CLINICAL PRACTICE

Caren G. Solomon, M.D., M.P.H., *Editor*

Management of Acute Hip Fracture

Mohit Bhandari, M.D., Ph.D., and Marc Swiontkowski, M.D.

This Journal *feature begins with a case vignette highlighting a common clinical problem. Evidence supporting various strategies is then presented, followed by a review of formal guidelines, when they exist. The article ends with the authors' clinical recommendations.*

A 65-year-old woman who has been healthy and active presents to the emergency department several hours after a slip and fall. She is unable bear any weight on her right leg and reports that she has pain with any attempt to move. On inspection, her right leg is shortened and externally rotated. A plain radiograph of her pelvis and hip confirms a nondisplaced fracture of the femoral neck. Careful review of the radiograph determines that her fracture is located at the base of the femoral neck (sometimes called a basicervical fracture) with a more vertically oriented fracture line. How should her case be managed?

THE CLINICAL PROBLEM

Worldwide, 4.5 million people are disabled from hip fractures each year, with an expected increase to 21 million persons living with this disability in the next 40 years.[1] Globally, hip fracture ranks among the top 10 causes of disability.[1] By the year 2040, the estimated annual health care costs will reach $9.8 billion in the United States and $650 million in Canada.[2] However, given that three quarters of the world population live in Asia, it is projected that Asian countries will contribute more to the pool of hip fractures in coming years. It is estimated that by 2050, more than 50% of all osteoporotic fractures will occur in Asia.[3]

Hip fractures are anatomically classified in relation to the hip capsule as intracapsular fractures (i.e., at the femoral neck) or extracapsular fractures (i.e., intertrochanteric or subtrochanteric fractures) (Figs. 1 and 2). Intertrochanteric fracture and femoral-neck fracture represent the majority of hip fractures and occur with similar frequency. Femoral-neck fractures may be either nondisplaced (i.e., very little separation at the fracture site, which occurs in approximately one third of femoral-neck fractures) or displaced (i.e., greater separation). By convention, fractures of the femoral neck can be further classified as Garden type I or II, representing nondisplaced or impacted fracture patterns, and Garden type III or IV, representing displaced fracture patterns.[4] Fractures below the femoral neck are referred to as intertrochanteric fractures, and those below the lesser trochanter as subtrochanteric fractures (Fig. 1).

The natural history of hip fractures is dismal if they are left untreated. Patients who have had a hip fracture are at risk for cardiovascular, pulmonary, thrombotic, infectious, and bleeding complications.[5,6] These complications can result in death. Therefore, timely surgery for hip fracture remains the mainstay of treatment. However, functional decline and a diminished quality of life are common after

From the Department of Surgery, Division of Orthopaedic Surgery, McMaster University, Hamilton, ON, Canada (M.B.); and the Department of Orthopedic Surgery, University of Minnesota, Minneapolis (M.S.). Address reprint requests to Dr. Swiontkowski at the University of Minnesota, Department of Orthopedic Surgery, 2450 Riverside Ave. S., Mail Stop R200, Minneapolis, MN 55454, or at swion001@umn.edu.

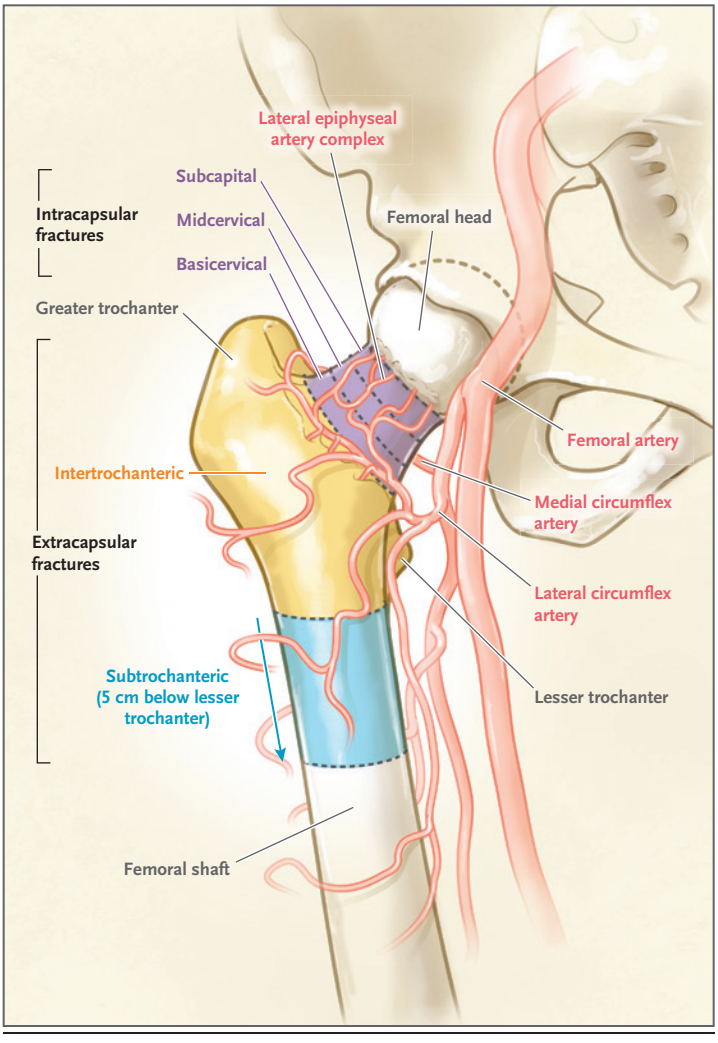
N Engl J Med 2017;377:2053-62.
DOI: 10.1056/NEJMcp1611090

