

OPERATIVE TREATMENT OF FEMORAL NECK FRACTURES IN PATIENTS BETWEEN THE AGES OF FIFTEEN AND FIFTY YEARS

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Background: There is a paucity of data on the treatment of femoral neck fractures in young patients. The purpose of the present study was to review the results and complications associated with the treatment of femoral neck fractures with internal fixation in a large consecutive series of young patients.

Methods: Between 1975 and 2000, eighty-three femoral neck fractures in eighty-two consecutive patients who were between fifteen and fifty years old were treated with internal fixation at our institution. Two patients died, and eight were lost to follow-up. Seventy-three fractures were followed until union, until conversion to hip arthroplasty, or for a minimum of two years; the mean duration of follow-up was 6.6 years. Fifty-one of the seventy-three fractures were displaced, and twenty-two were nondisplaced. The results and complications of treatment were retrospectively reviewed, and the effects of fracture displacement, reduction quality, and capsular decompression on outcome were evaluated. Function was assessed by evaluating pain, walking capacity, and the need for gait aids. The mean duration of follow-up for the fifty-seven patients (fifty-eight fractures) who had not undergone early conversion to arthroplasty was 8.1 years.

Results: Fifty-three (73%) of the seventy-three fractures healed after one operation and were associated with no evidence of osteonecrosis of the femoral head. Osteonecrosis developed in association with seventeen fractures (23%), and a nonunion developed in association with six (8%). Four of the six nonunions later healed after a secondary procedure. At the time of the final follow-up, thirteen patients had had a conversion to a total hip arthroplasty because of osteonecrosis (eleven), nonunion (one), or both (one). Five (9.8%) of the fifty-one displaced fractures were associated with the development of nonunion, and fourteen (27%) were associated with the development of osteonecrosis. Three (14%) of the twenty-two nondisplaced fractures were associated with the development of osteonecrosis, and one (4.5%) was associated with the development of nonunion. Eleven (24%) of the forty-six displaced fractures with a good to excellent reduction were associated with the development of osteonecrosis, and two (4%) were associated with the development of nonunion. Four of the five displaced fractures with a fair or poor reduction were associated with the development of osteonecrosis, nonunion, or both.

Conclusions: The ten-year survival rate of the native femoral head free of conversion to total hip arthroplasty was 85%. Osteonecrosis was the main reason for conversion to total hip arthroplasty, but not all patients with osteonecrosis required further surgery. The results of treatment were influenced by fracture displacement and the quality of reduction.

Level of Evidence: Therapeutic study, Level IV (case series [no, or historical, control group]). See Instructions to Authors for a complete description of levels of evidence.

The majority of femoral neck fractures occur in elderly patients with osteopenic bone, but femoral neck fractures also occur in younger patients, frequently as a re-

sult of high-energy trauma. Although prosthetic replacement frequently is considered for the treatment of displaced fractures in elderly patients, efforts are focused on preserving the femoral head in physiologically younger patients¹⁻⁶. Complications such as osteonecrosis and nonunion have been reported to occur in 10% to 45% and 10% to 30% of patients who have a femoral neck fracture, respectively^{4,13}. There is a surprising



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paucity of data regarding the outcomes of treatment of femoral neck fractures in young patients, perhaps because young, mobile patients have been difficult to follow regularly. The purpose of the present study was to evaluate a large consecutive series of young patients with femoral neck fractures that had been treated with contemporary methods of internal fixation at a level-1 trauma center in order to learn more about the results and complications of treatment of these potentially devastating injuries.

Materials and Methods

Between 1975 and 2000, eighty-three femoral neck fractures in eighty-two consecutive patients with a mean age of thirty-six years (range, fifteen to fifty years) were treated with internal fixation at our level-1 trauma center. All fractures were classified as type 31B according to the system of the Orthopaedic Trauma Association¹⁴. All patients were skeletally mature, and those who had pathologic fractures due to neoplasm were excluded. Fifty-three patients were male, and twenty-nine were female. Fifty-nine fractures were displaced, and twenty-four were nondisplaced. Two patients died, and eight (9.8%) were lost to follow-up. Seventy-three fractures in seventy-two patients were followed until union, until conversion to hip arthroplasty, or for a minimum of two years. The mean duration of clinical follow-up for the group as a whole was 6.6 years (range, three months to twenty-three years). Ten patients demonstrated fracture union but did not subsequently return for follow-up. These ten patients had been followed for a mean of ten months (range, three months to 1.3 years). Five patients required conversion to total hip arthroplasty after less than two years of follow-up. Therefore, fifty-seven patients with fifty-eight fractures were followed for a minimum of two years (mean, 8.1 years; range, two to twenty-three years).

