PERSPECTIVE

Background

Ancient Egyptian and Greek drawings depict persons with hip deformities ambulating with assistive crutches. The first available written description of a hip fracture was by the 16th-century French surgeon Ambroise Paré.1 In 1850, von Langenbeck was the first to attempt repair of a hip fracture with a nail for internal fixation. Later, Davis used ordinary wood screws in an attempt to aid the healing of femoral neck fractures.2 With the advent of radiography in the 19th century, the types of fractures and dislocations became easily identifiable, thus allowing discussion and investigation of management strategies, classification systems, and prognosis.

Epidemiology

Both age and gender are important predisposing factors for specific injury patterns and pathologic conditions found in the hip, femur, and thigh.

Approximately 10 million adults in the United States have osteoporosis, and an additional 33.6 million have low bone density of the hip, both of which predispose to hip fracture.3 The annual incidence of hip fracture continues to grow as our population ages. During the late 1990s, approximately 250,000 patients a year sought treatment in emergency departments (EDs) after sustaining hip fractures.4 In 2005 alone, this number exceeded 290,600 patients.5 It is estimated that this number will surpass half a million patients a year by 2025.6 Although hip fractures represent only 14% of all fractures in adults, they account for 72% of medical costs related to fractures.7 Femoral neck fractures have a female to male ratio of 4:1 and typically occur in elderly patients with osteoporosis.8 There is an increasing incidence of intertrochanteric fractures with advancing age, and women are affected six times more often than men.9 Overall, more than three quarters of all hip fractures occur in postmenopausal women older than 50 years.3

Among the elderly segment of society, nontraumatic hip pathology is also very common. Osteoarthritis of the hip can severely limit the affected person’s ability to perform activities of daily living.

The elderly are not the only population affected by hip and femur pathology. Perthes’ disease—avascular necrosis (AVN) of the femoral head—occurs from 2 to 14 years of age, with a peak age of onset of 5 years, and it is five times more common in boys than in girls.4 Slipped capital femoral epiphysis (SCFE) peaks at 13.5 years of age among boys and 12 years among girls, in association with the onset of puberty, and is nearly twice as common in boys.9

PRINCIPLES OF DISEASE

Anatomy of the Hip and Femur

Skeletal Anatomy

The femoral head is firmly seated in the acetabulum, which is reinforced by labral cartilage. The well-developed capsule, overlying ligaments, and proximal musculature of the lower extremity add strength to the joint (Fig. 56-1). The nearly spherical femoral head articulates with the acetabular cup in a variation of the ball-and-socket joint.

The femur is the longest and strongest bone in the human body and is routinely subjected to substantial forces produced during powerful muscle contraction and weight transmission. In an anatomic position, the two femurs extend obliquely from the pelvis medially to the knee and bring the legs closer to the midline, where they can best support the body. Structurally, the femoral neck serves as an oblique strut between the pelvis (the horizontal beam) and the shaft of the femur (the vertical beam) (Fig. 56-2). The length, angle, and narrow circumference of the femoral neck permit substantial range of motion at the hip, but these same characteristics subject the neck to incredible shearing forces. A fracture results when these forces exceed the strength of the bone. As drawn on an anteroposterior (AP) radiograph, the intertrochanteric line, an oblique line connecting the greater and lesser trochanters, marks the junction of the femoral neck and its shaft.

The bone in the femoral head, neck, and intertrochanteric region is predominantly cancellous, which is less resistant to torsional forces. Distal to the intertrochanteric region, including both the subtrochanteric region and femoral shaft, the bone is cortical, requiring great forces to break. At the distal metaphysis, the femur widens and the cortical bone thins, lessening its resistance to stress.

Musculature

The musculature of the hip and thigh is the largest and most powerful in the human body. The muscles in this region of the body are located within three different compartments, each containing associated nerves and vessels (Table 56-1). The muscles also are grouped according to their primary action at the hip. Knowledge of the major muscle actions offers insight into the injury patterns and deformities commonly seen (Fig. 56-3).
Chapter 56 / Femur and Hip

673

of the thigh. Here, the superficial femoral artery passes through the adductor hiatus and becomes the popliteal artery. The deep femoral artery runs posterolaterally to the superficial femoral artery, supplies the hamstrings, and terminates in the distal third of the thigh as small branches piercing the belly of the adductor magnus. These perforating branches constitute an additional site of potential injury. The abundant muscle coverage and blood supply of the thigh aid in healing fractures of the femoral shaft.

Venous System

In the proximal two thirds of the thigh, the common and superficial femoral veins lie adjacent to the common and superficial femoral arteries. At the inguinal ligament, the common femoral vein is posterior and medial to the common femoral artery and moves to the lateral position as it passes distally. The deep femoral vein and the greater saphenous vein are the two main tributaries to the common and superficial femoral veins. The deep femoral vein and artery run in parallel as the vein joins the superficial femoral vein just distal to the inguinal ligament. The greater saphenous vein arises in the dorsum of the foot and ascends anterior to the medial malleolus. This vein is relatively superficial as it passes up the medial aspect of the leg to join the common femoral vein distal to the inguinal ligament.10

Nerves

The femoral and sciatic nerves are the major nerves within the thigh. The femoral nerve is the largest branch of the lumbar plexus; it passes under the inguinal ligament lateral to the femoral artery and divides into anterior and posterior branches soon after entering the thigh. The sensory divisions of the anterior branch, the intermediate and medial cutaneous nerves, supply sensation to the anteromedial aspect of the leg to join the common femoral vein distal to the inguinal ligament. The motor division of the anterior branch innervates the pectineus and sartorius muscles. The posterior femoral branch gives off the saphenous nerve, which supplies sensation to the skin along the medial aspect of the lower leg.

Vascular Anatomy

Arterial Supply

The arterial supply to the femoral head arises from two main sources (Fig. 56-4). The major source is the ascending cervical arteries as they branch off the extracapsular ring and run along the femoral neck beneath the synovium. Some blood is supplied to the femoral head from the second source, within the marrow spaces—the intraosseous cervical vessels. A third and minor source is the foveal artery, which lies within the ligamentum teres.

As the external iliac artery passes beneath the inguinal ligament, it becomes the common femoral artery.10 At this point the artery is located midway between the anterior superior iliac spine (ASIS) and the symphysis pubis. Approximately 3 to 4 cm distal to the inguinal ligament, the common femoral artery branches to form the superficial and deep femoral arteries. The larger superficial femoral artery passes along the anteromedial aspect of the thigh and terminates at the junction of the middle third and lower third

Figure 56-1. The ligaments of the hip combine to form a tough joint capsule, as seen on both anterior (A) and posterior (B) views.

Figure 56-2. Bony architecture of proximal end of the femur.
Table 56-1  Structures within Compartments of the Thigh

<table>
<thead>
<tr>
<th>COMPARTMENT</th>
<th>MUSCLES</th>
<th>NERVES</th>
<th>VESSELS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>Quadriceps femoris, sartorius, iliacus, psoas, pectineus</td>
<td>Lateral femoral cutaneous</td>
<td>Femoral artery and vein</td>
</tr>
<tr>
<td>Medial</td>
<td>Gracilis, adductor longus and magnus, obturator externus</td>
<td>Obturator</td>
<td>Profundus femoris artery, obturator artery and vein</td>
</tr>
<tr>
<td>Posterior</td>
<td>Biceps femoris, semitendinosus, semimembranosus, adductor magnus</td>
<td>Sciatic, posterior femoral cutaneous</td>
<td>Profundus femoris artery branches</td>
</tr>
</tbody>
</table>

Figure 56-3. Anatomic illustrations of the major muscles acting about the hip and thigh.

Figure 56-4. The arterial blood supply of the femoral neck and head is provided to varying degrees by three sources: the ascending cervical arteries, the arterial branches within the marrow (not illustrated), and the foveal artery within the ligamentum teres.
part of the leg. The posterior branch also supplies motor function to the muscles of the quadriceps femoris group.\(^\text{10}\)

The sciatic nerve is the largest peripheral nerve in the body. It arises from the sacral plexus. The sciatic nerve exits the pelvis through the greater sciatic foramen and travels through the posterior thigh; it extends from the inferior border of the piriformis to the distal third of the thigh. The sciatic nerve gives off articular branches that supply the hip joint. In the thigh, muscular branches innervate the adductor magnus and hamstring muscles. Just proximal to the popliteal fossa, the sciatic nerve divides to form the tibial and common peroneal nerves.\(^\text{10}\)

**Pathophysiology**

**Fractures and Trauma of the Femur and Hip**

The pathophysiology of specific femur and hip fractures is discussed later in this chapter. The vast majority of hip fractures occur in elderly patients with preexisting bone disease and result from relatively low-energy trauma, usually a ground-level fall. In young healthy individuals, major trauma, such as a motor vehicle collision (MVC) or a fall from a significant height, is responsible for the majority of fractures.

**Osteoporosis of the Femur**

Osteoporosis is the leading cause of hip fracture. Osteoporosis currently affects more than 10 million people in the United States and is projected to affect approximately 14 million adults older than 50 years by the year 2020. The number of hip fractures attributable to osteoporosis is expected to be 6.3 million by the year 2050, although the incidence in women has been decreasing in recent years, probably because of an increased awareness and more aggressive treatment of osteoporosis.\(^\text{2,11}\) Hip fractures can have a devastating impact. One in five patients dies during the first year after a hip fracture, mostly from causes other than the fracture itself; one third require nursing home placement after hospital discharge; and less than one third regain their prefracture level of physical function.\(^\text{12}\) The economic impact of these fractures is enormous.

The pathophysiology of osteoporosis is not completely understood, but strong associations with hormonal changes related to aging, genetic predisposition, vitamin D deficiency, lack of physical activity, and smoking have been recognized.\(^\text{13}\) Severe osteoporosis and hip fractures are most common in elderly white women; however, a decrease in bone density after age 30 is seen across all demographic groups. Radiography of the head of the femur can quantify the degree of osteoporosis, even in the nonfractured hip. The trabeculae of the femoral head and neck strengthen the bone and support the large mechanical forces produced across the hip joint. As osteoporosis begins and then progresses, these trabeculae disappear. This loss of trabeculae weakens the bone and increases the risk of fracture.

**Avascular Necrosis**

When a patient has an increasingly painful hip, buttock, thigh, or knee and no history of recent trauma, AVN of the femoral head should be considered. AVN has been referred to as aseptic necrosis, ischemic necrosis, and osteonecrosis. It is the result of ischemic bone death of the femoral head after compromise of its blood supply (Fig. 56-6). AVN is bilateral in 40 to 80% of patients. It is common in relatively young patients, the mean age at diagnosis being 38 years.\(^\text{16}\) Although a specific causative disorder is not identified in 20% of the cases, known atraumatic causes include chronic corticosteroid therapy, chronic alcoholism, hemoglobinopathy (e.g., sickle cell anemia), dysbarism, and chronic pancreatitis.\(^\text{16,17}\) AVN also is an emerging complication associated with human immunodeficiency virus (HIV) infection. It is unclear whether the virus itself or the treatments are the pathogenic agents.\(^\text{17}\)

Traumatic AVN is a subacute manifestation after hip dislocation or femoral neck fracture. It is a direct result of disruption of the blood supply to the femoral head. It is more common in males and African Americans. The incidence of AVN as a subacute complication is clearly related to both the initial degree of trauma and the amount of time the femoral head remains out of joint. Reduction of the hip within 6 hours after dislocation significantly decreases the incidence of AVN.\(^\text{18}\) Multiple studies have shown that there is relationship between the length of time the hip is dislocated and the rates of AVN, with as few as 4.8% of patients...
developing AVN with reduction within 6 hours, and as many as 58.8% developing AVN with reduction after more than 12 hours. For this reason, hip dislocation should be considered an orthopedic emergency. The emergency physician should perform reduction of the hip if there is any delay in orthopedic consultation.

