Instructional Course Lectures

THE AMERICAN ACADEMY OF ORTHOPAEDIC SURGEONS

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Preface

The annual Instructional Course Program of the Academy is a major and outstanding continuing medical education activity. From it, presentations are selected for publication in this volume by the Instructional Course Committee. Obviously, the text does not include all of the courses presented in any one year. A number of courses do not lend themselves to publication; to include some others would create a duplication of previously published material.

The Committee selects subjects with an emphasis on overall interest to those in the practice of orthopaedic surgery. In addition, an author's ability to convey information in a concise manner to the reader is a factor in the selection process. Further emphasis is placed on proven methods rather than on innovations that have not had the test of time or experience. Historically, this publication has not been a sounding board for unproven techniques or theories.

In addition to any benefits a reader may receive from information in a book of this type, time has shown the *Instructional Course Lectures* series serves as a good source of pertinent references to many subjects related to the musculoskeletal system. Readers with a desire to pursue subjects in greater depth will find this resource helpful.

The material presented in this publication has been made available by the American Academy of Orthopaedic Surgeons for educational purposes only. This material is not intended to represent the only, or necessarily the best, methods or procedures appropriate for the medical situations discussed; rather it is intended to present an approach, view, statement, or opinion of the authors that may be helpful to others who face similar situations.

We are especially grateful to all authors, without whom the *Instructional Course Lectures* series would not be possible.

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Chapter 1

Fractures of the neck of the femur

Part I

Displaced fractures of the femoral neck—internal fixation or hemiarthroplasty?

GORDON A. HUNTER

THE ROLE OF INTERNAL FIXATION AND PROSTHETIC REPLACEMENT

The displaced fracture of the femoral neck still presents problems to the orthopaedic surgeon and is of significance both economically to health service facilities and socially to patients and their relatives.

Nonoperative treatment should be restricted to those patients with severe mental illness or retardation, those living a bed-chair existence, or in the rare situation when deep pressure sores prevent a safe surgical incision.[27]

Operative treatment improves the comfort of the patient by relief of pain and facilitates nursing care, thus reducing the length of stay in an expensive "active treatment" hospital bed. It is debatable whether it reduces the incidence of thromboembolism, which may be in excess of 50% after surgical treatment of femoral neck fractures.[24]

Operative treatment should be carried out as soon as practical after assessment by either the internist or anesthetist. Early treatment should relieve the patient's discomfort and reduces further damage to the blood supply of the femoral head.

The possibilities of surgical treatment include the following:

1. Closed reduction and internal fixation
2. Open reduction and internal fixation, with or without a muscle pedicle graft supplemented by iliac bone chips[21]
3. Hemiarthroplasty, with or without the use of cement
4. Single assembly hip replacement of the Bateman or Giliberty type, with or without cement
5. Total hip replacement

Closed reduction of the fracture

Garden[12] stated that "achievement of accurate reduction was largely a matter of chance." Flynn[10] recommended the following method:

1. Gentle flexion of the limb to beyond 90 degrees of flexion with 10 degrees abduction and neutral rotation.
2. Traction in the line of the neck of the femur.
3. Gentle internal rotation as the leg is extended. Then the leg should be fixed in extension, internal rotation, and 10 degrees of abduction.

This method is less traumatic than that described by Leadbetter.[17] The reduction should then be checked by image intensifier if possible. Concerning the acceptability of reduction, Garden[13] has now come to rely on the appearance of the fragments as seen in a lateral radiograph as the best guide to the prognosis of union of the fracture.

I prefer to place a guide wire in the middle of the head and neck in both planes. It should be remembered that the head of the femur normally shows a slight posteroinferior overhang on the neck.[12] I prefer to use a sliding screw-type device and fix the plate to the shaft of the femur with two or three screws, often combined with a threaded pin to stabilize the fracture (Fig. 1-1).

Fig. 1-1. Placement of screw in the middle of head and neck in both planes. If the screw appears to be low in the head and neck, it may be combined with a threaded pin to stabilize the fracture.

The screw should be inserted just below the articular surface of the femoral head.

