Hip Fractures: I. Overview and Evaluation and Treatment of Femoral-Neck Fractures

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Abstract

Hip fractures remain a major source of morbidity and mortality in the elderly, and their incidence is increasing as the population ages. Surgical management followed by early mobilization is the treatment of choice for most patients with hip fractures. However, all comorbid medical conditions, particularly cardiopulmonary and fluid- electrolyte imbalances, must be evaluated and stabilized prior to operative intervention. Nondisplaced femoral-neck fractures should be stabilized with multiple parallel lag screws or pins. The treatment of displaced femoral-neck fractures is based on the patient's age and activity level: young active patients should undergo open reduction and internal fixation; older, less active patients are usually treated with hemiarthroplasty, either uncemented or cemented. Regardless of treatment method, the goal is to return the patient to his or her prefracture level of function.

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Hip fractures are a common and often devastating injury in the geriatric population, with an impact that extends far beyond the obvious orthopaedic injury into the domains of medicine, rehabilitation, psychiatry, social work, and medical economics. Despite improvements in patient care, including advances in surgical technique and implant technology, hip fractures continue to consume a major portion of national health care resources.

The increasing number of hip fractures that occur each year has made it difficult to keep pace with this growing health care problem. Currently, over 250,000 hip fractures occur in the United States each year, but with the aging of the population, the annual number of hip fractures is projected to double by the year 2050. While prevention of osteoporosis is the key to reducing these numbers, we must continue to seek refinements and improvements in surgical technique and perioperative care to optimize patient outcomes.

This article will review general treatment principles applicable to all hip fractures and the management specific to femoral-neck fractures.

Management of Hip Fractures

General Principles

The primary goal of fracture management is to return the patient to his or her prefracture level of function. There is general agreement that in the vast majority of hip-fracture patients, this can best be accomplished by surgical treatment, followed by early mobilization. Historically, nonoperative management has resulted in an unacceptable rate of medical morbidity, mortality, malunion, and nonunion.

However, there are certain situations in which surgery cannot be performed. For example, surgery is generally inadvisable for elderly patients whose medical condition carries an excessively high risk of mortality from anesthesia and surgery (e.g., patients who have sustained a recent myocardial infarction) and for patients who require ongoing anticoagulation that cannot be safely reversed for 72 hours during the perioperative period.

Nonoperative management may also be appropriate for selected elderly demented patients who were nonambulators prior to the fracture and who experience minimal discomfort from the injury. These patients should be mobilized as quickly as possible to avoid the complications of prolonged bed rest. The risks of decubitus ulcers, urinary tract infections, deep venous thrombosis, and pulmonary complications classically associated with nonoperative treatment may be diminished with meticulous nursing care and early mobilization from bed to chair.

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Clinical Evaluation

Virtually all patients who sustain hip fractures are unable to stand or walk following the injury. For elderly patients who live alone, it may be hours or even days before they are able to obtain medical evaluation, by which time they may be in a state of dehydration and confusion.

The range of clinical deformity of the involved lower extremity varies depending on the displacement and comminution of the fracture. Nondisplaced fractures may present with virtual absence of clinical deformity. Displaced comminuted fractures classically present with a shortened and externally rotated extremity.

Neurovascular injuries are rare. Nevertheless, a careful evaluation should be performed. Preexisting peripheral vascular disease or peripheral neuropathy requires careful monitoring of the skin and avoidance of excessive pressure during reduction maneuvers. Buck's skin traction with light weight (up to 5 lb) should be used, both to maximize patient comfort and to avoid additional injury. However, it should be used carefully when peripheral vascular or sensory changes are present. If surgery is delayed, the traction should be removed twice a day for careful inspection of the skin.

Preoperative Imaging Studies

The standard radiographic examination of the hip includes an anteroposterior (AP) view of the hip and pelvis and a cross-table lateral view. The AP view of the pelvis allows comparison with the contralateral side, which may be helpful in identifying nondisplaced and impacted fractures. A cross-table lateral view is preferred over a frog-leg lateral view because the latter requires abduction, flexion, and external rotation of the affected lower extremity. The frog-leg lateral view is poorly tolerated by hip-fracture patients and may actually result in fracture displacement.

If a femoral-neck fracture is suspected, an internal-rotation view of the hip may be helpful to identify a nondisplaced or impacted fracture. This view is taken with the lower extremity internally rotated approximately 15 degrees, permitting visualization of the entire femoral neck. If a displaced comminuted intertrochanteric fracture is suspected, a true lateral radiograph should be obtained to evaluate the presence and extent of posteromedial comminution. Nondisplaced intertrochanteric fractures may be difficult to identify on standard AP and lateral views, and an AP view with the lower extremity internally rotated 15 degrees may be helpful.

