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Hip Fractures: A Practical Approach to Diagnosis and Treatment

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Abstract

Purpose of Review To summarize relevant anatomy, imaging, and treatment of hip fractures, and to synthesize a treatment-based approach for description and classification of hip fractures.

Recent Findings Hip fractures are predominantly seen in the elderly, where they are increasing in incidence, and can substantially reduce healthy life-years. The osseous and vascular anatomy of the proximal femur can help to understand the clinical implications of various types of hip fracture. Radiographs are the principal imaging modality for assessment of hip fracture, although there is a clear role for CT and MRI for assessment of radiographically occult fractures. There are multiple classifications of hip fractures in the orthopedic literature; however, these are not commonly used in clinical practice due to complexity, poor reported inter-observer agreement, and relatively few methods of surgical fixation.

Summary A simplified anatomic and treatment-based approach to hip fractures can help guide image interpretation and clinical management.

Keywords Hip fractures · Imaging · Emergency radiology

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Introduction: Epidemiology and Societal Impact of Hip Fracture

Hip fractures have a large societal financial burden [1] and can substantially reduce healthy life-years. There is a reported incidence of 2.7% per 10 years in patients aged 50 or older, and a mortality rate of 5.3% directly attributable to the diagnosis of hip fracture [2]. As the baby-boomer generation ages and people remain more active as they age, the incidence of hip fractures is expected to rise, with an estimated 367,000 hip fractures predicted by the year 2040 [3]. Many elderly patients with hip fracture have osteoporosis, which increases susceptibility to fracture with relatively minor trauma such as falls [4] and also causes impaired healing [5], thereby contributing to increased mortality and fixation failures [6]. In addition to osteoporosis, additional important risk factors for hip fracture are current smoking, physical inactivity, and diabetes [2]. In contrast, in young patients, hip fractures or fracture–dislocations generally require substantial force and are seen most commonly in the setting of motor vehicle crashes or other high-energy trauma, and concomitant injuries are often present. The purpose of this review is to provide a practical overview of hip fractures and fracture–dislocations, within the framework of a simplified treatment-based classification. Of note, this review uses the term “hip fracture” synonymously with proximal femoral fracture, which is the focus of this manuscript. Other traumatic injuries of the hip region, including fractures of the acetabulum, pelvis, and sacrum, are not emphasized.

Osseous and Vascular Anatomy of the Proximal Femur

The trabecular architecture of the femoral head and neck is composed of two complementary trabecular systems, which are formed along the lines of compressive and tensile stress in response to weight bearing [7]. These trabecular groups consist of primary and secondary compressive and tensile trabeculae (Fig. 1). Of these groups, it is the primary compressive group that is the predominant load-bearing structure, providing structural bridging of the femoral head to the femoral neck [8]. There is an area of relative weakness in the medial aspect of the femoral neck known as Ward’s triangle [9], where the compressive and tensile forces are balanced and where the trabecular architecture is composed of sparsely spaced, thin trabeculae. The calcar femorale (commonly known as the calcar) is an important trabecular condensation of the inferomedial femoral neck adjacent to the lesser trochanter [10]. It is a load-bearing structure that redistributes stress in the proximal femur [11] and is an important surgical landmark, as adequate reduction of this portion of bone allows for load sharing of the fracture implant and bone following fixation [12, 13•].

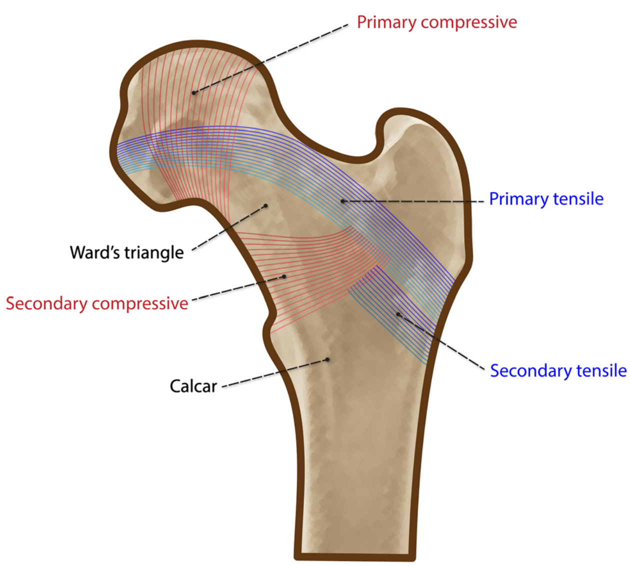

Fig. 1 Illustration demonstrating the complementary compressive and tensile trabecular systems of the proximal femur. The primary compressive group is the predominant load-bearing unit. Ward’s triangle is a relative area of weakness

In addition to the microtrabecular anatomy, an understanding of the macrostructure of the proximal femur is essential to understand the various types of hip fractures (Fig. 2). The articular surface of the hemispheric femoral head is almost completely smooth, regular, and covered by articular cartilage except for a small depression medially, which is termed the fovea, and this is where the ligamentum teres attaches. The femoral neck projects laterally and distally from the femoral head, creating a 130–140 degree angle when it joins to the shaft. The greater trochanter provides roughened attachments for the gluteus minimus and medius muscles, which are the major hip abductors. The lesser trochanter is a protuberance at the posterior and medial aspect of the proximal femur where the iliopsoas attaches, and the region between the greater and lesser trochanters is the intertrochanteric region. The interface between the femoral neck and the intertrochanteric region is a bony prominence termed the intertrochanteric crest. The subtrochanteric region extends below the lesser trochanter to 5 cm distally. More distal than the subtrochanteric region is simply termed the femoral shaft or femoral diaphysis. The hip joint has a large ligamentous capsule that attaches at the base of the femoral neck. The femoral head is completely intracapsular, and the femoral neck is mostly intracapsular (excepting the basicervical region, at the base of the femoral neck). The greater and lesser trochanters and intertrochanteric region are all extracapsular.

