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Fractures of the Femoral Neck

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Abstract

Fractures of the femoral neck are increasing at an exponential rate as a result of the longevity of the general population. The Garden and Pauwels classifications both are routinely used to describe displacement and stability of femoral neck fractures. Osteonecrosis and nonunion remain problematic because of the compromised blood supply to the femoral head in displaced fractures. Nondisplaced fractures and displaced fractures in patients physiologically younger than 65 years are treated with closed or open reduction and internal fixation. Anatomic reduction is the single most important step in the treatment and fixation of these difficult fractures. Because of the higher complication rate in patients physiologically older than 65 years, a prosthetic replacement may be considered for the treatment of displaced fractures. In patients who are low-level community ambulators or nursing home ambulators with comorbidities and who are not expected to live more than 5 years after injury, a hemiprosthesis is indicated. In active, elderly patients physiologically older than 65 years who are expected to live longer than 5 years after injury, a total hip replacement is the treatment of choice. Total hip replacement relieves pain and allows faster rehabilitation than other forms of treatment in this age group. Patients with preexisting hip disease also are treated with total hip replacement. An algorithm that considers physiologic age and activity level of the patient is helpful when deciding whether to fix or replace the hip in a patient with a displaced femoral neck fracture. It is also useful in deciding what type of prosthesis to use. The treatment of femoral neck fractures remains complex and difficult. Because of the enormous burden of this injury, orthopaedists must improve results in the care of femoral neck fractures.

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Fracture of the femoral neck is a common injury that is occurring more frequently. Most femoral neck fractures occur in elderly patients and usually result from a fall. In patients younger than 65 years, the injury is generally caused by a motor vehicle crash or other high-energy mechanism. Because of the intracapsular nature of the fracture, it is not apparent on initial presentation in elderly patients, unless transport has been delayed or overriding medical problems are present. In younger patients, multiple trauma or other serious injuries are present.[1,2] Twenty percent of young patients who have a femoral neck fracture also have a fracture of the ipsilateral femoral shaft.[2,3] Because the surgeon often focuses on the femoral shaft fracture, the femoral neck fracture may be missed in as many as 40% of these patients.

Clinical Presentation

Clinical signs and symptoms at presentation may be minor in a patient who has an incomplete, impacted, or nondisplaced fracture of the femoral neck. Internal rotation of the limb almost always elicits pain in the region of the hip and groin when a femoral neck fracture is present. In displaced femoral neck fractures, there is shortening and external rotation of the limb, with the hip usually held in slight abduction. The patient is in severe pain, and any attempt to move the hip causes pain. If a femoral neck fracture is suspected, the patient will be most comfortable with a pillow placed beneath the knee and the hip moderately flexed. This position allows

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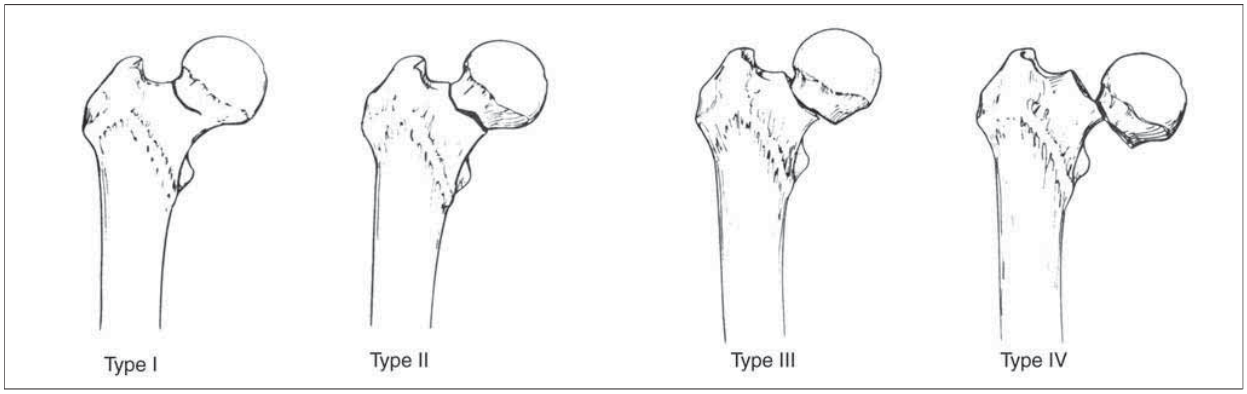

Figure 1 Garden classification for fractures of the femoral neck. (Reproduced with permission from Kyle RF, Gustilo RB, Templeman DC: Fractures of the hip, in *Fractures of the Hip*. St Louis, MO, Mosby-Yearbook, 1993, vol 2, p 795.)

relaxation of the hip capsule and reduces pressure and pain in the hip joint.