An audio version of this article is available at NEJM.org

KEY CLINICAL POINTS

ACUTE HIP FRACTURE

- Hip fractures (categorized according to anatomical location as a femoral-neck fracture or an intertrochanteric or subtrochanteric fracture) can have a devastating effect on quality of life and function, with a high risk of death at 1 year.
- Femoral-neck fractures, if nondisplaced or in a young patient, are typically treated with internal fixation.
- For fractures at the base of the femoral neck (sometimes called basicervical fractures), displaced fractures, and those with a more vertically oriented fracture line, reoperation rates are lower when a sliding hip screw is used than when multiple cancellous screws are used.
- Approaches to displaced femoral-neck fractures remain controversial, but evidence currently favors arthroplasty over internal fixation, especially in persons 65 years of age or older.
- Unstable intertrochanteric and subtrochanteric fractures of the femur are treated with the use of intramedullary nails, whereas stable fractures of these types are typically treated with the use of a sliding hip screw.
- Perioperative multidisciplinary care is important in regard to osteoporosis assessment and treatment as well as to postoperative functional mobility.



operative management.[7] Mortality at 1 month after hip-fracture surgery approaches 10%.[7] Patients who survive to 30 days are at substantial risk for disability. Even among patients who were community-dwelling before their hip fracture, 11% are bedridden, 16% are in a long-term care facility, and 80% are using a walking aid 1 year after the hip fracture.[7,8]

The mortality rate within 1 year after hip fracture is as high as 36% despite aggressive management including surgery and rehabilitation[9]; this rate has remained relatively stable over time, in contrast to declining mortality rates associated with other causes, such as acute myocardial infarction.[10] The unacceptably high risk of reoperation, ranging from 10 to 49%, after the initial hip-fracture surgery has fueled research that is intended to identify evidence-based management strategies.[9,11]

Figure 1. Classification of Hip Fracture According to Anatomical Fracture Site.

Hip fractures are anatomically classified in relation to the hip capsule as intracapsular (i.e., at the femoral neck) or extracapsular (i.e., intertrochanteric or subtrochanteric). Femoral-neck fractures may be nondisplaced (i.e., very little separation at the fracture site, occurring in approximately one third of femoral-neck fractures) or displaced (i.e., greater separation). Fractures below the femoral neck are referred as intertrochanteric fractures, and those below the lesser trochanter as subtrochanteric fractures.