The capsular and vascular anatomy of the proximal femur is clinically important, as intracapsular fractures and hip dislocations are at increased risk to develop avascular necrosis due to disruption of the femoral head blood supply. In adults, the main contributor to perfusion of the weight-bearing portion of the femoral head is the medial femoral circumflex artery (MFCA, although also known as the medial circumflex femoral artery) [14], which arises from the profunda femoris artery. The extraosseous retinacular branches of the MFCA are most susceptible to direct trauma, and are thought to predispose to avascular necrosis if lacerated, avulsed, or transected [14]. In contrast, the lateral femoral circumflex artery and the artery of the ligamentum teres provide insignificant contributions to femoral head perfusion in adults.

Imaging Assessment of Hip Fracture

Radiography

Imaging assessment of suspected hip fracture should begin with routine radiographs, including an anterior–posterior

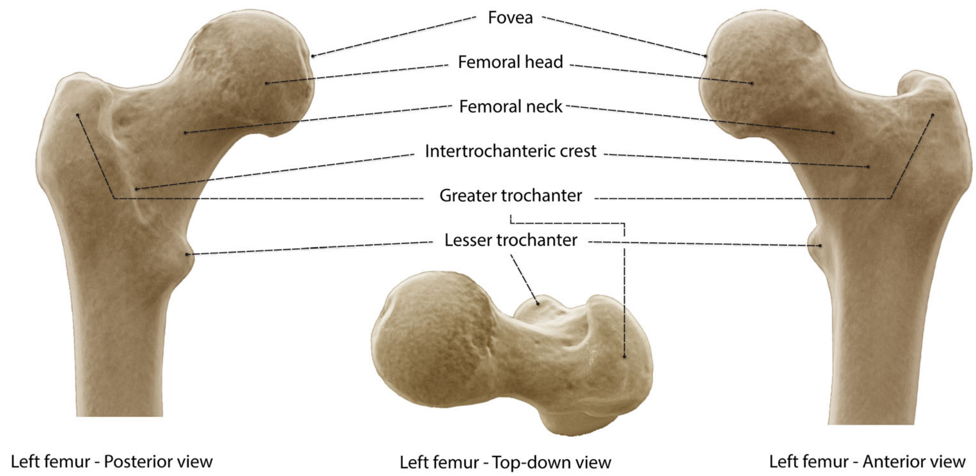

Fig. 2 Cinematic rendering of the proximal femur in posterior, top–down, and anterior views, demonstrating the topographic anatomy of important bony landmarks

radiograph of the pelvis, and frontal and cross-table lateral radiographs of the affected hip [12]. Frog-leg lateral radiographs, while commonly performed for evaluation of chronic hip pain and arthritis, are not recommended in the setting of acute trauma due to pain with possible fracture manipulation and possible risk of fracture displacement. Specialized pelvic radiographs, such as Judet or inlet/outlet views, are also not typically performed to assess hip trauma. A systematic approach to interpretation of hip radiographs is essential to be able to detect subtle fractures. Although not the focus of this review, fractures of the pelvis are commonly seen in the clinical setting of suspected hip fracture and the bony contours of the pelvis should be evaluated in every case. These include the ilioischial and iliopectineal lines, and Shenton's line (Fig. 3). The ilioischial line is a contour line that forms the posterior column of the acetabulum, and the iliopectineal line forms the anterior column. Shenton's line is an arc that spans the inferior margin of the superior pubic rams and the femoral neck. The lateral cortex of the femoral neck should also be smooth. The trabecular contours of the femoral neck and intertrochanteric region should be regular and continuous, without disruption.

If a hip fracture is seen, then a physician-assisted internal rotation traction radiograph [15] can be useful to improve classification accuracy and thus pre-operative planning strategies [16]. To perform this radiograph, the orthopedist gently applies traction to the leg with internal rotation.

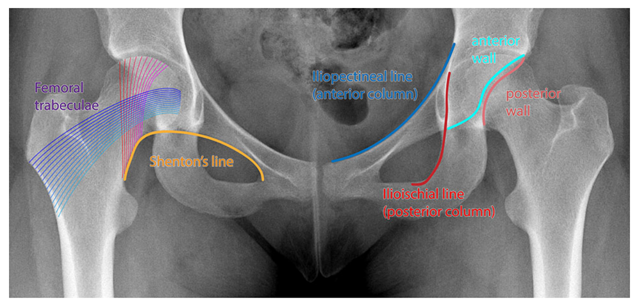

Fig. 3 Annotated normal pelvic radiograph demonstrating the important contour lines to carefully evaluate in every radiograph. These include the iliopectineal and ilioischial lines, which comprise the anterior and posterior columns of the acetabulum, respectively, Shenton's line, and the trabeculae of the proximal femur

Occult Hip Fracture and Role of Magnetic Resonance Imaging and Computed Tomography

The sensitivity of radiographs to detect proximal femoral fracture varies in the literature, but one consistent theme is the concept of the "occult" hip fracture; that is, a fracture that is present but cannot be seen on radiographs (Fig. 4). The reported prevalence of occult fractures ranges from 3 to 10% of all apparently negative hip/pelvic radiographs obtained for trauma [17–19]. While cross-sectional imaging, such as CT and MRI, is not routinely performed for assessment of a radiographically identified hip fracture, one clear role for either CT or MRI is in the setting of suspected occult hip fracture. Further imaging with CT or MRI is typically performed if there is persistent clinical concern for occult fracture, as the clinical examination has not been shown to distinguish between patients with and without fracture in all cases [20].

In this setting, MRI is considered the gold standard to diagnose occult hip fracture [21–24]. The accuracy of MRI for detection of non-displaced hip fracture approaches 100%; however, MRI is expensive, can be time-consuming to obtain, is susceptible to motion artifact, and some patients have implants that are not MRI compatible. An abbreviated MRI protocol [24] can mitigate some of these pitfalls, although in the emergency department CT is usually immediately available and therefore commonly performed for assessment of suspected occult fracture after negative radiographs.