Even with optimal treatment, femoral neck fractures are complicated by AVN in 11 to 19% of cases. For all practical purposes, femoral neck fractures are effectively intra-articular fractures. Acutely, bleeding from the fracture site may cause high intracapsular pressure and a tamponade effect on the femoral head, thereby further impairing the blood supply to it. In addition, if the bone fragments are not impacted, synovial fluid will lyse the blood clot. Such lysis prevents the development of capillary buds and the scaffolding needed for osseous repair. These factors all contribute to make AVN of the femoral head a common complication. Conversely, intertrochanteric and subtrochanteric fractures are located in an area of rich blood supply provided by an extracapsular arterial supply. AVN rarely complicates these fractures.

Treatment of AVN should be directed at reversing the underlying cause. Supportive treatment is the mainstay, with total hip replacement reserved for severe cases.

Myositis Ossificans

Myositis ossificans (heterotrophic ossification) is pathologic bone formation at a site where bone is not normally found. Traumatic myositis ossificans results most commonly from a direct blow to muscle. The thigh and hip muscles are often involved. The incidence of myositis has been reported as up to 17% of patients undergoing medical evaluation of thigh contusions, and the condition is thought to be related to the severity of the injury. The incidence of myositis ossificans after hip surgery is approximately 2%, but these lesions are clinically significant in only 10 to 20% of cases. Increased susceptibility to myositis ossificans has been described in persons with hemophilia or other bleeding disorders in conjunction with soft tissue injury.

Bleeding into the muscle after trauma produces a local hematoma with subsequent new bone formation within the hematoma. This inappropriate response may also result from repeated minor trauma. The ossific mass may be palpable and may limit motion, depending on its location.

Radiographically, myositis ossificans appears as irregularly shaped masses of heterogeneous bone in the soft tissues around the joint or along fascial planes (Fig. 56-7). It may be seen as early as 10 to 21 days after injury, but radiographic evidence typically lags behind onset of symptoms by weeks. Its appearance may simulate primary bone neoplasm, especially when the periosteum is involved. Osteosarcoma and periosteal osteogenic sarcoma should be considered in the differential diagnosis. Computed tomography (CT) scan can sometimes be helpful in distinguishing between neoplasm and myositis ossificans, as the lesions of myositis ossificans begin to calcify at the periphery and progress toward the center, and those of osteosarcoma begin to calcify at the center first. Orthopedic follow-up should be arranged for these patients.

Initial treatment of contusions is aimed at preventing myositis ossificans by use of the RICE principle of rest, ice, compression, and elevation. Immobilization of the extremity may prevent retraction of ruptured muscle and increasing size of hematoma formation but should be limited to less than 48 hours. Once a stable scar has formed, range of motion within limits of pain should be initiated. If myositis ossificans has already formed, the mainstay of treatment is supportive with rest, slow return to normal activity, and physical therapy. Although indomethacin is commonly used to prevent heterotopic ossification after surgery, it has not been validated for the prevention as well as the treatment of myositis ossificans. Its use based on the principle of inhibition of bone formation does not seem to be contraindicated. Operative removal of a mature lesion may be indicated if the lesion is near a joint or is causing permanent impairment or pain.

Calcific Bursitis and Calcifying Peritendinitis

Calcification surrounding tendons and bursae or occurring in the joint capsule is referred to as calcific bursitis or calcifying peritendinitis. The cause of these lesions is unknown. No relationship has been documented between the radiographic findings and acute...
symptoms. Calcific bursitis of the hip is uncommon, but when it does occur, it most frequently affects the trochanteric bursa (Fig. 56-8). Other possible affected areas include gluteal muscles and the hip flexors and adductors. The bursal calcification is seen on radiographs as an amorphous, poorly marginated line that is clearly separate from the cortex of the femur. Treatment should focus on stretching and strengthening of the hip.

Neoplastic Disease in the Hip

The most common neoplastic disease of bone is metastatic, generally from breast, kidney, lung, thyroid, or prostate tumors. Primary bone lesions also occur, with the most common being osteoid osteoma (Fig. 56-9). Bone lesions may be osteoblastic or osteolytic. Patients may come to the ED with significant bone pain or a large bothersome mass, such as a solitary osteochondroma (Fig. 56-10). Neoplasms place the patient at higher risk for pathologic fracture, especially if the lesions are large or lytic or have eroded the cortex.

CLINICAL FEATURES

History

Age and gender are predisposing factors for certain injuries. A detailed description of any antecedent trauma or other precipitating events is often helpful. With trauma, details of the mechanism of injury may aid in predicting injury patterns. With stress fractures, an alteration in physical activity or exercise routine provides a clue to the diagnosis. Systemic illnesses or known metabolic disorders should be noted. Previous cancer, irradiation, and chemotherapy are clues to pathologic fractures. Any past steroid use, including inhaled steroids, is important to identify because it predisposes patients to AVN of the femoral head. A linear relationship has been recognized between the cumulative steroid dose and the incidence and severity of osteoporosis and hip fracture.

Ascertainment of the location of the patient’s pain is paramount; true hip joint pain is often groin pain. However, pediatric patients with hip pathology often have knee pain as the sole presenting complaint. A review of systems should include information that may help in ascertaining hip or femur pathology versus another cause. Atypical pain may be the result of nephrolithiasis, pelvic inflammation, infection or tumor, inguinal and femoral hernia, or adenopathy from genital or cutaneous infection. A history of low back pain may suggest radiculopathy as the cause of the patient’s pain. A differential diagnosis of hip pain without obvious fracture on radiographs is listed in Box 56-1.

The history should also focus on comorbid conditions and injuries. Elderly patients with a hip fracture sustained in a fall at home may be unable to summon help for hours to days. They often have severe dehydration, electrolyte abnormalities, rhabdomyolysis, and renal insufficiency and require a thorough evaluation of these metabolic parameters before surgery is considered.
PART II • Trauma / Section Three • Orthopedic Lesions

Box 56-1 Differential Diagnosis of a Painful Hip without Obvious Fracture

- Referred pain (lumbar spine, hip, or knee)
- Avascular necrosis of the femoral head
- Degenerative joint disease or osteoarthritis
- Herniation of a lumbar disk
- Diskitis
- Transient synovitis of the hip
- Septic arthritis
- Bursitis
- Tendonitis
- Ligamentous injuries of the knee or hip
- Occult fracture
- Slipped capital femoral epiphysis
- Perthes’ disease
- Tumor (lymphoma)
- Deep venous thrombosis
- Arterial insufficiency
- Osteomyelitis
- Iliopsoas abscess
- Retroperitoneal hematoma
- Inguinal hernia
- Inguinal lymphadenopathy
- Genitourinary complaints
- Sports-related hernia

In addition, the reason for the fall should be determined, as it may reveal other comorbid conditions (e.g., syncope, cardiac dysrhythmias, polypharmacy, alcoholism). Sedative or antihypertensive medications predispose elderly patients to falling and should be prescribed carefully. In a fall, elderly patients may have sustained additional injuries; most commonly, these injuries involve fracture of a vertebral body or wrist. Cervical spine and intracranial injuries also are considered. Young patients with a hip fracture resulting from high-energy mechanisms have concomitant injuries in 40 to 75% of cases.

Physical Examination

Management principles for injuries of the hip and femur are the same as those for traumatic injuries elsewhere in the body. Hypotension is a problem commonly encountered during the initial resuscitation of a multitrauma patient. Although hypotension might result from the loss of up to 3 units of blood into the thigh with a femoral fracture, other conditions (cardiac, pulmonary, intra-abdominal, and pelvic trauma) must be considered. Hemorrhagic shock from an isolated femoral fracture should be a diagnosis of exclusion. Hypotension, neurovascular compromise, or suspicion for multiple injuries will necessitate consideration of transfer to a trauma center.

After life-threatening conditions have been addressed, the injured extremity should be carefully evaluated. Visual inspection will reveal any pallor, ecchymosis, asymmetry, or deformity. Abrasions, lacerations, and open wounds are critical because their presence alters the management of concomitant fractures. The position that the leg assumes offers a clue to what may be found radiographically. In the presence of a displaced femoral neck fracture, the leg classically assumes the position of external rotation, abduction, and shortening. In intertrochanteric fractures, the leg is found in external rotation with shortening. In intertrochanteric fractures, the leg is found in external rotation with shortening. Shortening or a limb-length discrepancy is found with fractures, dislocations, and osteoarthritis. Nondisplaced fractures, including stress fractures, will not produce limb shortening or rotation but will be painful on passive range of motion, particularly internal and external rotation. These fractures also will prevent the patient from being able to perform a straight leg raise. In patients with obvious deformities, range of motion should be deferred until after radiographs have been obtained.

Figure 56-10. Osteoid osteoma of the femur (solid black arrow). A, A large focal area of greater density than that of the surrounding femur represents both cortical and endosteal proliferation. The new cortical bone is smooth and sharply delineated, indicative of a nonaggressive process. The open arrow represents a bone island. B, A frontal-view tomogram demonstrates an oval central radiolucent nidus (solid black arrow). (From Harris JH, Harris WH, Novelline RA: The Radiology of Emergency Medicine, 3rd ed. Baltimore, Williams & Wilkins, 1993.)
Systematic examination of the injured extremity will reveal any focal tenderness or warmth that may indicate injury or infection. Active and passive range of motion, and muscle strength, though offering important information, are frequently limited by pain. Detailed neurovascular assessment is vital. Femoral nerve and arterial injury often occur with subtrochanteric and femoral shaft fractures or anterior hip dislocation. The sciatic nerve can be injured with a hip fracture or posterior hip dislocation. Neurologic examination includes evaluation of light touch and pinprick sensation. Femoral, popliteal, dorsalis pedis, and posterior tibial pulses are assessed. Comparative blood pressures obtained by Doppler examination in the injured and uninjured extremities (arterial pressure index) may be useful in diagnosing occult femoral arterial injuries. If the systolic pressure in the affected extremity is 90% or less (ratio less than 0.9) than that in the unaffected extremity, additional diagnostic studies should be undertaken. Additional diagnostic studies include Doppler flow ultrasound imaging, CT angiography, or angiography alone. The ankle-brachial index (ABI) also can be similarly determined by comparing the systolic pressures of the affected extremity and of the ipsilateral arm. An index less than 0.9 necessitates further diagnostic studies.25,26

**DIAGNOSTIC STRATEGIES**

**Radiographic Anatomy and Evaluation**

Normal radiographic and skeletal anatomy is familiar to emergency physicians (Fig. 56-11).