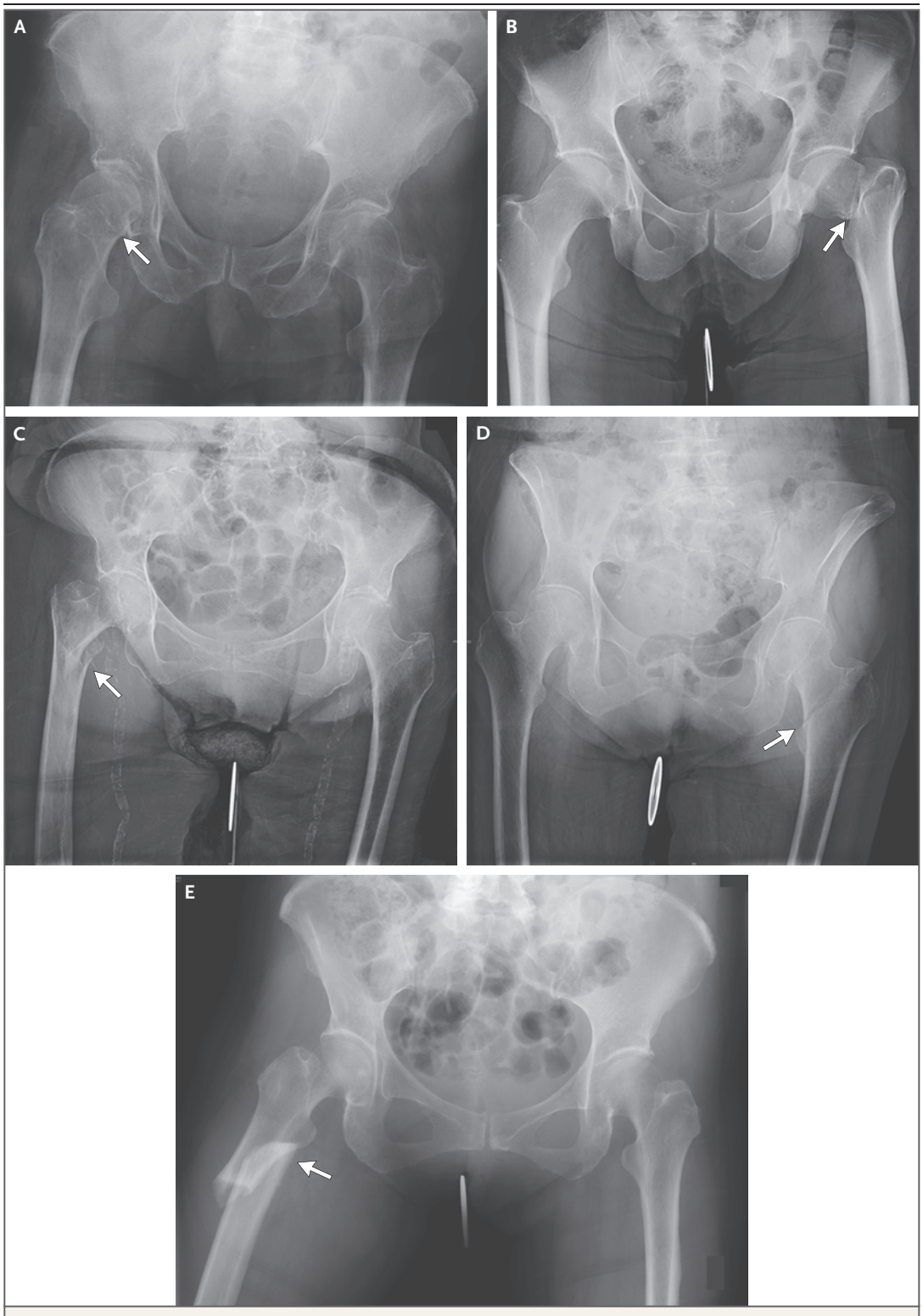


Figure 2. Plain Films Showing Various Types of Hip Fractures.

Panel A shows a nondisplaced femoral-neck fracture, and Panel B a displaced femoral-neck fracture. Panel C shows a displaced intertrochanteric fracture, Panel D an intertrochanteric fracture at the base of the femoral neck (the case presentation in this article), and Panel E a subtrochanteric fracture. An arrow indicates the location of the fracture in each panel.

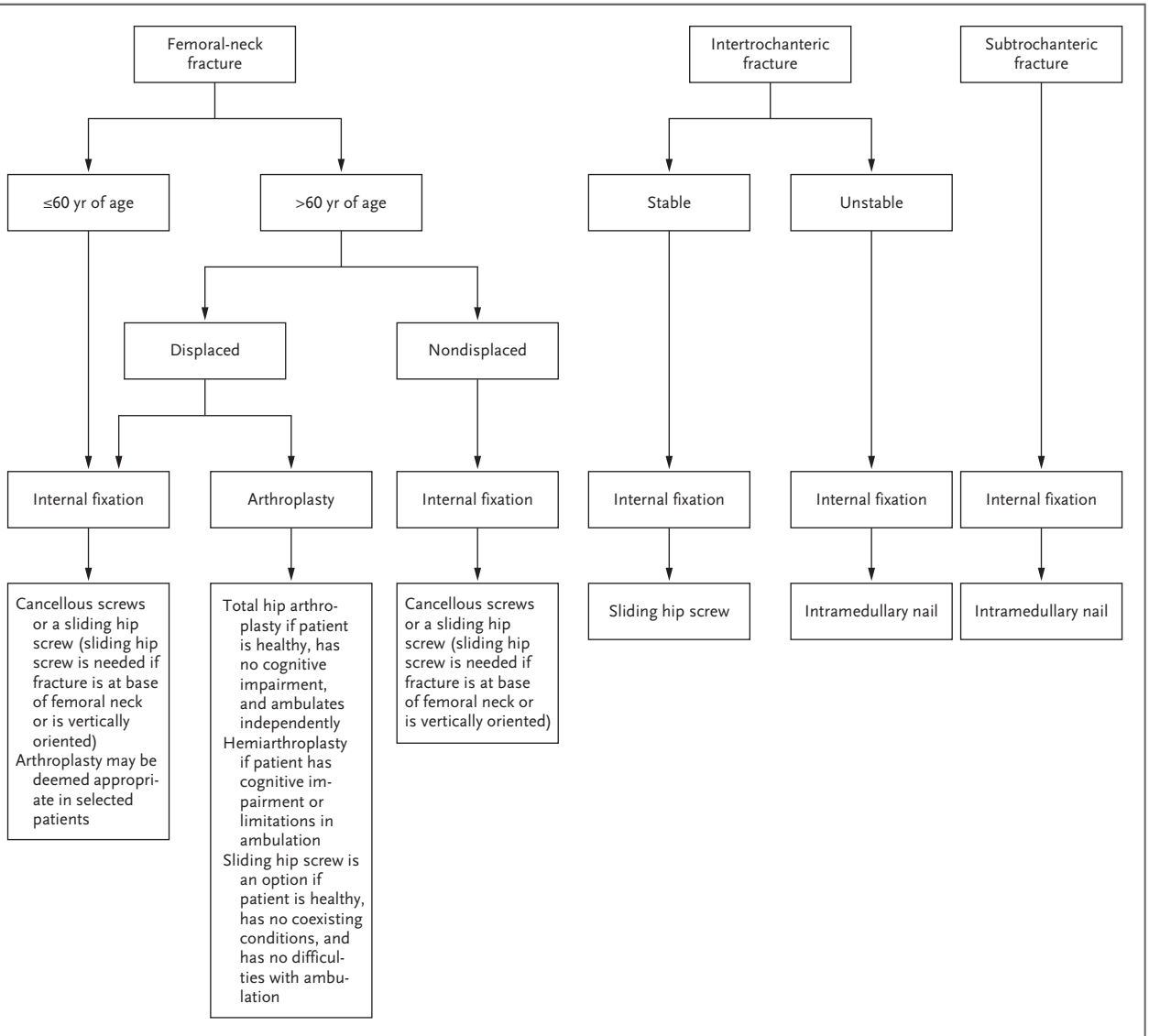


Figure 3. Recommended Management of Hip Fracture, Depending on Location of Fracture and Whether the Fracture Is Displaced.

