Ipsilateral Femoral Neck and Shaft Fractures

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Abstract

Ipsilateral femoral neck and shaft fractures are uncommon injuries that present a surgical challenge. Patients are relatively young, are usually victims of high-energy trauma, and have frequently sustained multisystem injuries. A comminuted midshaft femoral fracture secondary to axial loading should alert the treating physician to the possibility of an associated femoral neck fracture. This is important in light of the frequency of unrecognized ipsilateral femoral neck fractures. Several treatment options are described in the literature, but no clear consensus exists regarding the optimal treatment of these complex fractures. The authors contend that, given the potentially devastating complications of the femoral neck fracture in young patients (e.g., avascular necrosis, nonunion, and malunion), the neck fracture should be treated first and the shaft fracture second. The authors present an algorithm for the diagnosis and management of this injury based on a review of the literature, an understanding of the biology and severity of this injury, and the technical aspects of surgical treatment.

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Fractures of the femoral neck and fractures of the femoral shaft are both common. However, the combination of ipsilateral femoral neck and shaft fractures is an uncommon injury pattern, occurring in 2% to 6% of all femoral shaft fractures.[1,2] Wiss et al[3] encountered 33 such injuries over a 3-year period; Swiontkowski et al[4] treated 15 cases over a 10-year period; and Bose et al[5] treated 5 cases over a 2-year period.

Ipsilateral femoral neck and shaft fractures present a challenging problem for the treating surgeon. The ideal treatment of each injury often necessitates a less than ideal treatment for the associated fracture. Complications of the injury and its management include avascular necrosis (AVN) of the femoral head, nonunion, malunion, and fat embolism.

The associated injury pattern was initially described in 1953. Since then, approximately 300 instances of this injury have been reported in the literature, and more than 60 treatment alternatives have been described.[6] There appears to be little consensus regarding the optimal management of this difficult injury pattern.

Epidemiology

The typical patient is relatively young (average age, 34.6 years)[1,3-5,7-10] and has been the victim of high-energy trauma. In four of the larger series,[3,4,7,8] open fractures were present in 22.6% of the patients. Multisystem injuries occurred in 73% to 100% of patients.[1,3-7,11,12] Knee injuries such as patellar fractures, knee contusions, and lacerations are the most commonly associated musculoskeletal injuries, coexisting in 14% to 40% of reported cases.[1,4,6,7-9]

The shaft component of the combined injury pattern in an ipsilateral femoral neck and shaft injury is typically in the middle third and is often comminuted. The neck fracture is usually vertical, basilar, and minimally displaced. Before 1974 (the year the first review article on this injury was published), 41.7% of femoral neck fractures were initially undiagnosed.[6,8,10] The diagnosis was often delayed for days to weeks. Since 1974, however, the associated neck fracture was initially unrecognized in only 11% of the cases reported.[3,5,6,8,10,13] Awareness of the combined injury, improved radiographic assessment, the implementation of standardized protocols, and the development of regional trauma centers have contributed to the improvement in diagnosis of this injury pattern.

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Mechanism of Injury

Most of these fractures result from high-energy trauma, usually motor-vehicle accidents.[1,3-5,7,8,14] Falls from heights, motorcycle accidents, and accidents in which pedestrians are struck by motor vehicles account for the remainder of cases.[1,3,4,5,7,8,14]

In 1958, Ritchey et al[11] coined the term "dashboard femoral fracture" to describe the comminuted midshaft femur fracture caused by axial load in a motor-vehicle collision. In their series of five patients, all were front-seat passengers who survived head-on collisions. Injury to the hip depends on the position of the proximal femur when axial load is applied. In an adducted position, a posterior hip dislocation may occur; in an abducted position, an acetabular fracture or a femoral neck fracture may occur.

In 1976, Wolfgang[15] reported that high-energy axial compression of the femur had three possible associated injuries: ipsilateral hip dislocation or acetabular fracture, ipsilateral hip fracture, or ipsilateral fracture of the greater trochanter. In his summary of 144 combined injuries, there were 95 ipsilateral dislocations, 43 femoral neck fractures, and 6 greater trochanteric fractures.

