9

Salvage of Failed Treatment of Femoral Neck Fractures

George J. Haidukewych, MD

Abstract

The number of patients treated for femoral neck fractures continues to increase. Although most fractures will heal, reported rates of nonunion and osteonecrosis are cause for concern; therefore, implementation of effective salvage strategies is important. The choice of salvage strategy generally is guided by patient age, remaining bone quality, the status of the articular surface of the hip joint, and the viability of the femoral head. Nonunions in patients younger than 60 years are typically treated with valgus-producing osteotomies, which convert shear forces to compressive forces and have demonstrated relatively high union rates. The role of various vascularized and nonvascularized bone grafts remains undefined. Nonunions in patients older than 60 years are typically salvaged with some form of hip arthroplasty. Both hemiarthroplasty and total hip arthroplasty can be effective. Surgical challenges include osteopenic bone; bony defects from hardware; and contracted, scarred, and shortened limbs. Careful attention to detail during surgery is necessary to avoid complications and provide durable reconstructions in this setting.

Instr Course Lect 2009;58:83-90.

The number of patients with hip fractures in the United States continues to increase.[1] Although most femoral neck fractures treated with contemporary techniques of open reduction and internal fixation will heal, revision rates after nonunion or osteonecrosis reportedly remain at 30% to 40%.[1] Interestingly, these failure rates have not changed over the past seven decades, despite advances in implants, materials, surgical techniques, and intraoperative fluoroscopy. When the economic impact of such revision rates is considered, it becomes evident that initial treatment decisions and failure salvage options need to be available and effective. Unfavorable fracture patterns, poor implant placement, fracture displacement, increasing age, and poor bone quality are factors that increase the likelihood of fracture fixation failure.[1-3] Effective treatment strategies for fracture fixation failure are important because patients typically are severely disabled. The main management options are revision internal fixation, with or without bone grafting, corrective osteotomy, or prosthetic replacement. Salvage of failure is individualized according to physiologic age, activity level, remaining bone quality, the viability of the femoral head, and the status of the articular surface of the hip joint. This chapter reviews the evaluation, surgical options, and results of salvage of failed treatment of femoral neck fractures in patients younger than 60 years and those older than 60 years.

Preoperative Evaluation

When evaluating a patient with a failed internal fixation of a hip fracture, the surgeon should consider occult infection as a potential etiology of fixation failure. During evaluation, preoperative complete blood counts with manual differentials, erythrocyte sedimentation rates, and C-reactive protein serologies are obtained. Aspiration of the nonunion site is not routinely performed because it would be technically difficult to obtain an adequate specimen and the reliability of the results has not been documented. Intraoperative tissue from the nonunion site (if it is directly exposed, as when performing an arthroplasty) is obtained for frozen section histology. If there is evidence of infection, all hardware is removed, deep cultures are obtained, necrotic tissue is débrided, and antibiotic-impregnated polymethylmethacrylate beads or spacers are placed. If staged arthroplasty is contemplated, then a Girdlestone resection with placement of an antibiotic-impregnated spacer may be considered if the femoral head is thought to be infected. The definitive reconstruction is then performed after a period of organism-specific intravenous antibiotics. A staged approach can be done when infection is present, whether arthro-