STRATEGIES AND EVIDENCE

Evidence-based management of hip fractures includes the consideration of surgical options and perioperative care (Fig. 3). Observational studies have identified several risk factors for short-term and intermediate-term death in patients who have a hip fracture, including age, male sex, socioeconomic deprivation, coexisting conditions, dementia, and nursing home residency. Unfortunately, most risk factors are not modifiable.[12]

OPERATIVE MANAGEMENT

Surgeons are faced with three major decisions in the treatment of a patient with an acute hip fracture. Is surgery an option, given the patient's health status? If so, how quickly can it be performed and what type of operation is needed, given the anatomical location, degree of fracture displacement, and the physiological condition of the patient?

Unless the patient's health status is such that there is high risk of intraoperative death or if access to surgical care is difficult, operative

treatment for most hip fractures is recommended. In a single-center retrospective study, patients with hip fracture who were treated nonoperatively had a risk of death at 1 year that was 4 times as high, and a risk of death at 2 years that was 3 times as high, as the risk among patients who underwent surgery.[13] In another retrospective study, patients undergoing nonoperative treatment with bed rest had a risk of death at 30 days that was 3.8 times as high (absolute risk, 73%) as those who had early mobilization.[14] The observation that mortality rates did not differ significantly among patients who were treated operatively and those who were treated nonoperatively but who mobilized early[14] argues for early mobilization in patients who are too sick to undergo surgery.

Time to Surgery

Guidelines recommend that surgery for hip fracture be performed within 48 hours after the event. This recommendation is based on observational studies suggesting that a shorter time to surgery is associated with improved outcomes in patients.[15,16] In addition, physiological data indicating that the pain, bleeding, and immobility that are associated with an acute hip fracture result in inflammation, hypercoagulability, and catabolism provide further support for early surgery.

Recent evidence suggests that minimizing the time from hospital admission to surgery to as little as 6 hours is associated with a greater reduction in the incidence of postoperative complications at 30 days than is a time of more than 6 hours.[17] In a meta-analysis of observational studies (involving 4208 patients and 721 deaths) that was adjusted for the American Anesthetists Society score (a measure of a patient's fitness for surgery), age, and sex, earlier surgery (≤24 hours after admission) was associated with significantly lower mortality than was later surgery (relative risk, 0.81; 95% confidence interval [CI], 0.68 to 0.96; P=0.01).[8] In unadjusted analyses, earlier surgery was also associated with lower risks of in-hospital pneumonia.[8] However, a key confounder in these studies is that surgery is more likely to be delayed (or not performed at all) in patients who are sicker on admission (and thus more likely to die, independent of surgery). In a small, randomized, pilot trial (Hip Fracture Accelerated Surgical Treatment and Care Track [HIP ATTACK]; ClinicalTrials.gov number, NCT01344343) involving 60 patients, the rate of major perioperative complications was 30% with accelerated hip-fracture surgery (≤6 hours after hospital admission) and 47% with standard care (hazard ratio, 0.60; 95% CI, 0.26 to 1.39; P=0.20)[17]; a large, international trial of early (≤6 hours) versus later surgery for hip fractures is currently under way (NCT02027896).

Femoral-Neck Fracture

Surgical options for femoral-neck fractures include internal fixation (i.e., multiple cancellous screws or a single large screw and side plate, often called a sliding hip screw) or arthroplasty (a hemiarthroplasty or total hip arthroplasty) (Fig. 4). Hemiarthroplasty involves the insertion of a metal prosthesis in the proximal femur, whereas total hip arthroplasty includes the insertion of a metal femoral prosthesis and the addition of an acetabular component for the hip socket.

The choice of implant depends largely on the degree of displacement and the physiological condition of the patient. A greater degree of fracture displacement is associated with a higher risk of disruption of the critical blood supply to the femoral head, which is largely provided by the lateral circumflex femoral artery, a branch of the medial circumflex femoral artery.[18] Bleeding from an intracapsular fracture can result in a tamponade effect that may also affect femoral-head microcirculation by compromising venous drainage. Compromise of blood supply can lead to avascular necrosis of the femoral head and to failure of the fracture to unite. Surgical decision making must account for the likelihood of restoring blood supply to the femoral head through anatomical fracture reduction, stable implant fixation, and consideration of intracapsular pressure-reducing capsulotomy.[18]

In patients with a nondisplaced fracture (Garden type I or II), internal fixation is the treatment of choice. Regardless of the age of the patient, small, randomized trials have shown similar outcomes after internal fixation with multiple cancellous screws and after internal fixation with a single large compression screw with a side plate. A recent large trial (Fixation Alternatives in the Treatment of Hip Fractures [FAITH]), in which 1079 patients with a femoral-