Radiographic Evaluation

Standard AP and lateral radiographs of the hip are essential when evaluating a femoral neck fracture. Any discontinuity in the cortical outline or overlapping of the trabecular pattern of the head and neck should be noted. Displaced femoral neck fractures are quite obvious; the surgeon should pay particular attention to the lateral radiograph to evaluate the amount of posterior comminution because the greater the degree of comminution, the greater the instability of the fracture. Nondisplaced fractures that cannot be seen on plain radiographs are apparent on an MRI scan immediately and on a bone scan after 3 days. A negative MRI scan assures the surgeon that there is no hip fracture.[4]

Classification

The Garden classification is the most widely accepted classification of femoral neck fractures and primarily describes subcapital fractures.[3,5-8] Types I through IV are based on the degree of displacement evident on an AP radiograph of the hip (Figure 1). These grades correspond to both the prognosis for healing and the rate of osteonecrosis. Displaced fractures (types III and IV) are associated with a higher prevalence of osteonecrosis and nonunion than are nondisplaced fractures (types I and II).[5-8]

An alternative classification system, in which the type of femoral neck fracture is based on the angle formed by the fracture line and the horizontal plane, was proposed by Pauwels.[9] Fractures that are more vertical are subject to higher shear stresses and are associated with a correspondingly poorer prognosis.[9] The closer the fracture line to the horizontal, the less shear force is exerted on the fracture or on any device used to fix the fracture. The more vertical the fracture line, the more unstable the fracture. The more vertical the fracture, the higher the failure rate.[10] The rotation of the femoral head and the amount of comminution of the femoral neck also must be considered when the severity of the fracture is estimated. Neither of these classification systems takes into account the rotational alignment of the head or the degree of posterior comminution. Rotational malalignment is difficult to diagnose, but its presence should be suspected when the major compressive trabeculae in the head and neck are not aligned accurately, even if there is overall good alignment of the cortical shells (Figure 2).

Treatment

All patients must be evaluated thoroughly and their medical condition stabilized before they are taken to the operating room.[11] The optimal timing for internal fixation of femoral neck fractures remains controversial.[12-14] Several authors have reported lower rates of osteonecrosis and nonunion in patients who had emergent reduction and rigid internal fixation of the fracture.[14-17] In contrast, Barnes and associates,[12] in one of the largest overall series of femoral neck fractures, did not identify a significant increase in the rate of osteonecrosis or nonunion when fixation had been delayed for as long as 1 week. In an animal model, Swiontkowski and associates[18] showed that a minimal increase in intracapsular pressure occludes the blood supply to

the femoral head. There is a theoretical advantage, on the basis of the pathophysiology of the fracture, to reduction and stabilization of the fracture as soon as the patient is medically stable.

The treatment of the fracture depends primarily on the physiologic age of the patient and the degree of displacement. A patient who has a nondisplaced or a minimally displaced femoral neck fracture is at low risk (0% to 10%) for osteonecrosis or nonunion if the degree of displacement remains unchanged.[8] These fractures are best treated with internal fixation to prevent displacement and to decrease the attendant risks of osteonecrosis and nonunion.[19]

The treatment of displaced femoral neck fractures is based on the age and the physical demands of the patient. In a younger, healthy, physically active patient, every effort should be made to preserve the femoral head. In an elderly, physically debilitated patient, a second operation can be avoided by using primary prosthetic replacement. There is, however, no documentation as to the exact age at which reduction and internal fixation to preserve the femoral head should be abandoned in favor of prosthetic replacement.