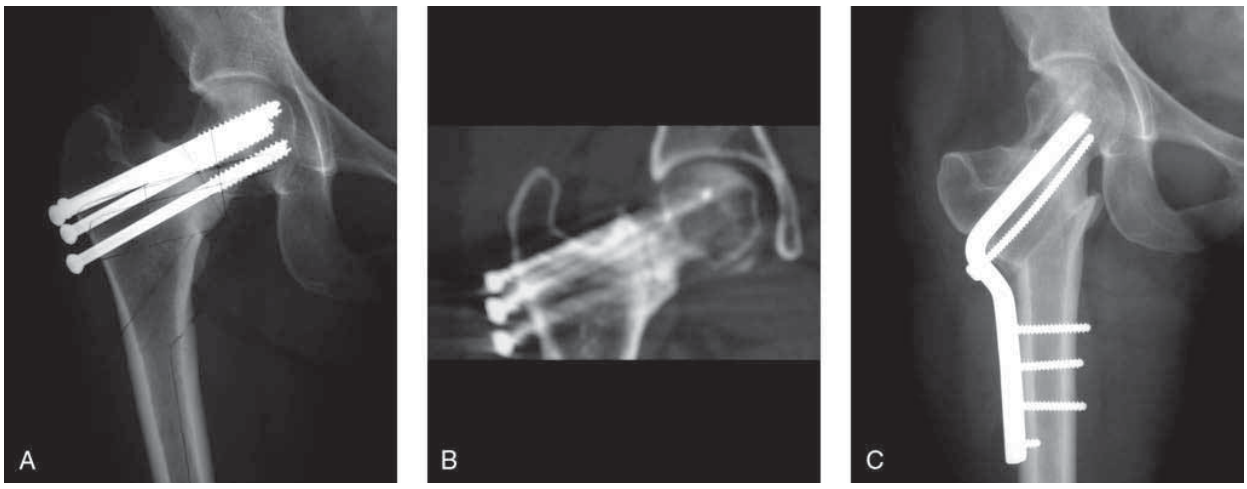

Figure 1 **A,** AP radiograph of the hip of a 35-year-old woman with persistent groin pain 1 year after internal fixation of a displaced femoral neck fracture. **B,** CT scan demonstrating persistence of a vertical fracture line, confirming nonunion. **C,** Follow-up radiograph after valgus-producing intertrochanteric osteotomy. (Reproduced from Haidukewych GH, Berry DJ: Salvage of failed treatment of hip fractures. *J Am Acad Orthop Surg* 2005;13:101-109.)

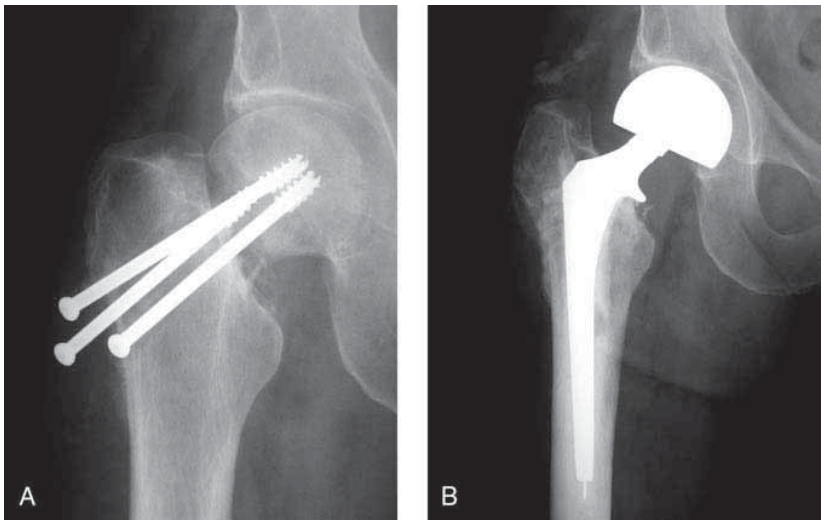

Figure 2 **A,** AP radiograph of a failed internal fixation of a femoral neck fracture in an elderly woman. Note the well-preserved joint space. **B,** Salvage with a cemented bipolar hemiarthroplasty. (Courtesy of G.J. Haidukewych, MD.)

plasty or an attempt to salvage the femoral head is planned.