If hip fracture is suspected but is not apparent on standard radiographs, a technetium-99m bone scan or magnetic resonance imaging study should be obtained. The bone scan is a sensitive indicator of unrecognized hip fractures, although in the elderly patient it may not become positive until 2 or 3 days after the fracture. Magnetic resonance imaging has been shown to be as accurate as bone scanning in the assessment of occult fractures of the hip and can be reliably performed within 24 hours of injury[1] (Fig. 1). However, this test is costly and is not readily available in some hospitals. Therefore, it should be considered only in special problem cases.

Timing of Surgery

In general, surgery should be performed as soon after injury as possible, usually within 24 to 48 hours after admission. It is essential, however, that all comorbid medical conditions, particularly cardiopulmonary and fluid-electrolyte imbalances, be evaluated and treated before proceeding with surgical treatment. Delays of 24 hours or more to achieve medical stabilization have been shown not to increase morbidity or mortality. Kenzora et al[2] found that even healthy patients who underwent surgery within 24 hours had a 34% mortality at 1-year follow-up, compared with 5.8% for those who underwent surgery between the second and fifth days after injury. They also reported that a surgical delay of less than 1 week that permitted stabilization of medical problems was not associated with increased mortality. In contrast, surgical treatment of medically unstable patients significantly increases the mortality risk. Sexson and Lehner[3] also found that early surgery was detrimental to medically unstable elderly hip-fracture patients.

Anesthetic Considerations

The choice of anesthesia (regional versus general) has not been shown to affect the incidence of postoperative confusion or mortality in elderly hip-fracture patients. In a prospective, randomized, multicenter study of 538 geriatric hip-fracture patients, Davis et al[4] found no difference in

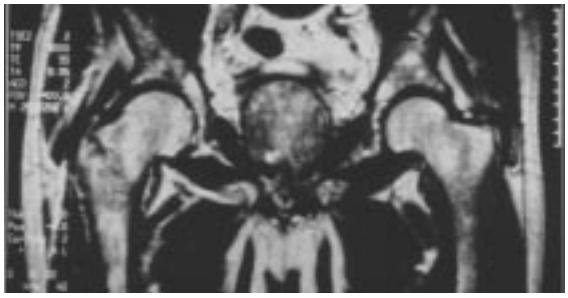

Fig. 1 Magnetic resonance imaging study of a minimally displaced fracture of the right hip taken within 24 hours of injury. The fracture was not apparent on plain radiographs.

short-term or long-term mortality between patients who underwent surgery with general anesthesia and those who underwent surgery with regional anesthesia. These findings were supported by Valentin et al[5] in a prospective series of 578 elderly hip-fracture patients.

Postoperative Management

Postoperative management after intertrochanteric hip-fracture stabilization should be directed toward early mobilization to avoid the previously mentioned complications of recumbency, such as decubitus ulcers, atelectasis, and urinary tract infection. All patients should receive broad-spectrum antibiotic prophylaxis for 24 to 48 hours after surgery.

Postoperative mobilization remains an area of controversy. Some authors have recommended restricted weight-bearing until the fracture has healed, while others have shown that unrestricted weight-bearing can be started immediately without detrimental effects. Biomechanical data have shown that non-weight-bearing ambulation places significant stresses across the hip as a result of muscular contraction at the hip and knee. Also, the simple act of moving onto a bedpan places forces across the hip that are greater than body weight. Therefore, attempts at unloading the hip by non- weight-bearing ambulation are not realistic. In addition, geriatric patients have great difficulty ambulating under these conditions. Restricted weight-bearing in this patient population will significantly limit their ability to regain ambulatory ability. Therefore, it has been our approach to allow weight-bearing as tolerated for virtually all geriatric hip-fracture patients. We would consider limited weight-bearing in younger patients, but at present there are no data to suggest that restricted weight-bearing has a beneficial effect on outcome even in this younger patient group.

Thromboembolic Prophylaxis

We believe that all hip-fracture patients should receive some form of postoperative thromboembolic prophylaxis. The high incidence of thromboembolic disease (deep venous thrombosis, pulmonary emboli) in hip- fracture patients has resulted in the development of a variety of prophylactic regimens, some of which have been extrapolated from their use in patients undergoing total hip replacement.