Follow-up radiographs were available for fifty-four (74%) of the seventy-three fractures. The radiographs for the other nineteen fractures had been discarded as part of institutional policy or lost. In those cases, however, the notes of the radiologist and the treating orthopaedic surgeon clearly documented the outcome with respect to fracture-healing and femoral head osteonecrosis; thus, these fractures were included in the study. The mean duration of radiographic follow-up for the group as a whole was 5.4 years (range, three months to twenty-three years). Fifty-one of the fifty-seven patients with a minimum of two years of clinical follow-up had a minimum of two years (mean, 7.4 years; range, two to twenty-three years) of radiographic follow-up.

Clinical and radiographic data were retrospectively reviewed, and the results and complications were analyzed. Institutional review board approval was obtained for a retrospective review. In polytraumatized patients, life-threatening injuries were treated first and then the femoral neck fractures were treated in an urgent fashion. Fifty-three fractures were treated within twenty-four hours after diagnosis, and twenty were treated after more than twenty-four hours because of late presentation (fifteen) or the need to treat other life-threatening injuries (five). The mechanism of injury was a fall for thirty-five

patients (thirty-five fractures), a motor-vehicle accident for twenty-seven patients (twenty-eight fractures), and a stress or insufficiency fracture with no documented single traumatic event for ten patients (ten fractures).

Fifty-one fractures were displaced, and twenty-two were nondisplaced. According to the system of the Orthopaedic Trauma Association, there were thirty-seven transcervical (type-31B2) fractures, twenty-six subcapital (type-31B1) fractures, and ten basicervical (type-31B2.1) fractures. The choice of fixation device, the operative approach, and the need for capsulotomy were determined by the treating surgeon. Fifty-two fractures were treated with cannulated screws; seventeen, with a sliding hip screw; two, with a reconstruction nail; one, with an angled blade-plate; and one, with a McLaughlin plate.

Fourteen of the fifty-one displaced fractures were treated with open reduction (with direct visualization of the fracture fragments) and internal fixation, and thirty-seven were treated with closed reduction and internal fixation. Four of the thirty-seven displaced fractures that were treated with closed reduction also were treated with capsulotomy. Three of the twenty-two nondisplaced fractures were treated with capsulotomy, and one was treated with aspiration of the hip.

Thirty-one (43%) of the seventy-two patients had seventy associated injuries, including an ipsilateral femoral shaft fracture (fifteen patients; 21%), a contralateral femoral fracture (two), a tibial or ankle fracture (ten), an upper extremity fracture (seven), a closed head injury (seven), a patellar fracture (six), a pelvic fracture (six), a foot fracture (five), an acetabular fracture (four), a rib fracture (two), and a skull fracture, facial fracture, cervical spine fracture, liver laceration, renal artery occlusion, and duodenal transection (one each).

Because there is no generally accepted method of grading the quality of reduction of a femoral neck fracture, fracture reduction was graded on the basis of the degree of residual angulation and the amount of displacement as excellent (<2 mm of displacement and <5° of angulation in any plane), good (2 to 5 mm of displacement and/or 5° to 10° of angulation), fair (>5 to 10 mm of displacement and/or >10° to 20° of angulation), or poor (>10 mm of displacement and/or >20° of angulation)^{5,15-17}. Nonunion was defined as failure of fixation with implant breakage, loss of reduction, or persistence of a visible fracture line at a minimum of six months after the index procedure. Osteonecrosis was classified radiographically with use of the method of Ficat and Arlet¹⁸. Functional assessment at the time of follow-up was performed by evaluating pain, walking status, and the need for gait aids as documented by the treating surgeon. Survival of the native femoral head was calculated with use of the Kaplan-Meier method, with conversion to total hip arthroplasty as the end point.