Although most nonunions with failed fixation devices and persistent fracture instability do not pose a diagnostic dilemma, occasionally nonunion can be more subtle and difficult to diagnose. Patients may present with persistent pain and difficulty with ambulation several months after internal fixation. Radiographs may demonstrate settling of the fracture, or backing out of the hardware. Alho and associates[4] reviewed the radiographic signs predictive of failure for patients with internally fixed femoral neck fractures. Three months was considered the critical time for evaluating prognosis. Change in fracture position by 10 mm, change in screw position by 5%, backing out of the screws by 20 mm, or perforation of the femoral head by a screw all correlated with a high rate of revision. If plain radiographs are equivocal, conventional radiographs or CT can be useful in this setting to determine whether bony union has occurred (Figures 1 and 2). Revision usually is considered for acute fracture fixation failure, unacceptable fracture alignment, or established fracture nonunion. Although 3 months is a reasonable time frame to expect union in most patients, fixation failure sometimes is evident well before 3 months; in some patients, especially those with radiographic evidence of progressive but incomplete healing, a longer period of observation is necessary.

Symptomatic malunion is uncommonly reported after hip fracture. However, shortening of the

femoral neck, shortening through the intertrochanteric area, and malunion of the greater trochanter all can occur after hip fractures and can lead to limb-length discrepancy or adverse hip biomechanics resulting in a limp or pain. In most instances, moderately suboptimal hip biomechanics are accepted as the trade-off to gain good bone apposition and fracture union. Very little has been written about the options for salvage of a severe malunion, with most data gathered from the treatment of neglected intertrochanteric hip fractures. In one small series,[5] corrective osteotomy was recommended for symptomatic intertrochanteric malunions in younger patients, while older patients were typically treated with hip arthroplasty. More studies are needed to determine the ideal way to prevent and salvage malunions after hip fracture. Fortunately, malunions after transcervical femoral neck fractures are exceedingly rare.

The viability of the femoral head can be assessed with plain radiographs, using the radiographic changes described for osteonecrosis.[6] If necessary, bone scintigraphy or MRI (if titanium implants are present) can be useful.[6] Additional modalities are rarely used in the younger patient without collapse of the femoral head because all attempts are focused on preserving the femoral head, even if patches of avascular bone are present.

When evaluating the patient in whom hip fracture fixation has failed, certain patient-specific issues also should be addressed. When osteosynthesis is attempted, tobacco use in any form should be discontinued, if possible. Medical and nutritional optimization, especially in elderly, debilitated patients, also is desirable. It is important to discuss the salvage nature of the reconstruction, and the fact that the hip will never be "normal," especially with younger patients.

Salvage of Failed Femoral Neck Fractures: Young Patients

Femoral neck fracture nonunions in physiologically young patients usually are treated with methods designed to salvage the femoral head and preserve the hip joint. Preservation of the femoral head in this patient population is preferable to prosthetic replacement. The most common techniques used for salvage of femoral neck nonunions in young patients fall into two categories: those designed to improve the mechanical environment at the fracture site (for example, valgus-producing osteotomies) and those designed to improve the biologic environment at the nonunion site with some form of bone grafting (nonvascularized, free vascularized, or muscle-pedicle type grafts).[6] The Meyers quadratus femoris pedicle graft, the most widely studied grafting technique, provides a vascularized local bone graft to improve the biology at the nonunion site.[7-9] This graft may be used when there is a loss of bone stock posteriorly or for well-aligned fractures with low shear angles. The results of various methods of bone grafting for femoral neck nonunions [7,8,10-16]are summarized in Table 1. The indications for these techniques have yet to be fully elucidated; however, they may be useful for patients with neglected fractures, those who have undergone failed fixation attempts, or those who have well-aligned nonunions with osteonecrosis. The clear superiority of any bone grafting choice is unsubstantiated by the current literature.

