

Hemiarthroplasty for hip fracture

Anatomy & Pathophysiology

BONY ANATOMY

- Intertrochanteric fractures are extracapsular fractures of the proximal femur, distinct from intracapsular femoral neck fractures [1].
- The trochanteric region consists of a variable combination of cortical and cancellous bone that is well-vascularized [7].
- Structural integrity in the trochanteric region depends on a laminated cancellous bone arcade extending from the femoral head and epiphyseal scar, around Ward's triangle, to the lesser trochanter [7].
- The calcar femorale, also known as Adam's arch, is a strong plate of bone located posteriorly and medially that is most affected by posteromedial fracture comminution [7].
- Tensile trabeculae are located between Ward's triangle and the greater trochanter [7].
- The best quality bone in the proximal femur is located beneath the articular surface [7].
- Aging causes thinning of the cortex, expansion of the bone diameter, and loss of tension and compression trabeculae in the hip [7].
- The proximal femur consists of a single physis at birth that later separates into two distinct centers of ossification: the capital epiphysis and the trochanteric apophysis [8].
- The femoral neck-shaft angle is 135 degrees at birth, increases to approximately 145 degrees by 1 to 3 years, and matures to an average of 130 degrees at skeletal maturity [8].
- Femoral anteversion is approximately 30 degrees at birth and decreases to an average of 10.4 degrees at skeletal maturity [8].
- The trochanteric physis closes between 16 and 18 years, and the proximal femoral physis closes at approximately 18 years [8].
- The proximal femoral physis contributes approximately 15% of the growth of the entire extremity [8].

VASCULAR ANATOMY

- The blood supply to the intertrochanteric region is rich, resulting in a much lower rate of healing complications such as nonunion and osteonecrosis compared to intracapsular fractures [1].

- The major blood supply to the proximal femur comes from the medial and lateral circumflex arteries, which are branches of the profunda femoris artery originating at the level of the tendinous portion of the iliopsoas muscle [8].
- The lateral circumflex artery travels posterior to the femoral neck, while the medial circumflex artery travels anterior to it [8].
- The transverse branch of the lateral circumflex artery divides at the anterolateral border of the intertrochanteric line and gives off branches that penetrate the lateral and anterolateral portions of the greater trochanter [8].
- Until the age of 5 to 6 months, the transverse branch of the lateral circumflex artery supplies much of the anterior portion of the proximal femoral epiphysis and physis [8].
- The medial circumflex artery travels posterior to the iliopsoas tendon and to the medial side of the proximal femur between the insertion of the inferomedial capsule and the lesser trochanter [8].
- Two major branches of the medial circumflex artery are the posterior inferior branch, which travels along the inferior margin of the posterior neck, and the posterior superior branch, which travels along the superior margin [8].
- By age 3 years, the contribution of the lateral circumflex vessel to the blood supply of the proximal femur diminishes, and the entire blood supply of the proximal femoral epiphysis and physis comes from lateral epiphyseal vessels derived from the medial circumflex artery [8].
- The lateral cervical ascending artery, a branch of the medial circumflex artery, is considered by some authors to play a more significant role in femoral head blood supply than the posterosuperior and posteroinferior vessels [8].
- Vessels supplying the femoral head lie external to the joint capsule at the level of the intertrochanteric line and then traverse the capsule to travel proximally within the retinacular folds [8].
- Very few vessels supplying the femoral head travel within the capsule, meaning a capsulotomy incision should not compromise femoral head vascularity [8].
- The artery of the ligamentum teres provides approximately 20% of the blood supply to the femoral head beginning at approximately 8 years of age and is maintained into adulthood [8].

SOFT TISSUE ANATOMY

- The main structural attachments to the proximal femur include the hip capsule and the musculotendinous junctions of the gluteus medius, gluteus minimus, iliopsoas, piriformis, short external rotators, oblique head of the rectus femoris, and vastus lateralis [7].
- The hip capsule is especially important in the reduction of pertrochanteric fractures and provides the soft tissue attachment necessary for a stable reduction [7].
- With capsular disruption, fracture fragment displacement is dependent on musculotendinous attachments to the respective fragments [7].
- The greater trochanter is abducted and externally rotated by the gluteus medius and short external rotators [7].
- The femoral shaft is displaced posteriorly and medially by the adductors and hamstrings [7].

- The usual shortening and coxa vara deformity of displaced trochanteric fractures is accounted for by the displacement of the greater trochanter and the femoral shaft [7].
- The femoral nerve is located anteriorly and the sciatic nerve posteriorly relative to the trochanteric region [7].
- Neurologic and vascular injuries are rare in surgical approaches for repair of trochanteric fractures [7].