A patient with a displaced femoral neck fracture who is physiologically younger than 65 years and capable of withstanding a second operation should be treated with reduction and internal fixation. A patient who is physiologically older than 65 years should be considered a candidate for primary prosthetic replacement to avoid a second operation. Because of the high reoperation rate in patients with displaced fractures, those patients between ages 65 and 85 years who are considered active are candidates for a total hip replacement (Figure 3). A patient's physiologic age is dependent on concurrent medical conditions that result in a change in activities of daily living and is not always the same as chronologic age. Total hip replacement also may be chosen when a patient has severe preexisting hip disease, such as osteoarthritis or rheumatoid arthritis compounded by a femoral neck fracture. In the 2004 report of Schep and associates,[20] treatment

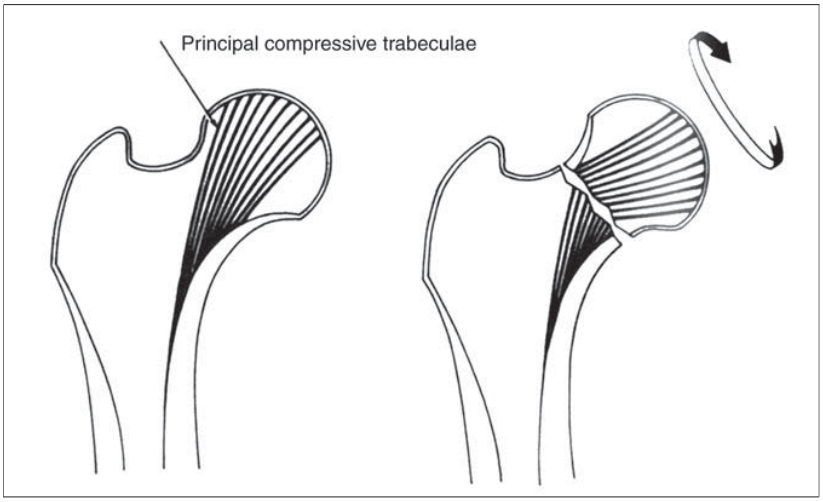

Figure 2 Rotational malalignment of the femoral head can be determined on the basis of observation of the malalignment of the compressive trabeculae. (Reproduced with permission from Kyle RF, Gustilo RB, Templeman DC: Fractures of the hip, in *Fractures of the Hip*. St Louis, MO, Mosby-Yearbook, 1993, vol 2, p 796.)

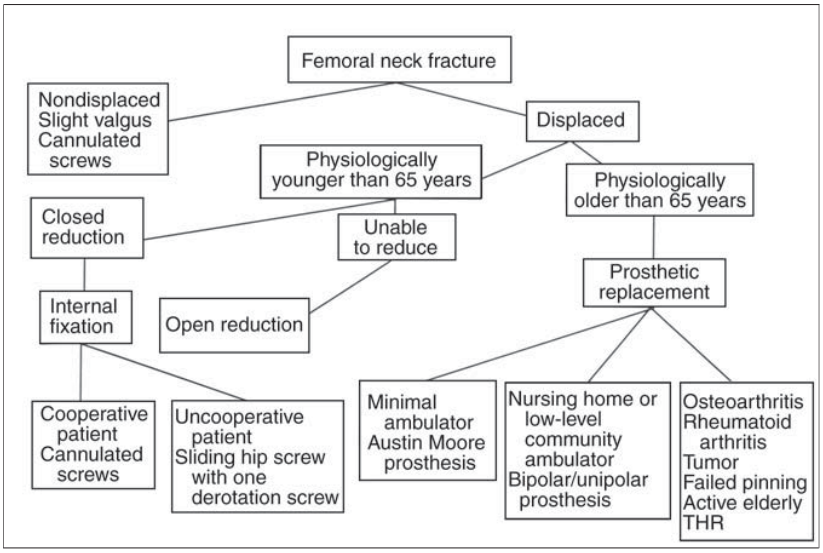

Figure 3 Algorithm indicating the various methods of treatment of fractures of the femoral neck, as determined by the amount of displacement of the fracture, the physiologic age of the patient, and whether there is a history of hip disease. THR = total hip replacement.

was selected with a 20-point scale based on activity and comorbidity. This algorithm substantially reduced the rate of osteonecrosis and nonunion in patients with displaced femoral neck fractures. A patient older than 85 years was treated with prosthetic replacement. Patients between ages 70 and 85 years were given a physiologic score based on walking aids, mental status, and comorbidities. Higher-scoring patients were treated with internal fixation, and lower-scoring patients were treated with prosthetic replacement. This scheme showed the value of a treatment protocol based on a patient's physiologic age to help the surgeon decide between internal fixation and prosthetic replacement.