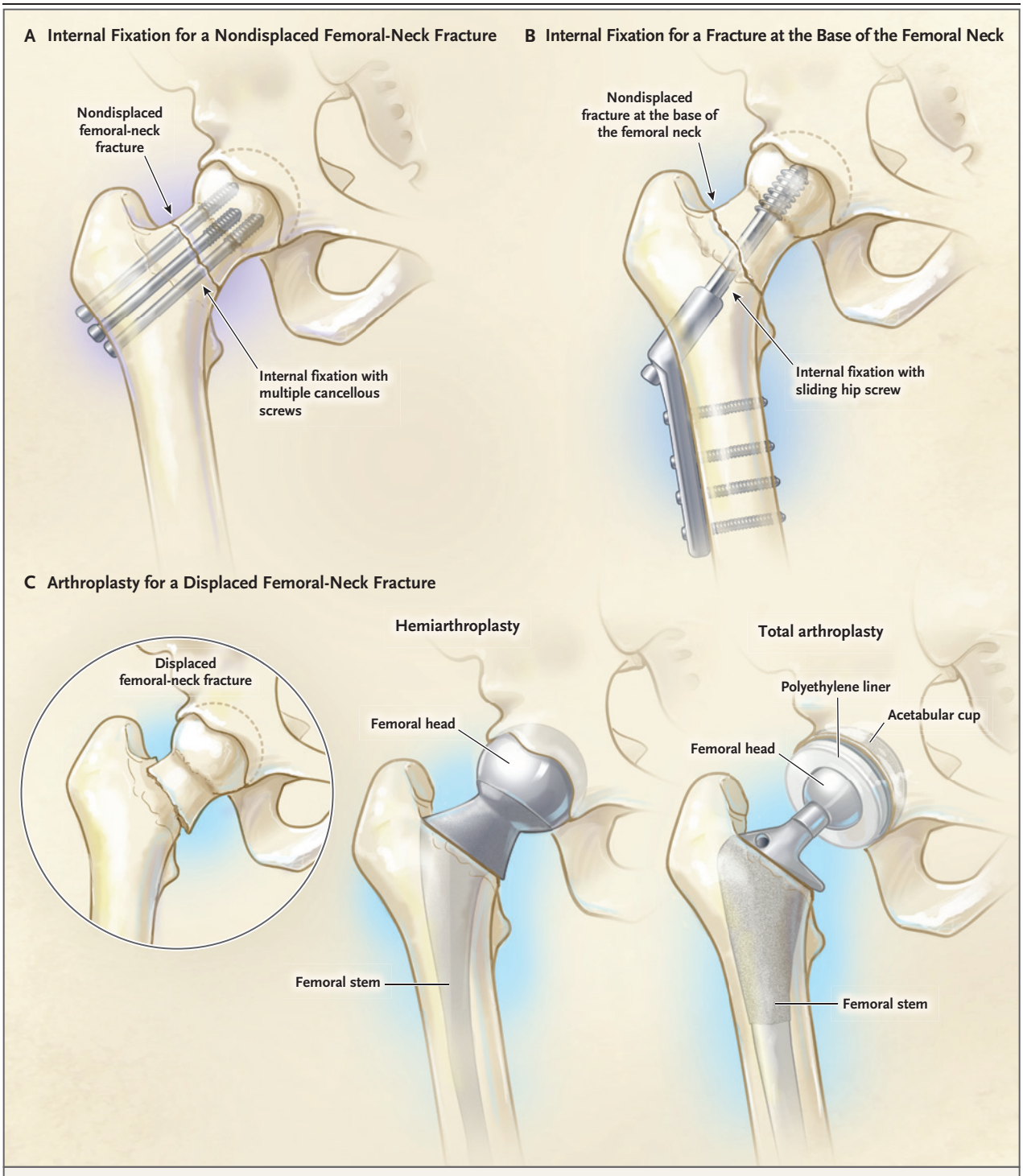


Figure 4. Selected Treatments for Hip Fracture.

Panel A shows internal fixation with multiple screws for a nondisplaced femoral-neck fracture. Panel B shows internal fixation with a sliding hip screw for the treatment of a fracture at the base of the femoral neck. The same fixation is recommended for stable intertrochanteric fractures. Panel C shows a hemiarthroplasty and a total hip arthroplasty for a displaced femoral-neck fracture.

neck fracture (729 patients with a nondisplaced fracture and 350 with a displaced fracture) were randomly assigned to receive either multiple cancellous screws or a sliding hip screw showed no significant difference between groups in the risk of reoperation over 2 years (17.5% vs. 17.4%; relative risk, 1.04; 95% CI, 0.72 to 1.50).[19] However, subgroup analysis suggested that patients had improved outcomes with a sliding hip screw when fractures were displaced or located at the base of femoral neck and when fractures had more vertically oriented fracture lines.[19] In laboratory testing involving these fracture types, a sliding hip screw has shown a better ability to tolerate greater biomechanical loads than have multiple cancellous screws.[20,21]

Arthroplasty is generally preferred over internal fixation for the management of displaced femoral-neck fractures in patients 65 years of age or older who have low-energy, or fragility-type, fractures. A meta-analysis of 14 randomized trials (involving 1907 patients) comparing these surgical approaches in patients 65 years of age or older showed that arthroplasty was associated with a lower risk of reoperation than was internal fixation (relative risk, 0.23; 95% CI, 0.13 to 0.42).[9] Reoperation rates in the internal-fixation group ranged from 10.0% to 48.8% among the trials and often resulted from failure of the fracture to unite (in 18.5% of patients) or avascular necrosis (in 9.7%).[9] Hemiarthroplasty and total hip arthroplasty have each resulted in better functional outcome and quality of life within 1 year after surgery than has internal fixation.[9,22] Long-term follow-up of a randomized trial involving 100 patients showed that hip function at 17 years, as measured by the Harris Hip Score, was better after total hip arthroplasty than after internal fixation.[23] However, arthroplasty also has some disadvantages. A meta-analysis showed a higher risk of infection with arthroplasty than with internal fixation (relative risk, 1.81; 95% CI, 1.16 to 2.85).[9] Dislocations also may occur after arthroplasty.[9]