PATHOPHYSIOLOGY OF DISPLACEMENT

- Displaced trochanteric fractures typically present with a shortened and externally rotated limb [1].
- The displacement pattern of trochanteric fractures is determined by the pull of the gluteus medius and short external rotators on the greater trochanter and the adductors and hamstrings on the shaft [7].
- Subtrochanteric fractures are associated with greater blood loss than trochanteric fractures [15].
- In subtrochanteric fractures, the proximal fragment is abducted and externally rotated by the gluteal muscles and flexed by the psoas, making reduction more difficult [15].

CLASSIFICATION AND STABILITY

- The Evans classification system divides intertrochanteric fractures into stable and unstable categories based on posteromedial cortex apposition [1].
- Type 1 fractures in the Evans classification are true intertrochanteric fractures with the fracture line extending from the lesser trochanter proximally and laterally along the intertrochanteric line [1].
- Type 2 fractures in the Evans classification are reverse obliquity fractures where the fracture line extends from the lesser trochanter distally and laterally [1].
- Reverse obliquity and intertrochanteric fractures with subtrochanteric extension represent an unstable injury and a transitional continuum between true intertrochanteric and subtrochanteric fractures [1].
- Lateral wall integrity is as important to the stability of intertrochanteric fractures as posteromedial cortex apposition [1].
- A lateral wall thickness of less than 20.5 mm predicts a risk of failure when fixed with a sliding hip screw implant [1].
- The AO/OTA classification defines three broad groups for trochanteric fractures: 31-A1 (two-part/stable), 31-A2 (comminuted/unstable), and 31-A3 (reverse/transverse) [14].
- Two-part trochanteric fractures (A1) have a fracture line running through the trochanters and are termed stable [14].
- Comminuted trochanteric fractures (A2) have a main fracture line running through the trochanters with three or four main parts and are termed unstable [14].
- Reversed/transverse fractures (A3) have a fracture line at the level of the lesser trochanter [14].
- Basicervical or basal fractures are two-part fractures that run along the intertrochanteric line and may cross capsular attachments, classifying them as both intra- and extracapsular [14].
- The AO/OTA classification system has an acceptable degree of intra- and interobserver variation and is useful in determining treatment and outcome [14].

- Additional subdivisions within the AO/OTA classification groups have not been demonstrated to be relevant for determining treatment and have unacceptable intra- and interobserver variation [14].
- Radiographic features with clinical relevance not represented in standard classifications include pathologic fractures, subtrochanteric extension, loss of lateral cortical support, medialization of the femur, and severe displacement or angulation [14].
- The traction-internal rotation view on radiographs leads to better agreement among surgeons in classifying fracture type and stability and may change the choice of implant [1].
- CT scan or magnetic resonance imaging may be used to diagnose occult intertrochanteric hip fractures when radiographs are nondiagnostic [1].
- Isolated fractures of the greater trochanter carry a risk of an extension of the fracture line between the trochanters, requiring supplementary imaging such as MRI for confirmation [7].
- Isolated fractures of the lesser trochanter are uncommon and may be pathologic related to local tumor if there is no history of trauma [7].

Clinical Presentation

ETIOLOGY

- Three main factors are involved in the etiology of a trochanteric hip fracture: influence of falls/trauma, protective mechanisms, and strength of the bone [21].
- Impairment of protective mechanisms, such as putting out the arms to reduce impact, is largely related to aging but may also be impaired by associated medical conditions and medication [21].
- Factors associated with an increased risk of falling include increased age, concurrent medical illness, mental impairment, disorders of gait and balance, physical disability, not taking regular exercise, greater dependence on others, undernourishment, postural imbalance, previous stroke, visual abnormalities, tranquilizers, alcohol, antihypertensive medication, and multiple medications [21].
- The most common cause for a reduction in bone strength is osteoporosis [21].
- Osteoporosis is particularly common in elderly females [21].
- Bone strength may be reduced by other medical conditions, alcohol abuse, smoking, and medications [21].
- Genetic factors influence bone strength, with the highest hip fracture incidence found in Caucasians and the lowest in the Black population [21].

ASSOCIATED INJURIES

- A trochanteric hip fracture is generally an isolated injury [21].
- An additional fracture is present in about 4% of patients with a trochanteric hip fracture [21].
- The most commonly associated fractures are an ipsilateral distal radius fracture (2%) or an ipsilateral proximal humerus fracture (1%) [21].

- Trauma to the head of sufficient severity to justify a CT scan has been reported for 21% of low-energy fracture patients [21].
- Of the patients with head trauma severe enough for CT scan, 6% had an acute finding [21].
- No patient with head trauma in the cited low-energy fracture cohort required neurosurgical intervention [21].