True AP and lateral radiographs of the femur are usually adequate for the evaluation of potential fractures. The femur should be in as much internal rotation as possible. Fracture lines may be very subtle, particularly with femoral neck fractures. Experts have found three methods useful for identifying inconspicuous fractures. The use of Shenton’s line is described in a subsequent section on hip dislocations. (A second method is illustrated in Fig. 56-15.) In searching for a fracture of the femoral neck, both the medial and lateral cortical margins of the femoral head and neck should be carefully examined for the normal S and reverse S curves seen on radiographs of nonfractured hips. The convex outline of a normal femoral head smoothly joins the concave outline of the femoral neck when in anatomic position. This produces an S curve and a reverse S curve, regardless of the orientation of the radiographic projection. A fracture produces a tangential or sharp angle, indicative of disruption of the normal anatomic relationship. A third method, useful in the evaluation of seemingly remarkable hip radiographs, is to trace the trabecular lines as they pass from the femoral shaft to the femoral head. These lines will be disrupted as they pass through the fracture site, and such disruption often provides the only, albeit subtle, clue. If a fracture is found, radiographs of the knee should be obtained as well. It is a basic orthopedic principle to image the joint above and below any fracture.25

One common inaccuracy in hip radiography merits clarification: The soft tissue linear radiolucencies superolateral and inferomedial to the femoral head and neck do not represent the hip capsule, as is commonly believed. Instead, they represent the fat within the fascial plane covering the gluteus minimus superiorly and the tendon of the iliopsoas muscle inferiorly.27 Comparison of these lines on the symptomatic side with those on the unaffected side should not be used to determine whether an effusion of the hip is present.

**Occult Hip Fracture**

If radiographs do not show a fracture, or suggestion of injury, ambulation may be attempted. Inability to ambulate or difficulty in ambulation heightens the suspicion of occult fracture. Approximately 2 to 10% of all hip fractures are radiographically “occult” on plain films.28 Failure to detect these injuries results in increased mortality, risk of subsequent displacement of the fracture, and a higher incidence of AVN.29,30 When a painful hip prevents ambulation and plain radiographs do not reveal a fracture, magnetic resonance imaging (MRI) should be performed.28,29 In addition, elderly patients with unexplained chronic hip pain for more than 3 weeks may harbor an occult fracture even if they continue to ambulate. T1-weighted MRI will reveal a fracture that was imperceptible at the time of injury with 100% accuracy and has been found to be cost-effective when compared with other strategies.29 A small study comparing CT scans with MRI in the diagnosis of occult hip fractures revealed a 66% misdiagnosis rate for CT scans.28 MRI remains the “gold standard” modality for diagnosing occult hip fractures and helps determine the treatment of these fractures (Fig. 56-12).

Bone scans have been useful in these patients, yet such scans lack adequate sensitivity. To identify most occult fractures, the

---

**Figure 56-11.** Normal radiographic anatomy of the hip. A, Anteroposterior view of the normal adult hip. The open arrow indicates the edge of the iliopsoas muscle shadow. This muscle lies immediately on the capsule of the hip joint. The small concavity in the center of the femoral head is for the attachment of the ligamentum teres. B, Cross-table lateral view of the hip demonstrating the normal relationship of the femoral head to the neck. The asterisk indicates the ischial tuberosity. (From Harris JH, Harris WH, Novelline RA: The Radiology of Emergency Medicine, 3rd ed. Baltimore, Williams & Wilkins, 1993.)
The potential for significant blood loss and the multiple common associated injuries constitute important justification for this recommendation. Hemodynamic instability may result from dehydration and blood loss of up to 3 units into the fracture site. Currently, treatment of these fractures is hemiarthroplasty or open reduction and internal fixation for femoral neck fractures. Internal fixation with a sliding compression screw generally is used to treat intertrochanteric fractures. The goal is to promote immediate postoperative mobilization. It has become widely accepted that the risks of surgery in elderly patients are minimal when compared with the risks of prolonged bed rest, deep vein thrombosis, pulmonary embolism, pneumonia, and urosepsis from an indwelling Foley catheter. If possible, the repair is conducted with use of spinal anesthesia to decrease the operative risk. Operative repair should be performed after the patient is resuscitated and is in optimal preoperative condition. Care of an elderly patient with a hip fracture requires a multidisciplinary approach and often involves coordination of the efforts of the emergency physician, orthopedist, internist, neurologist, and cardiologist to stabilize the patient before surgery. Comprehensive hip fracture programs for the elderly that include comanagement by geriatricians and orthopedic surgeons have been shown to improve short-term outcomes and may even lower mortality, highlighting the importance of medical management of these complex patients.31,32

Traction and Immobilization

Emergency rescue personnel often place a Hare splint, Sager splint, or similar device that applies traction to the leg before transport if they suspect a femoral fracture. This management strategy is popular as it provides pain relief and immobilization and limits blood loss. However, great care should be taken to ensure the proper use of these devices. Prolonged traction during the assessment and management of other injuries can cause or worsen serious neurologic injury in the thigh. The traction used in the field for transport may cause skin breakdown at pressure points and may produce potentially damaging tension on the nerve. The femoral and sciatic nerves are more likely to be injured from traction or during surgery than from a femoral fracture.

Contraindications to the use of traction splints include pelvic fractures, patellar fractures, ligamentous knee injuries, and tibia or fibula fractures. Traction in the prehospital setting should not be applied to any open fracture that has exposed bone. Such reduction pulls grossly contaminated bone fragments back into the wound before adequate débridement can be undertaken in the operating room. A study that evaluated patients with multisystem trauma in whom traction splints were placed in the field for femur fractures showed that up to 38% of the cases had contraindications to the splints that were placed.33

With or without traction, the injured extremity should be immobilized when the patient is moved, to prevent further damage from mobile bone fragments. This can be done with simple splinting in the prehospital setting. In the ED, maintaining the leg in slight flexion at the hip reduces intracapsular pressure, whereas extension of the leg increases pressure and potential for ischemic necrosis of the femoral head. Therefore traction for proximal femur fractures may be discontinued once the patient has arrived in the ED. The leg may be supported in a position of comfort with a pillow placed under the thigh. The theoretic advantages for continuation of traction in the ED are pain control and fracture reduction, making operations easier to perform. This is likely true in femoral shaft fractures; however, a Cochrane systematic review looking at preoperative traction for fractures of the proximal femur in adults found no evidence to support these proposed advantages.34

Scan should be delayed 72 hours after the injury. The intervening 3 days of bed rest and hospitalization until a bone scan can be performed are costly and not without risk. Various measures should be implemented to diminish the likelihood of deep vein thrombosis.

**MANAGEMENT**

Patients with traumatic fracture of the hip or femur should have blood typed and crossmatched for at least 2 units of blood.
Femoral Nerve Block

Femoral nerve blocks have been used to treat femoral shaft fractures for more than 50 years. Despite proven effectiveness and a low complication rate, this technique has not been widely embraced by emergency physicians or surgeons. The femoral nerve block is an excellent option as an adjunct or alternative to systemic analgesics in patients at risk for hypotension. It has been shown to significantly decrease time to lowest pain score as compared with intravenous narcotics, and patients have been found to require significantly lower doses of narcotics in conjunction with femoral nerve blocks. The block can be performed with the assistance of a peripheral nerve stimulator to localize the nerve, or bedside ultrasound to directly visualize the nerve before anesthetic injection. Femoral nerve blocks have been shown to be effective when performed by newly trained emergency physicians without the assistance of peripheral nerve stimulators or ultrasound. If a long-acting anesthetic such as bupivacaine is used, the expected onset of analgesia is within 30 minutes, and its duration is 6 to 8 hours.

Careful neurovascular examination should be undertaken and documented before the femoral nerve block is performed. After the nerve block procedure, continued assessment of the femoral muscular compartments is advisable to check for the development of compartment syndrome. If an injury is considered at especially high risk for compartment syndrome, orthopedic surgery consultation should be obtained before the block, and there should be consideration of measurement of compartment pressures after the block. As the sciatic nerve innervates the compartments of the lower limb, a femoral nerve block should not mask the clinical presentation of compartment syndrome in the lower leg.

Hip Arthroplasty

Background and Epidemiology

Sir John Charnley first described the modern form of total hip arthroplasty (THA) in 1961. Despite many changes in both the design and materials used, Charnley’s essential design has been established as the standard. The number of THA procedures performed annually in the United States rose from 65,000 in 1982 to more than 230,000 in 2007. The most common indication for THA is joint failure resulting from severe osteoarthritis. Other indications include rheumatoid arthritis, certain types of hip fracture, AVN, and certain tumors. Arthritis associated with Paget’s disease, trauma, ankylosing spondylitis, and juvenile rheumatoid arthritis are also relative indications for THA or partial hip arthroplasty.

Outcomes and Complications

THA provides an immediate, substantial reduction of pain and improvement in functional ability and overall quality of life. A 10-year follow-up study of patient outcomes, including gait, perception of pain, physical mobility, sleep patterns, and energy scores, showed positive results in more than 90% of cases. Despite the tremendous success of THA, numerous complications have been reported. Aseptic loosening of the prosthesis is the most common. Other complications include component wear, infection, adjacent femoral fractures, deep vein thrombosis, and postoperative dislocation of the femoral component. In general, flexion past 90 degrees, adduction, and internal rotation place the hip at risk for dislocation. This combination can occur when patients bend at the waist (e.g., to sit on a normal low toilet or to get out of a chair) or cross the legs (Fig. 56-13).

---

**Table 56-2** Classification of Open Fractures

<table>
<thead>
<tr>
<th>CRITERION</th>
<th>TYPE I</th>
<th>TYPE II</th>
<th>TYPE III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wound size</td>
<td>&lt;1 cm</td>
<td>1-10 cm</td>
<td>&gt;10 cm</td>
</tr>
<tr>
<td>Soft tissue</td>
<td>Minimal, if any</td>
<td>Moderate, without nerve, arterial, or periosteal stripping</td>
<td>Extensive muscle devitalization; nerve and arterial involvement often classified as type IIIb</td>
</tr>
<tr>
<td>Mechanism of injury</td>
<td>Bone edge pierces outward</td>
<td>Variable</td>
<td>High-energy shotgun blast, high-velocity gunshot</td>
</tr>
</tbody>
</table>


---

**Open Fracture Care**

By definition, an open fracture is any fracture in which a break in the integrity of the skin and soft tissue allows communication with the fracture and its hematoma. Any nearby wound or break in the skin must be considered to communicate with the fracture. Open fractures are divided into three categories (Table 56-2). A bone piercing from the inside outward often causes only a small wound. The contaminated bone tip may then slip deceptively back into the soft tissue; therefore any break in the integrity of the skin makes the fracture an open one. Open wounds should be irrigated and then covered with sterile saline-moistened gauze.

For all type I open fractures, a first-generation cephalosporin should be administered intravenously. Types II and III may require additional gram-negative coverage because of the amount of devitalized tissue and increased gram-negative skin flora found in the groin. This additional coverage could be provided by an aminoglycoside such as gentamicin or tobramycin. The use of perioperative first-generation cephalosporins has been shown to reduce postoperative infection even in closed fractures in patients who are to undergo surgery.

Great care should be taken to identify tetanus-prone wounds so that appropriate prophylaxis can be provided with tetanus immune globulin when indicated. Immunization status should be verified in all patients and immunizations updated as needed.