Valgus intertrochanteric osteotomies convert shear forces at the nonunion site to compressive forces that promote fracture healing. Marti and associates[17] reported a series of 50 patients (mean age, 53 years) treated with valgus intertrochanteric osteotomy for femoral neck nonunion. Eighty-six percent of nonunions united in a mean of 4 months. Of the 22 patients who had radiographic evidence of osteonecrosis (without collapse) at the time of osteotomy, only 3 patients (14%) showed progressive collapse of the femoral head, necessitating hip replacement. Anglen[18] reported a series of 13 patients followed a mean of 25 months after valgus osteotomy for failed internal fixation of a femoral neck fracture. All fractures healed, and 11 of 13 patients had good to excellent results. Two patients (15%) later were converted to arthroplasty because of osteonecrosis. Ballmer and associates[19] reported a series of 17 patients with nonunions of the femoral neck treated with valgus-producing osteotomies. Twelve of 17 patients (70%) healed with one procedure. Three patients required revision fixation but eventually healed, increasing the overall union rate to 88%. Three patients (17%) had progressive osteonecrosis and required hip arthroplasty. Thus, even with areas of osteonecrosis, the results of salvage of the femoral head can be good (Figure 1). If segmental collapse of the femoral head is present, valgus osteotomy would rarely be performed because the results would be less predictable, and the osteotomy deforms the proximal femur, which may make later total hip arthroplasty, if needed, more difficult.

Wu and associates[20] compared the use of a sliding compression

Table 1
Summary of Results of Various Bone Grafting Techniques for Nonunion of the Femoral Neck

Series	No. Patients	Mean F/U	Mean Age or Age Range	% Osteonecrosis Preoperative	Type of Graft	% Fracture Union	% Osteonecrosis Progression	% Converted to THA
LeCroy et al[10]	22	85 months	29	All 16/22 stage I and II 6/22 stage III and up	Free vascularized fibula	20/22 (91%)	13/22 (59%)	2/22
Nagi et al[11]	40 neglected fractures	68 months	35	8/40 (20%)	Free vascularized fibula	37/40 (93%)	7/40 (18%)	3/40
Hou et al[12]	5 neglected fractures	2 years	24	None	Iliac crest pedicle (deep circumflex iliac artery)	5/5 (100%)	None	None
Leung et al[13]	15	3.5 years	38	None	Iliac crest pedicle (deep circumflex iliac artery)	15/15 (100%)	1/15	1/15
Nagi et al[14]	26	29 months	39	4/26 (15%)	Autograft fibula nonvascularized	25/26 (96%)	0	None
Baksi[7]	56	35 months	42	34/56 All stage I and II (61%)	Quadratus femoris muscle-pedicle	42/56 (75%)	2/34 (6%)	Not stated
Meyers et al[8]	32	14 followed > 1 yr	16-79	Not stated	Quadratus femoris muscle-pedicle	23/32 (72%)	Not stated	Not stated
Bonfiglio and Voke[15]	77	5 years	31-79	All	Autogenous tibial strut, nonvascularized	72/77 (94%)	Not stated	Not stated
Henderson[16]	77	69 followed to union	46	Not stated	Autograft fibula or tibia, nonvascularized	46/49 (69%)	Not stated	Not stated

THA = total hip arthroplasty; F/U = follow-up
(Reproduced from Haidukewych GJ, Berry DJ: Salvage of failed treatment of hip fractures. *J Am Acad Orthop Surg* 2005;13:101-109.)

screw with and without subtrochanteric valgus osteotomy for femoral neck nonunions in 32 patients (mean age, 38 years). All of the nonunions healed at a mean of 4.6 months. Although there were fewer complications in the nonosteotomy group, the authors recommended valgus osteotomy for patients with shortening of more than 1.5 cm because the valgus osteotomy helps increase leg length.

Although previous work has focused on union rates and osteonecrosis progression after valgus osteotomy, little has been written about the clinical function after such salvage procedures. Recently, Mathews and associates evaluated the functional outcome of 15 patients with valgus-producing osteotomies for femoral neck nonunions at a mean of 4 years after operation (V Matthews, MD, DJ Berry, MD, RT Trousdale, MD, unpublished data presented at the American Academy of Orthopaedic Surgeons annual meeting, Dallas, TX, 2002). Although fracture union without progression of osteonecrosis was achieved in most patients, a persistent limp was common, probably because of loss of femoral offset and abductor moment arm.

