Fractures of the Proximal Femur

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Hip fracture is among the most common injuries necessitating hospital admission. Fractures of the hip include fractures of the proximal femur and pelvic ring and may be classified as pathologic or nonpathologic. Regardless of the type of fracture, however, hip fractures can lead to substantial morbidity and mortality.

This article discusses the epidemiology of fractures of the proximal femur and the evaluation and treatment of nonpathologic and osteoporotic pathologic proximal femoral fractures. The specific types of proximal femoral fracture discussed are intertrochanteric, femoral neck, subtrochanteric, and greater trochanteric fractures. A future article in this journal will discuss fractures of the pelvic ring, including sacral and acetabular injuries.

EPIDEMIOLOGY OF PROXIMAL FEMORAL FRACTURES

Between 220,000 and 250,000 proximal femoral fractures occur in the United States each year[1,2]; 90% of these fractures occur in patients older than 50 years.[1,2] In younger patients, proximal femoral fractures are usually the result of high-energy physical trauma (eg, high-speed motor vehicle accidents) and usually occur in the absence of disease. Intertrochanteric and femoral neck fractures account for 90% of the proximal femoral fractures occurring in elderly patients.[1] Proximal femoral fractures in elderly patients are often pathologic, usually resulting from minimal-to-moderate physical trauma to areas of bone significantly affected by osteoporosis. However, pathologic fractures can occur at any age; typically, these fractures result from low-energy injuries and may be characterized by unusual fracture patterns.[3]

The incidence of proximal femoral fractures among females is 2 to 3 times higher than the incidence of such fractures among males.[1] Also, the risk of sustaining a proximal femoral fracture doubles every 10 years after age 50 years.[1] Other risk factors for proximal femoral fractures include osteoporosis,[1] a maternal history of hip fractures,[4] excessive alcohol consumption,[5] high caffeine intake,[5] physical inactivity,[6] low body weight,[7] previous hip fracture,[8] the use of certain psychotropic medications,[9] visual impairment,[4] dementia,[10] residence in an institution,[11] and smoking.[12]

INITIAL EVALUATION

The evaluation of a patient who definitely or potentially has a hip fracture involves reviewing the patient's medical history, performing a physical examination, and carrying out radiographic studies. The radiographic studies are used to determine the exact location (**Figure 1**) and degree of displacement of the fracture; this information can help clinicians to differentiate the various subtypes of proximal femoral fracture (eg, intertrochanteric, femoral neck, subtrochanteric, greater trochanteric).

The patient's symptoms and the physical examination findings usually depend on the type of fracture and its degree of displacement. For most proximal femoral fractures, ecchymosis generally appears during the first few days after the fractures occur. However, ecchymosis may not develop with femoral neck fractures because the fracture hematoma may be contained within the hip capsule.

Fractures of the proximal femur that are incomplete or nondisplaced may cause only minimal pain with movement and weight bearing. However, clinical evidence of such fractures can be obtained by using the Stinchfield test.[12] With this test, the patient lies in a supine position and attempts to lift the affected leg against gravity and then against weight resistance. If groin or thigh pain is elicited during either of these exercises, the test is positive.

Patients with displaced fractures of the proximal femur usually cannot bear weight and report pain with even slight movement of the affected extremity. The displaced fracture usually causes the leg to shorten and become abducted and externally rotated to some degree.[13] Furthermore, there may be pain or crepitation with palpation of the lateral femur and trochanter.

Most fractures of the proximal femur can be observed on plain radiographs. Standard views include an

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anteroposterior (AP) view of the pelvis and a true lateral view of the hip. With respect to hard-to-see fractures, another view that may be helpful is an AP view obtained with the hip internally rotated approximately 15 degrees.[13] Magnetic resonance imaging (MRI) and technetium bone scans may also prove useful. Although bone scans have a high sensitivity in diagnosing fractures 48 to 72 hours after they occur, MRI has been found to be 100% sensitive, can be used to identify fractures sooner, and is very useful for finding occult fractures.[3]

Patients with acute hip pain and normal results on plain radiographs must be assumed to have a hip fracture until proven otherwise; MRI or a technetium bone scan may be needed to confirm the diagnosis of a symptomatic, nondisplaced fracture.[14–21] If the hip joint is irritable on physical examination, limited MRI is the best technique to confirm a fracture within the first 2 to 3 days after it is thought to have occurred. If the patient's pain is more diffuse, a technetium bone scan of the pelvis, lumbar spine, and hips may be preferred; a 3-day interval between the injury and the performance of this test is necessary to allow sufficient sensitivity. During this 3-day period, patients should practice protected weight bearing and should receive treatment for pain.