Results

For the group as a whole, fifty-three (73%) of the seventy-three fractures healed after one operation and demonstrated no evidence of osteonecrosis at the time of the last follow-up. Seventeen fractures (23%) were associated with the development of osteonecrosis, which was classified as stage I

TABLE I Data on the Patients

Number of patients/number of fractures	72/73
Mean age (range) (yr)	36 (15-50)
Mean duration of follow-up (range)	6.6 years (3 months to 23 years)
Fracture type (no. of fractures)	
Displaced	51
Nondisplaced	22
Rate of fracture union after a single operation	92% (67 of 73)
Rate of osteonecrosis (overall)	23% (17 of 73)
Rate of complications according to fracture type	
Displaced	Osteonecrosis, 27%; nonunion, 9.8%
Nondisplaced	Osteonecrosis, 14%; nonunion, 4.5%
Rate of conversion to total hip arthroplasty	18% (13 of 73)
Ten-year rate of survival of native femoral head free of revision to total hip arthroplasty	85% (95% confidence interval, 74.1% to 95.9%)

in one hip, stage II in four, stage III in five, and stage IV in seven. Six fractures (8%) were associated with the development of nonunion. Three fractures, therefore, were associated with the development of both osteonecrosis and nonunion (Table I).

Five (9.8%) of the fifty-one displaced fractures were associated with the development of nonunion, and fourteen (27%) were associated with the development of osteonecrosis. Three displaced fractures were associated with the development of both osteonecrosis and nonunion. Three (14%) of the twenty-two nondisplaced fractures were associated with the development of osteonecrosis, and one (4.5%) was associated with the development of nonunion. There was a strong trend for displaced fractures to demonstrate higher rates of osteonecrosis and nonunion; however, with the numbers available, the difference was not significant ($p = 0.17$).

At the time of the most recent follow-up, thirteen (18%) of the seventy-three fractures had been treated with a total hip arthroplasty because of the development of osteonecrosis (eleven), nonunion (one), or both (one). The mean time to conversion to total hip arthroplasty from the time of the injury was 7.3 years (range, three months to fifteen years). The rate of survival of the native femoral head free of conversion to total hip arthroplasty was 88.4% (95% confidence interval, 80.3% to 97%) at five years and 85% (95% confidence interval, 74.1% to 95.9%) at ten years (Fig. 1). Five other patients had additional operations for the treatment of nonunion or osteonecrosis. Specifically, four additional procedures (two procedures involving a quadratus femoris muscle-pedicle bone graft, one valgus-producing intertrochanteric osteotomy, and one repeat open reduction and internal fixation with autologous bone-grafting) were performed for the treatment of nonunion, and one additional procedure (a repositioning proximal femoral osteotomy) was performed for the treatment of osteonecrosis. All four secondary attempts to achieve fracture union were successful; however, one patient in whom successful union was achieved later required total hip arthro-

plasty for the treatment of osteonecrosis. Therefore, seventy-one (97%) of seventy-three fractures ultimately demonstrated osseous union.

All nondisplaced fractures, by definition, had an excellent reduction. Therefore, in the group as a whole, sixty-eight (93%) of the seventy-three fractures had a good to excellent reduction. Of these, fourteen (21%) were associated with the development of osteonecrosis and three (4%) were associated with the development of nonunion. Of the forty-six displaced fractures with a good to excellent reduction, eleven (24%) were associated with the development of osteonecrosis and two (4%) were associated with the development of nonunion. Five displaced fractures (10%) had a fair or poor reduction. Two fractures were associated with the development of both osteonecrosis and nonunion, one was associated with the development of osteonecrosis, and one was associated with the development of nonunion. Thus, only one of five fractures that had a fair or poor reduction healed without complication.

Fourteen displaced fractures were treated with open reduction, with direct visualization of the fracture fragments. These fractures, by definition, were treated with capsulotomy. Four additional fractures that were treated with successful closed reduction and internal fixation also were treated with capsulotomy. Three nondisplaced fractures were treated with capsulotomy, and one was treated with aspiration of the hip. Therefore, for the group as a whole, twenty-two (30%) of the seventy-three fractures were treated with some form of capsular decompression and fifty-one of the seventy-three fractures were not. At the time of the most recent follow-up, four (18%) of the twenty-two fractures that had been treated with capsular decompression and thirteen (25%) of the fifty-one fractures that had been treated without decompression were associated with the development of osteonecrosis. With the numbers available, this difference was not significant ($p = 0.50$). Additionally, we could not demonstrate a significant difference when analyzing the impact of capsular decompression on the