Various options for prosthetic replacement are available. The choice of the prosthesis depends on the walking requirements of the patient and the degree of associated hip disease. In a patient who cannot walk and transfers only from bed to chair, a one-piece hemiprosthesis without cement may be used. This type of prosthesis is best suited for patients who do not walk because weight bearing on the uncemented prosthesis is associated with a high prevalence of both pain and acetabular protrusion.[21]

For a patient who is a low-level community ambulator or nursing home ambulator, a bipolar or unipolar prosthesis with cement has yielded good results.[21,22] Despite multiple studies comparing the use of bipolar and unipolar hemiprostheses, there is no evidence of superiority in either head replacement system reported to date. All randomized, prospective studies that compare hemiprosthetic replacements and total hip replacements record a higher hip score after a total hip replacement.[22] These studies have shown that in patients followed long term, a total hip replacement gives the best clinical result and also is the most cost-effective treatment.[22,23] These studies calculate the overall cost of treatment by adding the initial cost of treatment to the cost of treating the complications. When revision rates in reduction and internal fixation and hemiprosthesis in long-term studies are compared, the overall cost of total hip replacement is less.[23] For this reason, in an active elderly patient with a femoral neck fracture, total hip replacement is the treatment of choice when prosthetic replacement is appropriate. A total hip replacement is also the treatment of choice in patients with a femoral neck fracture and associated severe osteoarthrosis, rheumatoid arthritis, or cancer.

Results

A patient who has a displaced femoral neck fracture is at high risk for both osteonecrosis and nonunion. Several authors, in studies of more than 100 patients, reported an average rate of nonunion of 20% (range, 6% to 40%) and an average rate of osteonecrosis of 25% (range, 10% to 43%).[12,24-32] In a study of 1,000 nonpathologic fractures, including 670 displaced fractures, Arnold and associates[24] reported an overall rate of nonunion of 15%. In the patients who had a displaced fracture, the rate of osteonecrosis was 12%, and in those who had a nondisplaced fracture, it was 7%. In their study of 1,503 subcapital fractures, Barnes and associates[12] reported that 289 (19%) did not unite and 183 (12%) had late segmental collapse after 3 years of follow-up.

In a 1935 study by Speed,[33] an osteonecrosis rate of 30%, a nonunion rate of 20%, and a reoperation rate of 36% were reported. In a recent meta-analysis by Bhandari and associates,[34] an osteonecrosis rate of 12%, a nonunion rate of 9%, and a reoperation rate of 34% were reported. The treatment results of femoral neck fractures have not improved substantially in the past 30 years.

Protzman and Burkhalter[3] reported disastrous results, including very high rates of osteonecrosis and nonunion in 19 patients (86%) and 13 patients (59%), respectively, of 22 patients who had femoral neck fractures and were younger than 55 years. In a study of 27 patients younger than 50 years, Swiontkowski and associates[2] reported no nonunion, and osteonecrosis developed in 5 patients (19%). In a study by the Orthopaedic Trauma Hospital Association, Kyle[1] reported the rates of osteonecrosis (15%) and nonunion (25%) of 120 patients younger than 55 years. These rates of osteonecrosis and nonunion are consistent with those reported in elderly patients.

Evaluation of Reduction and Acceptable Guidelines

A poor reduction of a femoral neck fracture prevents reestablishment of the blood supply to the femoral head and decreases the amount of apposition of bone between the proximal and distal fragments, leaving poor mechanical stability after fixation. Garden[7] and others[1,2] have shown that reduction of more than 20° of valgus is associated with a higher rate of osteonecrosis. Any varus deformity after reduction is also associated with increased rates of osteonecrosis and nonunion.[1] Anterior or posterior angulation of more than 10° should not be accepted, particularly in osteoporotic bone; such angulation increases the potential for redisplacement of the fracture because the bone is weak. The

surgeon should pay particular attention to the degree of posterior comminution seen on the lateral radiograph.

Both Garden[6,8] and Banks[35] have shown that fractures with marked posterior comminution have a higher prevalence of nonunion. When treating fractures with a large amount of posterior comminution, the surgeon should place the inferior and posterior screws along the calcar femorale to resist posterior collapse. A displaced fracture that cannot be reduced closed in an elderly patient who has high functional requirements and is a community ambulatory (generally, a patient who is younger than 70 years and has few medical conditions) should be treated with open reduction and internal fixation. In a more fragile, elderly patient, the surgeon should proceed with prosthetic replacement.