In 1981, Zettas and Zettas[1] theorized that with fractures of the ipsilateral femoral neck and shaft, the knee and femoral shaft absorb most of the energy of impact, reducing the energy transferred to the femoral neck. The authors argued that this would minimize displacement of an associated femoral neck fracture, accounting for missed and delayed diagnoses despite appropriate plain radiographs. Some femoral neck fractures may be minimally symptomatic and thus may not be recognized throughout a patient's hospitalization and may heal without specific treatment. Kimbrough[14] described such a case in 1961.

It has recently been suggested that an ipsilateral femoral neck fracture may result from iatrogenic trauma during antegrade intramedullary femoral nailing. In a 1993 cadaver study, Miller et al[16] found that an anteriorly placed starting hole in the proximal femur produces a stress riser that weakens the bone, with resultant basicervical fractures on loading. The literature contains a few cases of iatrogenically induced femoral neck fractures during antegrade femoral nailing attributable to a misplaced starting point.[17-19]

Table 1
Factors Associated With Ipsilateral Femoral Neck and Shaft Fractures

Mechanism of injury
Head-on motor-vehicle accident
Fall from height
Motorcycle accident
Pedestrian struck by car
Associated injuries
Ipsilateral comminuted femoral shaft fracture
Ipsilateral knee injury

Diagnosis

Most ipsilateral femoral neck and shaft fractures are diagnosed during the evaluation of the injured patient. Reducing the frequency of missed diagnoses is dependent on maintaining a high index of suspicion (Table 1). Encountering a high-energy comminuted midshaft femoral fracture should occasion vigilance for an associated femoral neck fracture. The presence of an ipsilateral knee injury should also alert the treating physician to search for a femoral neck fracture.

Adequate radiographs are essential to the evaluation. One should visualize the entire femur from the hip to the knee. A plain anteroposterior (AP) pelvis view and orthogonal views of the femur are recommended. Due to the natural anteversion of the femoral neck, a full profile of the neck requires internal rotation of the leg. In the presence of a shaft fracture, internal rotation is often impossible; this may account for the initial failure to recognize some nondisplaced neck fractures.

When there is a high index of suspicion, AP and lateral views of the hip (with internal rotation of the leg if possible) and a computed tomographic scan of the proximal femur or intraoperative fluoroscopy should be obtained before initiation of surgical treatment to evaluate for a nondisplaced femoral neck fracture. With intraoperative fluoroscopy, the x-ray beam can be angled to visualize the femoral neck in profile without the need to physically manipulate the thigh. The femoral neck should always be visualized in the operating room before treating the shaft fracture. Despite attentive pursuit, however, ipsilateral neck fractures will occasionally be missed during the early evaluation.[20] If a patient has persistent complaints of ipsilateral hip pain after treatment of a shaft fracture, the hip should be further evaluated for the presence of a femoral neck fracture.

Management Concepts

Ipsilateral femoral neck and shaft fractures are best treated with surgical stabilization. Pulmonary complications can be reduced with expeditious stabilization. Prolonged traction is rarely indicated or beneficial; the literature clearly documents increased complications in patients treated nonoperatively.[6-10,21]

Issues that remain controversial include the timing of surgery, injury triage, and methods of fixation. Femoral neck fractures in young patients are considered orthopaedic emergencies. In 1976, Protzman and Burkhalter[22] reported AVN in 86% and nonunion in 59% of 22 young patients with femoral neck fractures treated with open reduction and internal fixation. The distinguishing factor in the young patient who presents with a femoral neck fracture, in contrast to an elderly patient, is the amount of energy absorbed to produce it. In 1984, Swiontkowski et al[23] found AVN in about 20% of young patients despite aggressive treatment. In 1985, Tooke and Favero[24] found the rate of AVN to be 18.8% in a small group of young patients with low-energy femoral neck fractures, but the rates of AVN in displaced and nondisplaced fractures were 33% and 5.5%, respectively. With regard to femoral shaft fractures, Bone et al[21] clearly demonstrated the efficacy of aggressive treatment in cases of polytrauma.