Consensus is lacking regarding the preferred implant (total hip arthroplasty or hemiarthroplasty) when arthroplasty is performed.[24] A meta-analysis of 14 trials (involving 1890 patients) showed a lower risk of reoperation after total hip arthroplasty than after hemiarthroplasty (relative risk, 0.57; 95% CI, 0.34 to 0.96); however, this effect was driven mainly by trials that did not use concealed information regarding treatment assignment.[25] Ratings of hip function after follow-up periods of 12 to 48 months also were consistently better after total hip arthroplasty than after hemiarthroplasty. However, the risk of dislocation was higher after total hip arthroplasty than after hemiarthroplasty (9% vs. 3%; relative risk, 2.53; 95% CI, 1.05 to 6.10).[26] A large, randomized trial comparing total hip arthroplasty with hemiarthroplasty in 1500 patients with a displaced femoral-neck fracture is currently ongoing (HEALTH).[27]

Although less commonly performed, internal fixation for displaced femoral-neck fractures has some advantages, including that it is less invasive, is associated with a reduced risk of infection (as mentioned above), and is preferred by many patients when they are presented with other options.[9,28] Younger patients who have higher-energy hip fractures (e.g., from motor vehicle accidents) are typically treated with internal fixation, regardless of displacement of the fracture, given that arthroplasty implants are unlikely to last more than 20 years. A critical factor in the use of internal fixation for displaced femoral-neck fracture is the accurate reduction of the fracture before the insertion of any screws or plates. Inadequate fracture reduction is a risk factor for subsequent failure of the fixation.[18]

Intertrochanteric Fractures

Intertrochanteric hip fractures are managed primarily by means of internal fixation, either with a sliding hip screw or an intramedullary nail, because the blood supply to the femoral head is generally intact. For fractures that are deemed to be stable, randomized trials comparing these implants have shown no significant difference in functional outcomes, but sliding hip screws are more cost-effective than intramedullary nails.[29-31] Unstable fractures (i.e., those with a large posteromedial fragment) and those with a reverse-oblique orientation of the fracture line are typically managed with intramedullary nails. A meta-analysis of eight randomized trials (involving a total of 1322 patients) showed improved mobility with their use.[31-38]

Subtrochanteric Fractures

Although subtrochanteric fractures are the least frequent type of hip fracture, they provide unique challenges because of the instability of the fracture fragments. Failure rates of the resultant fixation have been reported to be as high as 35%.[39] A rare variant of subtrochanteric fracture (so-called atypical femur fracture) has been associated with long-term use of bisphosphonates and has also been reported to occur in patients taking newer antiresorptive agents.[40,41] In a meta-analysis involving 232 patients with a subtrochanteric fracture, the use of intramedullary nails resulted in a significantly lower incidence of reoperation and nonunion than did extramedullary plates and screws.[42] Although mortality rates and overall function at 1 year were similar in patients who received intramedullary nails and in those who received extramedullary plates and screws, intramedullary nails have become standard in the treatment of the majority of elderly patients with subtrochanteric fractures and atypical femur-fracture variants.

PERIOPERATIVE CARE

Comprehensive, interdisciplinary care in a geriatric ward has been shown to significantly improve mobility, activities of daily living, and quality of life, as compared with usual care in an orthopedic ward.[43] Although aggressive and early mobilization is strongly recommended, movement deficits can persist for several months after rehabilitation for hip fracture.[15,43,44,45] Care also includes the provision of venous thromboprophylaxis and antibiotic prophylaxis and the evaluation for and treatment of osteoporosis.[15] Osteoporosis is common in patients with hip fracture and is frequently undertreated. Calcium and vitamin D supplementation are routinely recommended after fracture, as is dual-energy x-ray absorptiometry for the assessment of bone mineral density.[15] The prompt initiation of bisphosphonates after a fracture is encouraged in order to reduce the risk of a subsequent fracture; the administration of bisphosphonates has not been associated with deleterious effects on fracture healing.[46,47]

AREAS OF UNCERTAINTY

Whether expedited surgery affects major surgical outcomes is uncertain. The ongoing HIP ATTACK trial is comparing accelerated medical clearance (with the goal of starting surgery for hip fracture within 6 hours after presentation) with standard care with respect to a composite outcome of death and serious perioperative complications. Data are limited but randomized trials are under way for guiding the choice between total hip arthroplasty and hemiarthroplasty for displaced femoral-neck fractures (the HEALTH trial) and for guiding the management of femoral-neck fracture in patients 60 years of age or younger, and randomized trials investigating these questions are currently in progress (the FAITH-2 trial; NCT01908751).

GUIDELINES

Several organizations have published guidelines for the operative treatment of hip fractures, including the National Institutes of Health and Care Excellence,[16] the American Academy of Orthopaedic Surgeons,[15] and the National Hip Fracture Model of Care and Toolkit.[48] Guidelines that are relevant to the preoperative assessment of cardiac risk have been published by the Canadian Cardiovascular Society.[49] The recommendations in this article are generally consistent with these guidelines.

CONCLUSIONS AND RECOMMENDATIONS

The woman in the vignette has a nondisplaced fracture of her femoral neck. As with other nondisplaced femoral fractures, this fracture is best managed with internal fixation. Given her previously active lifestyle and state of generally good health, she is a good candidate for this surgery. We would recommend the use of a sliding hip screw because of location of her fracture at the base of the femoral neck and the more vertical orientation of the fracture line. Surgery should not be delayed. We would recommend performing surgery the same day, if possible, on the basis of studies that have shown better outcomes in patients with earlier surgery and on the pending results of a randomized trial comparing outcomes of prompt versus less-prompt surgery. A multidisciplinary approach to that patient's perioperative care that includes a geriatrician, physical therapist, and occupational therapist is recommended, with a focus on return to function, activities of daily living, and appropriate assessment and treatment of osteoporosis to mitigate the risks of subsequent fractures.

Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

REFERENCES

1. Cooper C, Campion G, Melton LJ III. Hip fractures in the elderly: a world-wide projection. Osteoporos Int 1992;2:285-9.
2. Cummings SR, Rubin SM, Black D. The future of hip fractures in the United States: numbers, costs, and potential effects of postmenopausal estrogen. Clin Orthop Relat Res 1990;252:163-6.
3. Dhanwal DK, Dennison EM, Harvey NC, Cooper C. Epidemiology of hip fracture: worldwide geographic variation. Indian J Orthop 2011;45:15-22.
4. Garden RS. Reduction and fixation of subcapital fractures of the femur. Orthop Clin North Am 1974;5:683-712.
5. LeBlanc ES, Hillier TA, Pedula KL, et al. Hip fracture and increased short-term but not long-term mortality in healthy older women. Arch Intern Med 2011;171:1831-7.
6. Prevention of pulmonary embolism and deep vein thrombosis with low dose aspirin: Pulmonary Embolism Prevention (PEP) trial. Lancet 2000;355:1295-302.
7. Nurmi I, Narinen A, Lüthje P, Tanninen S. Functional outcome and survival after hip fracture in elderly: a prospective study of 106 consecutive patients. J Orthop Traumatol 2004;5:7-14.
8. Simunovic N, Devereaux PJ, Sprague S, et al. Effect of early surgery after hip fracture on mortality and complications: systematic review and meta-analysis. CMAJ 2010;182:1609-16.
9. Bhandari M, Devereaux PJ, Swiontkowski MF, et al. Internal fixation compared with arthroplasty for displaced fractures of the femoral neck: a meta-analysis. J Bone Joint Surg Am 2003;85-A:1673-81.
10. Fox KAA, Steg PG, Eagle KA, et al. Decline in rates of death and heart failure in acute coronary syndromes, 1999-2006. JAMA 2007;297:1892-900.
11. Jackson JA, Sisk JN. Hip injuries: solution of the "unsolved fracture." Am J Surg 1939;45:48-52.
12. Bhandari M, Koo H, Saunders L, Shaughnessy SG, Dunlop RB, Schemitsch EH. Predictors of in-hospital mortality following hip fractures. Int J Surg Investig 1999;1:319-26.
13. Tay E. Hip fractures in the elderly: operative versus nonoperative management. Singapore Med J 2016;57:178-81.
14. Jain R, Basinski A, Kreder HJ. Nonoperative treatment of hip fractures. Int Orthop 2003;27:11-7.
15. Management of hip fractures in the elderly: evidence-based clinical practice guideline. Rosemont, IL: American Academy of Orthopaedic Surgeons, September 5, 2014.
16. Hip fracture: management. London: National Institutes for Health and Care Excellence, June 22, 2011 (https://www.nice.org.uk/guidance/cg124).
17. Hip Fracture Accelerated Surgical Treatment and Care Track (HIP ATTACK) Investigators. Accelerated care versus standard care among patients with hip fracture: the HIP ATTACK pilot trial. CMAJ 2014;186(1):E52-E60.
18. Swiontkowski MF. Intracapsular fractures of the hip. J Bone Joint Surg Am 1994;76:129-38.
19. Fixation using Alternative Implants for the Treatment of Hip fractures (FAITH) Investigators. Fracture fixation in the operative management of hip fractures (FAITH): an international, multicentre, randomised controlled trial. Lancet 2017;389:1519-27.
20. Deneka DA, Simonian PT, Stankewich CJ, Eckert D, Chapman JR, Tencer AF. Biomechanical comparison of internal fixation techniques for the treatment of unstable basicervical femoral neck fractures. J Orthop Trauma 1997;11:337-43.
21. Hoshino CM, O'Toole RV. Fixed angle devices versus multiple cancellous screws: what does the evidence tell us? Injury 2015;46:474-7.
22. Keating JF, Grant A, Masson M, Scott NW, Forbes JF. Displaced intracapsular hip fractures in fit, older people: a randomised comparison of reduction and fixation, bipolar hemiarthroplasty and total hip arthroplasty. Health Technol Assess 2005;9:iii-iv, ix-x, 1-65.
23. Chammout GK, Mukka SS, Carlsson T, Neander GF, Stark AW, Skoldenberg OG. Total hip replacement versus open reduction and internal fixation of displaced femoral neck fractures: a randomized long-term follow-up study. J Bone Joint Surg Am 2012;94:1921-8.
24. Bhandari M, Devereaux PJ, Tornetta P III, et al. Operative management of displaced femoral neck fractures in elderly patients: an international survey. J Bone Joint Surg Am 2005;87:2122-30.
25. Hopley C, Stengel D, Ekkernkamp A, Wich M. Primary total hip arthroplasty versus hemiarthroplasty in older patients: systematic review. BMJ 2010;340:C2332.
26. Burgers P, Van Geene AR, Van den Bekerom M, et al. Total hip arthroplasty versus hemiarthroplasty for displaced femoral neck fractures in the healthy elderly: a meta-analysis and systematic review of randomized trials. Int Orthop 2012;36:1549-60.
27. Bhandari M, Devereaux PJ, Einhorn TA, et al. Hip fracture evaluation with alternatives of total hip arthroplasty versus hemiarthroplasty (HEALTH): protocol for a multicentre randomised trial. BMJ Open 2015;5(2):e006263.
28. Alolabi B, Bajammal S, Shirali J, Karanicolas PJ, Gafni A, Bhandari M. Treatment of displaced femoral neck fractures in the elderly: a cost-benefit analysis. J Orthop Trauma 2009;23:442-6.
29. Socci AR, Casemyr NE, Leslie MP, Baumgaertner MR. Implant options for the treatment of intertrochanteric fractures of the hip: rationale, evidence, and recommendations. Bone Joint J 2017;99-B:128-33.
30. Egol KA, Marcano AI, Lewis L, Tejwani NC, McLaurin TM, Davidovitch RI. Can the use of an evidence-based algorithm for the treatment of intertrochanteric fractures of the hip maintain quality at a reduced cost? Bone Joint J 2014;96-B:1192-7.
31. Bhandari M, Schemitsch E, Jönsson A, Zlowodzki M, Haidukewych GJ. Gamma nails revisited: gamma nails versus compression hip screws in the management of intertrochanteric fractures of the hip: a meta-analysis. J Orthop Trauma 2009;23:460-4.
32. Hardy DCR, Descamps PY, Krallis P, et al. Use of an intramedullary hip-screw compared with a compression hip-screw with a plate for intertrochanteric femoral fractures: a prospective, randomized study of one hundred patients. J Bone Joint Surg Am 1998;80:618-30.
33. Little NJ, Verma V, Fernando C, Elliott DS, Khaleel A. A prospective trial comparing the Holland nail with the dynamic hip screw in the treatment of intertrochanteric fractures of the hip. J Bone Joint Surg Br 2008;90:1073-8.
34. Saudan M, Lübbeke A, Sadowski C, Riand N, Stern R, Hoffmeyer P. Pertrochanteric fractures: is there an advantage to an intramedullary nail?: a randomized, prospective study of 206 patients comparing the dynamic hip screw and proximal femoral nail. J Orthop Trauma 2002;16:386-93.
35. Parker MJ, Bowers TR, Pryor GA. Sliding hip screw versus the Targon PF nail in the treatment of trochanteric fractures of the hip: a randomised trial of 600 fractures. J Bone Joint Surg Br 2012;94:391-7.
36. Xu YZ, Geng DC, Mao HQ, Zhu XS, Yang HL. A comparison of the proximal femoral nail antirotation device and dynamic hip screw in the treatment of unstable pertrochanteric fracture. J Int Med Res 2010;38:1266-75.
37. Utrilla AL, Reig JS, Muñoz FM, Tufanisco CB. Trochanteric gamma nail and compression hip screw for trochanteric fractures: a randomized, prospective, comparative study in 210 elderly patients with a new design of the gamma nail. J Orthop Trauma 2005;19:229-33.
38. Aktselis I, Kokoroghiannis C, Fragkomichalos E, et al. Prospective randomised controlled trial of an intramedullary nail versus a sliding hip screw for intertrochanteric fractures of the femur. Int Orthop 2014;38:155-61.
39. Kuzyk PR, Bhandari M, McKee MD, Russell TA, Schemitsch EH. Intramedullary versus extramedullary fixation for subtrochanteric femur fractures. J Orthop Trauma 2009;23:465-70.
40. Koh A, Guerado E, Giannoudis PV. Atypical femoral fractures related to bisphosphonate treatment: issues and con-