Some authors have proposed that the accuracy of CT is 100% for detection of occult hip fracture [25–28], although

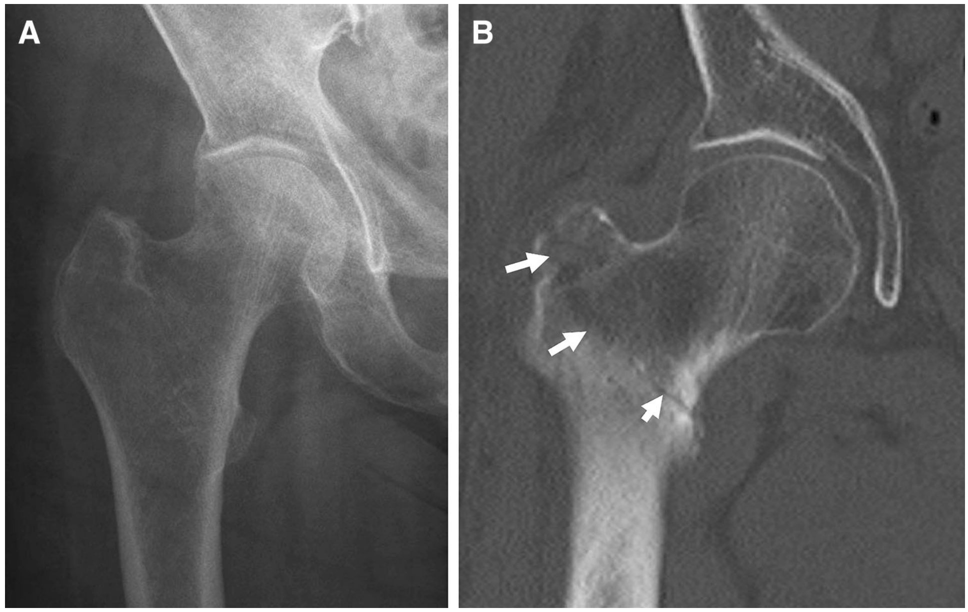

Fig. 4 86-year-old woman with a radio-occult intertrochanteric fracture. Initial AP radiograph of the right hip (**a**) demonstrates no fracture. Based on clinical concern, a CT was performed (**b**), which demonstrates a non-displaced intertrochanteric fracture extending from the greater trochanter, through the intertrochanteric region, and through the lesser trochanter (arrows)

others have found a lower sensitivity, between 83 and 96% [29–32]. Importantly, the negative predictive value of a negative CT in the clinical setting of occult fracture is well over 90%, as shown in these studies. It is the authors' experience that while CT is able to detect the majority of occult fractures not evident on radiography, the findings on MRI often define the injury more clearly [33]. However, the orthopedic surgeons at our institution continue to banter regarding the clinical significance of fractures that are not evident on CT (therefore with apparently intact cortices) but with an intramedullary fracture line evident on MRI. However, regardless of how the fracture was first identified (radiographs, CT, or MRI), once an identifiable hip fracture is discovered then a discussion is required to discern the best treatment options.

Dual-energy CT is a promising new modality that offers several of the advantages of CT including rapid examination time and increasing availability, and is less expensive than MRI. By creating a virtual non-calcium reconstructed image, it is possible to visualize intramedullary hemorrhage and edema (what would be called bone marrow edema-like signal on MRI) (Fig. 5). A recent report demonstrated that these virtual non-calcium images increase sensitivity for detection of non-displaced hip fractures, as well as increase reader confidence [34•].

General Principles of Proximal Femoral Fracture Fixation

There are only a handful of fixation methods commonly used to treat proximal femoral fractures, despite the numerous fracture classification systems that have been described to date in the orthopedic literature. This relatively limited treatment repertoire can guide a simplified classification of proximal femoral fractures based on the anatomic location and expected treatment of the fracture. The main anatomic zones of the proximal femur related to fracture classification include the head, intracapsular neck, basicervical region (extracapsular neck), greater trochanter, intertrochanteric region, and subtrochanteric region (Fig. 6). The most commonly utilized methods to treat proximal femoral fractures include screw fixation (for some femoral head and non-displaced femoral neck fractures), arthroplasty (either hemiarthroplasty or total hip arthroplasty; for displaced femoral neck fractures), sliding hip screw (for basicervical and stable intertrochanteric fractures), and trochanteric fixation nail (for unstable intertrochanteric and all subtrochanteric fractures). Non-displaced fractures isolated to the greater trochanter are typically treated non-operatively, while displaced fractures usually undergo operative repair, especially in younger or active patients. A summary of this anatomic and treatment-based simplified classification is demonstrated in flowchart form in Fig. 7.

Femoral Head Fractures and Hip Dislocations

Femoral head fractures are seen most commonly in association with hip dislocations or gunshot wounds as the femoral head is normally protected by the bony acetabulum. A femoral head fracture without apparent dislocation at the time of imaging is usually in the setting of spontaneous reduction of a hip dislocation. Hip dislocations require high impact force due to the inherent osseo-

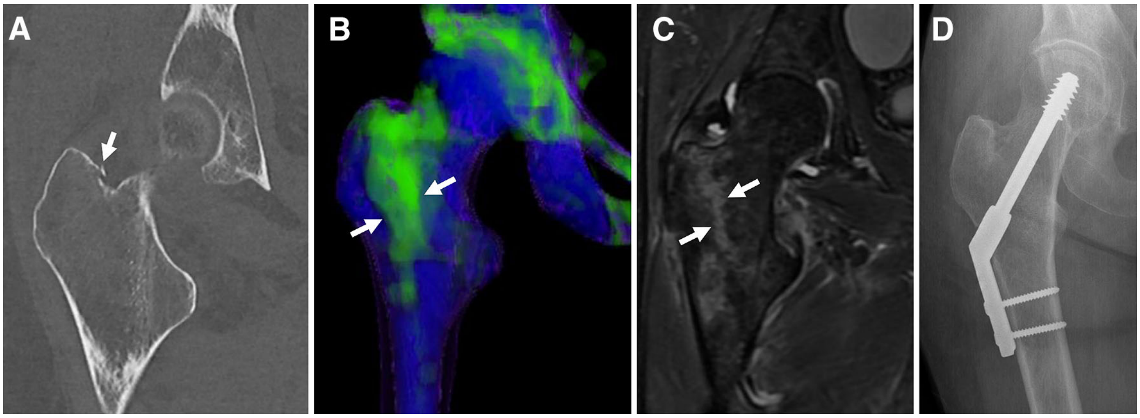

Fig. 5 64-year-old woman with intertrochanteric extension of a greater trochanteric fracture, demonstrated on dual-energy CT and MRI. Initial radiographs (not shown) were negative for fracture. Subsequently performed dual-energy CT demonstrates subtle irregularity of the greater trochanter on conventional CT images (arrow; **a**). A virtual non-calcium image (**b**) shows marrow edema extending through the intertrochanteric region towards the lesser trochanter (arrows). STIR MRI (**c**) confirms intertrochanteric marrow edema and fracture (arrows). This was treated as a stable intertrochanteric fracture with a sliding hip screw (**d**)