I use prophylactic antibiotics for 2 or 3 days and anticoagulants in selected high-risk patients.

I allow early weight bearing as soon as practical and transfer the patient to a convalescent hospital 2 to 3 weeks after the operation.

COMPLICATIONS OF INTERNAL FIXATION

Avascular necrosis, with or without late segmental collapse. Published figures of rate of incidence report a range of 6% to 84%,[8,26] averaging approximately 25% to 30%. It should be remembered that avascular necrosis may be partial or complete. It is frequently asymptomatic, and, even if symptomatic, it does not always require reconstructive surgery.

Nonunion. The reported incidence varies from 5% to 35%,[20,21] but if these figures are reversed, union may occur in 65% to 95% of patients. From a large review of 1503 patients,[3] 67% of Type III and IV fractures united, often demonstrating delayed union. Surprisingly enough, a delay of up to 1 week before operation had no significant effect on the incidence of nonunion.

Table 1. Comparative deep infection rate in reported series of fractures of the neck of the femur treated by prosthetic replacement and internal fixation

	Primary prosthesis	*Internal fixation*
Hunter[14]	9%	0%
Raine[23]	6%	0%
Arnold et al.[2]	8% (approximately)	0.5%
Fielding et al.[9]	8%	0%
Hunter[15]	9%	3%

Table 2. Incidence of dislocation of hemiarthroplasty

Lunt[18]	10%
Wrighton and Woodyard[32]	3%
Raine[23]	8%
Hunter[15]	7%
Chan and Hoskinson[5]	8%
D'Arcy and Devas[7]	2%
Bracey[4]	7%
Hunter[16]	11%

Infection. The reported incidence varies from 0% to 3%.[14,15] Malcolm and Schatzker[19] have recently stressed that subluxation or dislocation of the femoral head after internal fixation of the fracture is an important clue to the diagnosis of deep infection.

Hemiarthroplasty

If the complications of closed reduction and internal fixation are so frequent, why should we not advise routine excision of the femoral head and replacement with a femoral prosthesis?

COMPLICATIONS

The reasons we should not adopt this method of treatment routinely relate to the problems arising from deep infection, dislocation of the prosthesis, problems of revision, especially with cemented prostheses, and mortality figures.

Infection. The incidence of deep infection after prosthetic replacement has been reported to be as high as 42%[22] and compares most unfavorably with the rate of incidence after closed reduction and internal fixation (Table 1).

Table 3. Comparative mortality figures after internal fixation, primary and secondary replacement

Author	*Time period*	*Internal fixation*	*Primary prosthesis*	*Secondary prosthesis*
Garcia et al.[11]	6 Months	4%	18%	
Stein and Costen[30]	Postoperative		12%	1%
Hunter[14]	6 Months	15%	41%	10%
Raine[23]	6 Months	12%	33%	
Arnold et al.[2]	In Hospital	1%	11%	0.4%
Hunter[15]	6 Months	15%	24%	10%
Albright and Weinstein[1]	1 Year		41%	10%
Bracey[4]	6 Months	21%	30%	5%

Dislocation of the prosthesis. The reported incidence in recent literature varies from 2% to 11%[7,16] (Table 2). When dislocation is associated with sepsis, the outcome is invariably fatal.

In view of the high incidence of dislocation reported by Whittaker et al.[31] and Coughlin and Templeton,[6] I would avoid prosthetic replacement in patients with Parkinson's disease.

Problems of revision after prosthetic replacement. Unlike the revision procedure after failed internal fixation, in which a number of alternatives are available, a failed hemiarthroplasty must be converted to a total hip replacement, provided that sepsis is excluded as a possible cause of pain. Smith and Amstutz[29] reviewed 41 failed femoral hemiarthroplasties converted to total hip replacements. They reported intraoperative femoral shaft fractures, two dislocations, and one deep infection. There was a high incidence of loosening of the femoral component, and technically imperfect cement fixation was recorded in 30 of 41 hips in the first postoperative radiograph.