Aspirin is effective and has the advantages of easy administration and low cost.[6] However, its efficacy has been demonstrated primarily in men. Warfarin (Coumadin) has been shown to be effective, but its use results in an increased incidence of bleeding problems (hematoma), particularly if the prothrombin time exceeds 1.5 times the control value. Dextran, alone or in combination with dihydroergotamine, has also been effective. However, use of dextran necessitates a large fluid administration, which increases the risk of fluid overload. Low-dose intravenous heparin or heparin in combination with dihydroergotamine has also been effective in hip-fracture patients, but low-dose subcutaneous heparin has not. Subcutaneous injection of low-molecular-weight heparin has recently been reported to be effective prophylaxis in patients undergoing total joint and hip fracture surgery.[7] Intermittent external pneumatic compression may also be of value, but the cost of specialized equipment and the need for recumbency limit its usefulness.

Compression ultrasonography has been shown to be a very reliable technique for diagnosing venous thrombosis in hip-fracture patients. This technique has a reported accuracy of 97%, sensitivity of 100%, and specificity of 97% when compared with venography.[8] It is safe, quickly performed, and readily repeated and carries no inherent risks.

Functional Recovery

Successful treatment of geriatric hip-fracture patients is frequently evaluated on the basis of the number of patients who regain their prefracture level of function. This goal is often quite difficult to achieve, however. Of patients who were functionally independent and living at home before hip fracture, 15% to 40% will require institutionalized care for more than a year after fracture. Only 50% to 60% of patients will regain their prefracture ambulatory status within a year after fracture.

Some studies have tried to identify the factors that affect the patient's ability to regain prefracture ambulatory status following hip fracture.[9-12] The important factors identified include age, sex, the presence of preexisting dementia, and prefracture ambulatory status.

To achieve functional independence, one must be able to perform certain activities of daily living (ADLs). The functions necessary for community dwelling have been identified and divided into two categories: basic ADLs and instrumental ADLs. Basic ADLs include feeding, bathing, dressing, and toileting. Instrumental ADLs include food shopping, food preparation, banking, laundry, housework, and use of public transportation. The vast majority of patients will require assistance in performing ADLs. Of those who were independent in ADLs before fracture, only 20% to 35% will regain their prefracture ADL independence. The factors reported to be predictive of recovery of function in ADLs are younger age, absence of dementia or delirium in nondemented patients, and a strong social network.[9,10,12]

Femoral-Neck Fractures

Fractures of the femoral neck are intracapsular fractures that occur in the proximal femur in an area beginning

distal to the articular surface of the femoral head and ending just proximal to the intertrochanteric region.

Epidemiology

The age-adjusted incidence of femoral-neck fracture in the United States is 63.3 per 100,000 person-years for women and 27.7 per 100,000 person-years for men. The incidences of femoral-neck fractures and intertrochanteric fractures are approximately equal in this country.

Mechanisms of Injury

According to Frankel,[13] femoral-neck fractures occur in the presence of a high ratio of axial load to bending load. Altered muscle dynamics may increase the risk of hip fracture in the elderly. The energy of a fall, which would be readily dissipated by contracting muscles in younger patients, is poorly dissipated by the slower, weaker muscles of the elderly patient. Another mechanism is muscle contraction in an effort to regain balance after slipping, which may be sufficiently intense to overload the bone and cause a fracture.

Other mechanisms have also been proposed. Falls onto the hip with a direct blow to the greater trochanter may generate an axial force along the neck, creating an impaction fracture. Some investigators postulate that the lower extremity externally rotates during a severe fall. At the extremes of external rotation, the femoral neck impinges against the posterior acetabular rim, which then acts like a fulcrum to concentrate the stress in this region. The combination of axial and rotational forces then produces the fracture. This mechanism helps to explain the comminution of the posterior femoral neck often associated with these fractures.