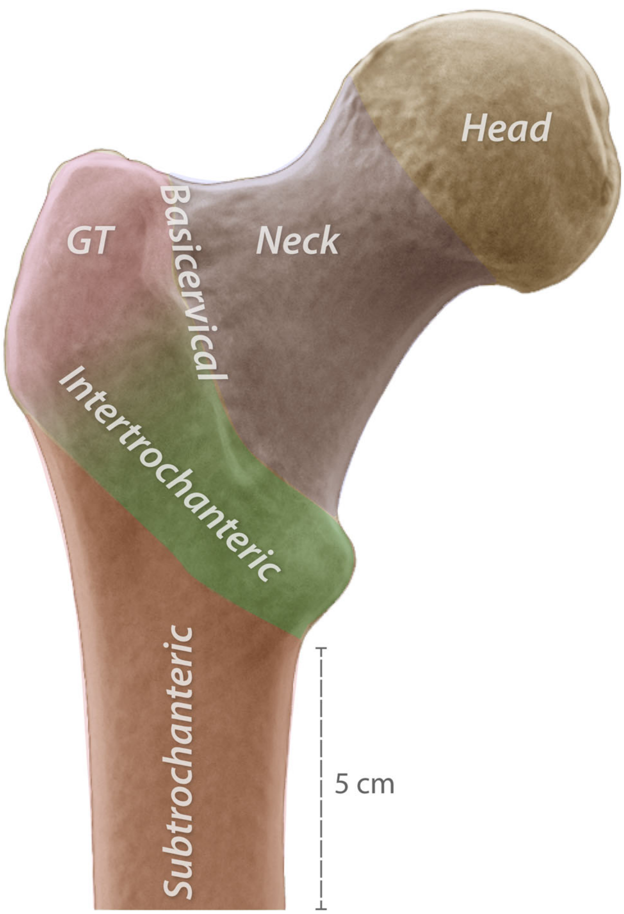

Fig. 6 Annotated cinematic rendering of a proximal femur, from a posterior projection, demonstrating the six distinct anatomic regions of the proximal femur that are most relevant to fracture classification. *GT* greater trochanter

labroligamentous passive stability of the hip as well as the strong hip girdle musculature providing active stability [35]. These injuries are typically seen in younger patients following high-energy trauma, most commonly motor vehicle crashes, or less commonly sports injuries. A hip dislocation is considered an orthopedic emergency, with increased potential for long-term disability if not treated promptly. Post-traumatic osteoarthritis is the most common complication, ranging in incidence from 14 to 89% [36–38], highly dependent on the severity of injury and associated femoral head and acetabular fractures. Avascular necrosis is the second most common complication, which is most dependent on the time to reduction. Avascular necrosis has been reported in 4.8% of hips reduced within 6 h, in comparison to 52.9% of hips reduced after 6 h [39].

About 90% of hip dislocations are posterior in direction, where the femoral head is positioned posterior and superolateral to the acetabulum, with the hip in internal rotation. The internal rotation of the proximal femur rotates the lesser trochanter posteriorly, partially obscuring it on the frontal radiograph due to superimposition of the medial femoral cortex. In distinction, when the relatively uncommon anterior dislocation occurs, the femoral head is typically positioned inferomedial to the acetabulum with the hip in external rotation. This position results in relative larger appearance of the affected femoral head on the AP radiograph due to magnification effect and exposes the lesser trochanter, which is visualized in its entirety on the frontal view. There is an additional very rare direction of dislocation, where the femoral head is positioned anterior and *superior* to the acetabulum. This appearance mimics the much more commonly seen posterior dislocation, but the hip is in external rotation with the rare anterior–superior dislocation, thereby completely exposing the lesser trochanter. It is important to recognize the direction and type of dislocation based only on a standard frontal view, as the reduction maneuvers differ between these types of

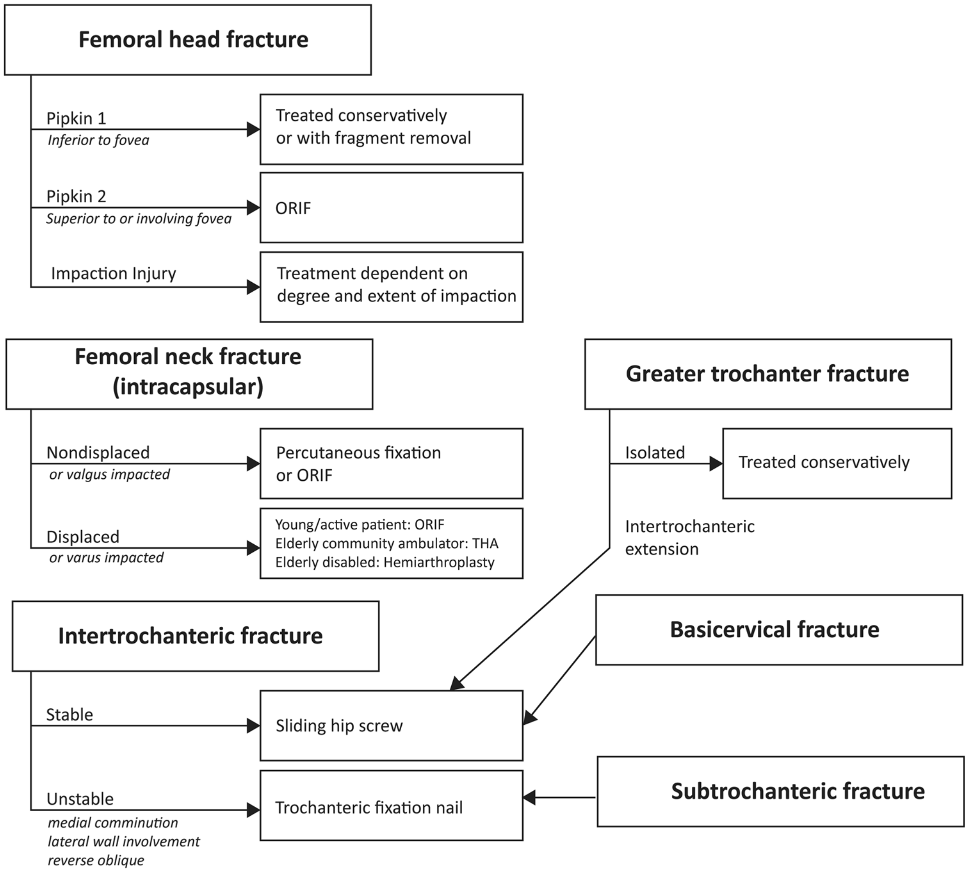

Fig. 7 Flowchart demonstrating the simplified anatomic and treatment-based classification of proximal femur fractures. *ORIF* open reduction internal fixation, *THA* total hip arthroplasty