Mortality rate. The mortality rate 6 months after primary prosthetic replacement ranges from 18% to 41%.[11,14] These figures should be compared to the lower mortality figures at the same time period after internal fixation and after secondary prosthetic replacement (Table 3).

Other complications. An analysis of the incidence and problems of loosening of the femoral prosthesis, acetabular erosion, and fractures of the femoral shaft around the prosthesis during or after the operation will not be presented here.

USE OF CEMENT

Whether or not to routinely cement a prosthesis has been well discussed by Sledge,[28] but it is interesting that in a recent personal review,[16] there was little difference in the results and complications of 55 patients with uncemented Moore prostheses and 45 patients with cemented Thompson prostheses for displaced femoral neck fractures.

CONCLUSIONS

I would remind you that Senn[25] pointed out that "the only cause for nonunion of intracapsular fractures is our inability to maintain perfect coaptation and immobilization of the fragments until bony union has taken place". Almost all displaced femoral neck fractures should be treated by careful closed reduction and internal fixation whenever possible. Accurate reduction of the fracture is more important than the actual instruments used for internal fixation, which may depend on the personal preference of the individual surgeon.

In the management of the patient with a fresh displaced fracture of the femoral neck, I would consider alternative procedures only in the following circumstances:

1. Failure of closed reduction
2. Delay of more than a few days after the accident, to avoid problems of avascular necrosis and nonunion
3. Pathologic fracture due to metastatic disease
4. A "high-level" subcapital fracture
5. A fracture of the neck of the femur associated with dislocation of the femoral head
6. Pre-existing Paget's disease or arthritis associated with a fracture of the neck of the femur

I would remind you that the only conditions preventing further procedures on the hip joint after fracture of the neck of the femur are a dead patient and an infected hip joint. We should, therefore, strive to reduce the incidence of infection, morbidity, and mortality in this common but serious fracture. The best way of doing this at the present time is to reduce the fracture accu-

rately as soon as possible and to treat the fracture by internal fixation.

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Part II

Treatment by muscle pedicle graft and internal fixation

MARVIN H. MEYERS

Because of the continued high incidence of avascular necrosis and nonunion after open reduction and internal fixation of displaced femoral neck fractures, a literature review and study of this fracture was started in 1965. In spite of the endless introduction of innovative metallic fixatives, it was apparent that little headway had

been made in reducing the incidence of these two undesirable complications. The rate of nonunion, 15% to 35%, and the rate of large segmental collapse, 30% of the cases that united, remained unchanged.

Most authors concluded that nonunion was caused by failure to maintain coaptation and immobilization of the fracture fragments prior to union. Other contributing factors that were suggested included the patient, type of fracture, technical errors in fixation, the healing mechanism, time from fracture to fixation, and premature weight bearing.

Authors were in agreement that accurate reduction, impaction of the fracture fragments after reduction, and rigid fixation were essential if the best rate of union was to be obtained.

Fig. 1-2. Posterior neck defect with large cavity left after crushing of trabeculae in neck and head of femur.

However, achievement of these goals is not always possible due to marked comminution of the posterior neck of the femur. This was identified in 70% of a series of fractures I treated by a muscle pedicle graft and internal fixation. Frequently, a large gap was noted in the posterior neck, which was devoid of bone (Fig. 1-2). This can be confirmed preoperatively on x-ray examination with good across-table lateral x-rays films of the involved hip. Anatomic reduction is not possible in the presence of severe posterior neck comminution, and impaction is only possible in two thirds or less of the opposing cortical rims at the fracture site. Although rigid fixation is desirable, the paucity and attenuation of the intramedullary trabeculae in the head fragment of the elderly patient makes this difficult to achieve. (Fig. 1-3).