Classification

The Garden classification of femoral-neck fractures is the one most commonly utilized in the literature. In this classification, femoral-neck fractures are divided into four grades on the basis of the degree of displacement of the fracture fragments. Grade I is an incomplete or valgus impacted fracture. Grade II is a complete fracture without displacement of the fracture fragments. Grade III is a complete fracture with partial displacement of fracture fragments. Grade IV is a complete fracture with total displacement of the fracture fragments, allowing the femoral head to rotate back to an anatomic position. In practice, however, it is difficult to differentiate the four grades of fractures; therefore, it may be more accurate to classify femoral-neck fractures as nondisplaced (Garden grades I and II) or displaced (Garden grades III and IV) (Fig. 2).[14]

Treatment

There is general agreement that treatment of nondisplaced femoral-neck fractures (Garden grades I and II) should consist of internal fixation with the use of multiple lag screws or pins placed in parallel. Impacted fractures (Garden grade I) are inherently stable because of impaction at the fracture site. As a result, some authors have recommended nonoperative management. However, Bentley[15,16] found a disimpaction rate between 8% and 15% in his series of patients. In addition, nonoperative management of impacted fractures has generally included a prolonged period of toe-touch weight-bearing ambulation. This is poorly tolerated in the elderly and is therefore not an acceptable treatment option. Nondisplaced fractures that are not impacted (Garden grade II) lack the inherent stability of impacted fractures and carry a high risk of displacement. There has been no consensus as to the optimal number of pins or screws to use, although

A B

Fig. 2 **A,** Valgus impacted (nondisplaced) right femoral-neck fracture. **B,** Displaced right femoral-neck fracture.

most studies indicate successful treatment using three or four pins or screws for both nondisplaced and displaced fractures.[17] Nonunion and osteonecrosis are uncommon complications following the internal fixation of nondisplaced fractures, with nonunion occurring in less than 5% of cases and osteonecrosis in less than 8%.[18]

Treatment of displaced femoral-neck fractures remains controversial. Most authors advocate closed or open reduction and internal fixation in younger active patients and primary prosthetic replacement in older, less active patients. There is general agreement that when internal fixation is used, the ability to achieve anatomic reduction is the most important factor in achieving complication-free union. An acceptable reduction may have up to 15 degrees of valgus angulation and less than 10 degrees of anterior or posterior angulation. Prompt reduction of displaced fractures has been advocated, but has not been consistently shown to decrease the incidence of nonunion or osteonecrosis. Following closed reduction, permanent AP and lateral radiographs are necessary to determine the adequacy of reduction. If a closed reduction is unacceptable, open reduction through an anterolateral approach may be required. Internal fixation of displaced fractures is most commonly performed with the use of multiple lag screws or pins placed in parallel (Fig. 3). Sliding-screw devices have been utilized, but the results have been found inferior.

Nonunion and osteonecrosis continue to be problems following displaced femoral-neck fracture. The rate of nonunion has ranged from 10% to 30%, and the rate of osteonecrosis has ranged from 15% to 33%.[18,19] Increased intracapsular pressure has been implicated as a possible cause of posttraumatic osteonecrosis. However, the clinical usefulness of immediate joint aspiration following femoral-neck fracture has not yet been established. The need for reoperation following internal fixation of displaced fractures has been variable. Approximately one third of patients with osteonecrosis and three fourths of patients with nonunion or early fixation failure require additional surgery.

Fig. 3 Displaced femoral-neck fracture in a 30-year-old patient treated with open reduction and internal fixation with the use of three parallel cannulated cancellous screws.

Hemiarthroplasty is a treatment alternative for displaced femoral-neck fractures and is advocated for older, less active patients. Historically, the one-piece Austin Moore and Thompson designs were the prostheses of choice. Although successful in select patient populations, use of these prostheses has been reported to be associated with increased rates of acetabular erosion and femoral-stem loosening.[20] The availability and use of methylmethacrylate have reduced the incidence of femoral-stem loosening, but acetabular wear has remained a problem.[21] The factors that best correlate with the severity of acetabular erosion are patient activity level and duration of follow-up.

The bipolar prosthesis, a self-articulating device, was designed to decrease the incidence of acetabular erosion by encouraging hip motion at a low-friction inner bearing (Fig. 4). However, controversy remains regarding the indications for its use, as well as the amount of motion that occurs at the outer and inner surfaces of the prosthesis. Lestrange[22] reported that the results with cemented bipolar prostheses were better than those with cemented unipolar prostheses in a retrospective series of 496 femoral-neck fracture patients. His patients with a cemented bipolar prosthesis had a greater range of hip motion and a reduced incidence of acetabular wear, thigh pain, and femoral-stem loosening. Drinker and Murray,[23] however, reported no significant advantages of the bipolar

Fig. 4: Cemented bipolar prosthesis.

prosthesis over the unipolar prosthesis in a retrospective series of 261 hip fractures. Motion-analysis research has been performed to determine the amount of motion occurring at the inner and outer bearings of the bipolar prosthesis during hip motion. Some studies support the inner bearing as the dominant articulation, while others report that the outer bearing provides a substantial percentage of the motion. Considering the higher cost of the bipolar prosthesis and its questionable clinical benefit, some authors now advocate use of a cemented modular unipolar endoprosthesis.