**Compartment Syndrome**

Because of the thigh’s larger volume, compartment syndrome within the thigh is far less common than in the lower part of the leg. A large amount of bleeding into the compartment is required before the pressure rises above capillary perfusion pressure. When compartment syndrome does occur in the thigh, only 50% of the cases are associated with a femur fracture. It is difficult to clinically differentiate the expected swelling after an injury from early compartment syndrome. Clinical examination and the use of direct compartment pressure measurements can detect the development of compartment syndrome at an early stage.

**Pain Management**

**Systemic Analgesia**

It is well known that control of pain in EDs is often inadequate. In the case of femoral fractures, narcotic analgesia is often indicated in combination with other pain-relief strategies including immobilization of the injured extremity, placement of the injured extremity in a position of comfort, and the consideration of local analgesia in the form of nerve blocks.
Proximal Femoral Fractures

**Classification Systems.** Fractures of the proximal end of the femur have been classified on the basis of their relationship to the hip capsule (e.g., intracapsular and extracapsular), anatomic location (neck, trochanteric, intertrochanteric, subtrochanteric, and shaft fractures), and degree of displacement. A working knowledge of the classification system will allow the emergency physician to communicate with the consulting orthopedist regarding the fracture's pattern and stability and treatment options.

**Pathophysiology.** Many experts now refer to femoral neck fractures as **insufficiency fractures** in acknowledgment of the major role played by osteoporosis. Age-related bone loss is believed to be the most important etiologic factor in femoral neck fractures. The theory that these fractures result from primary skeletal pathology is supported by the fact that minimal or no injury is associated with most of these fractures. Pathologic fractures from metastatic carcinoma are also well described.

**Classification.** Although several classification systems were formerly used to describe these fractures, they have been abandoned because of poor inter-rater reliability and limited clinical utility.
Currently, femoral neck fractures should be classified as either nondisplaced or displaced fractures.

From 15 to 20% of all femoral neck fractures are nondisplaced fractures. The fracture line often may be very subtle. Techniques described for detection of subtle fracture lines may be useful for this reason. Evaluation of the continuity of the subcapital cortical lines, search for an indistinct broad band of increased subcapital density, and identification of the S and reverse S curves (Fig. 56-15) will lead to the correct diagnosis in most cases. In impacted femoral neck fractures, the neck cortex is driven into the cancellous femoral head. Bone impaction lends a certain inherent stability (Fig. 56-16). Because of this inherent stability, two different management approaches have been advocated: early ambulation and internal fixation. Internal fixation has been associated with a reduced length of hospital stay and improved rehabilitation and has become the preferred treatment modality. Without impaction, a nondisplaced femoral neck fracture is unstable and will become displaced without internal fixation.

On initial evaluation, a patient with a displaced fracture of the femoral neck lies with the limb externally rotated, abducted, and slightly shortened. The diagnosis is confirmed with plain hip films. To avoid further disruption of the blood supply to the femoral head, range-of-motion assessment should be deferred unless radiographs fail to reveal a fracture. Treatment of these displaced fractures consists of open reduction with internal fixation, hemi-arthroplasty, or THA. In all displaced femoral neck fractures, the femoral head is rendered largely avascular, and signs of AVN and collapse may develop over the ensuing several years.

Outcome and Complications. The mortality rate during the first year after a femoral neck fracture is 14%, as compared with 9% for the control population. Factors affecting mortality include age, male sex, psychiatric illness, end-stage renal disease, and congestive heart failure. Institutionalized patients have a death rate up to three times higher than noninstitutionalized patients. Complications can be minimized by early reduction, stable internal fixation, early ambulation, and close attention to medical comorbidities.

AVN and nonunion are the two major complications of femoral neck fractures. AVN is the most common complication, despite optimal treatment, because of the complex arterial anatomy.

Figure 56-15. The normal anatomic appearance of the femoral head as smooth S and reversed S lines is drawn above. The concave outline of the femoral neck meets the convex outline of the femoral head as shown here in various views. Any tangential angle suggests a fracture.

Figure 56-16. A, Subtle nondisplaced impacted femoral neck fracture. Use of S curves aids in identification. B, A nondisplaced femoral neck fracture possesses no stability without impaction.
Deep infection in the form of osteomyelitis or septic arthritis is more common with femoral neck fractures because the fracture line extends into the joint. The rate of infection has been dramatically reduced with the use of perioperative antibiotics. Pulmonary embolism is another significant complication and is the leading cause of death 7 days after fracture in orthopedic patients. Anticoagulation is recommended for at least 10 days after any hip surgery in patients without significant contraindications. Fondaparinux has been shown to be an effective anticoagulant in this setting.52

Intertrochanteric Fractures

Anatomy. The fracture line of intertrochanteric fractures extends between the greater and lesser trochanters of the femur. These injuries are considered to be extracapsular fractures. The fracture line extends through cancellous bone, which has an excellent blood supply. The hip’s short external rotators remain attached to the distal fracture fragment, and the internal rotators are attached to the proximal fracture fragment. Owing to the strong action of the iliopsoas muscle, the leg is shortened and externally rotated.

Pathophysiology. An intertrochanteric fracture in younger adults usually is the result of high-speed collisions or high-energy trauma, such as falls from heights. An elderly person may sustain this injury during a fall from any height. The fracture lines are the result of both direct and indirect forces. The direct forces act along the axis of the femur, and on the greater trochanter as it strikes the ground. Indirect forces are produced as the iliopsoas pulls the lesser trochanter and the abductors pull the greater trochanter; these forces often cause fractures at the site of insertion.

Classification. A large number of classification systems for intertrochanteric fractures have been proposed to predict the possibility of achieving and maintaining stable reduction.25 A useful system designates the fracture according to the number of separate bone fragments produced (Fig. 56-17).

Management. Intertrochanteric fractures carry particular management pitfalls for the emergency physician. Great care must be taken to maintain focus on the entire patient and not on the fracture alone. Hemodynamic instability may result from blood loss of up to 3 units into the fracture site.54 Poor nutrition before the fall, chronic diuretic use, and decreased oral intake in patients who have to wait until they are found will contribute to the level of dehydration. Up to 70% of these patients are under-resuscitated.24 Associated distal radius fractures, proximal humerus fractures, rib fractures, and compression fractures of the lumbar and thoracic spine often are overlooked because the femoral fracture distracts the attention of both patient and physician.

A substantial majority of intertrochanteric fractures will require some type of internal fixation. Such fixation allows rapid mobilization, decreased hospital length of stay, reduced mortality, and improved function.25 The procedure should be performed on an urgent rather than an emergent basis. Mortality is increased when the patient is taken to the operating room on the day of injury; however, early repair within 24 to 48 hours is associated with a 1-year mortality reduction.35 Preoperative medical optimization by multidisciplinary medical teams may decrease the incidence of 1-year mortality in these patients.32

Outcomes. Intertrochanteric fractures have an associated mortality rate of 10 to 30% in the first year.32 Life expectancy returns to normal among patients who survive that year. Survival is most commonly related to the patient’s age and preexisting medical conditions. Additional risks associated with operative treatment include mechanical failure (1-16%), implant migration (2-10%), and infection (2-8%).36 Mechanical failure and nonunion are much more common in unstable fractures and those that were not adequately reduced. Approximately half of patients sustaining these fractures are eventually able to regain their original level of ambulation. Yearly infusion of zoledronic acid (a bisphosphonate) beginning within 90 days of hip fracture repair reduces the incidence of new fractures and decreases mortality.39,57

Pathologic Intertrochanteric Fractures

Aggressive treatment is indicated for patients who have pathologic intertrochanteric fractures or impending fractures if their life expectancy is more than a few months. Such treatment with subsequent radiation therapy improves the patient’s quality of life, decreases pain, and improves mobility.
Isolated Fractures of the Greater or Lesser Trochanter

Fractures of the greater or lesser trochanter are rare. They occur in women more often than in men and are the result of a fall directly onto the trochanter or avulsion by the iliopsoas muscle. There may be a comminuted fracture involving only part of the greater trochanter or more subtle impaction of the lateral cortex. If avulsed, the fragments are displaced superiorly and posteriorly.

Treatment consists of pain control and early mobilization with crutches; weightbearing is allowed as pain is tolerated. Outpatient management of this injury is possible with satisfactory support for home convalescence. The prognosis is good, and healing generally is excellent.

Subtrochanteric Fractures

Anatomy and Pathophysiology. Subtrochanteric fractures occur between the lesser trochanter and the proximal 5 cm of the femoral shaft. They may accompany intertrochanteric fractures. The subtrochanteric region is composed almost entirely of cortical bone, which lacks the vascularity important to new bone growth and repair. When fractured, it is more likely to be comminuted than bone with a higher cancellous content. In addition, the greater portion of the biomechanical forces of the femur is transmitted down the curved medial cortex of the femoral shaft. If this cortex is disrupted, the metal hardware undergoes the majority of the stress. This mechanism accounts for the increased incidence of hardware failure when the medial cortex is largely involved.

These fractures characteristically are deformed because of the unbalanced muscle forces. In displaced fractures the attachments of the iliopsoas, gluteal, and external rotator muscles consistently produce flexion, abduction, and external rotation of the proximal fragment.

Epidemiology. Subtrochanteric fractures account for 11% of all fractures of the proximal end of the femur. Although 10% of these fractures are caused by gunshots, the usual mechanism of injury is direct blunt trauma. A bimodal distribution for these injuries has been recognized. The first group consists of elderly patients who experience a fall, in whom the fracture occurs through an area of weakened cortical bone. Pathologic fractures from metastatic lesions, Paget’s disease, renal osteodystrophy, osteogenesis imperfecta, and osteomalacia are well-recognized clinical entities in these patients. The second group comprises victims of extreme high-energy trauma. In these patients, the subtrochanteric fracture is rarely an isolated injury because of the tremendous force required to produce it. Associated thoracic and abdominal injuries are common and should be aggressively sought to ensure adequate management. From 30 to 50% of patients with subtrochanteric fractures have associated fractures of the pelvis, spine, or other long bones. Stress fractures can occur in this region but are extremely uncommon.

Classification. Various classification systems for these fractures have been proposed, although none is widely accepted. From a practical standpoint, it is best to define and describe these fractures by location (proximal or distal), angle (transverse, oblique), and the presence of comminution (Fig. 56-19).

Management. Hemodynamic instability may result from blood loss of up to 3 units into the fracture site. Although such blood loss can lead to hypovolemic shock, other causes of hypotension in a trauma patient need to be considered. Open fractures are rare and when present are accompanied by significant soft tissue injury. Vascular and neurologic injuries are also uncommon.

Definitive management of subtrochanteric fractures is a complex issue. Maintaining limb length and controlling rotation are difficult. Open reduction with internal fixation generally is the treatment of choice. However, in the rare case with severe comminution or an open, grossly contaminated fracture, nonoperative
management may be preferable. Children younger than 10 years also may be managed nonoperatively. The amount of remodeling and growth stimulation occurring in children of this age usually ensures good results without internal fixation.