The issue of which fracture takes priority is controversial because the optimal treatment of one fracture may interfere with the optimal treatment of the other. Swiontkowski et al[4,6] and Casey and Chapman[8] reported that timely anatomic reduction of the femoral neck reduces the likelihood of AVN, the most difficult complication of this associated injury. The rationale for definitive fixation of the femoral neck as the initial step in surgical management is based on technical and biologic considerations. The blood supply to the femoral head comes from three sources: the lateral epiphyseal branch of the medial circumflex femoral artery, the inferior metaphyseal branch of the lateral circumflex femoral artery, and the medial epiphyseal artery of the ligamentum teres.[25] Intramedullary nailing of the shaft fracture may disrupt any remaining blood supply to the femoral head, either by directly injuring the important retinacular arteries of Weitbrecht at the superior femoral neck or by indirectly displacing the fracture fragments (Fig. 1). It is technically difficult to obtain stable fixation of the femoral neck in the presence of an antegrade intramedullary nail (Fig. 2). Conversely, stable fixation of the neck may preclude the ability to place a standard antegrade intramedullary nail (Fig. 3).

Because of concerns about potentially suboptimal shaft fixation, some authors support fixing the shaft first.[1,3,5,15,26-28] Shaft fractures are frequently unstable rotationally and axially and are best managed with a standard reamed interlocking nail. Adequate fixation of the neck is achievable, albeit technically difficult, with the use of supplemental screws around a standard intramedullary nail (Fig. 4); however, anatomic reduction of the femoral neck may be impeded by the nail.

With the advent of second-generation reconstruction-type nails (cephalomedullary), many have postulated that both fractures can be effectively treated with a single device. This approach was first advocated by Zettas and Zettas in 1981.[1] Its use has been described in several recent reports.[3,5,28-31]

Fig. 1 Antegrade nailing of ipsilateral femoral neck and shaft fractures. Note the proximity of the entrance point of the nail to the retinacular system of Weitbrecht, an important source of blood supply to the femoral head. Compromise can occur directly by injury during initial entry or reaming or indirectly by displacement of the neck fracture.

Treatment

Several general observations become apparent in reviewing the literature concerning ipsilateral femoral neck and shaft fractures. The prevalence of AVN of the femoral head appears to be on the order of 4%.[3-6,8-10,13] This may be underestimated, however, due to insufficient patient follow-up.[4] The prevalence of nonunion of the femoral neck is roughly 5%.[3-6,8,10] Nonunion of the shaft fracture is extremely uncommon. Unfortunately, true outcome studies concerning this injury do not exist. Most studies are uncontrolled case series, involving several different treatment methods, which makes comparison of results and complications difficult.