DIAGNOSIS

- The patient is invariably elderly and has had a trip or stumble causing a fall from a standing height [21].
- The low forward momentum from this group of patients means the fall is often sideways to land on the hip [21].
- Symptoms include acute pain around the hip and thigh with an inability to stand or walk [21].
- The affected leg may be shortened and externally rotated [21].
- All hip movements are extremely painful [21].
- Anteroposterior (AP) and lateral x-rays of the hip invariably confirm the diagnosis [21].
- It has been suggested that the lateral radiograph does not provide much additional information for most patients and could be omitted [21].
- Omitting the lateral radiograph is considered a false economy because it aids diagnosis in some patients [21].
- Excessive displacement or angulation of the fracture seen on the lateral view alerts the surgeon to potential operative difficulties [21].
- If the diagnosis remains uncertain after good-quality AP and lateral radiographs, an additional radiograph centered on the hip in 10 degrees of internal rotation may make the diagnosis more apparent [21].
- An x-ray taken with some traction applied to the limb can be used to assist in evaluating the fracture configuration [21].
- Supplementary investigations are only rarely required to confirm the diagnosis for a trochanteric hip fracture [21].
- Supplementary investigations are typically required when an occult fracture is suspected [21].
- Magnetic resonance imaging (MRI) is the optimum technique for confirming an occult trochanteric hip fracture [21].
- If no fracture is present, MRI may visualize other conditions that have occurred after the fall, such as an incomplete trochanteric fracture, bone bruise, pubic rami fracture, or other local tissue damage [21].
- Computed tomographic (CT) scanning is a useful alternative if MRI imaging is not available or cannot be used [21].
- An incomplete trochanteric fracture may be described only on MRI scans and not visible on plain x-ray imaging [21].
- Treatment for an incomplete trochanteric fracture is conservative with analgesia and mobilization as able [21].

Investigations

ADULT HIP FRACTURE DIAGNOSIS

- The diagnosis of hip fracture can be made initially from clinical presentation, including a history of a fall from standing height and a shortened and externally rotated limb on examination [1].
- Plain radiographs of the pelvis and the hip are the next step in diagnosis for hip fractures [1].
- The use of a traction-internal rotation view of the affected hip on radiograph may help elucidate the true fracture pattern [1].
- In a study of 47 complete sets of hip fracture radiographs, traction-internal rotation views led to better agreement among surgeons in classifying fracture type and stability [1].
- In some cases, traction-internal rotation views led to a change in the choice of the implant used to fix the fracture [1].
- When radiographs are nondiagnostic and suspicion is high, CT scan or magnetic resonance imaging may be used to diagnose occult intertrochanteric hip fractures [1].
- Magnetic resonance imaging is more reliable than CT scan for diagnosing occult intertrochanteric hip fractures when radiographs are nondiagnostic [1].
- The thickness of the lateral wall can be measured on radiographs to predict which intertrochanteric fractures are at risk for failure using a sliding hip screw implant design [1].
- A lateral wall thickness of less than 20.5 mm should be given strong consideration for cephalomedullary nail fixation of the intertrochanteric fracture [1].
- The AO/Orthopaedic Trauma Association (OTA) classification of intertrochanteric fractures, types 31-A1 through 31-A3, has been advocated as the most comprehensive and useful classification system to date [1].
- The AO/OTA classification system classifies fractures on the basis of stability and was shown to help guide implant choice [1].
- For experienced surgeons, the AO/OTA classification system may be more reliable with minimal interobserver variability [1].

PEDIATRIC HIP FRACTURE DIAGNOSIS

- Diagnosis of a hip fracture in children is based on history, physical examination, and radiographs [2].
- A standard anteroposterior radiograph of the pelvis and lateral of the hip should be obtained, as well as imaging of the entire femur [2].
- Advanced imaging may be helpful to rule out an occult injury or to evaluate the extent of the fracture in children [2].
- In infants, where the epiphysis is not easily defined on X-ray, ultrasonography, MRI, and arthrography may help with diagnosis [23].
- In older children, the diagnosis of hip fracture is usually obvious on plain X-ray examination [23].

- It is important to establish whether a pediatric hip fracture is displaced or undisplaced, as displaced fractures carry a much higher risk of complications [23].
- MRI has been shown as superior to CT scan in detecting structural injury to the hip, especially the posterior labrum/chondrolabral junction, after closed reduction of traumatic hip dislocations in children [20].
- MRI is better than CT scan for detection of structural pathologies after traumatic posterior hip dislocation in children and adolescents [3].

ATYPICAL SUBTROCHANTERIC FRACTURES

- For atypical subtrochanteric fractures associated with long-term bisphosphonate use, contralateral femur x-rays should be obtained [5].
- If there is cortical beaking and the patient is symptomatic, prophylactic nailing is recommended for the contralateral femur [5].
- If the patient is asymptomatic with cortical beaking on the contralateral femur, it is acceptable to monitor [5].

POST-REDUCTION IMAGING

- Postreduction radiographs (AP pelvis and Judet views) and CT are used to rule out associated acetabular fracture, femoral head fracture, and intra-articular loose bodies [5].

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