Outcomes. The bone in the subtrochanteric region is largely cortical and relatively avascular when compared with the cancellous intertrochanteric region. It logically follows that healing is comparatively slow. Comminution is common and increases the likelihood of nonunion. Comminuted and distal subtrochanteric fractures carry a worse prognosis.

Complications include fat embolism in patients of all ages, and the adverse effects of prolonged immobilization in the elderly. Reported mortality rates from subtrochanteric fractures range from 9.6 to 13.3%. The violent force and common associated injuries contribute to the high mortality among patients who sustain these fractures.

Femoral Shaft Fractures

Pathophysiology. Femoral shaft fractures are common injuries in young adults after high-energy trauma. As is the case with other femoral cortical fractures, considerable violent force is required to produce a fracture in a normal shaft. Automobile and motorcycle accidents, falls, and pedestrian accidents account for a majority of femoral shaft fractures. The femoral shaft usually fails under tensile strain, and a transverse fracture results. Higher forces produce varying degrees of segmentation or comminution. Open fractures of the femoral shaft are less frequent and are often the result of a gunshot wound. Pathologic fractures occur from a low-mechanism force that may produce torsion and spiral fractures.

Classification. There is no commonly accepted or easily remembered classification for femoral shaft fractures. Location and geometry of the fracture line should be used to describe these fractures. Transverse, oblique, spiral, wedge, and comminuted are useful terms for describing these fractures.

Clinical Features. Patients often arrive in the ED with the injured extremity immobilized by traction devices, which should be removed while immobilization of the limb is maintained. Neurovascular injuries are rarely associated with closed femoral shaft fractures. Significant hemorrhage into the thigh can occur with a femoral shaft fracture, just as it can with intertrochanteric and subtrochanteric fractures. Injuries commonly occurring in the presence of femoral shaft fractures include hip fractures, fracture-dislocations, femoral neck fractures, supracondylar femoral fractures, and patellar fractures. Almost half of femoral shaft fractures have associated ligamentous damage in the knee. If the patient has a femoral fracture, pain often prevents adequate evaluation of knee stability. Any attempt to evaluate the stability of the knee acutely will result in additional pain and hemmorhage without providing useful, reliable information.

Management. Internal fixation with intramedullary rods has been demonstrated to shorten both hospitalization and total disability time with most femoral shaft fractures. The vast majority of femoral shaft fractures heal well in time, regardless of the mode of treatment. Severely comminuted fractures are more likely to be treated by closed reduction.

Outcomes. Femoral shaft fractures have close to a 100% union rate, and most patients are able to return to work after approximately 6 months. Even a minor degree of limb shortening or malalignment can result in arthritis of the hip or knee or chronic back pain. Refracture is a rare occurrence that is most likely at two times during the healing process: during early healing and callus formation or during the brief period after the hardware is removed. After the hardware removal, the unsupported bone is required to bear the entire weight of axial loading and is at risk for refracture.

Fractures with Minimal or No Trauma

Most patients who arrive in the ED with hip or thigh pain will provide a clear history of a traumatic event. Hip or knee pain in the young, in athletes, and in the elderly deserves investigation, even when minimal or no trauma has been reported. This patient population commonly has occult hip pathology and occasionally femoral pathology. Although senile osteoporosis is the leading cause of femoral neck fractures after minor trauma, pathologic fractures of the femur may result from metastatic, metabolic, or endocrine disease.

Stress Fractures

Pathophysiology. Stress fracture of the femoral neck was first reported in 1905 by Blecher. Stress fractures occur when normal bone is repeatedly subjected to submaximal forces. This recurring stress stimulates the bones to remodel and strengthen. In a stress fracture, osteoblasts are unable to lay down new bone and remodel fast enough, so the bone fails. Stress fractures can also occur in diseased bone when it is subjected to repeated minimal stress.

Clinical Features. The symptoms of a stress fracture of the femoral neck often are so subtle that they may be mistaken for muscle strain or an overuse injury. Early symptoms frequently include morning stiffness and aching in the hip on the first steps after a period of rest. The pain gradually increases during prolonged exercise and may reach the point at which bearing weight becomes impossible. Pain is felt in the groin or along the medial aspect of the thigh toward the knee.

On examination, a painful limp is obvious. This painful or antalgic gait is characterized by shortening of the stance phase of the injured extremity. No obvious external rotation or shortening of the leg is seen; the patient experiences only minor discomfort with active or passive motion, except at the extremes of flexion and internal rotation. Tenderness is minimal because of the large amount of soft tissue coverage at the femoral neck.

Diagnostic Strategies. Radiographs are helpful if they demonstrate a fracture, but findings are often negative until 10 to 14 days after the injury. Endosteal or subperiosteal callus develops at the fracture site during this period. In addition to the standard AP and lateral views of the hip, oblique views may delineate the fracture line. Close attention should be paid to the trabecular fibers of the femoral neck. A stress fracture often can be identified as an isolated disruption of either the tensile (lateral aspect of the femoral neck) (Fig. 56-20A) or the compressive (medial aspect of the femoral neck) (Fig. 56-20B) trabecular fibers. If a fracture is

Figure 56-20. Schematic illustrating femoral neck fractures through the tensile (A) and compressive (B) trabecular fibers.
suspected clinically but radiographic findings are negative, the next step is MRI. If a fracture is found, the contralateral hip should be extensively evaluated because of the significant incidence of bilateral stress fractures.

Management. Treatment of stress fractures of the femoral neck is determined by the involvement of the compressive or tensile aspect. Compressive-side fractures involving less than half of the cortex are inherently stable and can be treated conservatively with partial weightbearing with crutches. Tension-side fractures and compressive-side fractures involving more than half the cortex are considered unstable and at risk for displacement. These fractures should be treated operatively with screw fixation.

Other Causes of Pain
Considerations in the diagnosis of atraumatic pain of the hip and thigh are listed in Box 56-1.

Dislocations and Fracture-Dislocations of the Hip and Femur

Injury Patterns
Epidemiologists have identified injury patterns in victims according to the mechanism of injury.68 Pedestrians who are struck by a car may have head, chest, pelvic, arm, and femur injuries. Motorcyclists tend to sustain pelvic and ipsilateral leg injuries. A person who stumbles and falls seldom has major associated injuries unless there is underlying bone pathology (e.g., osteogenesis imperfecta, osteoporosis). Each of these main categories of injury is discussed next.

Hip Dislocations
Dislocations and fracture-dislocations of the hip are two true orthopedic emergencies. The hip joint possesses impressive inherent strength and stability; therefore considerable force is required to produce these injuries. With this understanding, a hip dislocation serves as a “red flag” for multisystem injury and should prompt a diligent search for other occult injuries. Serious associated injuries are found in up to 95% of patients with a dislocated hip. There is an associated acetabular fracture in up to 70% of cases. Knee fractures, ligamentous injuries, and dislocations are present in up to 30% of patients sustaining a hip dislocation.69 It is highly recommended that in the presence of this type of injury, patients be managed as major trauma victims.

Mechanism and Biomechanics. Traumatic hip dislocations occur primarily in patients sustaining severe multisystem trauma, most often as a result of a high-speed MVC. Failure to use seat belts is a significant risk factor. Less common mechanisms include falls, sports injuries, and pedestrians struck by automobiles.

Posterior dislocations are almost always the result of MVCs. A seated vehicle occupant typically has the hip adducted, flexed, and internally rotated at the time of impact. As the knee strikes the dashboard, the force is transmitted through the femoral shaft to the femoral head. With sufficient force, the femoral head dislocates posteriorly. Anterior dislocations result from forceful extension, abduction, and external rotation of the femoral head. These forces lever the head out of the acetabular cup. Such dislocation most often occurs after an MVC when the occupant has the hip abducted and externally rotated at the time of impact. It may also result from a fall or sports injury when the hip is forcefully hyperextended.

Classification. The relationship of the femoral head to the acetabulum is used to classify dislocations into anterior, posterior, central, and inferior types. A fracture-dislocation includes an associated fracture of the acetabulum or femoral head. Posterior dislocations (Fig. 56-21) account for 80 to 90% of dislocations. Anterior dislocations (Fig. 56-22) are seen in 10 to 15% of patients. In anterior dislocations the femoral head may dislocate medially toward the obturator foramen (obturator dislocation) (Fig. 56-23) or laterally toward the pubis (pubic dislocation), or toward the iliac crest. Central dislocations, which occur in 2 to 4% of cases, are not true dislocations because the entire femoral head is forced centrally through a comminuted fracture of the acetabulum. Inferior dislocation of the hip associated with inversion of the femoral shaft (luxatio erecta femoris) is a very rare condition that may occur with or without associated trochanteric fracture.

Clinical Features. The position of the injured extremity may provide valuable clues in the evaluation of a hip dislocation. A patient with a posterior dislocation typically holds the hip flexed, adducted, and internally rotated. The knee of the affected extremity rests on the opposite thigh. The extremity generally is shortened, and the greater trochanter and buttock may be unusually prominent. By contrast, a patient with an anterior dislocation holds the hip in abduction, slight flexion, and external rotation, and the leg may appear lengthened. These physical findings may be absent in patients with an associated ipsilateral femoral shaft fracture.
The neurovascular examination should focus on the sciatic nerve and femoral vessels. Sciatic palsy is present in approximately 10% of patients with hip dislocation and most commonly involves the peroneal nerve branch. The most sensitive clinical sign of peroneal nerve palsy is weakness of the extensor hallucis longus; other signs include weakness of dorsiflexion and numbness or tingling over the dorsum of the foot. The femoral vessels and nerve are particularly prone to injury after an anterior dislocation.71

Diagnostic Strategies. Radiologic investigation begins with an AP view of the pelvis. This view alone will identify a majority of hip dislocations. An AP pelvis film should be obtained in all trauma patients with the aforementioned deformities. The AP radiograph should include the entire pelvis and the proximal third of the femur to allow comparison of both hips. When a dislocation is found or suspected, a lateral view of the hip will provide additional definition of the injury.

Although most hip dislocations are seen clearly with these two views, several more subtle radiographic signs may assist physicians in making a confident diagnosis. The first indicator involves the position of the lesser trochanter. Because a posteriorly dislocated hip is internally rotated, the lesser trochanter is superimposed on the femoral shaft and is not seen on the AP projection. By contrast, an anteriorly dislocated hip is externally rotated, and the lesser trochanter appears in profile. The second clue is found in the size of the femoral head. Because a posteriorly dislocated hip is larger than the unaffected side to the x-ray cassette, it appears smaller. The converse is true in anterior dislocations, in which the hip is farther from the x-ray cassette than the contralateral side is and thus appears larger. The third finding relates to the integrity of Shenton’s line (Fig. 56-24). This line is a smooth, curved line drawn on the radiograph along the superior border of the obturator foramen and medial aspect of the femoral metaphysis. Disruption of this line should raise suspicion for a femoral neck fracture or hip dislocation.72

An obvious dislocation may distract the emergency physician from a search for concomitant fractures. Examination of the trabecular pattern can identify associated fractures of the acetabulum and femoral head, neck, or shaft. It is important to identify acetabular fractures before closed reduction is attempted because intra-articular bone fragments may interfere with effective reduction.73 Although these fractures may make the reduction more difficult, their presence is not a contraindication to reduction.