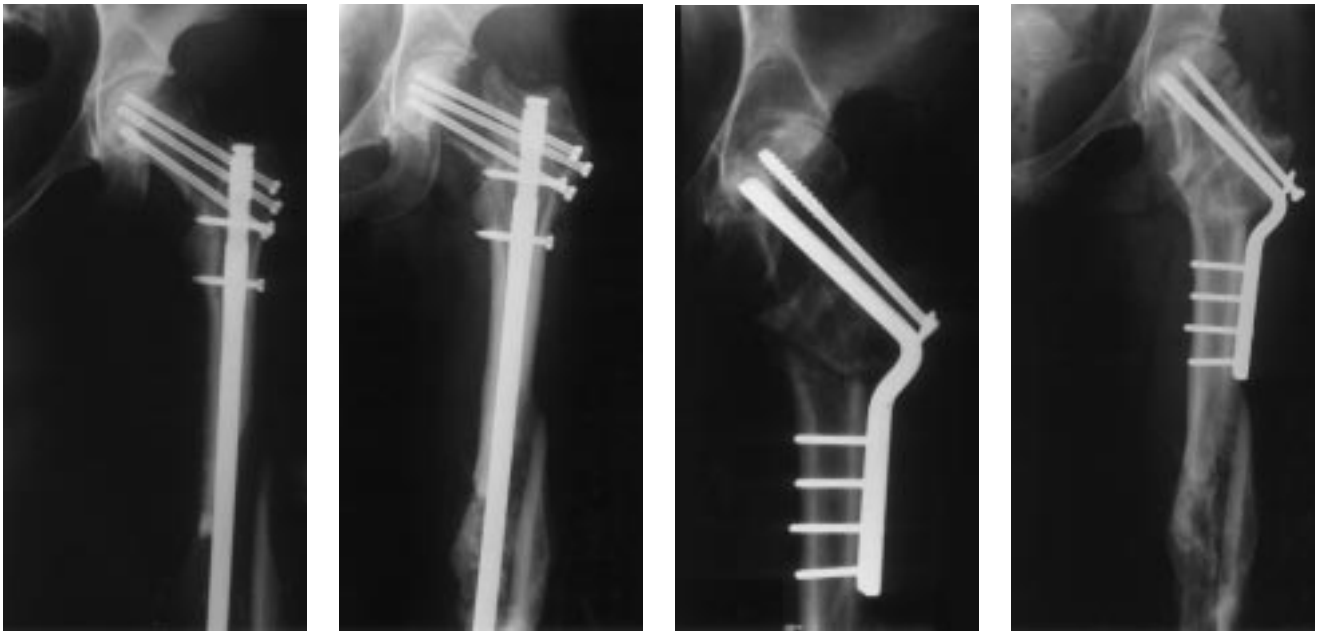

Fig. 2 Radiographs of a 20-year-old woman involved in a head-on motor-vehicle accident. Her femoral shaft fracture was treated by antegrade reamed intramedullary femoral nailing (standard centromedullary nail) at another institution. Three weeks later, a displaced ipsilateral femoral neck fracture was identified after persistent complaints of hip pain. **A,** Initial treatment consisted of removing the reamed nail and inserting a narrower nonreamed antegrade centromedullary nail, with supplemental screw fixation of the femoral neck with multiple cannulated screws. Note the persistent displacement of the femoral neck. **B,** Varus nonunion of the femoral neck developed. The femoral shaft required secondary autogenous bone grafting due to delayed union. **C,** Eleven months after the revision procedure, the patient underwent corrective valgus osteotomy and removal of the intramedullary nail. **D,** Four months after the Pauwel's osteotomy, the neck fracture had healed, but sclerotic changes in the femoral head and subchondral collapse consistent with AVN were noted.