dislocations, and reduction is usually attempted before additional imaging is obtained.

It is also critical to make the orthopedic team aware of a femoral neck fracture (or even a suspected femoral neck fracture) in the setting of a hip dislocation, as the presence of a femoral neck fracture necessitates expedient operative management. Bedside attempted reduction is contraindicated in the presence of a femoral neck fracture, as there is risk to displace the fracture, thereby necessitating a more involved surgery and increased risk for long-term complications.

Imaging and treatment of hip dislocations are typically performed in two stages. Initial imaging usually consists of radiographs, and initial treatment by the orthopedic team is expeditious attempted reduction. Subsequently, CT imaging is performed to assess congruency of the joint, assess for presence of small fractures that may not be evident on radiographs, evaluate for intra-articular bodies (such as bony fragments trapped within the joint), and perform a systematic search for associated osseous and soft tissue injuries of the pelvis or acetabulum. In addition to routine bone windows, evaluation of the joint with soft tissue windows is helpful to aid in detection of chondral fragments [40]. However, CT is not reliable to detect small intra-articular bodies after a hip dislocation, which may be clinically significant and a cause of persistent pain after dislocation. Intra-articular bodies are highly prevalent, having been reported in a recent systematic review to be present in 89% of patients who had a hip dislocation and subsequent arthroscopy [41]. The same study demonstrated that intra-articular bodies were present at arthroscopy in 43% of patients who had a negative pre-operative CT.

Femoral head fractures are classified by the Pipkin classification [42]. The fovea of the femoral head is the critical landmark to distinguish between a Pipkin 1 fracture (inferior to the fovea; which may be treated conservatively or with fragment removal) and a Pipkin 2 fracture (Fig. 8). Fractures above the fovea are within the weight-bearing portion of the femoral head and are associated with a worse prognosis and require more aggressive surgical management. In addition to fractures of the femoral head, it is important to note the presence of an osteochondral impaction injury of the anterior femoral head, which can be analogous to a reverse Hill–Sachs lesion of the humeral head [43]. Thus, even subtle flattening of the femoral head should be described.

Acetabular fractures are commonly associated with hip dislocation, typically of the posterior wall. A fracture involving less than 20% of the posterior wall is presumed stable, and fixation is not typically required. In contrast, > 40–50% involvement of the posterior wall is considered unstable [44, 45], and fractures between 20 and 40% involvement are indeterminate. However, it is not always evident what size or location of acetabular fracture would be unstable, and occasionally even small (< 20% posterior wall involvement) fractures are unstable, particularly those that involve the superior aspect of the posterior wall [46], or a reverse Bankart-like avulsion of the posterior acetabular rim [47]. Marginal impaction fractures of the acetabulum, characterized by impaction of the subchondral bone, should always be reported. Articular impaction portends a worse prognosis and must be addressed surgically with elevation and bone grafting. The gold standard for assessment of stability and the need for surgical repair is intraoperative fluoroscopic stress radiography under general anesthesia after reduction, which is performed at the discretion of the orthopedic surgeon.

Intracapsular Femoral Neck Fractures

Femoral neck fractures, including intracapsular and basicervical fractures (subsequently discussed) are typically seen in the elderly after low-energy trauma. Only 3–5% of femoral neck fractures occur in younger patients [48], typically from high-energy trauma such as motor vehicle crashes. The two main orthopedic classification systems that have been described are the Garden and Pauwel classifications [12, 13]. A Garden grade I is an incomplete or valgus-impacted fracture; Garden grade II is a non-displaced fracture; Garden grade III is a varus displaced fracture; and Garden grade IV is a completely displaced fracture, such that the separated femoral head and supra-acetabular pelvic trabeculae are parallel. The Pauwel classification is based on the angle of the fracture line relative to the horizontal plane. However, both Garden and Pauwel have shown poor inter-reader agreement [49–51], and the current method of classification utilized by most orthopedists is to simply describe femoral neck fractures as displaced or non-displaced [12, 52].

Additionally, the specific location of the fracture within the intracapsular portion of the femoral neck, such as subcapital or transcervical, has not been shown to have prognostic significance or influence on operative management [53]. To maintain consistency with current orthopedic terminology and preferred classification, the authors recommend simply describing a femoral neck fracture as either non-displaced (Fig. 9) or displaced (Fig. 10). Of note, a valgus-impacted fracture (Fig. 9) is equivalent to a non-displaced fracture, and a varus-impacted fracture (Fig. 10) is equivalent to a displaced fracture.