Management. Hip dislocations constitute a true orthopedic emergency, and reduction should be performed within 6 hours. The earlier the reduction, the better the results. The incidence of AVN, traumatic arthritis, permanent sciatic nerve palsy, and joint instability logarithmically increases with the length of time for which the hip remains dislocated.73,74

The timing and method of reduction are dependent on the overall condition of the patient, the type of dislocation, and the presence or absence of associated fractures. In cases of simple dislocation, closed reduction should be attempted first. Although some clinicians recommend that this procedure be performed with the patient under general anesthesia, this delay, with its associated increase in the rate of AVN, is not warranted when moderate or deep sedation in the ED is readily available. If the emergency physician chooses to attempt closed reduction, the principles of procedural sedation and monitoring should be followed. The primary relative contraindication to closed reduction is the presence of a femoral neck fracture. Another relative contraindication is the presence of fractures in the dislocated extremity because such fractures preclude application of traction to the limb. Techniques of closed reduction are described next.

Reduction Techniques. Stimson’s technique and the Allis technique are the methods most commonly used for reduction of posterior hip dislocations25 (Fig. 56-25). The Allis technique is usually effective for both posterior and obturator dislocations (Fig. 56-26). It is perhaps the most commonly used method for hip reductions in the ED.

Allis technique for reduction of posterior hip dislocation:
1. The patient is placed in the supine position, and the pelvis is stabilized by an assistant.
2. With the knee flexed, the operator applies steady traction in line with the deformity.
3. The hip is slowly brought to 90 degrees of flexion while steady upward traction and gentle rotation are applied.
4. The assistant pushes the greater trochanter forward toward the acetabulum.
5. Once reduction has been achieved, the hip is brought to the extended position while traction is maintained.

Stimson’s technique (Fig. 56-27) uses the weight of the limb and the force of gravity to reduce the dislocation and is relatively atraumatic. Although Stimson’s technique generally is effective,

Figure 56-23. Radiograph of obturator dislocation.

Figure 56-24. Shenton’s line is a smooth curved line drawn along the superior border of the obturator foramen and medial aspect of the femoral metaphysis. Disruption of this line should raise suspicion of a femoral neck fracture or hip dislocation.
Chapter 56 / Femur and Hip

2. An assistant stabilizes the pelvis.
3. The operator applies steady downward traction in line with the femur.
4. The femoral head is gently rotated, and the assistant pushes the greater trochanter anteriorly toward the acetabulum.
5. Once reduction has been achieved, the hip is brought to the extended position while traction is maintained.

Other techniques for closed reduction of posterior hip dislocations include the Rochester method, the Whistler method, and the traction-countertraction technique.

Closed reduction of a pubic dislocation can be quite difficult. The anterior position of the femoral head will resist flexion, making the Allis technique impossible. The following sequence of maneuvers is recommended:

**Technique for reduction of pubic dislocation:**
1. The patient is placed in the supine position.
2. Longitudinal traction is applied in line with the deformity.
3. The hip is hyperextended and internally rotated as an assistant applies downward pressure on the femoral head.

Although prompt anatomic reduction is clearly desirable, multiple attempts at reduction in the ED should be avoided because of potential damage to the articular surface and because the incidence of osteonecrosis increases with the number of attempts at reduction as well as the duration of the dislocation. Difficulty with reduction is usually the result of incarceration of a tendon, a capsular structure, or an osteochondral fragment that is blocking reduction. In the case of an irreducible dislocation, closed reduction with the patient under general anesthesia or an open reduction procedure often is required.

**Postreduction Management.** After closed reduction, the hip should be tested for stability, which is accomplished by gently taking it through a full range of motion to see whether it will redislocate. After testing has ensured stability, the injured extremity should be placed in a knee immobilizer and an abduction pillow should be applied to prevent repeat dislocation. An AP radiograph of the pelvis should be obtained to verify the adequacy of reduction. The radiograph should be carefully inspected to verify that the femoral head is in the acetabulum, the shaft of the femur is in neutral position, Shenton’s line is intact, and the profile of the lesser trochanter is well visualized. The intra-articular space should be symmetrical and, when measured, of the same depth as in the unaffected joint. Asymmetry signals an entrapped intra-articular fragment and is an indication for CT scanning (Fig. 56-28).
Outcomes. The precarious blood supply to the femoral head is particularly important with regard to the long-term consequence of hip dislocations. The development of AVN of the femoral head has been reported in 1 to 17% of dislocations. Other risk factors for the development of AVN include the total dislocation time, the severity of the injury, the number of reduction attempts, and the presence of comorbid conditions.

Fracture-Dislocation of the Femoral Head

Epidemiology and Mechanism. Hip dislocations may be associated with fractures of the femoral head (Fig. 56-29A). Femoral head fracture occurs in 35 to 55% of anterior hip dislocations and in 10 to 16% of posterior hip dislocations. These injuries are almost always the result of high-speed vehicular trauma. Because of the tremendous force required to produce this injury pattern, coexistent multisystem trauma is the rule.

When a femoral head fracture and hip dislocation coexist, patients assume the position typical for the dislocation. Hip mobility is markedly reduced, and pain usually is severe. After initial stabilization, the involved extremity should be carefully examined for associated fractures of the femoral shaft and knee. The neurovascular examination should assess for femoral or sciatic nerve injury. Radiographs should be evaluated carefully for any femoral head fracture in all patients with hip dislocations. Evidence for fracture of the femoral head can be subtle. These fractures may be detected on radiographs by following the curve of the dislocated head and the acetabular cup to search for a small fragment that may otherwise be overlooked. Known or suspected injuries can be further defined by CT or MRI.

In most cases, satisfactory results can be obtained with closed reduction (see Fig. 56-29B). Several experts recommend obtaining a CT scan of the hip before closed reduction to further define the injury and locate fracture fragments. If the hip cannot be reduced by manipulation or if reduction of the femoral head fragment is unsatisfactory, open reduction will be required.

Dislocation of Hip Prosthetics

An increasing number of patients have undergone hip arthroplasty. In addition to those procedures performed for treatment of femoral neck fractures, more than 230,000 patients undergo elective primary THA each year. Postoperative dislocation may occur in 0.5 to 3% of patients with primary THA and in 5 to 27% of patients with a revised THA. Although most dislocations take place within 3 months of surgery, “late dislocations” have been reported up to 10 years after the operative procedure. Postoperative dislocations account for 75 to 90% of cases. Reduction techniques for prosthetic hip dislocations are identical to those described earlier. Consultation with an orthopedic surgeon is essential for safe reduction and development of a long-term treatment plan for the patient. Reduction of the prosthesis does not carry the same...
urgency as for reduction of a dislocated native hip because there is no risk for the development of AVN once the femoral head has been replaced. Traction on the sciatic nerve can occur, however, making early reduction more compelling. In addition, the reduction itself carries the unique dangers of loosening of the components, fracturing of the surrounding bone, and movement of the acetabular cup. Reduction is best performed with an orthopedic consultant.

**Soft Tissue Injuries**

Soft tissues may be subject to muscle or tendon strain or contusions from misuse, overuse, or accidental trauma. Rupture, hemorrhage, or myositis ossificans may develop in muscles.

**Muscular Injuries**

Strenuous exercise in a poorly conditioned person, sudden exertion, and direct trauma all may traumatize soft tissues. Cold temperature, vascular or infectious disease, fatigue, and poor training are known predisposing conditions for muscular injury.81

A detailed classification system of muscular injuries has been devised, but it is of little clinical significance for the emergency physician. Classification of complete and partial tears is reasonable and of greater clinical utility. Partial tears are reversible injuries that are aggravated by movement or tension. Mild spasm, swelling, ecchymosis, and tenderness cause minor loss of function and strength. Complete tears produce a palpable depression, and the torn muscle edge also is often palpable. Other possible findings include severe spasm, swelling, ecchymosis, tenderness, and loss of muscle function. In significant muscle strains, radiographs are needed to evaluate for the possibility of an accompanying bone avulsion injury.

Initial management of incomplete tears traditionally includes the local application of ice for the first 48 hours, followed by heat. Compressive wraps cause distal venostasis with the potential for distal venous clot formation and do not significantly decrease recovery time. A regimen of nonsteroidal anti-inflammatory agents to achieve sufficient analgesia is important for recovery and patient satisfaction. Muscle relaxants may be useful when the injury is accompanied by muscular spasm. In general, complete rest of the affected muscle should be maintained, with the recommendation of “weightbearing as pain tolerated.” This progressive muscle loading can be started within 3 to 5 days once sufficient scar has formed. In order to prevent reinjury, the muscle loading should be limited by the patient’s pain. Any patient with significant injury should be referred for physical therapy.

A complete muscle tear is a serious condition. Consultation plus follow-up care with an orthopedic surgeon or sports medicine specialist is vital for these patients.

**Sports Injury Patterns.** Athletes commonly experience muscular injury from accidents and overtraining. The two most common injuries involve the hamstrings and the quadriceps.

*The Hamstrings.* Hamstring muscle strains are common in sports involving running and sudden acceleration. The injury is accompanied by sudden intense pain in the posterior aspect of the thigh. Any active or passive motion at the hip is poorly tolerated because of the intense pain that movement causes. Ischial avulsion fractures can occur, and pelvic radiographs should be obtained if the examination reveals bony tenderness. Crutches and toe-touch weightbearing are recommended until the patient is evaluated by a physician trained in sports medicine. *Toe-touch weightbearing* refers to walking with crutches while the toes of the injured extremity rest on the ground without placing any weight on it. Appropriate weight-training programs have been shown to speed rehabilitation of this injury. Complete recovery from a hamstring muscle strain may take weeks to months.

Muscular Injuries

**The Quadriceps.** The quadriceps is the most common muscular group to sustain complete tears. This injury occurs when the muscles are contracted suddenly against the body’s weight, as may occur when an athlete slips or stumbles and attempts to avoid a fall. Ambulation is significantly affected. There is pain with active and passive knee extension. In significant tears, the patient may be unable to actively extend the knee or maintain its extension against gravity. A palpable depression just proximal to the superior pole of the patella suggests a complete tear. It is imperative to document an intact patellar mechanism on examination because a complete tear of the quadriceps most often requires surgical repair and extensive rehabilitation.

*iliopsoas Strain.* Gymnasts and dancers are the group of athletes most likely to experience an injury to the iliopsoas as a result of sudden forcible hip flexion against resistance. Severe pain often is experienced in the groin, thigh, or lower back region. Severe intra-abdominal pain is common at the muscle origin and may dominate the clinical picture. Examination reveals groin tenderness and pain with active hip flexion. Radiographs of the femur should be obtained to identify an avulsion fracture of the lesser trochanter. CT frequently will demonstrate a large hematoma. Bed rest with partial flexion at the knee and hip generally is required for 7 to 10 days. With severe strains, symptoms may persist for 2 to 3 months.

*Hip Adductor Strain.* Injury to the hip adductors occurs as the thigh is forcefully abducted, as in a straddle injury. The patient reports pain in the groin, the pubic region, and the medial proximal aspect of the thigh. Abduction and adduction are often limited because of pain. Swelling and skin discoloration may confirm presence of the tear. If the tear is complete, a defect in the muscle may be felt by the examiner along the medial aspect of the thigh near the groin. Treatment is conservative, with patients initially benefiting from rest, with gradual progression in a stretching and strengthening program.