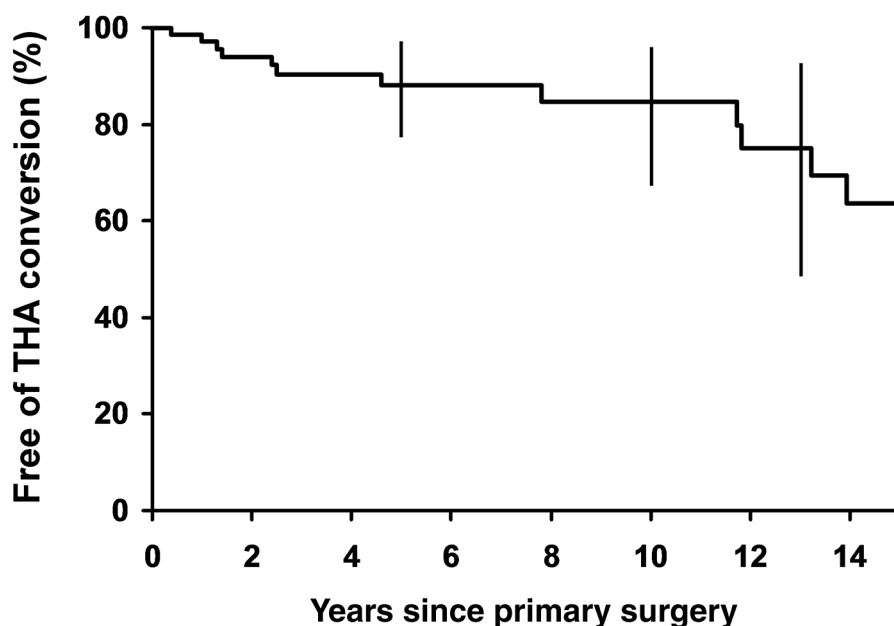


Fig. 1
Kaplan-Meier curve (with 95% confidence intervals) demonstrating the survival of the native femoral head free of conversion to total hip arthroplasty (THA).

rate of osteonecrosis for displaced fractures ($p = 0.33$) and nondisplaced fractures ($p = 0.47$).

Of the fifty-three fractures that were treated within twenty-four hours after diagnosis, thirteen (25%) were associated with the development of osteonecrosis and four (7%) were associated with the development of nonunion; two of these fractures were associated with the development of both. Of the twenty fractures that were treated more than twenty-four hours after diagnosis, four (20%) were associated with the development of osteonecrosis and two (10%) were associated with the development of nonunion; one of these fractures was associated with the development of both. With the numbers available, the difference was not significant.

Two patients had an intraoperative complication. In one patient an intra-articular screw necessitated a return to the operating room for screw repositioning, and in one patient a broken drill-bit was left in the proximal part of the femur. Twelve (17%) of the seventy-two patients had a postoperative complication; the complications included pneumonia (four patients), wound infection requiring incision and drainage and delayed closure (two), deep venous thrombosis (one), sepsis (one), urinary tract infection (one), ileus (one), thrombocytopenia (one), and atrial fibrillation (one).

At the time of the last follow-up, the fifty-nine patients (sixty fractures) with a preserved femoral head generally had excellent clinical function: fifty-eight fractures (97%) caused no or mild pain (that is, pain that was associated with no activity restrictions and no use or occasional use of nonnarcotic analgesics), and two caused moderate pain (that is, pain that was associated with activity limitations and regular use of nonnarcotic analgesics). The great majority of patients did

not require gait aids and reported no activity restrictions; only seven used a cane occasionally, and only one required two-arm support (secondary to traumatic brain injury and hemiparesis). One patient was unable to walk because of other injuries. In the subset of five patients with osteonecrosis who had not undergone conversion to total hip arthroplasty, three reported no pain and two reported mild pain. One patient occasionally used a cane; the rest were unrestricted and used no gait aids.