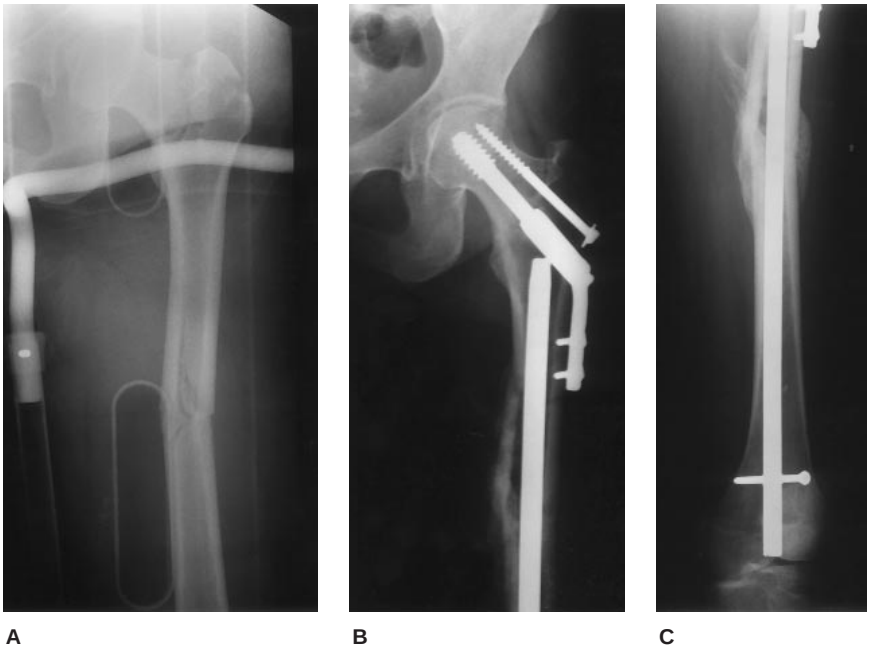

Fig. 3 Radiographs of a 38-year-old woman who was involved in a head-on motor-vehicle accident. Her injuries included a severe closed head injury, closed ipsilateral femoral neck and shaft fractures on the left, a closed right humeral shaft fracture, a closed right calcaneal fracture, and closed left metatarsal fractures. The femoral fractures on the left were initially treated with anatomic reduction and fixation of the femoral neck, followed by retrograde intra-articular intramedullary nailing of the femoral shaft. **A,** Initial AP view of the hip demonstrates a comminuted midshaft femoral fracture and a minimally displaced basilar neck–greater trochanter fracture. **B,** Five months after surgery, the femoral neck and shaft fractures were healed. **C,** Note the intra-articular placement of the retrograde nail.

Fig. 4 Radiographs of a middle-aged woman who was a passenger on a motorcycle involved in a collision. Her initial injuries were a closed comminuted femoral shaft fracture and an ipsilateral open knee laceration. **A,** Presenting AP view of the hip. **B** and **C,** Intraoperative AP and lateral hip radiographs after centromedullary nailing. Note the basilar femoral neck fracture. **D,** Anatomic reduction and fixation of the neck was possible with supplemental cancellous screws. Union of both fractures occurred without complication.

Historical Review

The earliest studies produced the greatest variety of treatment recommendations. Traction, intramedullary devices (flexible and rigid), plates, pins, and nail-plate devices were all utilized. The neck fractures often went undiagnosed for days to weeks (in one case, for one and a half years).[14] Surgical intervention was commonly delayed for days. Traction, despite its limitations, was considered a reliable treatment option.

Kimbrough,[14] in 1961, was the first to advocate early aggressive management of the femoral neck fracture. The reliability of internal fixation in treating the neck fracture was not demonstrated until Bernstein[7] published his series in 1974. The only femoral neck nonunion occurred in a patient treated with traction. Despite this finding, Bernstein did not recommend routine internal fixation for the femoral shaft fracture except in the case of ipsilateral knee injury.

Traction was considered a viable option even in the late 1970s. In a series of 20 patients with ipsilateral femoral neck and shaft fractures published in 1978, Wright and Becker[12] found that only 2 of 13 patients treated with traction experienced unsatisfactory outcomes, compared with 3 of 7 patients treated operatively. The only advantage to operative intervention appeared to be a reduction in the length of hospitalization.

Surgical Philosophy

In the 1980s, standardized treatment protocols and algorithms became integrated into trauma care, and operative intervention, especially intramedullary fixation, for musculoskeletal injuries, became more commonplace. Reports that documented the devastating outcomes in young patients who sustained femoral neck fractures were published.[22-24] Furthermore, the advantages of early fracture stabilization and patient mobilization became apparent.[21]

In 1979, Casey and Chapman[8] reviewed their series of 21 patients who sustained ipsilateral femoral neck and shaft fractures at a level 1 trauma center. Although they found no cases complicated by AVN or nonunion, they reported nine serious pulmonary complications in 10 patients treated nonoperatively. Eleven patients treated with various internal fixation devices for both injuries did not have any serious complications.

Zettas and Zettas[1] presented their case series in 1981. A variety of fixation devices were used, most commonly a plate for the shaft and a nail-screw device for the femoral

neck. They gravitated toward the concept that ideal fixation would be accomplished with an antegrade femoral nail and supplemental pinning of the femoral neck. Neither AVN nor nonunion was reported.