GENERAL TREATMENT CONSIDERATIONS

The goal of treatment is to limit pain and to help the patient return to the level of activity he or she had prior to sustaining the fracture. Efforts to attain this goal may or may not involve surgery. Nonoperative treatment is usually reserved for impacted or nondisplaced proximal femoral fractures. The premise behind nonoperative treatment is that if the patient can be mobilized and his or her pain controlled, the risk of complications such as skin breakdown and pulmonary illness is decreased. However, the risk of displacement of the fracture must also be considered. In cases of femoral neck fractures, operative treatment is favored to avoid displacement and possible avascular necrosis of the hip. For most proximal femoral fractures, operative treatment is more appropriate.

Although hip fractures in young patients may be complicated by medical issues, surgical treatment for these individuals is typically emergent. However, for elderly patients, who sometimes have cardiac, pulmonary, and psychiatric comorbidities, an immediate surgical procedure may initially carry too high a risk for substantial morbidity and mortality. Prior to surgery, elderly patients need to be medically evaluated to minimize any potential risks of surgery. Medical work-up usually involves evaluating the patient for hypertension,

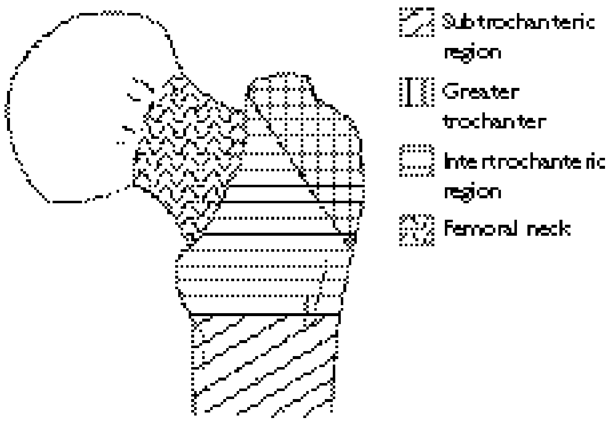

Figure 1. Anatomic regions relating to areas of proximal femoral fractures.

heart disease (including coronary artery disease, dysrhythmias, and congestive heart failure), diabetes mellitus, chronic obstructive pulmonary disease, cerebral vascular disease, and urinary tract infection.

The time needed to perform a complete medical evaluation and treat or manage comorbidities in elderly patients can delay surgery for at least 12 to 24 hours.[7] Although there is conflicting evidence about the mortality rate if surgery is delayed for 24 hours or less, there is substantial evidence suggesting that if surgery is postponed for more than 3 days, the mortality rate within the first year after this treatment doubles.[3,22–27] It may be true, however, that the patients who experience a delay of more than 3 days in undergoing their surgical procedure are the most ill on presentation. Furthermore, prolonging the time before surgery increases the risk of skin breakdown, urinary tract infection, deep vein thrombosis (DVT), and pulmonary complications.[1]

Moreover, if a patient, regardless of age, is receiving anticoagulation therapy because of atrial fibrillation, valve replacement, history of transient ischemic attacks, or other reasons, reversal of this therapy may be appropriate before the surgical procedure is performed. In general, anticoagulation therapy can be reversed by administering fresh frozen plasma or vitamin K (ie, phytonadione). However, fresh frozen plasma is usually transient in its effect and can be associated with transfusion reactions and other problems. Moreover, reversal of the anticoagulative effect of warfarin with vitamin K can be complicated by thrombosis, and doses of vitamin K greater than 10 mg can lead to warfarin resistance for as long as a week.[25] If a patient has been receiving warfarin, the prothrombin time and international normalized ratio (INR) can be allowed to normalize by simply discontinuing the warfarin. In patients with a history of