*Gluteus Muscle Strain.* The gluteus muscles may be injured with vigorous or forced hip extension, as seen in track-and-field jumping events. The pain typically is less severe than that associated with injuries to other muscle groups. The hip is tender when extended or abducted.

**Tendon Injuries**

Clinically, tendon strains tend to have a more insidious onset than that typical for muscle strains. These strains may occur at the attachment of the muscles to the superior or inferior pubic ramus, the pubic symphysis, the ischium, and the femur.

A *groin pull* is the lay term for an injury to the tendons of the hip adductors. One study found adductor strains to be the most common groin injury in athletes, with 62% of the cases involving the adductor longus muscle.84 The adductor magnus and brevis and the pectineus often are involved as well.85 This injury commonly occurs in skaters and cross-country skiers when an accidental stress abducts the thigh during a powerful contraction of the adductors. These muscles also may be injured from overuse in an unconditioned patient. Local pain is noted at the inferior pubic ramus and the ischial tuberosity. Extension, abduction, and adduction of the hip are painful. The pain may radiate to the back of the thigh.

Pain over the greater trochanter may represent tendon strain of the attachments of the gluteus medius, gluteus minimus, tensor fasciae latae, or piriiformis. The pain is aggravated by resisted abduction. Tenderness in the groin and painful hip movement suggest a strain of the iliopsoas tendon at its attachment to the lesser trochanter. Trochanteric bursitis, peritendinitis, AVN, neoplasm, and other possible causes should be considered.

Treatment of a tendon strain is similar to that for other soft tissue injuries. The use of crutches with weightbearing as tolerated
given. Complete tendon disruption may require surgical repair.

Gesics and a short course of anti-inflammatory agents should (i.e., as pain permits) is helpful for the first 2 weeks. Opioid analgesics and a short course of anti-inflammatory agents should be given. Complete tendon disruption may require surgical repair.

Osteitis Pubis

Osteitis pubis is a poorly understood disorder. It is characterized by pubic symphysis pain and joint disruption and is most common in distance runners and soccer players. The adductor muscles act as a “compression strut,” displacing forces across the hip. The most likely mechanism is repetitive pulling of the adductor muscles, causing increased shearing at the pubic symphysis.

Clinically, patients have groin pain of insidious onset, with most reporting pain at the symphysis and adductor muscles. Pain usually can be elicited on palpation of the symphysis and also can be provoked by adduction of the hip or by sit-ups. Plain radiographs show widening of the symphysis, irregular contour of the articular surfaces, or periarticular sclerosis (a late finding) (Fig. 56-30). These features are not specific and in one study were seen in 76% of asymptomatic soccer players. MRI is the imaging study of choice and will show marrow edema on T2 images early in disease. Osteitis pubis has been associated with spontaneous cases of pubic symphysis osteomyelitis, and this should be considered in the differential diagnosis.

Treatment is conservative, and in most cases the process is self-limited. Patients benefit from activity modification, good shoe wear, and therapy addressing flexibility and strength of the pelvic and hip musculature. Average time to heal has been reported to be 9 months. Owing to the length of healing associated with these injuries, follow-up care should be arranged at the time of initial injury to prevent unnecessary ED visits.

Vascular Injuries

Hip dislocations and femoral fractures may have associated arterial injury. The vessel may be partially lacerated, dissected, completely severed, or thrombosed. Lack of distal arterial flow may also represent a stretched vessel in spasm. The superficial femoral artery is most commonly injured with trauma to the hip and thigh. The common and the deep femoral arteries are less frequently injured. In the acute setting, penetrating trauma is the usual mechanism of injury. Arterial injury with femoral shaft fractures is rare. Anterior- and superior-type dislocations may produce femoral artery injury.

Comparative blood pressures obtained by Doppler examination in the injured and uninjured extremities at the ankle may be useful in suspected arterial injuries. If the systolic pressure in the affected extremity is 90% or less (index less than 0.9) than that in the unaffected extremity, additional diagnostic studies should be undertaken. The ABI also can be similarly determined by comparing the systolic pressures of the affected extremity and of the ipsilateral arm. An index less than 0.9 necessitates further diagnostic studies. Additional diagnostic studies include Doppler flow ultrasound imaging, CT angiography, and angiography alone. CT angiography, however, is becoming more prevalent, with recent studies showing 96 and 97% sensitivity and specificity, respectively, when compared with conventional radiography.

Diagnostic evaluation must not delay surgical exploration when clinical signs and symptoms of vascular injury are obvious. These hard signs and symptoms of injury include active or pulsatile hemorrhaging, expanding or pulsatile hematoma, diminished or absent pulses, auscultated bruit or palpable thrill, and evidence of limb ischemia. Early restoration of blood flow is essential to prevent ischemic damage to the leg.

Neurologic Injuries

Peripheral nerve injury can be caused by trauma, infectious agents, and degenerative disease. In trauma, nerves may be injured by a blunt object that causes a contusion, by a sharp penetrating object that produces a partial or complete tear, or by stretch. Nerves are particularly vulnerable to prolonged ischemia, which can lead to necrosis. Compression of the nerve from a hematoma or a displaced femoral head may also appear as a neurapraxia manifested by transient loss of conductivity. The femoral and sciatic nerves are rarely injured with femoral shaft fractures because they are encased in muscle throughout the length of the thigh.

Treatment of neurovascular compromise from a hip dislocation or a displaced femoral fracture consists of immediate reduction to ensure limb viability. Whenever possible, reduction should be accomplished before transfer of the patient to another treatment center.

Femoral Nerve. When the femoral nerve is injured, the iliac and femoral arteries are commonly involved because of their anatomic proximity. The femoral nerve is most often traumatized in penetrating trauma of the pelvis, groin, or thigh. Femoral neuropathy can occasionally result from compression by a hematoma within the abdominal wall or the iliopsoas as a complication of hemophilia, anticoagulant therapy, or severe trauma.

The motor deficit in complete femoral neuropathy manifests as marked weakness of knee extension. The patient is able to walk on level ground yet has extreme difficulty walking up stairs or an incline. Patients cannot rise from a sitting position because of significant proximal muscle weakness. The sensory deficit varies but is localized along the anterior aspect of the thigh and medial lower aspect of the leg. The most reliable spot for testing for a sensory deficit is just superior and medial to the patella. The deep tendon reflex of the knee will be diminished or absent with such deficits.

If a traumatic neuropathy is suspected, immediate orthopedic consultation should be obtained. Nerve exploration and repair generally are preferred for penetrating trauma and when direct impingement on the nerve by bone fragments or hematoma is suspected. Surgical exploration and drainage of a hematoma that is impinging on the femoral nerve are appropriate.
Progressive nontraumatic neuropathies warrant urgent neurology consultation. With a chronic neuropathy, atrophy of the anterior aspect of the thigh will already have developed. The motor deficits were discussed previously.

**Sciatic Nerve.** Sciatic injury is rare with femur fractures, but occasionally it may be the result of traction used to stabilize the fracture during the initial management period. Complete traumatic injury may result from a deep penetrating wound in the hip, thigh, or buttock. Posterior hip dislocations and fracture-dislocations produce sciatic neurapraxia in 10 to 14% of these injuries. Patients with complete sciatic neuropathy have paralysis of the hamstring muscles and all muscles below the knee. With partial injury, a peroneal palsy with weakness of the extensor hallucis longus muscle is the most sensitive clinical sign. There is sensory loss below the knee and along the posterior aspect of the thigh. The deep tendon reflex at the ankle is absent or diminished. Sciatic nerve palsy from inadvertent injection into the nerve or secondary to intraneural or extraneural hemorrhage in patients taking anticoagulants has been described.

Sciatic injury from posterior dislocations often consists of only transient loss of conductivity, particularly in motor fibers. Unfortunately, the other patterns of injury to the sciatic nerve carry the worst prognosis of all peripheral nerve injuries. The prognosis is poorest when the injury is proximal and complete. Even with optimal repair, recovery often is inadequate. Sciatic neuropathy is a disabling problem. Obvious atrophy of the lower part of the leg and foot develops, followed by ulceration of the sole of the foot and infection. A below-the-knee amputation frequently is necessary in these cases.

**SPECIAL PEDIATRIC CONSIDERATIONS**

**Anatomy**

Development of the femoral head and neck with its growth plates and two primary ossification centers is illustrated in Figure 56-31. A significant proportion of the pediatric hip is cartilage and developing new bone. For this reason, almost any type of trauma in this location carries the potential for premature growth arrest. Recognition that large portions of the pediatric hip are radiolucent will counter the tendency to focus attention on the ossified elements only.

**Hip Dislocation**

The incidence of hip fractures and dislocations is increasing in young patients, often as a result of high-energy trauma. Up to 50% of children with a hip dislocation also will have fractures elsewhere. In small children, dislocation of the hip is more common than femoral neck fractures. The force required to dislocate a pediatric hip is much less than that required in an adult because the acetabulum is less completely developed than in adults. Seemingly negligible trauma, such as tripping or a minor fall, may dislocate the femoral head in a young child. In a school-age child, athletic injuries are the major cause of traumatic hip dislocation. In the teenage years, MVCs predominate as the cause of hip dislocations.

**Hip and Femur Fractures**

The vast majority of pediatric hip fractures result from high-energy violent trauma. These fractures usually are the result of falling from heights, jumping out of a swing, being struck by a car, or having a bicycle accident. Whereas a car commonly strikes an adult pedestrian at the tibial level, a smaller child most often is hit at the level of the hip, which results in a fracture there.

The Salter-Harris classification of fractures in the pediatric population is not used for hip fractures. The Delbet classification is a well-accepted system used for pediatric femoral fractures. This system separates fractures through the physes and the transcervical, cervicotrchanteric, and intertrochanteric regions (Fig. 56-32).
Spiral Shaft Fractures

If seemingly trivial trauma has resulted in a spiral femoral shaft fracture in a child, nonaccidental trauma and pathologic fracture should be considered. Common causes of pathologic fracture include unicameral bone cysts, fibrous dysplasia, osteogenesis imperfecta, and malignancy.

Management. Although these pediatric injuries are extremely rare, their complications are significant. Unlike in an adult, a child’s femur has growth potential, and any disruption carries the possibility of lifetime disability. Treatment of femoral shaft fractures in adults is aimed at prevention of the complications of prolonged immobilization. Unlike adults, children tolerate bed rest well, which allows more treatment options. The primary goal in children is prevention of the many complications common with femoral fractures. Premature closure of the physeal plate results in a valgus deformity of the hip. AVN, malunion, nonunion, and femoral fractures. For these reasons, referral to a pediatric orthopedist is recommended.

Child with a Limp

A child who comes to the ED with a limp presents a diagnostic challenge. Both life-threatening and benign disease processes can produce a limp. When the child is too young to give an adequate history, the cause becomes more elusive. The emergency physician should inquire about the chronology of the symptoms, the child’s development (i.e., social milestones, weight gain, physical development), and diet. Associated illness and a family history may be helpful. Although identification of a specific causative disorder is challenging, the history and physical examination, combined with appropriate diagnostic modalities, will allow definitive diagnosis in most patients. An important point is that in the pediatric population, the knee is a common site for referred hip pain. Proper follow-up care is crucial to prevent additional morbidity in these children.