Treatment of femoral neck fractures is dependent on two main factors: the degree of displacement, and the age/functional status of the patient [54]. Non-displaced or valgus-impacted femoral neck fractures are usually treated with fixation, which can be performed percutaneously with

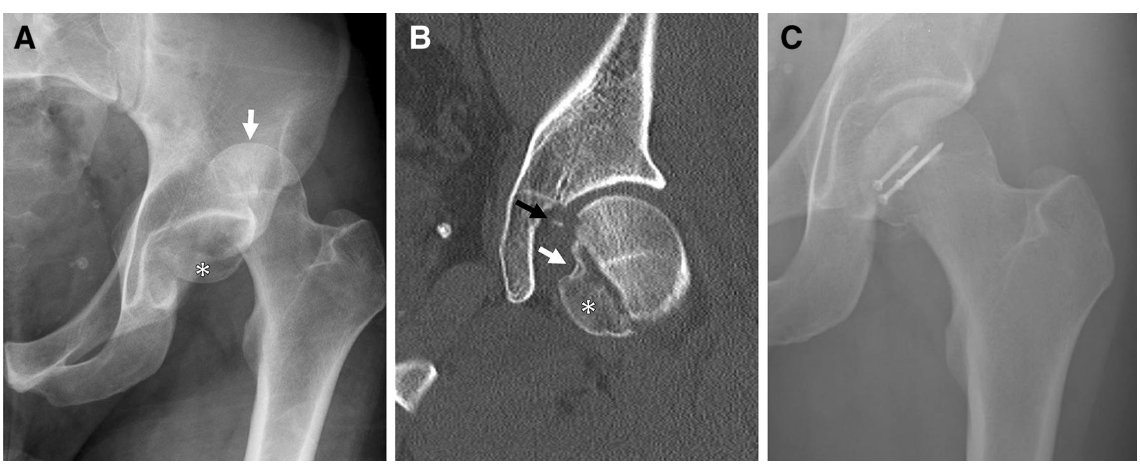

Fig. 8 27-year-old man with a left posterior hip dislocation and Pipkin 2 femoral head fracture. Initial AP radiograph of the left hip (**a**) demonstrates a posterior hip dislocation with superolateral position of the femoral head (white arrow). There is a femoral head fracture with a large crescentic fragment (asterisk) projecting over the acetabular fossa. Interestingly, in this case the proximal femur is not in the typical extreme internal rotation and the lesser trochanter remains visible. Post-reduction CT (**b**) shows a successful reduction. The femoral head fracture fragment (asterisk) involves the fovea (white arrow), making this a Pipkin 2 injury. Note the tiny intra-articular fragment (black arrow). The patient underwent open reduction internal fixation of the femoral head fragment (**c**)

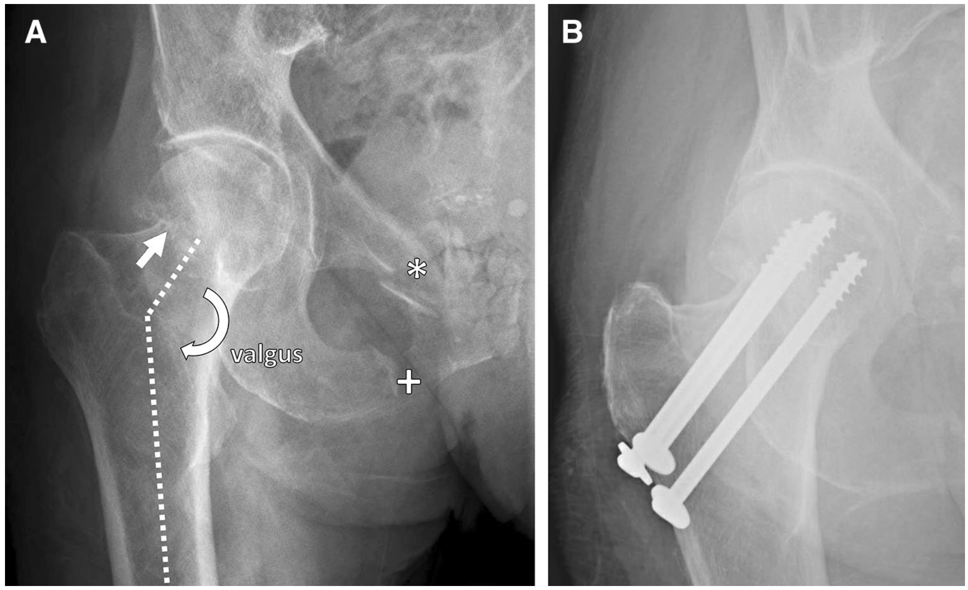

Fig. 9 89-year-old woman with a valgus-impacted femoral neck fracture. AP radiograph of the right hip (**a**) demonstrates an impacted femoral neck fracture with accentuation of the offset at the femoral head/neck junction (arrow), resulting in widening of the angle between the femoral head and neck (dashed line and curved arrow). There are also fractures of the superior (asterisk) and inferior (plus sign) pubic rami. For treatment purposes, a valgus-impacted fracture (with the femoral diaphysis directed laterally) is considered a stable fracture, equivalent to a non-displaced fracture. This was treated with percutaneous screws (**b**)

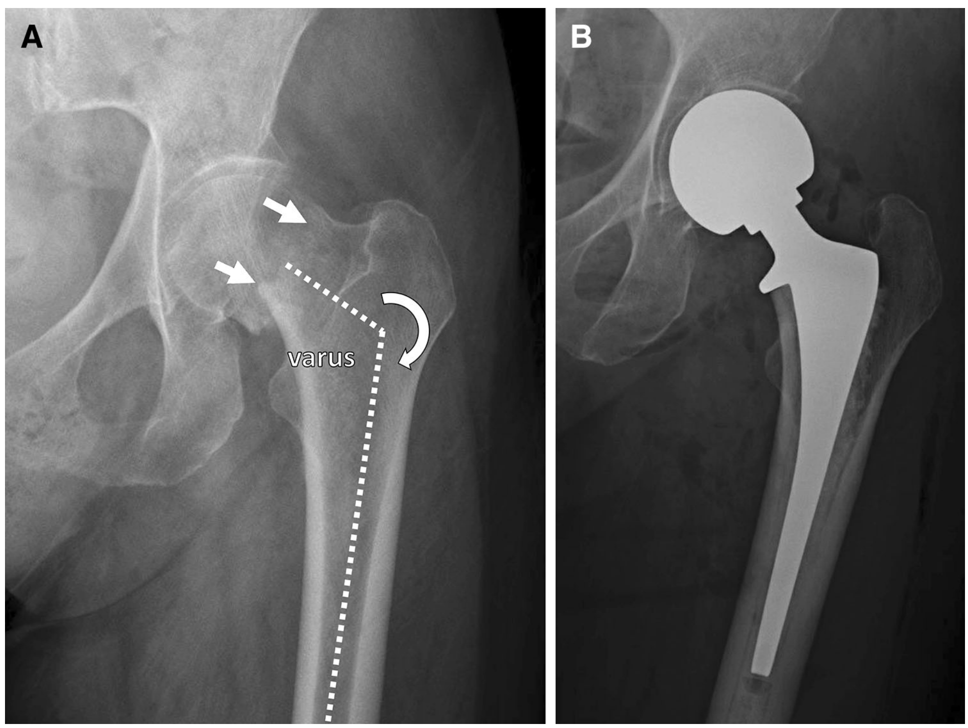

Fig. 10 73-year-old woman with a varus-impacted femoral neck fracture. AP radiograph of the right hip (**a**) demonstrates an impacted femoral neck fracture (arrows) with loss of the normal offset at the femoral head/neck junction, resulting in a decreased angle between the femoral head and neck (dashed line and curved arrow). For treatment purposes, a varus-impacted femoral neck fracture (with the femoral diaphysis directed medially) is considered an unstable fracture, equivalent to a displaced fracture. This was treated with hemiarthroplasty (**b**)

