography (MRA) is more appropriate to determine injuries to the labrochondral structures and the ligamentum teres and identify the presence of loose bodies and synovial chondromatosis [25].
- The utility of MRA in the accurate detection and staging of articular cartilage lesions is reduced, with sensitivity reported to be less than 50% compared with arthroscopic findings [25].
- Recent advances in MRI imaging techniques, such as delayed gadolinium-enhanced MR imaging and T2* mapping, allow for a more in-depth analysis of the structure of articular cartilage [25].
- Delayed gadolinium-enhanced MR imaging and T2* mapping were effective at detecting early changes to the articular cartilage surfaces of patients with hip dysplasia and femoroacetabular impingement [25].
- MRI provides information regarding the integrity of the acetabular labrum and articular cartilage [3].

- The anatomy of the proximal femur as well as the version of the acetabulum and femur may be assessed using MRI [3].
- The sensitivity of MRI to acetabular rim chondral lesions is limited [3].
- Noncontrast MRI at 3T is generally adequate for diagnosing intra-articular pathology [28].
- If 3T imaging is unavailable, MRA can be considered at 1.5T for increased diagnostic accuracy [28].
- MRI is helpful in identifying femoral neck stress fracture in athletes and predicting patients that may require surgical intervention [28].
- MRI is helpful in assessing complications of conventional and resurfacing hip arthroplasties, particularly those with metal-on-metal bearing systems [28].
- Major MRI findings that help predict histologic ALVAL scores include synovial thickening, synovitis, synovial volume, abductor disruption, and soft-tissue edema [28].
- A prospective study found similar accuracies between noncontrast 3T MRI and 1.5T MRA in femoroacetabular impingement [26].
- A retrospective study evaluating the accuracy of noncontrast 3T MRI versus hip arthroscopy found accuracy for labral tears and acetabular cartilage lesions was 98% and 90%, respectively [26].

COMPUTED TOMOGRAPHY (CT)

- CT scans are effective for examining cortical and cancellous bone and can be used to create three-dimensional reconstructions of the hip for use in surgical planning [25].
- Measurements of femoral head coverage and acetabular and femoral impingement can also be performed reliably using CT images [25].
- Low-dose CT with three-dimensional reformats is particularly useful in surgical planning of complex or borderline deformities [3].
- CT overcomes the limitations of radiography by providing three-dimensional assessment of bony morphology and, to some degree, assessment of soft-tissue abnormalities [10].
- Combined with arthrography, CT can evaluate chondrolabral abnormalities, specifically in patients with contraindications to MRI [10].
- CT is helpful in fracture evaluation, particularly in the setting of negative radiographs, or for further defining fracture morphology in patients requiring surgical reduction [10].
- The multiplanar and 3D capabilities of CT make it an invaluable tool for assessing bone morphology, but at higher cost and radiation dose [28].
- 3D volume renderings are useful to aid in preoperative planning in FAI and subspine impingement [28].

ULTRASONOGRAPHY

- Ultrasonography provides real-time dynamic assessment of the hip and is useful in diagnosing soft-tissue abnormalities about the hip joint, and to a lesser degree, within the hip joint itself [10].
- Ultrasonography is particularly useful in providing real-time guidance during diagnostic and therapeutic procedures [10].

- Ultrasonography can be an effective modality to identify musculotendinous disruptions, effusions associated with intra-articular pathology, or inflammatory conditions, such as bursitis [25].
- Ultrasonography is being increasingly used for targeted injections into muscles, tendons, or intra-articularly around the hip, for use with corticosteroids or biologic treatments [25].
- Although ultrasonography is a valuable tool to examine pediatric hip conditions, its utility in evaluating the adult hip is limited [25].
- Ultrasonography allows bedside evaluation of the hip and can be used to guide interventions in the office setting [28].
- Ultrasonography uses high-frequency sound waves to produce images [29].
- A higher frequency ultrasonographic beam can provide higher resolution images of superficial structures such as tendons and ligaments [29].
- Doppler ultrasonography can be used to image blood vessels for flow velocity and direction [29].
- Elastography is an ultrasonography technique that can assess the elasticity of soft tissues and identify pathology that changes the elasticity of soft-tissue structures, like tendinopathy [29].
- Elastography technology is used mostly in research studies but not for clinical use at this point [29].
- Ultrasonography is noninvasive at the frequencies used for diagnostic imaging [29].
- Ultrasonography equipment is portable and inexpensive compared with MRI and CT equipment [29].
- Highly echogenic structures, such as a foreign body that may not be visible on radiographs, can be easily detected using ultrasonography [29].
- Ultrasonography can be used to guide targeted therapy, such as injections and ablations, and is useful to guide injections and aspirations [29].
- Ultrasonography provides dynamic assessment of structures, such as tendon and nerve subluxation [29].
- Image quality and interpretation depend on the experience of the ultrasonography technician and the radiologist [29].
- Ultrasonography cannot image inside bone because bone cortex reflects almost all sound waves [29].
- Internal joint structures are not well visualized unless they are in a superficial location [29].

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