

Intertrochanteric fracture

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 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 femoral neck and shaft are the greater and lesser trochanters, 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 the femoral condyles, with a range of 1 to 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].
- Fractures of the proximal femur follow the path of least resistance [18].
- The amount of energy absorbed by the bone determines the degree of comminution in proximal femur fractures [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 hip joint capsule extends anteriorly to the intertrochanteric crest but posteriorly only partially across the femoral neck [5].
- The basicervical and intertrochanteric crest regions are extracapsular [5].
- The iliofemoral ligament, also known as the Y ligament of Bigelow, is the strongest ligament in the body [5].
- The iliofemoral ligament attaches from the anterior inferior iliac spine (AIIS) to the intertrochanteric line in an inverted Y manner [5].
- The iliofemoral ligament functions to limit external rotation, while its lateral arm limits extension of the joint [8].
- The ischiofemoral ligament extends from the ischial margin of the acetabulum to the greater trochanter of the femur and restricts internal rotation motion [8].
- The pubofemoral ligament extends from the obturator crest of the pubic bone to the femoral neck and 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 is attached to the femur anteriorly along the intertrochanteric crest [9].
- On the posterior side, the hip 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].

VASCULAR ANATOMY

- The medial femoral circumflex artery is the main blood supply to the femoral head [18].

- The medial femoral circumflex artery terminates in the posterior aspect of the extracapsular arterial ring [18].
- The lateral femoral circumflex artery gives rise to the anterior aspect of the extracapsular arterial ring [18].
- The superior and inferior gluteal arteries contribute branches to the extracapsular arterial ring [18].
- The ascending cervical arteries originate from the extracapsular arterial ring and are divided into lateral, medial, posterior, and anterior groups based on their anatomic relationship to the femoral neck [18].
- The lateral group of ascending branches is the main blood supply to the femoral head [18].
- The ascending branches give off multiple perforator vessels to the femoral neck and terminate in the subsynovial arterial ring located at the margin of the articular surface of 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].
- From birth to approximately 4 years of age, the major blood supply to the femoral head comes from the medial and lateral femoral circumflex arteries, with major contributions from the artery of the ligamentum teres [21].
- From the age of 4 years to adulthood, the posterosuperior and posteroinferior retinacular arteries from the medial circumflex artery are the major blood supply [21].

FRACTURE PATHOPHYSIOLOGY

- Intertrochanteric femur fractures account for approximately 50% of all proximal femur fractures [18].
- Intertrochanteric fractures are considered extracapsular fractures [18].
- Callus formation is common in intertrochanteric fracture patterns [18].
- Nonunion is rare in intertrochanteric fractures because of the absence of synovial fluid and the presence of an abundant blood supply [18].
- Femoral neck fractures are considered intracapsular fractures and are at higher risk of nonunion [18].
- Because of the absence of a periosteal or extraosseous blood supply, no callus forms during healing of femoral neck fractures [18].
- Fracture healing in femoral neck fractures occurs by intraosseous bone healing [18].

Investigations

RADIOGRAPHY

- Conventional radiographs remain critical in the initial imaging evaluation of the hip and can be used to diagnose fractures [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].
- 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 [2].
- Plain radiographs are the first imaging studies obtained for patients presenting with hip pain and can determine the presence of fractures, degenerative changes, and abnormal joint morphology [25].
- 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].
- Radiographs are essential in the workup of patients with hip pain and may be used to assess for osteoarthritis, femoroacetabular impingement (FAI), and developmental dysplasia of the hip (DDH) [28].

COMPUTED TOMOGRAPHY

- CT overcomes the limitations of radiography by providing three-dimensional assessment of bony morphology and, to some degree, assessment of soft-tissue abnormalities [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].
- 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 be performed reliably using CT images [25].
- 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].

MAGNETIC RESONANCE IMAGING

- 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].

CQ HAND + UPPER LIMB

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- 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].
- In the accurate detection and staging of articular cartilage lesions, the utility of MRA 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].
- MRI is useful for the assessment of developmental dysplasia of the hip (DDH) and femoroacetabular impingement (FAI), as well as for extra-articular pathologies, stress injuries of bone, and hip arthroplasties [28].
- 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 findings that help predict histologic ALVAL scores include synovial thickening, synovitis, synovial volume, abductor disruption, and soft-tissue edema [28].

ULTRASONOGRAPHY

- Ultrasonography provides real-time dynamic assessment of the hip and is useful in diagnosing soft-tissue abnormalities about the hip joint [10].
- Ultrasonography is particularly useful in providing real-time guidance during diagnostic and therapeutic procedures [10].
- Although ultrasonography is a valuable tool to examine pediatric hip conditions, its utility in evaluating the adult hip is limited [25].
- 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 increasingly used for targeted injections into muscles, tendons, or intra-articularly around the hip for use with corticosteroids or biologic treatments [25].
- Ultrasonography allows bedside evaluation of the hip and can be used to guide interventions in the office setting [28].
- 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].

GENERAL PRINCIPLES

- Findings from imaging studies should complement clinical examination findings to provide the most accurate diagnosis [1].

- A thorough history is essential to differentiating between common causes of hip pain, and clinical examination tests and imaging findings should be used to confirm a suspected clinical diagnosis [1].

Treatment

- Appropriate identification of associated medical comorbidities, medical and orthopaedic comanagement, and prompt surgical treatment may minimize the risks of complications, morbidity, and mortality while improving outcomes [33].
- The implant choice should be based on fracture pattern, cost, and the surgeon's familiarity [33].
- The goal of implant selection is to deliver patient-appropriate care in a timely manner [33].
- The use of multidisciplinary teams, which include primary care providers, geriatricians, internists, social workers, physiatrists, and care managers, can help to lower cost by decreasing complications and hospital lengths of stay [33].
- Stable and unstable fracture patterns of intertrochanteric fractures in the Evans classification are differentiated by presence of posteromedial cortex apposition and lateral wall integrity [33].
- Outcome after intertrochanteric hip fracture depends on the patient's preinjury functional levels and medical comorbidities [33].
- One-year mortality rates after intertrochanteric hip fracture are between 10% and 30% [33].

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