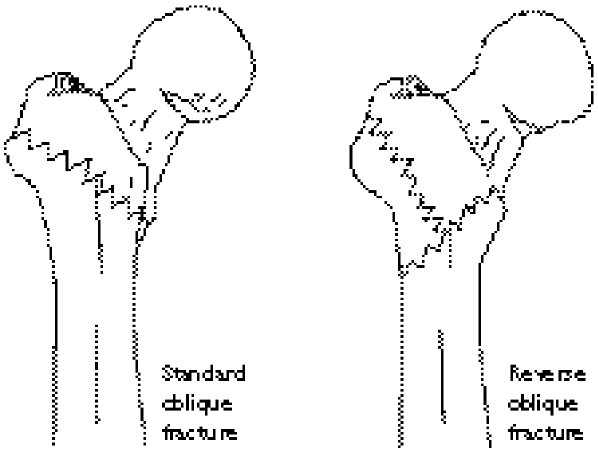

Figure 2. Simplified Evans' classification of intertrochanteric fractures: standard oblique fracture (stable) and reverse oblique fracture (unstable).

transient ischemic attacks, cardiomyopathy, and atrial fibrillation, discontinuation of warfarin is unlikely to lead to an adverse event.[26] However, in patients with prosthetic heart valves whose warfarin anticoagulation therapy is being reversed, unfractionated heparin should be administered as the INR decreases to an acceptable level; the heparin can then be discontinued hours prior to surgery.[26]

Prior to surgery for hip fractures, most patients—irrespective of age—are confined to bed. During this time, they most likely will require an analgesic agent, which can contribute to the increased mental status changes seen in elderly patients. To help with the discomfort of a displaced fracture, 5 lb of longitudinal (Buck's) skin traction can be used, although pillow support alone has been shown to be just as effective.[28] If surgery is delayed for a considerable amount of time, DVT prophylaxis is indicated and can include graduated compression stockings; sequential pneumatic calf, thigh, or ankle pumps; and low-molecular-weight heparin.

INTERTROCHANTERIC FRACTURES

General Characteristics

Intertrochanteric fractures occur in the transitional bone between the femoral neck and the femoral shaft (Figure 1).[27] These fractures may involve both the greater and the lesser trochanters. Transitional bone is composed of cortical and trabecular bone. These bone types form the calcar femorale posteromedially, which provides the strength to distribute the stresses of weight bearing. Consequently, the stability of intertrochanteric fractures depends on the preservation of the posteromedial cortical buttress.[29] Osteonecrosis is uncommon because these fractures usually do not disturb the femoral head blood supply. Moreover, because transitional bone is highly vascular, complications such as nonunions are uncommon as well.[27]

Classification

The most often used classification system for intertrochanteric fractures is based on the stability of the fracture pattern and the ease in achieving a stable reduction.[27] This classification was introduced by Evans in 1949 and accurately differentiates stable fractures (standard oblique fracture pattern) from unstable fractures (reverse oblique fracture pattern) (**Figure 2**). It is important to identify a reverse oblique fracture because this type of fracture should not be treated with a standard compression plate. The stability of intertrochanteric fractures depends on the integrity of the posteromedial cortex, and instability increases with comminution of the fracture, extension of the fracture into the subtrochanteric region, and the presence of a reverse oblique fracture pattern.[27]

Treatment

Surgery is the mainstay of treatment for both displaced and nondisplaced intertrochanteric fractures. The primary reason for surgery is to allow the early mobilization of the patient, with partial weight-bearing restrictions depending on the stability of the reduction.[27]

The most common internal fixation device used today is the sliding screw-plate device (**Figure 3**).[27] This implant consists of a large lag screw placed in the center of the femoral neck and head and a side plate along the lateral femur. The screw-plate interface angle is variable and depends on the anatomy of the patient and the fracture. The advantage of the sliding lag screw, compared with a static screw, is that it allows for impaction of the fragments; this impaction increases the bone-on-bone contact, promoting osseous healing while decreasing implant stress.[27] The disadvantage is common shortening and rotation at the fracture site.

Although repair of an intertrochanteric fracture is often referred to as *open reduction with internal fixation* (ORIF), the term *closed reduction with internal fixation* (CRIF) may be more accurate. The patient rests in a supine position on a fracture table that allows the affected leg to be placed in traction. The fracture is anatomically reduced by longitudinal traction and rotation of the leg.[27] An incision is made, and after the bone is exposed, the lag screw is placed into the center of the femoral neck and head with fluoroscopic guidance. Optimally, the end of the lag screw should be placed in close proximity to the apex of the femoral