cannulated screw fixation or with an open approach and placement of a sliding hip screw. In contrast, the treatment of displaced or varus-impacted femoral neck fractures is dependent on the age and functional status of the patient. The fixation options include reduction and fixation or reconstruction with an arthroplasty (either hemiarthroplasty or total hip arthroplasty). In younger or very active patients, displaced femoral neck fractures are treated with reduction and fixation, in an attempt to preserve the native hip joint despite the potential need for future reoperation if avascular necrosis develops. The most important factor in predicting long-term outcome is the ability to achieve an anatomic reduction of the fracture, regardless of approach or implant choice. In contrast, arthroplasty is considered the most definitive single operation in elderly individuals. The decision to perform a total hip arthroplasty versus a hemiarthroplasty is dependent on the functional status of the patient, with total hip arthroplasty generally preferred for more active patients and community ambulators, and

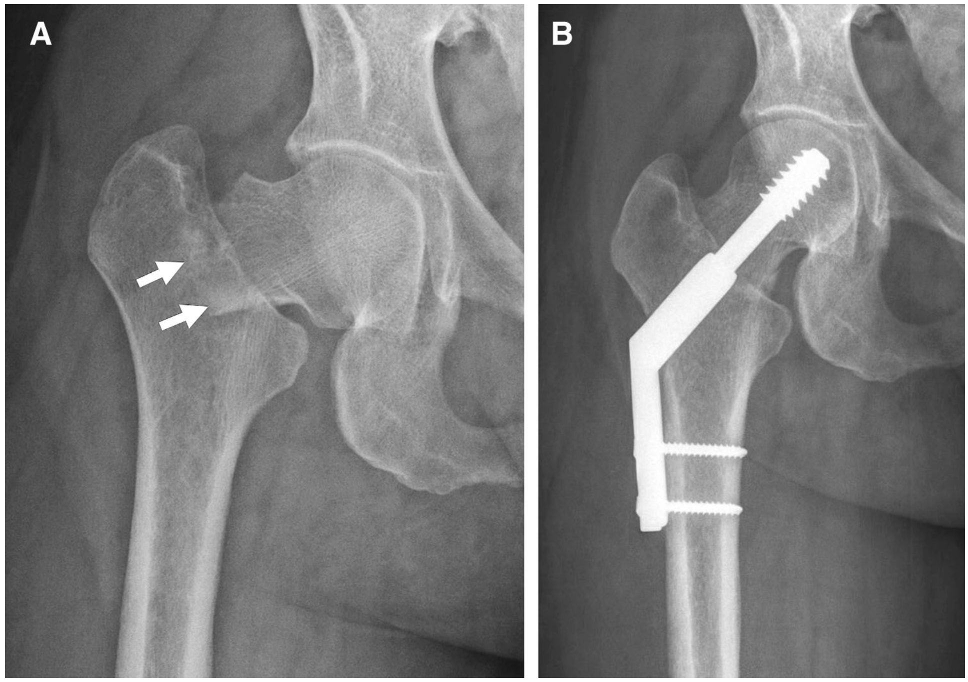

Fig. 11 50-year-old woman with a basicervical fracture. AP radiograph of the right hip (**a**) demonstrates a fracture through the base of the femoral neck (arrows) just proximal to the intertrochanteric crest, with varus angulation. This was treated with a sliding hip screw (**b**)

hemiarthroplasty (a less involved surgery) reserved for those with significant baseline functional limitations.

Basicervical (Extracapsular Femoral Neck) Fractures

Basicervical fractures (Fig. 11) are a relatively uncommon type of fracture involving the extracapsular portion of the femoral neck, located just proximal to the intertrochanteric crest. In contrast to intracapsular femoral neck fractures, the risk of avascular necrosis is low in basicervical fractures. These fractures are important to recognize, as unlike more proximal femoral neck fracture, they are generally treated with reduction and fixation with a sliding hip screw regardless of the patient age or degree of displacement. Fixation with an intramedullary rod may be associated with an increased risk of loss of fixation and need for reoperation [55•].

Greater Trochanteric Fractures

Greater trochanter fractures may be due to avulsion of the abductors (typically seen in children or adolescents) or impaction injuries related to direct trauma (more common in the elderly) [56]. Greater trochanter fractures may be isolated to the greater trochanter, or may extend to the intertrochanteric region (Fig. 5). Non-displaced fractures isolated to the greater trochanter are typically treated conservatively unless there is complete displacement [57]. However, a greater trochanteric fracture extending through the intertrochanteric region is typically treated operatively as a stable intertrochanteric fracture. This distinction is emerging as an area of interest in the literature, given that there is increased recognition of the ability of MR to identify intertrochanteric extension of greater trochanteric fractures seen on radiography [58] and CT [59, 60]. A recent systematic review showed that MRI documented intertrochanteric extension in 90% of patients with greater trochanteric fractures seen on radiography [61]; however, the clinical implications of this observation remain as yet unclear. At our institution the authors do not routinely recommend MR in every case of greater trochanter fracture.

Lesser Trochanter Fractures

Isolated traumatic avulsion fractures of the lesser trochanter are typically seen in adolescent athletes. In an adult or elderly individual, an isolated fracture or avulsion of the lesser trochanter should be considered as pathologic in origin (most commonly due to metastatic disease) until proven otherwise [62, 63].