The use of screws is a simple and effective technique for fixation of well reduced femoral neck fractures. Stability at the fracture site is maximized by the placement of three screws in a triangular configuration.[36] Mechanical studies have not proved the effectiveness of the use of more screws.

Care must be taken to place the pins or screws at an angle of 130° to 135° in relation to the femoral shaft. If they are positioned at a higher angle (140° to 145°), the holes will be created in the lateral cortex, at or distal to the level of the lesser trochanter. Holes at this location have been associated with a 20% prevalence of subtrochanteric fracture.[37]

Surgical Technique With the Use of Three Cannulated Screws

A 1/8-inch (0.32-cm) guide pin is laid along the anterior aspect of the femoral neck at an angle of 135°, according to the technique of Tronzo.[38] This guide pin should appear, on image intensification, to lie adjacent to the medial cortex of the femoral neck. A 3.8-mm drill hole is made in the middle part of the lateral cortex, parallel to the anterior guide pin. The position of the drill bit is checked on AP and lateral radiographs. The drill is then removed, and the guide pin is placed in the drill hole. Under image intensification, the guide pin is tapped into place along the medial cortex of the femoral neck and into the head to within 5 mm of the subchondral bone. The guide pin should lie slightly inferior in the femoral head on the AP radiograph and in the center of the head on the lateral radiograph. After this guide pin has been placed, two more guide pins are inserted with the use of image intensification. On the AP radiograph, these pins lie slightly superior in the femoral head; on the lateral radiograph, one lies slightly anterior and the other slightly posterior, forming a triangular pattern of guide pins. Next, the length of the screws to be implanted is determined by direct measurement of the guide pins, each of which lies within 5 mm of the subchondral bone of the femoral head (Figure 4). Cannulated screws are then driven over the guide pins. The inferior screw is placed first, followed by the superior screws. The screws should be tightened simultaneously to apply uniform compression across the fracture and to avoid tipping of the femoral head into varus angulation. The guide pins are then removed, and image intensification is used to confirm the proper position of all three screws.

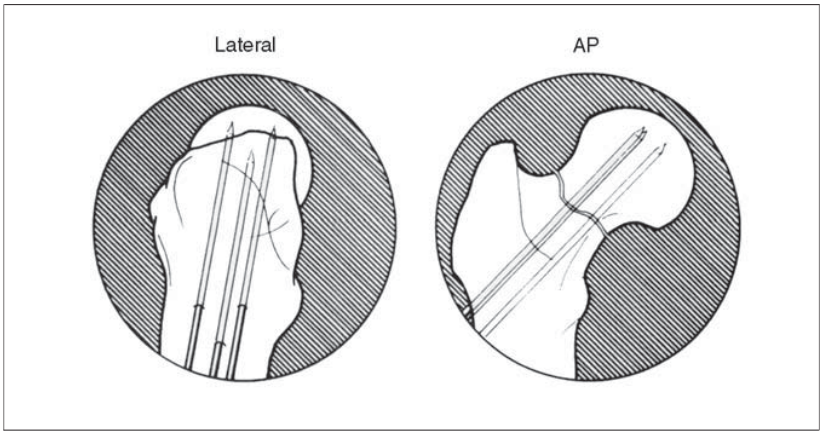

Figure 4 C-arm views of proper placement of guide pins. (Reproduced with permission from Kyle RF, Gustilo RB, Templeman DC: Fractures of the hip, in *Fractures of the Hip*. St Louis, MO, Mosby-Yearbook, 1993, vol 2, p 807.)

Complications

Nonunion

Nonunion of femoral neck fractures, which usually becomes apparent within 1 year, was reported in 34 of 301 patients (11%) in one series[39] and in 39 of 119 patients (33%) in another series.[2] Arnold and associates[24] reported a 15% rate of nonunion in 1,000 patients who had a displaced fracture. This range of occurrence may be explained by differences in the types of fractures and