The results of primary cemented total hip replacement after femoral-neck fracture have been disappointing, particularly in younger patients. Greenough and Jones[24] found that, at an average follow-up of 56 months, 18 (49%) of 37 patients less than 70 years old who had undergone primary total hip replacement after fracture had also undergone or were awaiting revision surgery. Another 4 patients (11%) had definite radiologic signs of loosening. Activity level correlated directly with early failure. In another, prospective study comparing range of hip motion following total hip replacement for arthritis and fracture, the authors reported significantly greater motion in the fracture group, suggesting that fracture is a predisposing factor for early loosening and dislocation.

Nevertheless, primary total hip arthroplasty has a place in the treatment of acute femoral-neck fractures for patients with preexisting acetabular disease (rheumatoid arthritis, osteoarthritis, Paget's disease). In this setting, the results can be expected to be comparable with those reported for elective total hip arthroplasty. Additional indications for its use have been based on age, activity level, medical condition, and contralateral hip disease, but their relevance to the eventual outcome continues to be difficult to define. The results of secondary total hip replacement performed after failed internal fixation of a femoral-neck fracture are reported to be similar to those obtained after primary arthroplasty for a femoral-neck fracture.

Occurrence in Young Adults

In most cases, femoral-neck fractures in young adults occur as a result of high-energy injuries, such as motor vehicle accidents and falls from heights. Those that occur as a result of a simple fall often are associated with predisposing risk factors, such as alcoholism and medication use. When these fractures result from high-energy trauma, careful evaluation for other injuries should be performed. Specific consideration should be given to the possibility of ipsilateral femoral-neck and femoral-shaft fractures.

Nondisplaced fractures should be treated by fixation with multiple lag screws or pins, with care taken to avoid loss of reduction during the surgical procedure. Nonunion and osteonecrosis are uncommon following nondisplaced fractures, except in cases in which the fracture was not identified initially.

Successful treatment of displaced fractures depends on achieving anatomic reduction and stable internal fixation as soon as possible after the injury. Gentle closed or open reduction should be followed by fixation with multiple lag screws or pins. When the principles of prompt anatomic reduction and internal fixation are followed, the incidence of nonunion should be less than 10%, and that of osteonecrosis should be 20% to 33%.

Special Problems

Neurologically impaired patients include those with Parkinson's disease, previous stroke, and severe dementia. Both internal fixation and prosthetic replacement have been recommended for patients with Parkinson's disease who sustain a femoral-neck fracture.[25-27] The specific treatment chosen should be based on patient age, fracture type, and severity of disease. If prosthetic replacement is chosen, correction of a hip-adduction contracture by tenotomy and an anterior surgical approach should be considered to reduce the risk of dislocation.

Patients with previous strokes are at increased risk for hip fracture, primarily because of osteoporosis of the paretic limb and residual balance and gait problems. The treatment approach depends on the fracture type and functional status. When the fracture occurs within 1 week of the stroke, a poor functional recovery can be anticipated. As in patients with Parkinson's disease, an anterior approach and correction of a hip-adduction contracture by tenotomy should be considered when prosthetic replacement is chosen.

Demented institutionalized patients present a particular challenge, with reported 1-year mortality rates as high as 50%.[28] Nondisplaced fractures should be treated by internal fixation. For displaced fractures requiring prosthetic replacement, an anterior approach should be utilized to decrease the risk of dislocation and infection from wound contamination. In nonambulatory patients with severe dementia who do not experience significant discomfort from the injury, nonoperative treatment with early mobilization from bed to chair should be considered.

Femoral-neck fractures in patients with rheumatoid arthritis are associated with an increased incidence of complications. In general, nondisplaced fractures can be successfully treated by internal fixation. However, internal fixation of displaced fractures has been associated with a high complication rate, and prosthetic replacement is recommended.

If significant acetabular degeneration is present, total hip arthroplasty is indicated. Femoral-neck fractures are uncommon in patients with underlying osteoarthritis of the hip, but when they do occur, total hip arthroplasty is preferred.

Femoral-neck fractures (both displaced and nondisplaced) in patients with chronic renal disease or hyperparathyroidism carry an increased risk for complications of internal fixation because of the associated presence of metabolic bone disease. In these patients, cemented primary prosthetic replacement is recommended.