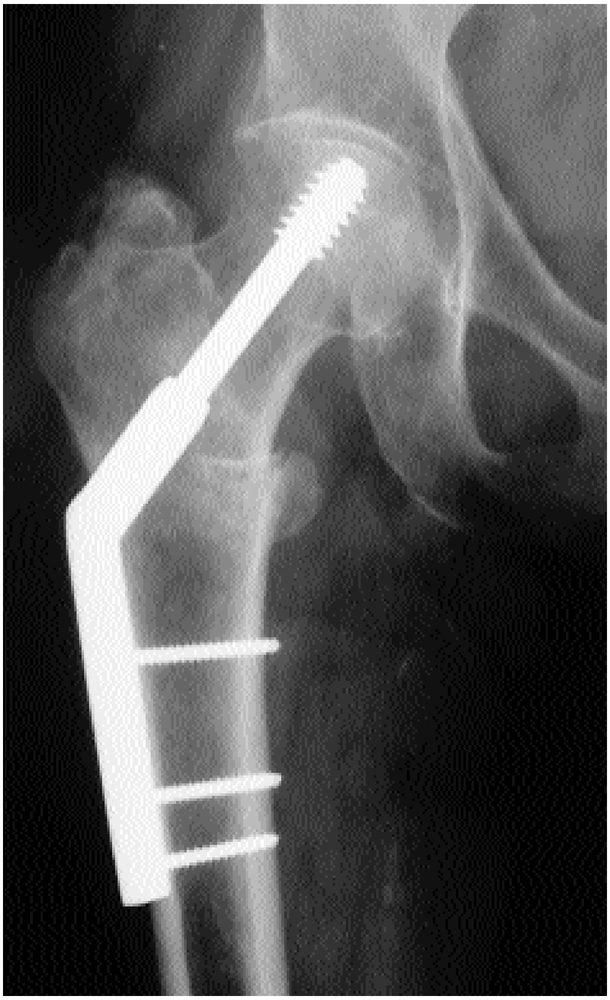

Figure 3. Radiograph (anteroposterior view) of an intertrochanteric fracture treated by way of internal fixation with a lag screw and side plate.

head so that the sum of the distances between the end of the screw and the apex of the femoral head in the AP and lateral views is less than 20 to 25 mm.[30,31] By doing this, the occurrence of the complication known as "cut out" of the lag screw from the femoral head can be almost completely prevented.[30,31] The next step is placement of the sliding side plate device, which is fixed to the shaft of the femur by using cortical screws.

CRIF of intertrochanteric fractures may allow for immediate weight bearing.[27] Depending on the stability of the fracture and its fixation, touchdown weight bearing or partial weight bearing is usually recommended for 4 to 6 weeks after the surgical procedure. When signs of healing are apparent and fracture collapse has diminished, weight-bearing status is usually increased. Long-term problems after these fractures

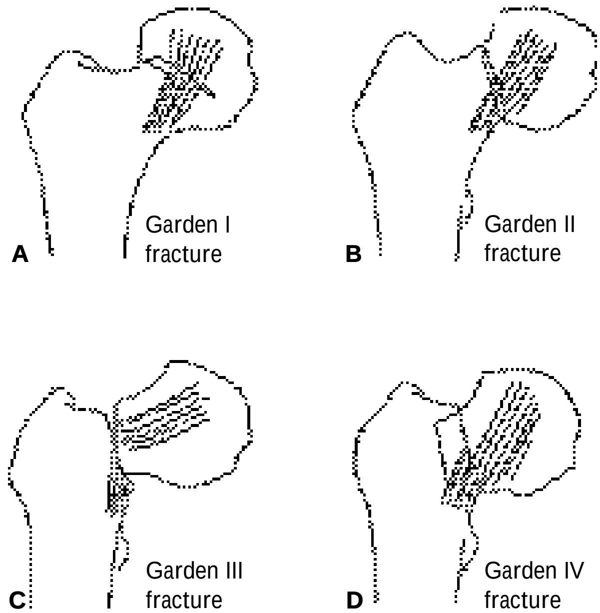

Figure 4. Garden classification system of femoral neck fractures. (**A**) Garden I fracture: incomplete and minimally displaced. The fracture shown is impacted and is in valgus malalignment. (**B**) Garden II fracture: complete, nondisplaced. (**C**) Garden III fracture: complete fracture and partially displaced. The fracture shown is in varus malalignment. (**D**) Garden IV fracture: completely displaced, with no engagement of the 2 principal fragments.

are healed include malrotation, abductor muscle biomechanical abnormalities, pain (owing to the hardware), and shortening of the leg at the fracture site (because of collapse).