Evaluation of the Child’s Gait

Gait is a learned, complex combination of motions produced through coordination of the musculoskeletal, peripheral, and central nervous systems. A limp is produced by anything that alters this process; the numerous clinical entities that may be associated with a limp can be divided into categories according to the underlying abnormality. Pain, muscle weakness, structural alteration, peripheral sensory deficit, and cerebellar or vestibular imbalance are major categories. A limp caused by pain is referred to as an “antalgic” gait. Conditions that disturb the biomechanics of the hip or cause the child pain may affect any of the elements of gait. Other conditions, such as cerebellar pathology or disease of the knee or foot, are discussed in their respective chapters.

Etiology of the Limp

Inflammation and Infection. Inflammation of the articular surface, the intra-articular synovium, or the joint capsule creates pain. Weightbearing increases the pain. The child limps in an attempt to limit the time during which the affected hip bears the body’s weight.

Transient synovitis (also known as toxic synovitis) is a common nonbacterial inflammatory clinical entity that can cause a limp. Little is known about its cause. It develops most frequently in boys 3 to 10 years of age. Clinically, the synovitis manifests as pain in the hip or knee. An antalgic gait is present, with minimal systemic symptoms. There is restriction of hip motion and associated muscle spasm, and the child often will refuse to bear weight on the hip. As the disease progresses, the joint capsule is increasingly stretched, and intra-articular pressure rises. The potential volume of the joint capsule is largest with the hip flexed, abducted, and externally rotated. The child prefers to lie in this position as the capsule begins to bulge, to minimize the tension and intra-articular pressure.

The diagnosis of transient synovitis is one of exclusion of more serious diseases that mimic this condition. Acute joint inflammation and pain may be associated with septic arthritis, juvenile rheumatic arthritis, systemic lupus erythematosus, Perthes’ disease, and tuberculous arthritis. Ultrasound imaging of the hip joint will detect an effusion in 78% of cases of transient synovitis but cannot distinguish this condition from septic arthritis. Joint aspiration may be required when the diagnosis is in doubt.

Distinguishing between transient synovitis and septic arthritis can be a diagnostic dilemma. Key predictors may include temperature higher than 38.5°C in the preceding week, non–weight-bearing status (refusal or inability to bear weight even with support), erythrocyte sedimentation rate higher than 40 mm/hr, and a white blood cell count greater than 12,000/mL. These four predictors were developed in a retrospective study and then validated in a prospective study. Based on the validation study, the probability of septic arthritis was 2% for zero predictors, 9.5% for one predictor, 35% for two predictors, 73% for three predictors, and 93% for four predictors.

The use of C-reactive protein (CRP) assay is becoming more prevalent in the evaluation of septic arthritis. A positive CRP (defined as a result greater than 2.0 mg/dL) has been identified as a strong independent risk factor for septic arthritis. Taken together, all of these predictors should be used in conjunction with clinical assessment.

Acute bacterial infections of the hip and femur require early identification and intervention to minimize subsequent morbidity and disability. Unfortunately, the diagnosis often is missed initially because the child may appear relatively nontoxic in the early phases of infection. Signs and symptoms of systemic illness usually accompany infection of the femur or hip. Fever, malaise, decreased oral intake, a limp, and refusal to bear any weight are common. Whereas osteomyelitis most commonly develops in the metaphysis in adults, the physeal region often is the infected site in children. Septic arthritis (pyarthrosis) may result from hematogenous seeding or direct extension of osteomyelitis. The hip and the knee are the most commonly infected joints.

The causative agent in osteomyelitis and pyarthrosis is nearly always a gram-positive organism, usually Staphylococcus. The incidence of Haemophilus influenzae infection has fallen as a direct result of addition of that vaccine to the childhood immunization regimen. Neonates, asplenic children, and children with sickle cell anemia are at risk for infection with gram-negative organisms. Salmonella infection also is more often seen in patients with sickle cell disease–related osteomyelitis. Viral and rickettsial diseases (e.g., Lyme disease) have been identified in subacute cases.

Identification of acute osteomyelitis on plain radiographs is difficult until 2 to 3 weeks after onset of infection. Pyarthrosis may manifest with widening of the space between the femoral head and the acetabular roof and bulging of the joint capsule and surrounding soft tissues. This is seen as a change in the contour of the gluteus minimus and ilioptosae fat stripes (Fig. 56-33). Care should be taken to identify the normal shadow of the muscles and the joint capsule, as described earlier in this chapter (see Fig. 56-11). Plain radiographs are seldom useful in the initial identification of infection because visualization of a joint effusion has low sensitivity for pyarthrosis. Bone scan, MRI, CT, and ultrasound-guided joint aspiration are appropriate to diagnose a septic joint.
The inflammatory process involved in the immune system’s attempt to eradicate the intruder in pyarthrosis may also begin to destroy the body’s own articular surfaces. Even with treatment, many children experience some arthritic disability.

**Slipped Capital Femoral Epiphysis**

*Anatomy.* The capital femoral epiphysis appears during the first year of life. The epiphysis of the greater trochanter appears by the age of 5 years and that of the lesser trochanter during the 13th year of life. All of these structures unite at age 17 to 19 years. The anatomic relationship has been compared with a scoop of ice cream sitting on a cone. This relationship remains symmetrical on both AP and frogleg lateral radiographs (Fig. 56-34A and B). Asymmetry in any view represents either SCFE or a subcapital fracture (Fig. 56-35).

*Epidemiology and Pathophysiology.* SCFE is the most common hip disorder in adolescents, with an incidence of approximately 5 per 100,000 population per year. From 25 to 50% of the cases are bilateral. SCFE occurs twice as frequently in boys as in girls, with the respective peaks of incidence at the ages of 13 and 11 years.

Epidemiologic data have provided clues to the pathophysiology of this injury. SCFE is associated with the onset of puberty and is rare before the age of 10 years. It most commonly is seen in boys 10 to 17 years of age during their period of rapid growth. It is believed to be the result of a structural weakness in phsyseal cartilage associated with pubescence.

The specific cause of SCFE is not well understood, and most cases are deemed idiopathic. There are likely genetic and environmental factors that influence the development of SCFE. It occurs more frequently in male African Americans than in the Caucasian population and has seasonal and geographic variation. Other risk factors identified are obesity, previous irradiation or chemotherapy, renal osteodystrophy, hypothyroidism, and neglected septic arthritis.

*Clinical Features.* SCFE is usually an insidious process extending over weeks to months. Initially, the only complaint may be slight discomfort in the groin, thigh, or knee after activity. Shear stress combined with a weaker phsyseal plate leads to slippage of the epiphysis inferiorly and posteriorly in the direction of weight-bearing force. Pain worsens as slippage progresses, and eventually...
pain may occur at rest as well. Referred pain to the knee is a classic manifestation, and patients frequently have groin, thigh, or knee pain rather than hip pain. This presentation often causes delay in diagnosis, potentially increasing displacement and worsening the prognosis. Parents often bring the child in for medical evaluation when they notice the child beginning to limp. Physical examination may reveal hip tenderness, decreased hip range of motion, and an abducted, externally rotated thigh.

**Diagnostic Strategies and Treatment.** Children with unexplained hip or knee pain merit clinical as well as radiographic evaluation. Initially, AP, lateral, and frogleg lateral radiographs of the hip should be obtained. The frogleg lateral projection shows the hip in a plane midway between the AP and lateral views. The earliest radiographic findings are subtle, with the abnormality visualized on only one projection. The most reliable initial finding with SCFE is asymmetry of the femoral epiphysis in relation to the neck. Small amounts of slippage can be detected by examining the epiphyseal edge as it becomes flush with the superior border of the femoral neck. This can be visualized as “the scoop slipping off the ice cream cone.” The dome of the epiphysis may be flattened. On the radiograph, a line drawn along the superior margin of the femoral neck (Klein’s line) should intersect some part of the normal femoral head. Failure of this line to intersect the head indicates medial and posterior movement of the head on the epiphysis. Comparative views of the two hips are indicated if initial radiographic findings are equivocal. If occult fracture is suspected, MRI or CT should be performed. The goal of treatment is to prevent further slippage and subsequent injury to the physis. The patient should be placed on non-weight-bearing status and referred for orthopedic management. Surgery is required to anchor the epiphysis and prevent further slippage.

**Perthes’ Disease.** Perthes’ disease is the name given to AVN of the pediatric femoral head (Fig. 56-36). It also has been called Legg-Calvé-Perthes disease and Calvé-Perthes disease. A majority of cases are diagnosed at ages 4 to 8, with the peak incidence at 6 years. It occurs five times more often in boys than in girls and affects both hips 15 to 24% of the time. Patients classically have a unilateral, often painless limp of insidious onset. As the disease progresses, pain becomes nearly constant and typically is exacerbated by activity and exercise. Treatment is controversial and determined by progression of disease and age at diagnosis.

**Isolated Fracture of the Greater or Lesser Trochanter in Children.** An isolated fracture of the greater trochanter is a rare injury. In children, this fracture occurs when the entire greater trochanteric epiphysis is avulsed from the femur. Children and adolescents aged 7 to 17 years are most commonly affected. The mechanism of injury generally is a powerful muscular contraction of the lateral rotators of the hip joint during a twisting fall. If the fragment is large and displaced by more than 1 cm, open reduction and internal fixation may be indicated.

**Figure 56-36.** Perthes’ disease affecting the left hip. Similar collapse of the femoral head as seen in adults. (From Kocher MS, Tucker R: Pediatric athletic hip disorders. Clin Sports Med 25:241, 2006.)

**Figure 56-37.** Forceful contraction of the iliopsoas muscle results in avulsion of the lesser trochanter. (From Kocher MS, Tucker R: Pediatric athletic hip disorders. Clin Sports Med 2006; 25:241.)
involves bed rest and early mobilization. Painless active hip motion is achieved within 3 weeks.

ACKNOWLEDGMENT

We would like to thank Drs. James F. Fiechtl and Robert W. Fitch for their work on this chapter in previous editions.

**KEY CONCEPTS**

- Hip dislocation is an orthopedic emergency. The likelihood of its complication, AVN, is related to both the initial degree of trauma and the amount of time the femoral head remains out of joint. Reduction of the hip within 6 hours after dislocation significantly decreases the incidence of AVN.
- Postreduction radiographs should be obtained to ensure the adequacy of reduction and assess for other injuries.
- When a painful hip makes ambulation difficult and plain radiographs do not reveal a fracture, CT or MRI should be performed. MRI is the gold standard.
- With intertrochanteric fracture, hemodynamic instability may result from dehydration and blood loss of up to 3 units into the fracture site. Up to 70% of patients with these injuries are under-resuscitated.
- It is important to identify acetabular fractures before closed reduction is attempted because intra-articular bone fragments may interfere with effective reduction.
- Slipped capital femoral epiphysis is most commonly seen in African American boys 10 to 17 years of age; 25% of cases are bilateral. The most reliable initial finding with SCFE is asymmetry of the femoral epiphysis in relation to the neck, wherein small amounts of slippage give the appearance of “the scoop slipping off the ice cream cone.”

The references for this chapter can be found online by accessing the accompanying Expert Consult website.
References