Femoral-neck fractures in patients with Paget's disease should be carefully evaluated for preexisting acetabular degeneration and deformity of the proximal femur. Nondisplaced fractures can be treated by internal fixation. Prosthetic replacement is preferred for displaced fractures. If there were prefracture symptoms of hip pain in the presence of acetabular degeneration, total hip arthroplasty is recommended; if acetabular degeneration is not present, cemented hemiarthroplasty should be performed. Deformity of the proximal femur and excessive bleeding may present technical difficulties.

Femoral-neck fractures that occur as a result of metastatic disease require prosthetic replacement. With involvement of the entire proximal femur, a calcar or proximal femoral replacement may be necessary. For patients with acetabular involvement, a cemented acetabular component should be used. If acetabular involvement is extensive, portions of the ilium may have to be reconstructed with the use of methylmethacrylate, wire mesh, and specialized acetabular components. Before performing prosthetic replacement for pathologic fractures of the proximal femur, it is important to identify any metastatic lesions that may be present in the femoral shaft and to use a long-stem prosthesis to decrease the risk of intraoperative fracture, shaft perforation, or later shaft fracture.

Complications

Complications following internal fixation of femoral-neck fractures include loss of fixation, infection, nonunion, and osteonecrosis. Early fixation failure (within 3 months after surgery) occurs in 12% to 24% of displaced femoral-neck fractures treated by internal fixation. Stappaerts[29] reported a 22% failure rate using Knowles pins or AO screws. He found that the most important factors associated with loss of fixation were advanced age and an inaccurate reduction. Other studies have shown the influence of the initial fracture type and the presence or absence of displacement on the incidence of early fixation failure. Scheck[30] and others have emphasized the importance of posterior comminution of the femoral neck as a cause of fixation failure and nonunion.

Infections following internal fixation of femoral-neck fractures are uncommon.[31] Superficial infection has been reported in up to 5% of cases. Deep infection has also been reported in up to 5% of cases, although there were no deep infections in one large series of 300 patients.[18] Perioperative antibiotic prophylaxis has now become standard in the treatment of elderly hip-fracture patients and is responsible, in part, for the low rates of infection.

The rate of nonunion is related to the fracture type. In nondisplaced fractures (Garden grades I and II), nonunion occurs in 0% to 5% of cases. However, for displaced fractures, the rate of nonunion has been reported to be from 9% to 35%. Nonunion is more common with posterior comminution and following an inadequate reduction.

The type of fixation device also influences the rate of nonunion, which is much greater with a nail-plate device than with a compression hip screw. However, comparison of the sliding hip screw with multiple pins has shown the use of multiple pins to be less traumatic and associated with a lower rate of nonunion. In general, the preferred treatment of symptomatic nonunion in the elderly patient is revision to prosthetic replacement. Hemiarthroplasty and total hip replacement are acceptable options; the choice is dependent on the clinical situation. Valgus osteotomy, bone grafting, and muscle-pedicle grafting are usually reserved for younger patients (Fig. 5).

The rate of osteonecrosis following nondisplaced femoral-neck fracture has been reported to be as high as 15%, but in general it is approxi-

Fig. 5 Intertrochanteric valgus osteotomy for treatment of femoral-neck nonunion in a 50-year-old patient.

mately 5% to 8%. The rate following displaced femoral-neck fracture (Fig. 6) has been reported to be as low as 9% and as high as 35%, but the usual range is 20% to 35%.[32,33] Factors associated with an increased rate of osteonecrosis include delay in reduction, inadequate reduction, and use of sliding hip-screw or nail-plate devices. Garden[32] found that the rate of late segmental collapse was directly related to the adequacy of reduction. When the reduction was acceptable, the rate of osteonecrosis with segmental collapse was 0%. Mild deviations of postreduction alignment resulted in a rate of segmental collapse of 6.6%, while moderate and severe alterations of postreduction alignment resulted in rates of 65% and 100%, respectively.

Symptomatic osteonecrosis may require reoperation for hardware removal or prosthetic replacement. A survey of four recent reports reveals that of 67 patients who developed osteonecrosis, only 25 (37%) required reoperation. This is consistent with the findings of Barnes et al,[34] who reported that only 30% of patients with late segmental collapse were significantly disabled.