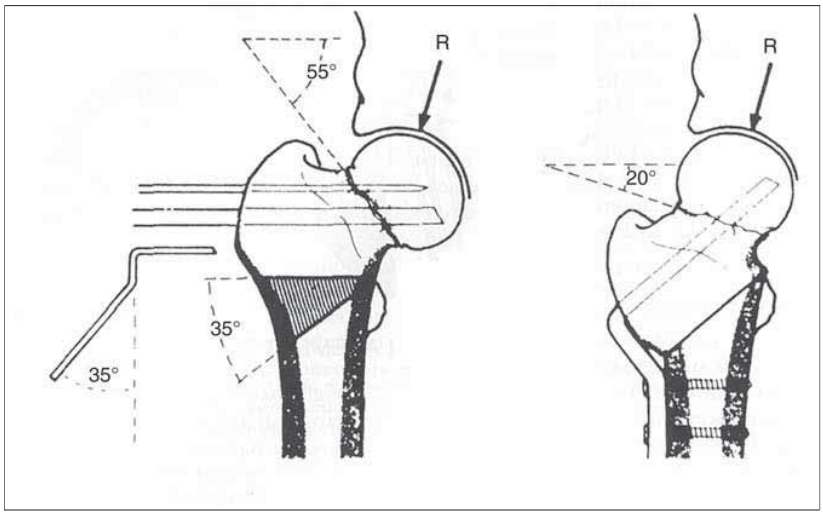

Figure 5 Drawings showing the technique for a valgus osteotomy of the proximal end of the femur in the treatment of a nonunion of a femoral neck fracture. The osteotomy changed the vertical orientation of the fracture line from 55º to 20º. R = joint reaction force. (Reproduced with permission from Weber BG, Cech O: *Pseudoarthrosis*. Bern, Switzerland, Hans Huber, 1976.)

in the methods used for reduction and fixation. Nonunion may or may not be accompanied by osteonecrosis. If nonunion occurs, MRI must be used to evaluate the viability of the femoral head before the options for treatment are considered. In an elderly patient who is a community ambulator, nonunion is treated with a total hip replacement; in a younger patient, a Pauwels valgus osteotomy and repeat fixation are used.[40] Most nonunions have drifted into some varus angulation, and a valgus intertrochanteric osteotomy allows compression loads to occur at the fracture site to promote healing[40] (Figure 5). In a younger patient who has collapse of the femoral head concurrent with a nonunion, a total hip replacement is indicated.

Osteonecrosis

Overall, the reported rate of osteonecrosis in patients who have had a displaced femoral neck fracture has ranged from 4% to 40%.[12,16,19,24,26-28,31,32,39] Fielding and associates[28] reported osteonecrosis in 40 of 256 patients (16%). The wide range in rates may be explained, at least in part, by differences in the types of fracture and in the respective authors' chosen methods of reduction and fixation. Osteonecrosis is usually partial and does not involve the entire femoral head. In many patients, the head does not collapse. If a patient is asymptomatic, no additional treatment is indicated. If the osteonecrotic fragment has collapsed and the patient is symptomatic but is able to walk about the community, a total hip arthroplasty is indicated.

Surgical Technique for Fractures of the Femoral Neck and the Ipsilateral Femoral Shaft

Special considerations may be necessary for a young patient who has a fracture of the ipsilateral femoral shaft. The injury of primary importance in this fracture complex is the femoral neck fracture, which must be reduced and stabilized before fixation of the femoral shaft is attempted. The fracture of the shaft may be treated with intramedullary fixation with a retrograde nail or a plate. The femoral neck should be reduced and fixed with cannulated screws by the technique described earlier. This approach allows the surgeon to adequately stabilize the more critical femoral neck fracture in the standard fashion. The femoral shaft may then be plated or nailed without fear of disrupting the femoral neck fixation.

Summary

Proper treatment of femoral neck fractures depends on the age of the patient and the degree of fracture displacement. Concomitant injuries and medical conditions must also be evaluated. A nondisplaced femoral neck fracture should be fixed in situ for the best results. A displaced femoral neck fracture remains the "unsolved fracture."[33] Reduction and fixation should be performed as soon as the patient is medically stable. Anatomic reduction and solid stabilization with multiple point fixation, with the use of cannulated screws, is the best way to prevent osteonecrosis and nonunion.

In the physiologically elderly patient who is not expected to live more than 5 years after surgery and is a low-level ambulator with a displaced femoral neck fracture, a cemented hemiprosthetic replacement is the best option. Total hip arthroplasty may be used in the active elderly patient who is expected to live more than 5 years after surgery; this treatment option has been shown to provide the best functional outcome with the least cost at long-term follow-up. Total hip arthroplasty

also should be used in patients with concomitant hip disease, such as osteoarthritis or rheumatoid arthritis, and where fixation has failed. A treatment algorithm is valuable in determining the correct treatment for any given patient.

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