FEMORAL NECK FRACTURES

General Characteristics

Femoral neck fractures occur between the end of the articular surface of the femoral head and the intertrochanteric region (Figure 1).[32] These fractures are intracapsular, and hip synovial fluid may interfere with their healing.[3] Healing may also be affected by disruption of the arterial blood supply to the fracture site and the femoral head; with femoral neck fractures, the lateral ascending cervical branches of the medial femoral circumflex artery are at risk for disruption. Loss of this blood supply increases the risk of nonunion at the fracture site and the risk for avascular necrosis of the femoral head.

Classification

The most commonly used classification system for femoral neck fractures is the Garden system (**Figure 4**).[3]

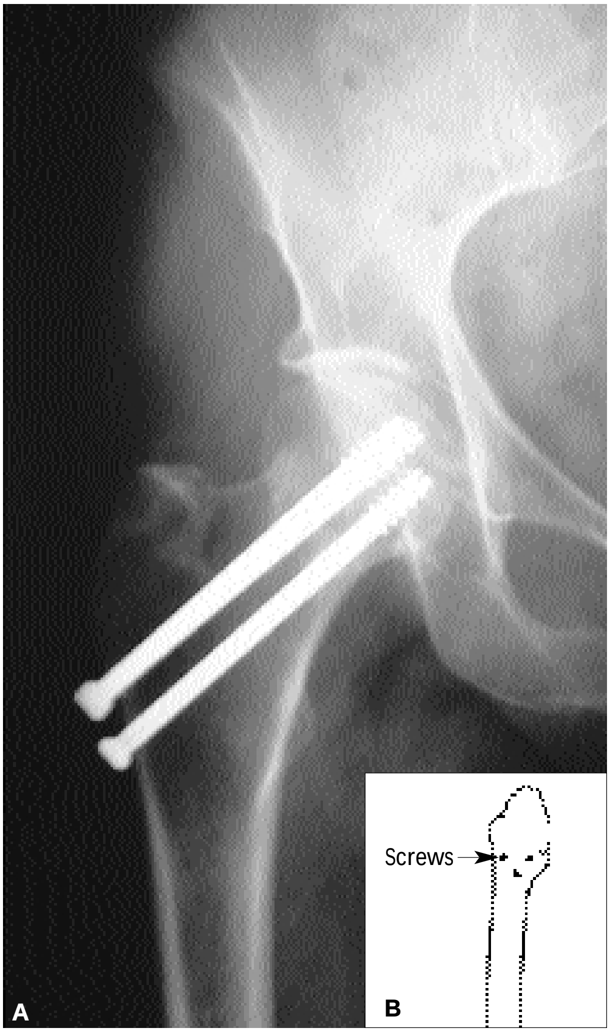

Figure 5. (**A**) Radiograph (anteroposterior view) of a valgus, impacted (Garden I) femoral neck fracture treated by way of internal fixation with 3 parallel cannulated lag screws. (**B**) Schematic representation of screw configuration as viewed from the side.

The Garden system is based on the amount of displacement of the fractures. Garden I fractures are minimally displaced and incomplete and are usually impacted with the femoral head tilting in the posterolateral direction. Garden II fractures are complete but nondisplaced. Garden III fractures are complete and partially displaced, and Garden IV fractures are completely displaced.[3] Although the Garden system is the most commonly used system of classification, there is much interobserver variability.[3]

Treatment

Operative treatment is favored for femoral neck fractures. The specific type of operative treatment depends on the age of the patient and the characteristics of the fracture (eg, location, displacement, degree of comminution).[1] In young patients, it is necessary to obtain reduction of the femoral neck fracture as soon as possible to decrease the risk of avascular necrosis.[3] Anatomic reduction and subsequent fixation are the goals of surgery. Young patients usually undergo closed or open reduction, with percutaneous placement of 3 parallel cannulated lag screws (**Figure 5**). The procedure is performed with the patient in a supine position on a fracture table. The parallel cannulated lag screws allow compression at the fracture site and maintain reduction while the fracture heals.