Discussion

The present study demonstrated that the use of contemporary internal fixation methods for the primary treatment of femoral neck fractures in young patients was associated with a high rate of fracture union (92%; sixty-seven of seventy-three). When secondary procedures were considered, rate of healing was even higher (97%; seventy-one of seventy-three). However, even with the use of contemporary treatment methods, seventeen (23%) of seventy-three fractures were associated with the development of osteonecrosis. Osteonecrosis, not nonunion, was the most common problem leading to conversion to hip arthroplasty. The overall rate of femoral head retention was 82% at a mean of 6.6 years. Although this finding is encouraging, 18% of our patients required conversion to hip arthroplasty at a young age, which demonstrates the need for continued efforts to optimize the treatment of this injury. The high rate of fracture-healing in these patients probably was due to the healing potential and good bone quality of the femoral head and neck of most young patients^{19,20}. In contrast, older patients with femoral neck fractures have poorer bone quality, which probably leads

to higher rates of nonunion; a rate of >30% was reported in a recent meta-analysis¹².

The 27% rate of osteonecrosis among patients with displaced fractures is similar to that reported in previous, smaller studies of younger patients with displaced fractures, even studies in which excellent reduction was achieved in a high percentage of patients and capsulotomy was used routinely^{5-7,9-11,13,16}. Fortunately, a substantial number of the patients who had osteonecrosis in the present series (five [29%] of seventeen) did not have marked symptoms and had not required additional surgery at the time of the latest follow-up. In a recent series by Jain et al.¹⁰, the occurrence of osteonecrosis did not significantly affect functional outcome; however, the mean duration of follow-up for the entire group was only 2.5 years.

The findings of the current study support the premise that the quality of reduction has an impact on the outcome of treatment. The outcome for patients with a fair or poor reduction was poor, although it is important to recognize that problems that make it difficult to obtain a good reduction, such as comminution and marked displacement, may reflect more severe injury patterns. It is also important to note that although most patients had a good to excellent reduction, approximately one in five still had development of osteonecrosis. It has been speculated that the fate of the femoral head is partly determined at the time of injury, and in many patients this is probably the case¹¹. On the basis of current data, we recommend continued efforts to obtain as accurate a reduction as possible. With the numbers available, however, we were not able to identify any correlation between the fracture classification or the method of internal fixation and the rate of osteonecrosis or nonunion.

The role of capsulotomy remains controversial²¹⁻²⁵. The decision to perform a capsulotomy or hip aspiration was made by the treating surgeon. Because of the retrospective nature of this review and some selection bias (resulting from the fact that patients with displaced fractures were more likely to have a capsulotomy to facilitate reduction), we were unable to clearly determine the impact of capsulotomy or hip aspiration on outcome. Although the numbers in the current study were too small for us to draw definitive conclusions, we did not detect a significant difference in the rate of osteonecrosis between fractures that had been treated with a decompressive maneuver and those that had not. The rate of osteonecrosis in the current series is very similar to the rates in previous studies in which capsulotomy was routinely performed^{5,6,13}. Additionally, in a recent series of thirty-eight patients under the age of sixty years, the reported rate of osteonecrosis was 16% overall, with only one patient undergoing capsular decompression¹⁰. Until a large, prospective, randomized series is available, however, we will continue to perform capsulotomy because it adds minimal additional risk, it is simple to perform, and it may theoret-

ically help a small subset of patients by decompressing the blood vessels supplying the femoral head.

The shortcomings of the present study include the use of retrospective methodology, the involvement of multiple surgeons using different fixation devices, the inconsistent use of capsulotomy, and the fact that these relatively rare fractures were treated over a period of many years during a time when surgical techniques and internal fixation devices were evolving. It is possible that complication rates may decrease further with the development of improved surgical techniques and internal fixation devices. In addition, a validated system was not used to describe patient outcomes.

The strengths of the present study include the large number of consecutive patients who had been treated at a single institution and the high rates of clinical and radiographic follow-up, which allowed us to accurately determine the rates of osteonecrosis, nonunion, and femoral head survival in a population of trauma patients after a relatively long duration of follow-up. The limitations of the current study do not undermine its most important findings, which were that (1) the ten-year survivorship of the native femoral head free of conversion to total hip arthroplasty after femoral neck fracture was 85% and (2) the functional outcome of the vast majority of patients was quite good. Despite contemporary techniques of stable internal fixation and the high percentage of good to excellent reductions, osteonecrosis developed in >20% of patients and nonunion developed in 8%. Even though a substantial subset of patients who had osteonecrosis were asymptomatic or minimally symptomatic, osteonecrosis was the main reason for conversion to total hip arthroplasty. In most patients with nonunited fractures, union was achieved after a secondary procedure. The results of treatment were influenced by fracture displacement and the quality of reduction. The role of capsulotomy remains controversial. ■

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