A major obstacle to the solution of the "unsolved" fracture is the extent of damage to the blood supply of the head fragment following fracture. Many authors including Catto,[2] Calandruccio,[1] and Sevitt[9] have reported that two thirds of the heads, following fracture of the neck of the femur with displacement, are totally or subtotally avascular. More than one third are completely avascular. Thus, avascular necrosis of bone must occur within a few hours of injury. Union of the fracture and revascularization follow in most avascular femoral heads that are reduced and ad-

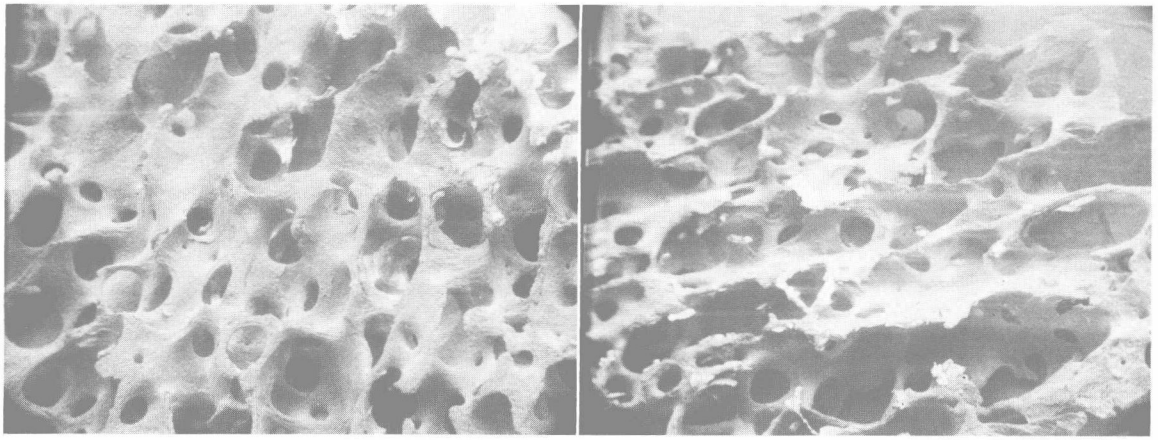

Fig. 1-3. Scanning electron microscopy section of macerated femoral heads (×20). **A,** Twenty-nine-year-old woman with average normal thickness and concentration of trabeculae. **B,** Sixty-eight-year-old woman with attenuation and decreased number of trabeculae.

equately fixed internally. Late segmental collapse of the femoral head, the troublesome complication of avascular necrosis, occurs at about 9 to 24 months after the injury in most cases.

This concept should be clearly understood. Avascular necrosis occurs within the first few hours after injury. Revascularization from the vascular distal fragment is a slow "creeping" process that cannot begin until the fracture is reduced and immobilized by metal fixation. Since revascularization of bone is a steady, orderly process dependent upon the ingrowth of capillaries along the framework of the intramedullary trabecular system, the defect subsequent to the comminution of the posterior neck must act as a barrier to the revascularization process in the proximal fragment. (See Fig. 1-2.) Thus, it can be hypothesized that nonunion in some cases and slow revascularization in others are due to the lack of bone in the large gap posteriorly.

In 1967, I was introduced to the muscle pedicle graft of the quadratus femoris muscle[3] as a means of providing an additional source of blood to the head fragment after femoral neck fracture when the blood supply was diminished or totally absent. This procedure permits the addition of supplemental iliac bone to fill the defect in the posterior neck, thereby providing a source of chemicals for new bone deposition and a scaffold for the ingrowth of capillaries in the revascularization process. The pedicle graft aids fracture stability by providing additional fixation.

Although it is well-established that avascular necrosis occurs immediately after the occurence of the fracture, the reason for late segmental collapse, which is rarely seen prior to 9 months after injury, is yet unknown. It is inappropriate at this point to engage in a long hypothetic discussion on the cause of late segmental collapse.

INDICATIONS FOR MUSCLE PEDICLE GRAFT

The indications for a muscle pedicle graft are (1) displaced fractures of the neck of the femur after closure of the proximal femoral epiphysis and (2) nondisplaced or impacted femoral neck fractures, when absence of a blood supply or severely impaired blood supply to the head fragment can be demonstrated. Technetium 99m sulfur colloid (SC) scans of the pelvis are 95% accurate in revealing the absence or severe damage of circulation in the femoral head[7] (Fig. 1-4).