troversies related to their surgical management. Bone Joint J 2017;99-B:295-302.
41. Shane E, Burr D, Abrahamsen B, et al. Atypical subtrochanteric and diaphyseal femoral fractures: second report of a task force of the American Society for Bone and Mineral Research. J Bone Miner Res 2014;29:1-23.
42. Liu P, Wu X, Shi H, et al. Intramedullary versus extramedullary fixation in the management of subtrochanteric femur fractures: a meta-analysis. Clin Interv Aging 2015;10:803-11.
43. Prestmo A, Hagen G, Sletvold O, et al. Comprehensive geriatric care for patients with hip fractures: a prospective, randomised, controlled trial. Lancet 2015;385:1623-33.
44. Moseley AM, Sherrington C, Lord SR, Barraclough E, St George RJ, Cameron ID. Mobility training after hip fracture: a randomised controlled trial. Age Ageing 2009;38:74-80.
45. Nightingale EJ, Sturnieks D, Sherrington C, Moseley AM, Cameron ID, Lord SR. Impaired weight transfer persists at least four months after hip fracture and rehabilitation. Clin Rehabil 2010;24:565-73.
46. Kim TY, Ha YC, Kang BJ, Lee YK, Koo KH. Does early administration of bisphosphonate affect fracture healing in patients with intertrochanteric fractures? J Bone Joint Surg Br 2012;94:956-60.
47. Lyles KW, Colón-Emeric CS, Magaziner JS, et al. Zoledronic acid and clinical fractures and mortality after hip fracture. N Engl J Med 2007;357:1799-809.
48. Bone and Joint Canada. National Hip Fracture Toolkit. June 30, 2011 (http://boneandjointcanada.com/hip-fracture/).
49. Duceppe E, Parlow J, MacDonald P, et al. Canadian Cardiovascular Society guidelines on perioperative cardiac risk assessment and management for patients who undergo noncardiac surgery. Can J Cardiol 2017;33:17-32.