Intertrochanteric Fractures

Although there are several classification schemes for intertrochanteric fractures, poor inter-reader agreement has been shown for both the AO [64] and Jensen modification

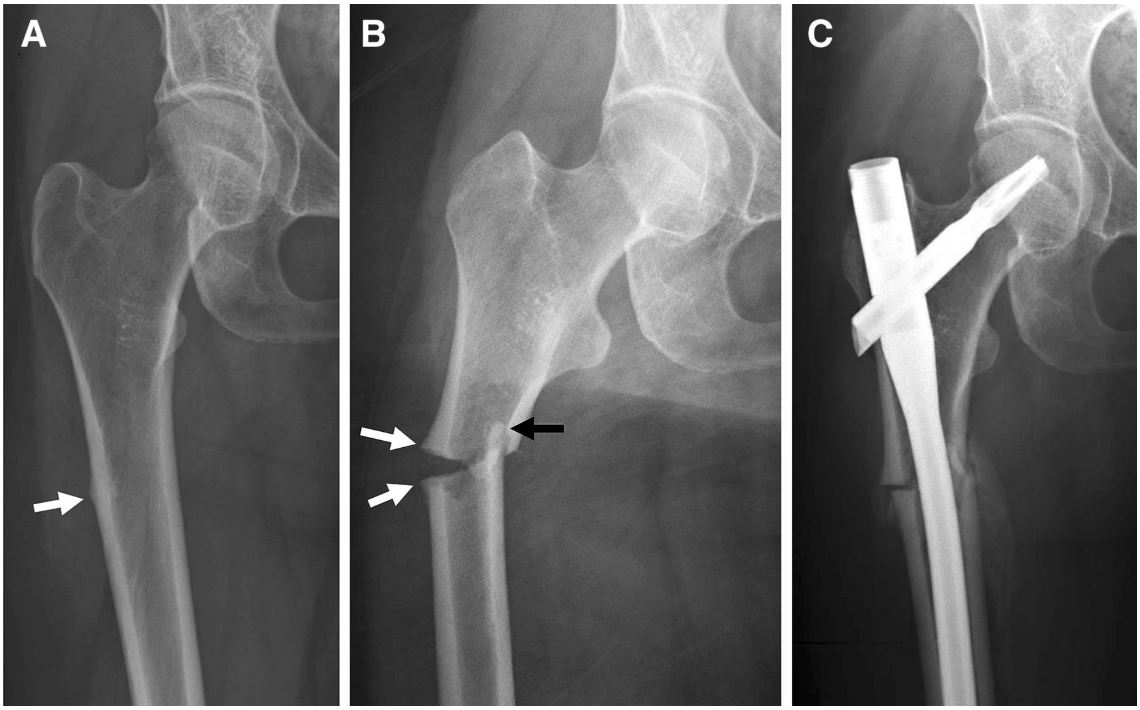

Fig. 12 75-year-old woman with an atypical subtrochanteric fracture related to bisphosphonate use. AP radiograph of the right hip (**a**) demonstrates focal cortical thickening of the lateral subtrochanteric cortex (arrow), consistent with an incomplete atypical fracture. Two months later, an AP radiograph of the right hip (**b**) demonstrates a complete transverse subtrochanteric fracture. Clues to atypical etiology include minimal comminution, transverse orientation, lateral cortical thickening (white arrows), and medial spike (black arrow). This was treated with trochanteric fixation nail (**c**)

of the Evans [64, 65] classification. The optimal treatment of intertrochanteric fractures is dependent on the stability of the fracture. Stable, 2-part fractures consisting of a single intertrochanteric fracture line (Fig. 4) are typically treated with a sliding hip screw. In contrast, unstable fractures are most commonly treated with a trochanteric fixation nail. An unstable fracture is one with comminution of the medial cortex, disruption of the calcar, fracture extension to the lateral wall, or a reverse obliquity fracture, where the fracture extends cranially in a lateral to medial direction. However, the decision to use a trochanteric fixation nail or sliding hip screw can be up to the discretion of the treating surgeon. In general, a trochanteric fixation nail is considered a more biomechanically stable construct.

Subtrochanteric Fractures

A subtrochanteric fracture involves the proximal diaphysis, extending up to 5 cm distal to the lesser trochanter. Similar to other proximal femur fracture types, the proposed classifications of subtrochanteric fractures have demonstrated poor inter-reader agreement, including the Seinsheimer, AO, and Russel-Taylor [66] classifications. Additionally, the principal treatment modality for subtrochanteric fractures, regardless of the specific classification, is trochanteric fixation nail, similar to unstable intertrochanteric fractures. Therefore, the authors do not classify subtrochanteric fractures.

An atypical femoral fracture is due to long-term bisphosphonate use and resultant alteration in osteoclast activation and bone remodeling. These fractures typically occur in the subtrochanteric region after minimal trauma [13•]. It is important to recognize an atypical femoral fracture because management of these types of fractures can be challenging, with the potential for delayed union or non-union [67]. If the fracture is complete, it can be challenging to identify the fracture as atypical in etiology. To aid in accurate classification of these fractures, the American Society for Bone and Mineral Research Task Force described imaging criteria for diagnosis of atypical fractures, most recently revised in 2013 [68••], where four of five major criteria must be met to classify a fracture as atypical. The five major criteria include mechanism of minimal to no trauma (such as a fall from standing height), transverse orientation, medial spike if complete, non- or minimal comminution, and periosteal reaction or cortical thickening at the lateral cortex fracture site (Fig. 12). If an atypical femoral fracture is identified or suspected, radiographs of the contralateral femur should be obtained to evaluate for early changes of atypical fracture including lateral subtrochanteric periosteal reaction or cortical thickening. In cases of incomplete fractures, then MRI may be useful to determine the degree of bone marrow edema. These fractures are generally treated with intramedullary fixation, but due to the metabolic derangement, often take an extended amount of time to heal.

Conclusion

Hip fractures are predominantly seen in the elderly, where they are increasing in incidence, and can substantially reduce healthy life-years. A simplified anatomic and treatment-based approach to hip fractures can help guide clinical management.

Compliance with Ethics Guidelines

Conflict of interest Jacob C. Mandell, Michael J. Weaver, Mitchel B. Harris, and Bharti Khurana each declare no potential conflicts of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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- • Of importance
- •• Of major importance

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