Femoral neck nonunions in younger patients often result from primarily mechanical instead of biologic reasons. The original fractures, and subsequent nonunions, typically have high shear angles (Pauwels type 3), have shortening, and are aligned in varus. Thus, the valgus-producing intertrochanteric osteotomy is the preferred treatment.

The technique of valgus-producing intertrochanteric osteotomy has been well described in the literature.[21] The principles involve converting a vertically oriented fracture to a more horizontally oriented fracture, thus minimizing the shear forces at the fracture site and promoting union. The recommended horizontality of the nonunion after osteotomy should be approximately 20° to 30°.[17] Thus, the size of the intertrochanteric wedge removed would be calculated as the difference between the current nonunion

verticality and the desired horizontality. For example, a patient with a 70° nonunion verticality would have a 40° to 50° wedge resected from the intertrochanteric region to properly reposition the proximal fragment. Fracture shear angles may be quite difficult to accurately measure because of leg rotation and should be measured from a line perpendicular to the femoral shaft.[18] It is preferable to perform such osteotomies on a fracture table that allows excellent fluoroscopic visualization of the proximal femur. Careful preoperative templating is performed to determine the appropriate blade plate angle. Blade plates with multiple angles are commercially available, and a plate that allows excellent fixation of the proximal fragment and the appropriate neck-shaft angle after correction should be used. After removal of all hardware, the proximal femur is prepared to accept the blade plate with the seating chisel before the osteotomy is performed. It is important to mark the correct leg rotation, usually with Kirschner wires in the proximal and distal fragments, before making the osteotomy. The chisel that creates a path for the blade is seated to the appropriate depth and subsequently removed. The osteotomy is then made parallel to the chisel tract, taking care to leave at least 2 cm of bone between the inferior aspect of the blade tract and the superior aspect of the osteotomy, thereby minimizing the chance of fracture of this inferior bony bridge. Commercially available protractors are available for exact calculation of the intertrochanteric wedge. These are typically placed along the anterior femur, and a fluoroscopic image is taken. Kirschner wires are used to mark the appropriate wedge trajectory, and a saw is used to make the osteotomy. It is important to cool the saw with periodic irrigation, as the bone in this anatomic region can be dense, and thermal necrosis may otherwise result. After the appropriate wedge has been removed, a blade plate of appropriate length and angle is impacted into the femoral head. A secondary proximal screw is placed below the blade; then distal screws are placed in the usual fashion. Good compression across the osteotomy site usually results as the distal screws are placed because of the osteotomy obliquity. Care should be taken to keep the bone proximal and distal to the osteotomy well aligned on the lateral view to avoid creating a deformity that would be difficult to convert to a hip arthroplasty later. It is wise to bone graft the osteotomy site by morsellizing the cancellous bone from the resected wedge and placing the cancellous bone along the osteotomy line. The wound is closed in the usual layered fashion. Patients should be cautioned that although union rates are high, a persistent limp is common. Minimization of the amount of femoral shaft medialization when performing such osteotomies should be attempted. One technique is to choose a slightly longer blade. When seated to the appropriate depth, the plate remains lateral, which helps keep the shaft lateral. Shaft medialization decreases offset, therefore decreasing abductor efficiency and increasing the joint reactive force. Additionally, excessive shaft medialization may cause valgus alignment at the knee.

Occasionally, despite often valiant efforts to preserve the femoral head in young patients, the situation will arise where there is no reasonable alternative to hip arthroplasty or hip arthrodesis. For example, a patient with total collapse of the femoral head and a nonunion would not be a good candidate for a joint-preserving procedure. Hip arthroplasty in young patients can be reserved for those in whom several well-done attempts to preserve the joint have failed and those with collapse of the femoral head.