Elderly patients who have Garden I or II fractures also benefit from parallel cannulated screw fixation, although this is usually performed *in situ*. Hemiarthroplasty is the procedure of choice for elderly patients with displaced femoral neck fractures. The previous activity level of the patient is important in determining the exact type of hemiarthroplasty to perform.[3] Independent ambulators benefit from a cemented hemiarthroplasty, because pain after surgery and component loosening are minimal with this approach. Hemiarthroplasty is most often performed with patients in the lateral decubitus position. After the incision is made and the joint exposed, the femoral head is extracted and the femoral neck is cut to allow placement of the prosthesis. There are many different prosthetic devices, ranging from unipolar devices (including the Austin-Moore prosthesis) to bipolar devices (**Figure 6**). The majority of these prostheses are cemented; however, in elderly patients, who usually have compromised cardiopulmonary reserves, excessive pressurization of the cement is avoided to prevent further metabolic and mechanical insult.[3]

Weight bearing after surgery for patients of all ages is dependent on the fracture type, patient demands and compliance, and surgeon preference. In general, patients who have undergone reduction and fixation with cannulated lag screws usually have a restricted weight-bearing status after the procedure. In contrast, patients who have undergone hemiarthroplasty can be allowed to bear weight as tolerated; certain restrictions of position are encouraged to prevent dislocation.

SUBTROCHANTERIC FRACTURES

General Characteristics

Subtrochanteric fractures occur between the lesser trochanter and the isthmus of the diaphysis of the femur (Figure 1).[3] These fractures are less common than femoral neck and intertrochanteric fractures.

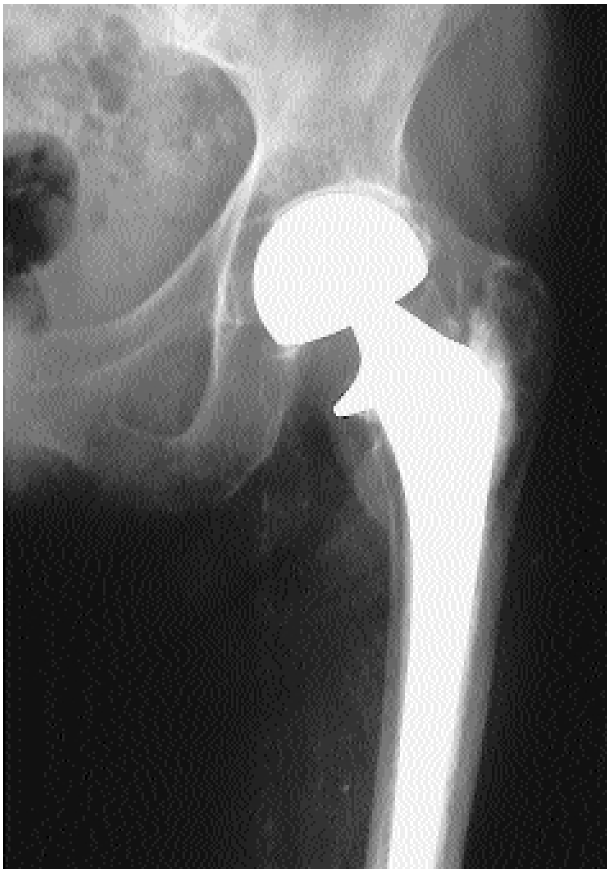

Figure 6. Radiograph (anteroposterior view) of a displaced femoral neck fracture treated by way of femoral head replacement with a bipolar prosthetic device.

Classification

Classification systems for subtrochanteric fractures have evolved in relation to the development of new treatment devices. Early classification systems were based on the location of the fracture and the number of fracture fragments.[3] With the advent of special intermedullary rods that can be used to treat these fractures, the Russell-Taylor classification system was established.

The Russell-Taylor system is based on the lesser trochanter continuity and whether the fracture extends posteriorly into the greater trochanter and involves the piriformis fossa **(Figure 7)**[3]; this system comprises 2 types of fractures. These fracture types can be differentiated on the basis of the appropriate use of the intramedullary nail. For type I fractures, which do not extend into the piriformis fossa, closed intramedullary nailing has the advantage of minimizing vascular compromise of the fragments.[3] In contrast, type II fractures involve the greater trochanter and the piriformis fossa, making use of closed intramedullary nailing less favorable.[3]