CONTRAINDICATIONS FOR MUSCLE PEDICLE GRAFT

The muscle pedicle graft procedure is contraindicated in the following patients:

1. Nonwalkers or minimal walkers
2. Those with a short life expectancy
3. Those unable to cooperate in a postoperative rehabilitation program due to the following:
   a. Senility
   b. Psychosis
   c. Mental retardation
   d. Parkinsonism
   e. Cerebrovascular accident (CVA) with residual hemiplegia or spasticity
   f. Severe debility
4. Those with rheumatoid arthritis with severe joint involvement, pathologic fractures, or advanced degenerative osteoarthritis of the hip

ADVANTAGES

The muscle pedicle graft procedure has several advantages. It allows direct visualization of the posterior neck of the femur. Thus, the degree of comminution can be adequately determined. (See Fig. 1-2.) It also permits a more accurate reduc-

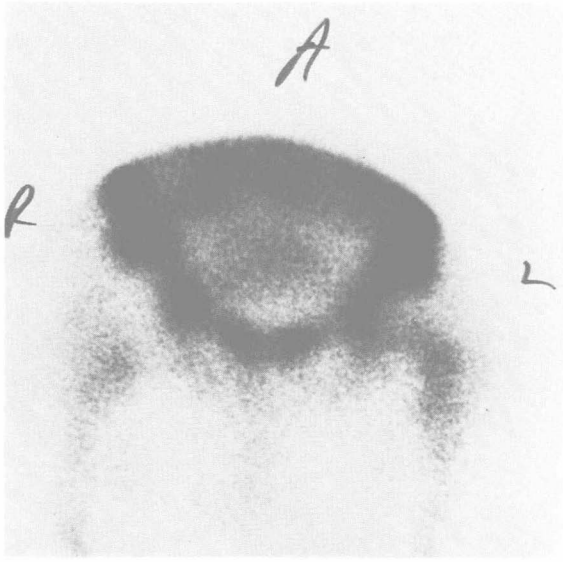

Fig. 1-4. Technetium 99m SC scan of pelvis with subcapital fracture of right hip. Activity absent in region of neck and head of femur on right.

tion, since the capsule is opened. The posterior approach facilitates the addition of supplemental iliac bone. The pedicle graft is secured by inserting the cephalad end into an opening in the femoral head and a screw in the caudal end of the graft. Fracture stability is provided by this additional fixation. Finally, the procedure provides an additional source of blood to the head fragment when the blood supply is diminished or totally absent.

DISADVANTAGES

There are certain disadvantages. However, the disadvantages are not serious enough to preclude using this procedure. The muscle pedicle graft requires a greater degree of technical skill, approximately 30 minutes of increased surgical time as compared to blind nailing, and an increased risk of infection due to greater soft dissection and invasion of the hip joint.

TECHNICAL CONSIDERATIONS

It is generally accepted that the following are principles of surgery for a displaced femoral neck fracture:

1. An accurate reduction must be obtained.
2. The fragment must be impacted.
3. Firm fixation is essential.

The reported experience of many surgeons interested in this fracture has proven this concept. The muscle pedicle graft technique has been adequately described previously.[4,5]

An accurate reduction does not require vigorous manipulation or complicated maneuvers. Manual traction and internal rotation usually are effective in reducing the fracture. Where the fracture is incompletely reduced, a final reduction can be accomplished under direct vision after opening the capsule.

Impaction of the fragments is accomplished by tightening the nut against the washer at the end of each nail, similar to the tightening procedure on the lugs of a tire wheel.

Firm fixation requires satisfactory placement of four modified Hagie nails (Fig. 1-5). The nails must be placed in the posterior one half and the inferior one half of the femoral head and come to rest no less than 3 mm from the subchondral surface of the femoral head (Fig. 1-6). The direction of the compression force on the femoral head forces the head to rotate posteriorly and inferiorly. The recommended nail placement acts as a neutralization force. The subchondral surface of the head fragment (the only area of compact trabeculae in the osteoporotic head) is the only available area for the fixative to anchor into firm bone. The sparse trabeculation in the intramedullary portions of the neck and head fragments is not conducive to firm fixation of the nails.