Salvage of Femoral Neck Fractures: Older Patients

Femoral neck fracture nonunions in physiologically older patients typically are salvaged with hip arthroplasty—either hemiarthroplasty or total hip arthroplasty. Hemiarthroplasty is advantageous because it is a less extensive operation and probably has a lower risk of instability (Figure 2). There are no data available comparing the longevity of bipolar versus unipolar bearings when the hemiarthroplasty is performed for salvage of failed open reduction and internal fixation. Bipolar bearings are preferable because long-term survivorship data (10 years or more) are available. Most short- and mid-term data have not shown a difference between the two choices; however, a recent meta-analysis demonstrated that for patients who survived longer than 7 years, the revision rates for unipolar bearings were twice as high as those for bipolar bearings. Clearly, more data are needed to investigate the performance of hemiarthroplasties for salvage of failed fixation of femoral neck fractures. When articular cartilage of the hip is badly damaged (from degenerative arthritis or erosion from hardware penetration), total hip arthroplasty usually is preferred (Figure 3). When the articular cartilage of the acetabulum is well preserved, the decision to use hemiarthroplasty or total hip arthroplasty is at the surgeon's discretion. Scrutiny of preoperative radiographs

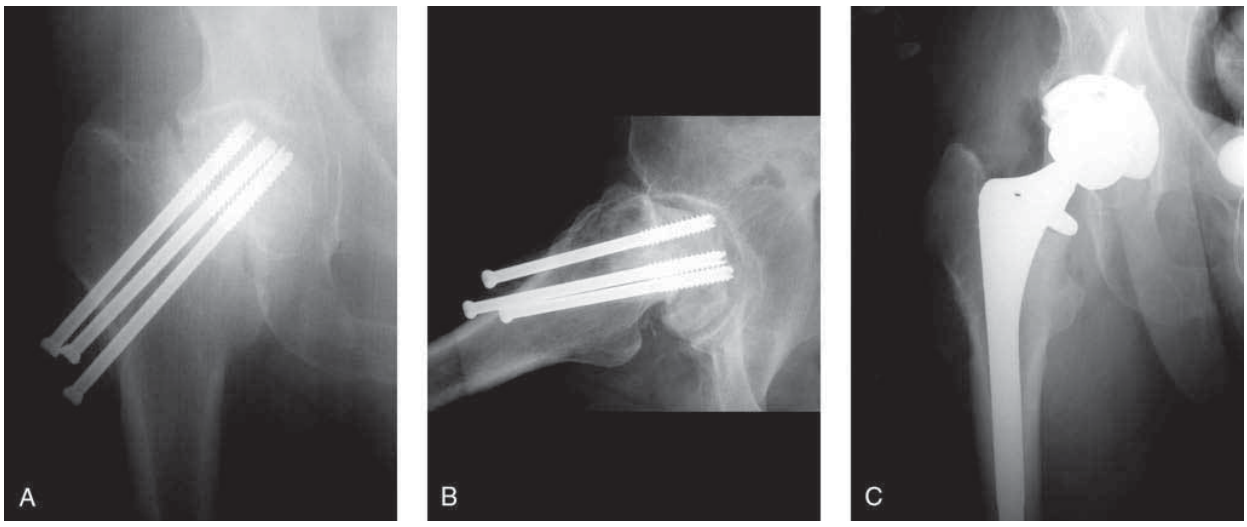

Figure 3 **A** and **B,** AP and lateral views of posttraumatic nonunion and osteonecrosis after femoral neck fracture. **C,** Salvage with a total hip arthroplasty. (Courtesy of G.J. Haidukewych, MD.)

and intraoperative inspection of the acetabular cartilage may guide decision making. Recent data regarding arthroplasty for acute femoral neck fractures have documented improved functional outcomes for patients treated with total hip arthroplasty; however, no such comparison has been performed for salvage situations. If hemiarthroplasty is planned, it is wise to have total hip arthroplasty components available as well because preoperative radiographs may underestimate the amount of articular surface damage.