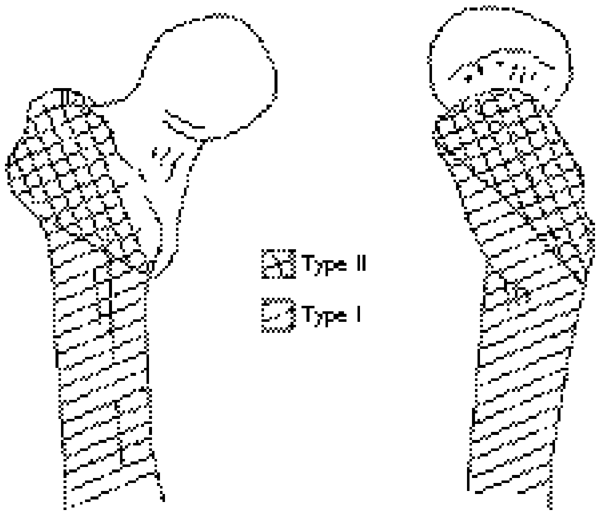

Figure 7. Russell-Taylor classification of subtrochanteric fractures. Type I fractures do not extend into the piriformis fossa, and thus, intramedullary nailing can be beneficial. Type II fractures extend proximally into the greater trochanter and involve the piriformis fossa; this involvement complicates closed intramedullary nailing techniques.

Treatment

Treatment options for subtrochanteric fractures include nonoperative and operative methods. However, as with intertrochanteric and femoral neck fractures, the mainstay of treatment is surgery.

The goal of treatment is fracture reduction so that near anatomic alignment and normal femoral anteversion are obtained. One option involves use of an intramedullary nail with interlocking hardware that extends into the femoral neck. Another option involves a fixed angle extramedullary device, such as a 95-degree lag screw and side plate or blade plate (**Figure 8**). The screw and side plate and blade plate have been shown to have high rates of fracture union when used with fractures involving the piriformis fossa, but intramedullary nails have been recommended if the posteromedial cortical buttress cannot be established in unstable fractures.[3] It has also be suggested that the fixed angle extramedullary devices do not allow compression at the fracture site[3]; however, with the use of a plate tensioning device, this can be overcome.

After fracture fixation, the patient usually requires protected weight bearing for 6 to 12 weeks, and as callous formation is observed radiographically, weight bearing is slowly increased. Operative treatment allows for immediate mobilization and pain management and decreases the risk of complications such as skin breakdown, DVT, and pulmonary abnormalities.

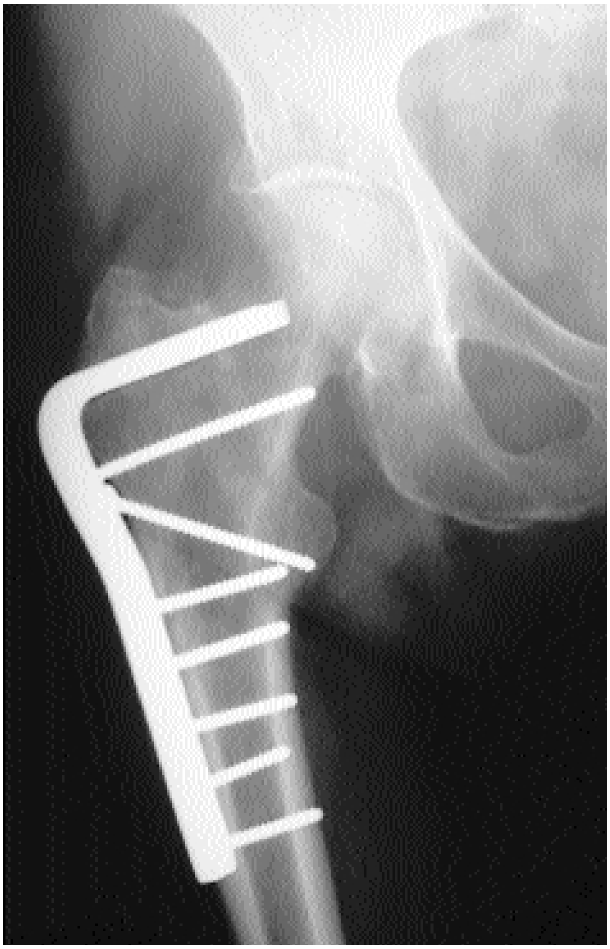

Figure 8. Radiograph (anteroposterior view) of a subtrochanteric fracture treated by way of internal fixation with a blade plate.

GREATER TROCHANTERIC FRACTURES

General Characteristics

The greater trochanter is the insertion site of the gluteus medius and gluteus minimus (which aid in hip abduction) and the insertion site of the piriformis, obturator internus, and gemelli muscles (which aid in hip rotation) (Figure 1).