In 1984, Swiontkowski et al[4] presented the first series of patients treated on the basis of a standard algorithm. The femoral neck fracture received priority. Ten of 13 patients underwent capsulotomy and pinning of the femoral neck within 8 hours, followed by closed extra-articular retrograde femoral nailing of the shaft. Plating of the shaft was used in cases of severe shaft comminution. No pulmonary complications or nonunions occurred in the 13 patients. Avascular necrosis of the femoral head was diagnosed in 2 patients. One patient was treated under the protocol; the other was 1 of the 2 earliest patients in whom the shaft fracture was treated first. Avascular necrosis of the hip was not clinically apparent in these 2 patients for more than 3 years after the injury. The authors concluded that long-term follow-up would be required to detect AVN in patients with these injuries.

In the 1990s, the authors of two separate studies advocated antegrade intramedullary nailing with supplemental pin fixation of the femoral neck. In the first study, Wu and Shih[30] reviewed the data on 33 patients they had treated over a 5-year period and found one case of AVN and five cases of femoral shaft nonunion in the 13 patients treated with plating. The authors concluded that antegrade intramedullary nailing followed by pin fixation of the neck fracture was the most successful treatment alternative, although they recognized the technical difficulty of the procedure.

In the second study, Bennett et al[31] treated 37 patients with ipsilateral femoral neck and shaft fractures over a period of 15 years. Nineteen patients were treated with antegrade intramedullary nailing followed by pin fixation of the neck. There were three femoral neck nonunions, all of which were associated with a malreduced femoral neck pinned around a nail. All femoral shafts treated with a single nail healed, and no cases of AVN were observed over the average 3-year follow-up period. The authors recommended antegrade nailing followed by neck fixation with pins as long as the neck could be anatomically reduced and fixed. It is important to note, however, that 12 (33%) of the neck fractures were initially undiagnosed and were treated only after the shaft fracture had been treated.

Reconstruction Nailing

The development of cephalomedullary nails provided the potential advantage of an all-in-one device. One manufacturer created a reconstruction-type nail device specifically for the treatment of ipsilateral femoral neck and shaft fractures. Proponents of reconstruction nailing cite the advantages of shorter operative time, single positioning, reduced blood loss through a single incision, and the biomechanical benefits of using a nail for the shaft fracture. The problems associated with retrograde nails, such as the use of small-diameter nails, varus displacement, spica-cast supplementation, nonunion, knee pain, and stiffness, are avoided with the use of a reconstruction nail. The disadvantages of extensive surgical dissection, blood loss, risk of infection, need for bone grafting, and problems with stress shielding associated with plating are also avoided with the use of reconstruction nails. Furthermore, reconstruction nailing presumably avoids the technical difficulties of placing supplemental screws to stabilize the femoral neck in the presence of a standard femoral nail.

Despite the theoretical promise, the recent literature has documented important problems associated with using reconstruction-type cephalomedullary nails for ipsilateral femoral neck and shaft fractures. These problems include the demanding surgical technique and the risks of nonunion, malunion, device failure, and AVN. In 1992, Wiss et al[3] reported on the treatment of 33 patients with (1) antegrade first-generation nails and supplemental screws for the femoral neck, (2) antegrade first-generation nails inserted proximal end first (reversed) and supplemental screws, or (3) a reconstruction nail. Reversed nails, used in 13 patients, fared the worst, with 4 instances of femoral neck nonunion, 2 of femoral neck malunion, and 2 of AVN after corrective osteotomy for nonunion. Of the 14 patients treated with a reconstruction nail, 2 required corrective osteotomy for femoral neck nonunion; the overall nonunion rate was 18%, and the rate of AVN was 6%. There were no complications associated with the use of a standard antegrade nail with supplemental screw fixation of the femoral neck.

In another study, Bose et al[5] treated five patients with ipsilateral femoral neck and shaft fractures on a delayed basis. Varus malunion of the femoral neck attributable to technical error in inserting the reconstruction nail developed in only one of the five. However, the authors described the use of the reconstruction nail as technically difficult in this setting.