There are several technical issues to consider when hip arthroplasty is done for failed fixation of a femoral neck fracture. Previous hardware usually needs to be removed. Acetabular bone quality in patients with femoral neck nonunions often is remarkably poor because of disuse osteopenia. Most patients do not have degenerative hip arthritis in this setting and thus do not have the sclerotic subchondral bone typically present in elective hip replacements performed for degenerative arthritis. When a cementless cup is used, acetabular fracture or poor press-fit fixation during implant insertion can be encountered. Judicious acetabular reaming, making an effort to preserve the subchondral bone, is recommended. Care should be taken to avoid forceful acetabular component impaction, and augmentation of fixation with screws may be considered.

Little has been written about the results and complications of hip arthroplasty for failed treatment of femoral neck fractures.[22-27] McKinley and Robinson[28] reported a matched-pair series of 107 patients treated with early cemented total hip arthroplasty for failed open reduction and internal fixation of a femoral neck fracture compared with a group of 107 patients who underwent arthroplasty as primary treatment of the fracture. The salvage arthroplasty group had significantly higher dislocation rates (21% versus 8%) and more superficial infections than the primary arthroplasty group. Functional scores and implant survivorship also were inferior for the salvage group.

Mabry and associates reported on 99 patients with femoral neck nonunions treated with Charnley hip arthroplasties between 1970 and 1977 (T Mabry, MD, B Prpa, MD, GJ Haidukewych, MD, unpublished data presented at the American Academy of Orthopaedic Surgeons annual meeting, Dallas, TX, 2002). The mean age was 68 years at the time of arthroplasty (range, 36 to 92 years). Eighty-two patients completed mean 12-year follow-up. Twelve percent of the arthroplasties (in 10 patients) were revised. Survivorship free of revision for any reason was 93% at 10 years and 76% at 20 years. Implant survivorship was better for patients older than 65 years. Instability occurred in seven patients (9%), half of whom developed recurrent dislocation. Thus, reported results clearly document the value of total hip arthroplasty for salvage of

femoral neck nonunion for older patients. Larger diameter femoral heads and certain surgical approaches may be useful to reduce the risk of dislocation in this patient population, although no published data substantiate this speculation. The Hardinge approach is a preferred option, along with use of largest femoral head compatible with the implanted cup diameter.

Summary

In younger patients, salvage of a failed hip fracture typically involves efforts to preserve the hip joint with revision internal fixation, whereas in many older patients prosthetic replacement is a reliable salvage option. The location of the nonunion, physiologic age of the patient, quality of the remaining proximal bone, presence of deformity, status of the hip joint, and viability of the femoral head all influence decision making. Regardless of the salvage method chosen, attention to specific technical details can improve the success rate and reduce the complications of treating these challenging conditions.