Complications following primary prosthetic replacement for acute femoral-neck fracture include infection, dislocation and pain associated with acetabular erosion, and prosthetic loosening. The rate of infection has been reported to range from 2% to 20%,[35-38] with the higher rates of infection found in earlier studies. In part, this wide range of infection rates is due to the fact that patients chosen for prosthetic replacement in the earlier studies were generally older and more debilitated than most patients with a femoral-neck fracture. More recent series of prosthetic replacements (mostly bipolar endoprostheses) have had infection rates of 2% to 8%.[37] This can be attributed in part to patient selection and use of prophylactic perioperative antibiotics. The rate of infection has been reported to vary with the surgical approach, with a high risk when a posterior approach is used. This probably reflects the risk of fecal contamination because of the proximity of the incision to the perineal area.

Fig. 6 Avascular necrosis with collapse after fixation of a displaced femoral-neck fracture.

The rate of dislocation following prosthetic replacement has varied from 1% to 10% and is higher when a posterior approach is used.[39,40] Dislocation appears to be less common after bipolar hemiarthroplasty. However, closed reduction of a dislocated bipolar endoprosthesis is more difficult to achieve than closed reduction of a dislocated unipolar hemiarthroplasty.

Hip pain that develops following prosthetic replacement may have a multitude of causes, many of which are unrelated to the prosthesis. The most important prosthesis-related causes of pain include acetabular erosion and prosthetic loosening. Bipolar endoprostheses may be associated with less acetabular erosion than unipolar hemiarthroplasties are. Cement fixation of the femoral component reduces the incidence of postoperative pain associated with prosthetic loosening. However, one must realize that the need for reoperation following prosthetic replacement is low despite the much higher rate of radiologic evidence of significant acetabular erosion and prosthetic loosening.

References

1. Rizzo PF, Gould ES, Lyden JP, et al: Diagnosis of occult fractures about the hip: Magnetic resonance imaging compared with bone-scanning. *J Bone Joint Surg Am* 1993;75:395-401.
2. Kenzora JE, McCarthy RE, Lowell JD, et al: Hip fracture mortality: Relation to age, treatment, preoperative illness, time of surgery, and complications. *Clin Orthop* 1984;186:45-56.
3. Sexson SB, Lehner JT: Factors affecting hip fracture mortality. *J Orthop Trauma* 1988;1:298-305.
4. Davis FM, Woolner DF, Frampton C, et al: Prospective, multi-centre trial of mortality following general or spinal anaesthesia for hip fracture surgery in the elderly. *Br J Anaesth* 1987; 59:1080-1088.
5. Valentin N, Lomholt B, Jensen JS, et al: Spinal or general anaesthesia for surgery of the fractured hip? A prospective study of mortality in 578 patients. *Br J Anaesth* 1986;58:284-291.
6. Feldman DS, Zuckerman JD, Walters I, et al: Clinical efficacy of aspirin and dextran for thromboprophylaxis in geriatric hip fracture patients. *J Orthop Trauma* 1993;7:1-5.
7. Gerhart TN, Yett HS, Robertson LK, et al: Low-molecular-weight heparinoid compared with warfarin for prophylaxis of deep-vein thrombosis in patients who