RESULTS

The surgical technique used presently was standarized in July of 1971. A total of 253 surgeries have been done, 144 since July, 1971, with a nonunion rate of 9% and 5% respectively. Late segmental collapse has occurred in 5% of the cases.

Results of treatment of displaced subcapital femoral neck fractures in patients under the age of 40 have been discouraging.[8] In this series there were 23 patients in the young adult group. Only one did not unite, and there has been no case with late segmental collapse. In a series of 32 undisplaced fractures or minimally displaced frac-

Fig. 1-5. Modified Hagie pin, $^{3}/_{16}$ inch (0.5 cm) thick with washer and nut; $1^{1}/_{4}$ inches (3.1 cm) of cancellous threads.

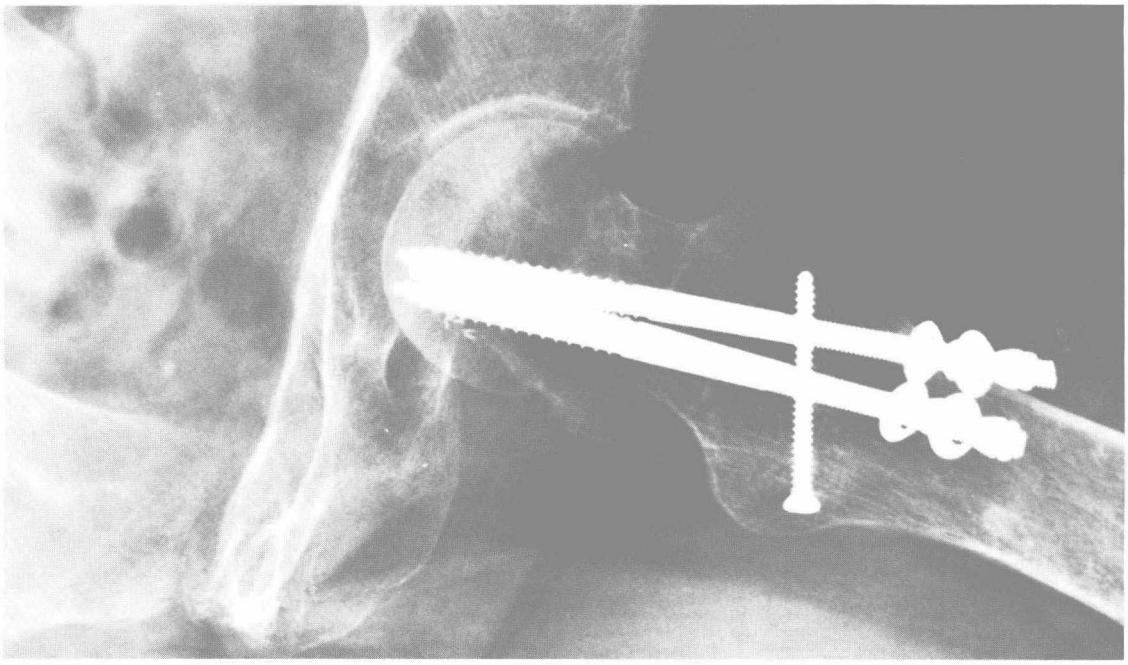

Fig. 1-6. Proper pin placement in posterior one half of head and neck. Pins are up to subchondral bone. Note viable pedicle graft in this healed fracture.

tures (Garden I and II), all have united without any instances of late segmental collapse. Two have had muscle pedicle grafts based on a negative technetium 99m SC hip scan.

CONCLUSION

The importance of strict adherence to the proven principles of accurate reduction, impaction, and rigid fixation in the treatment of displaced femoral neck fractures is to be emphasized. Additionally, the quadratus femoris muscle transplant and autogenous iliac bone chips to fill any defect that may be present in the posterior aspect of the neck are probably necessary to achieve the best results.

The technetium 99m SC bone scan is an important test to assess the status of circulation in the head fragment in undisplaced or minimally displaced fractures. A negative scan indicates severely impaired circulation and the need for a muscle pedicle graft.

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