References

1. Kyle RF, Cabanela ME, Russell TA, et al: Fractures of the proximal part of the femur. *Instr Course Lect* 1995;44: 227-253.
2. Baumgaertner MR, Solberg BD: Awareness of tip-apex distance reduces failure of fixation of trochanteric fractures of the hip. *J Bone Joint Surg Br* 1997;79:969-971.
3. Haidukewych GJ, Israel TA, Berry DJ: Reverse obliquity of fractures of the intertrochanteric region of the femur. *J Bone Joint Surg Am* 2001;83: 643-650.
4. Alho A, Benterud JG, Solovieva S: Internally fixed femoral neck fractures: Early prediction of failure in 203 elderly patients with displaced fractures. *Acta Orthop Scand* 1999;70:141-144.
5. Lifeso R, Younge D: The neglected hip fracture. *J Orthop Trauma* 1990;4: 287-292.
6. Jackson M, Learmonth ID: The treatment of nonunion after intracapsular fractures of the proximal femur. *Clin Orthop Relat Res* 2002;399:119-128.
7. Baksi DP: Internal fixation of ununited femoral neck fractures combined with muscle-pedicle bone grafting. *J Bone Joint Surg Br* 1986;68: 239-245.
8. Meyers MH, Harvey JP Jr, Moore TM: The muscle pedicle bone graft in the treatment of displaced fractures of the femoral neck: Indications, operative technique and results. *Orthop Clin North Am* 1974;5:779-792.
9. Meyers MH, Harvey P Jr, Moore TM: Treatment of displaced subcapital and transcervical fractures of the femoral neck by muscle-pedicle-bone graft and internal fixation. *J Bone Joint Surg Am* 1973;55:257-274.
10. LeCroy CM, Rizzo M, Gunneson EE, et al: Free vascularized fibular bone grafting in the management of femoral neck nonunion in patients younger than fifty years. *J Orthop Trauma* 2002;16:464-472.
11. Nagi ON, Dhillon MS, Goni VG: Open reduction, internal fixation and fibular autografting for neglected fracture of the femoral neck. *J Bone Joint Surg Br* 1998;80:798-804.
12. Hou SM, Hang YS, Liu TK: Ununited femoral neck fractures by open reduction and vascularized iliac bone graft. *Clin Orthop Relat Res* 1993;294: 176-180.
13. Leung PC, Shen WY: Fracture of the femoral neck in younger adults: A new method of treatment for delayed and nonunions. *Clin Orthop Relat Res* 1993;295:156-160.
14. Nagi ON, Gautam VK, Marya SK: Treatment of femoral neck fractures with a cancellous screw and fibular graft. *J Bone Joint Surg Br* 1986;68: 387-391.
15. Bonfiglio M, Voke EM: Aseptic necrosis of the femoral head and nonunion of the femoral neck. *J Bone Joint Surg Am* 1968;50:48-66.
16. Henderson MS: Ununited fracture of the neck of the femur treated by the aid of the bone graft. *J Bone Joint Surg Am* 1940;22:97-106.
17. Marti RK, Schuller HM, Raaymakers E: Intertrochanteric osteotomy for nonunion of the femoral neck. *J Bone Joint Surg Br* 1989;71:782-787.
18. Anglen JO: Intertrochanteric osteotomy for failed internal fixation of femoral neck fracture. *Clin Orthop Relat Res* 1997;341:175-182.
19. Ballmer FT, Ballmer PM, Baumgaertel F, et al: Pauwels osteotomy for nonunions of the femoral neck. *Orthop Clin North Am* 1990;21:759-767.
20. Wu CC, Shih CH, Chen WJ, et al: Treatment of femoral neck nonunions with a sliding compression screw: Comparison with and without subtrochanteric valgus osteotomy. *J Trauma* 1999;46:312-317.
21. Müller ME: Intertrochanteric osteotomy: Indication, preoperative planning, technique, in Schatzker J (ed): *The Intertrochanteric Osteotomy*. New York, NY, Springer-Verlag, 1984, pp 25-66.
22. Franzen H, Nilsson LT, Stromqvist B, et al: Secondary total hip replacement after fractures of the femoral neck. *J Bone Joint Surg Br* 1990;72: 784-787.
23. Hagglund G, Nordstrom B, Lidgren L: Total hip replacement after nailing failure in femoral neck fractures. *Arch Orthop Trauma Surg* 1984;103:125-127.
24. Knight WM, DeLee JC: Nonunion of intertrochanteric fractures of the hip: A case study and review. *Orthop Trans* 1982;16:438.
25. Nilsson LT, Jalovaara P, Franzen H, et al: Function after primary hemiarthroplasty and secondary total hip arthroplasty in femoral neck fracture. *J Arthroplasty* 1994;9:369-373.

26. Tabsh I, Waddell JP, Morton J: Total hip arthroplasty for complications of proximal femoral fractures. *J Orthop Trauma* 1997;11:166-169.

27. Turner A, Wroblewski BM: Charnley low-friction arthroplasty for the treatment of hips with late complications of femoral neck fractures . *Clin Orthop Relat Res* 1984;185:126-130.

28. McKinley JC, Robinson CM: Treatment of displaced intracapsular hip fractures with total hip arthroplasty: Comparison of primary arthroplasty with early salvage arthroplasty after failed internal fixation. *J Bone Joint Surg Am* 2002;84:2010-2015.