are operated on for fracture of the hip: A prospective, randomized trial. *J Bone Joint Surg Am* 1991;73:494-502.
8. Froehlich JA, Dorfman GS, Cronan JJ, et al: Compression ultrasonography for the detection of deep venous thrombosis in patients who have a fracture of the hip: A prospective study. *J Bone Joint Surg Am* 1989;71:249-256.
9. Cummings SR, Phillips SL, Wheat ME, et al: Recovery of function after hip fracture: The role of social supports. *J Am Geriatr Soc* 1988;36:801-806.
10. Magaziner J, Simonsick EM, Kashner TM, et al: Predictors of functional recovery one year following hospital discharge for hip fracture: A prospective study. *J Gerontol* 1990;45:M101-M107.
11. Miller CW: Survival and ambulation following hip fracture. *J Bone Joint Surg Am* 1978;60:930-934.
12. Jette AM, Harris BA, Cleary PD, et al: Functional recovery after hip fracture. *Arch Phys Med Rehabil* 1987;68:735-740.
13. Frankel VH: *The Femoral Neck: Function, Fracture Mechanism, Internal Fixation -- An experimental study.* Springfield, Ill: Charles C Thomas, 1960.
14. Frandsen PA, Andersen E, Madsen F, et al: Garden's classification of femoral neck fractures: An assessment of interobserver variation. *J Bone Joint Surg Br* 1988;70:588-590.
15. Bentley G: Impacted fractures of the neck of the femur. *J Bone Joint Surg Br* 1968;50:551-561.
16. Bentley G: Treatment of nondisplaced fractures of the femoral neck. *Clin Orthop* 1980;152:93-101.
17. Stappaerts KH, Broos PLO: Internal fixation of femoral neck fractures: A follow-up study of 118 cases. *Acta Chir Belg* 1987;87:247-251.
18. Stromqvist B, Hansson LI, Nilsson LT, et al: Hook-pin fixation in femoral neck fractures: A two-year follow-up study of 300 cases. *Clin Orthop* 1987:218:58-62.
19. Cobb AG, Gibson PH: Screw fixation of subcapital fractures of the femur: A better method of treatment? *Injury* 1986; 17:259-264.
20. Soreide O, Lillestol J, Alho A, et al: Acetabular protrusion following endoprosthetic hip surgery: A multifactorial study. *Acta Orthop Scand* 1980;51:943-948.
21. Beckenbaugh RD, Tressler HA, Johnson EW Jr: Results after hemiarthoplasty of the hip using a cemented femoral prosthesis: A review of 109 cases with an average follow-up of 36 months. *Mayo Clin Proc* 1977;52:349-353.
22. Lestrange NR: The Bateman UPF prosthesis: A 48-month experience. *Orthopedics* 1979;2:373-377.
23. Drinker H, Murray WR: The universal proximal femoral endoprosthesis: A short-term comparison with conventional hemiarthroplasty. *J Bone Joint Surg Am* 1979;61:1167-1174.
24. Greenough CG, Jones JR: Primary total hip replacement for displaced subcapital fracture of the femur. *J Bone Joint Surg Br* 1988;70:639-643.
25. Coughlin L, Templeton J: Hip fractures in patients with Parkinson's disease. *Clin Orthop* 1980;148:192-195.
26. Rothermel JE, Garcia A: Treatment of hip fractures in patients with Parkinson's syndrome on levodopa therapy. *J Bone Joint Surg Am* 1972;54:1251-1254.
27. Soto-Hall R: Treatment of transcervical fractures complicated by certain common neurological conditions. *Instr Course Lect* 1960;17:117-120.
28. El Banna S, Raynal L, Gerebtzof A: Fractures of the hip in the elderly: Therapeutic and medico-social considerations. *Arch Gerontol Geriatr* 1984;3:311-319.
29. Stappaerts KH: Early fixation failure in displaced femoral neck fractures. *Arch Orthop Trauma Surg* 1985;104:314-318.
30. Scheck M: The significance of posterior comminution in femoral neck fractures. *Clin Orthop* 1980;152:138-142.
31. Rodriguez J, Herrara A, Canales V, et al: Epidemiologic factors, morbidity and mortality after femoral neck fractures in the elderly: A comparative study—Internal fixation vs. hemiarthroplasty. *Acta Orthop Belg* 1987;53:472-479.
32. Garden RS: Malreduction and avascular necrosis in subcapital fractures of the femur. *J Bone Joint Surg Br* 1971; 53:183-197.
33. Christie J, Howie CR, Armour PC: Fixation of displaced subcapital femoral fractures: Compression screw fixation versus double divergent pins. *J Bone Joint Surg Br* 1988;70:199-201.
34. Barnes R, Brown JT, Garden RS, et al: Subcapital fractures of the femur: A prospective review. *J Bone Joint Surg Br* 1976;58:2-24.
35. Anderson LD, Hamsa WR Jr, Waring TL: Femoral-head prostheses: A review of three hundred and fifty-six operations and their results. *J Bone Joint Surg Am* 1964;46:1049-1065.
36. Carnesale PG, Anderson LD: Primary prosthetic replacement for femoral neck fractures. *Arch Surg* 1975;110:27-29.
37. Bray TJ, Smith-Hoefer E, Hooper A, et al: The displaced femoral neck fracture: Internal fixation versus bipolar endoprosthesis—Results of a prospective, randomized comparison. *Clin Orthop* 1988;230:127-140.
38. Cassebaum WH, Nugent G: Predictability of bony union in displaced intracapsular fractures of the hip. *J Trauma* 1963;3:421-424.
39. Bochner RM, Pellicci PM, Lyden JP: Bipolar hemiarthroplasty for fracture of the femoral neck: Clinical review with special emphasis on prosthetic motion. *J Bone Joint Surg Am* 1988; 70:1001-1010.
40. Chan RNW, Hoskinson J: Thompson prosthesis for fractured neck of femur: A comparison of surgical approaches. *J Bone Joint Surg Br* 1975;57:437-443.