In a third study, Kang et al[29] reviewed the data on 37 patients with femoral shaft fractures treated with reconstruction nailing. Four patients also had ipsilateral femoral

neck fractures. Varus nonunion of the femoral neck developed in 2 patients, necessitating a corrective valgus osteotomy; in one of these patients, AVN developed after the secondary procedure. A third patient's course was complicated by screw cutout that needed revision. The authors concluded that the reconstruction nail was a poor choice for the treatment of ipsilateral femoral neck and shaft fractures because of problems in obtaining simultaneous satisfactory reduction and stabilization of the two fractures.

The problems of reconstruction nailing for treatment of ipsilateral femoral neck and shaft fractures include the technical difficulty of placing these devices and the suboptimal neck fixation that is achieved. Initial provisional fixation of the femoral neck with an anteriorly placed screw may provide more anatomic alignment with reconstruction nails. Secondary procedures to heal the neck are demanding and can be further complicated by development of AVN of the femoral head. Henry and Seligson[27] treated 43 patients with three different reconstruction nails and a first-generation nail with supplemental screw fixation of the femoral neck. A loss of reduction and subsequent poor fixation was noted during insertion in 20% to 33% of patients treated with the reconstruction nails. Although femoral neck reduction was maintained when the standard antegrade nails were supplemented with screws, this technique was considered even more difficult.

Recommendations for Treatment

The goal of treatment of ipsilateral femoral neck and shaft fractures is anatomic reduction and stable fixation of both fractures in an environment that allows healing and reduces the incidence of associated complications. The primary problem with addressing the neck fracture first is the increased technical difficulty in then using an antegrade intramedullary nail.

In a recent study by Moed and Watson,[28] 20 patients with femoral shaft fractures were treated with intra-articular nonreamed retrograde intramedullary nailing. Three patients in the series had sustained ipsilateral femoral neck and shaft fractures. The femoral shaft fracture was initially stabilized with retrograde nailing, followed by internal fixation of the femoral neck fracture. The femoral neck fractures healed uneventfully.

The complications associated with treatment of femoral shaft fractures are less devastating than those associated with the treatment of femoral neck fractures in young patients (Fig. 2). In a series of 141 plated femoral shaft fractures, Riemer et al[32] reported effectively treating the seven plate failures with secondary antegrade nailing. Consequently, we believe that the biology and severity of this injury in young patients demands that the femoral neck fracture be treated first.

In our institution, ipsilateral femoral neck and shaft fractures are treated as orthopaedic emergencies. The first step is to obtain anatomic reduction and rigid fixation of the femoral neck fracture. This can be done with either screws or a screw-plate device in the case of basilar neck fractures (Fig. 3). The shaft fracture is then reduced and stabilized with either plating or retrograde intramedullary femoral nailing. If the femoral neck fracture is diagnosed after antegrade femoral nailing, two options exist. Supplemental screws can be inserted around the already placed nail if an anatomic reduction of the neck can be obtained and maintained (Fig. 4). Otherwise, the nail is removed, the femoral neck is internally fixed, and retrograde nailing or plating is performed.

It is important that the treating surgeon recognize the technical difficulty of anatomic femoral neck reduction after placement of an antegrade nail, whether it be a standard intramedullary type or a reconstruction type. If the nail has displaced the femoral neck fracture, anatomic reduction is virtually impossible unless the nail is removed. We believe that employing this algorithm optimally addresses the femoral neck fracture without sacrificing the importance of long-bone stabilization and early mobilization in the patient with multiple injuries.

Summary

Ipsilateral femoral neck and shaft fractures are uncommon but potentially devastating injuries. In addition to the problems associated with both fractures, patients often sustain multisystem trauma associated with this high-energy injury. The key to successful management lies in its initial recognition. Once the diagnosis has been established, prompt surgical treatment is required. The severity and biology of this injury, in addition to technical issues, mandate initial treatment of the femoral neck fracture followed by treatment of the femoral shaft fracture.

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