Classification

There are 2 common types of greater trochanteric fractures. The first and most common is avulsion of the greater trochanteric apophysis of the femur, which occurs in skeletally immature patients.[13] This fracture usually occurs from a powerful muscle contraction of the lateral hip rotators and is usually minimally displaced.[13] The second type of greater trochanteric fracture usually occurs in an elderly patient who has osteoporosis and results from direct trauma, such as a fall.[3] These fractures are most commonly minimally displaced, but the portion of the bone attached to the piriformis muscle can be markedly displaced.

Treatment

Both types of fracture can be treated conservatively with protected weight bearing on the affected leg until the symptoms resolve.[3,13] However, a nondisplaced greater trochanteric fracture that results from a fall needs to be evaluated to confirm that the fracture does not extend into the intertrochanteric region**,** which could result in displacement of the fracture. To evaluate the fracture, limited MRI[3] or a bone scan may be useful. If the trochanteric fracture involves a large, completely displaced, and mechanically significant fragment of bone, it may require reduction and fixation. Screws, cable devices, and tension band techniques have all been advocated in such cases to reattach the insertion site of the hip abductors and hip rotators to the proximal femur.

PROGNOSIS OF PROXIMAL FEMORAL FRACTURES

Most of the studies evaluating the prognosis of proximal fractures of the femur compare intertrochanteric fractures with femoral neck fractures. In the surgical treatment of intertrochanteric fractures, “cut out” of the implanted hardware is a preventable complication. However, following surgery, loss of fixation of any type is less than 15% for both intertrochanteric and femoral neck fractures.[1] Other complications of surgical treatment of proximal femoral fractures, such as nonunion and osteonecrosis, occur more often with femoral neck fractures than with intertrochanteric fractures.[1]

Complications that occur with hemiarthroplasty for femoral neck fractures include dislocation of the prosthesis in addition to prosthesis loosening. The dislocation rate is related to technique, but the overall incidence is low and can be decreased with strict hip-movement precautions taught to the patient by the physical and occupational therapists.

Hospital stays tend to be longer for patients with intertrochanteric fractures, as opposed to femoral neck fractures; likewise, a higher portion of patients with intertrochanteric fractures require placement in a nursing home.[2] Furthermore, although the overall 1-year mortality rate is the same among patients with intertrochanteric fractures and those with femoral neck fractures, patients with intertrochanteric fractures have a slower recovery rate and a higher mortality rate in the hospital at 2 months and at 6 months.[2]

Elderly men are twice as likely to die soon after a hip fracture than are elderly women. In a study of 804 community-dwelling patients, 31% of the men died within 1 year of sustaining a hip fracture and 42% within 2 years.[33] In comparison, only 15% of the women in the study died within 1 year and 23% within 2 years.[33]

PREVENTION OF HIP FRACTURES

Recovery from a hip fracture is complex and multidimensional: substantial losses in contralateral hip bone mineral content, lean body mass, and performance and function are not fully rectified in most cases. Therefore, prevention is important, especially for an aging population. By 2020 the estimated number of proximal femoral fractures expected to occur in the United States is 350,000 per year—and by 2040, between 530,000 and 840,000 fractures are expected to occur.[2]

Two preventive strategies to deal with this epidemic are the use of passive protective garments and prevention and treatment of osteoporosis. Passive protection through the use of hip pads has recently been demonstrated, and a gel pad with a rigid cover has been shown to diminish the impact of falls.[34] Current research is focusing on who should wear these garments and the best way to increase patient comfort and compliance.

The prevention and treatment of osteoporosis may significantly decrease the risk for hip fracture. It is particularly important to address this issue with respect to all elderly patients being treated for their first hip fracture. The incidence of hip fractures is increased among women older than 60 years who have sustained a hip fracture in the past. Bone mineral density measured at the femoral neck by dual energy x-ray absorptiometry may be the best predictor of hip fracture. Awareness of osteoporosis and a multifaceted team approach to osteoporosis prevention and treatment are the best strategy to prevent fractures.

CONCLUSION

Hip fracture is a common and debilitating injury necessitating hospital admission. The hospital physician should have a clear understanding of the scope of this problem, as well as the basic types of fracture and treatment options. The care and rehabilitation of elderly patients with hip fractures raise social and economic issues that extend beyond orthopaedic management and involve many different parts of the health care team. **HP**

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