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A Guide to Improving the Care of Patients With Fragility Fractures

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Foreword

Fragility fractures, low-energy injuries that occur from a fall from a standing or lower height, represent a serious public health problem. After age 50, the lifetime risk of having a fragility fracture is 33% for an American woman and 20% for a man.[1] In the United States, 2.1 million people will suffer a fragility fracture each year.[1] The incidence of fragility fractures increases steeply after age 65.[2] Osteoporosis is present in most patients with a fragility fracture.

Hip fractures are the most serious in terms of cost and morbidity. The average cost of inpatient care for a hip fracture in 2005 was $33 962.[3] The lifetime risk of having a hip fracture is 6% for men and 17.5% for women. Although the mortality risk after a hip fracture is much higher for a man, a woman's risk of dying from a hip fracture is high and exceeds the lifetime risk of death from breast cancer, uterine cancer, and ovarian cancer combined. For those who survive after a hip fracture, most do not regain their preinjury level of function, and 30% lose their independence. This loss of independence is greatly feared by patients and is very costly to patients and society.

Although a hip fracture may have the most serious consequences, other bones, such as the wrist, shoulder, ankle, pelvis, and spine, frequently fracture in the osteoporotic patient. For example, the lifetime risk of a forearm or vertebral compression fracture is 16% and 15.6%, respectively, for a woman and 2.5% and 5%, respectively, for a man.[4]

These statistics clearly show that fragility fractures are a major problem facing American society today,[5] and the care of such fractures presents an even greater challenge, in part because the quality of care delivered in the United States varies widely, even within one region. Many such fractures are treated in an outpatient setting, although some may be treated in the inpatient hospital setting. However, the quality of care for seniors with fragility fractures receives relatively little attention. In 2004, the United States Surgeon General issued a comprehensive report calling for health professionals to make significant improvements in our nation's bone health, and an improvement in the system and methods of care was suggested.[5] There has been little written on the subject of improving the system of care delivery in the United States.

The goals of this blue book are to review the methods used in inpatient and outpatient care, as well as rehabilitation of the patient with a fragility fracture. We discuss evidence-based best care models and, where evidence is lacking, present expert opinions in an effort to improve the standard and the quality of care for the patient with a fragility fracture. We hope that this monograph will provide guidance to physicians, nurses, rehabilitation therapists, other health care providers, and administrators.

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Scope of the Problem (S. Kates)

Fragility fractures represent an epidemic problem worldwide as the population ages at a rate much greater than once predicted. In the United States, the aging of the population is a result of improved life expectancy coupled with the aging of the baby boom generation (born 1946-1964). It is expected that these 77 million baby boomers will become senior citizens by 2026 and cause the fastest-growing segment of the population to be the group older than 85 years old.[1]

As the population ages, falls with subsequent fractures become much more prevalent. It has been shown that most patients who sustain a fracture and are older than 65 years old and have weakened bone quality from osteoporosis or osteopenia, conditions that are largely untreated and silent until a fracture occurs, even though osteoporosis is the most common disease of the bone.[2] Osteoporosis is a metabolic bone disease characterized by low bone mass and microarchitectural deterioration of bone tissue that results in increased bone fragility and a consequent increase in fracture risk. Although bone mass is an important component of the disease, it is the combination of bone mass and bone quality that results in a bone's overall strength and ability to resist fracture. Approximately 2.1 million osteoporotic fractures occur yearly in the United States[3]; in 2006, the fragility fracture rate was listed as 1056 per 100 000 people.[2] Most such fractures occur in those in the over-65 years age group.[2] The lack of osteoporosis treatment that commonly follows a serious osteoporotic fracture is worrisome: reported rates of treatment after hip fracture are in the 10% to 20% range.[3,4] Secondary prevention ideally should include osteoporosis treatment and falls assessment.

One important principle can be summarized as follows: when the highest quality of care is provided to the patient with a fragility fracture, not only does the patient benefit, but cost savings result.[5,6]

Hip Fractures (S. Kates)

Fragility fractures occur most commonly in the hip; such fractures can lead to serious morbidity, are associated with a high mortality risk, and are the most expensive of all the fragility fractures.

Approximately 330 000 hip fractures occur yearly in the United States.[7] This number is expected to increase to 550 000 by 2040, which may be a conservative estimate.[8] In 2006, the hip fracture rate was listed as 78.7 per 10 000 people. The mortality rate is in the 20% to 24% range at 1 year; many patients will lose their independence after hip fracture.[2] The cost of caring for hip fractures was reported to be $17 billion in 1997, and it is estimated that it will grow to $62 billion by 2040.[9] This number may also represent a conservative estimate because the medical consumer price index consistently outpaces the general consumer price index. In 2005, the average cost for inpatient care of a hip fracture was $33 962.[7] Nearly all patients with hip fractures are admitted to the hospital for care, and most hip fractures are treated surgically. The average length of hospital stay for a hip fracture in 2006 was 6.3 days[10]; the time spent in rehabilitation is less well defined.

Admission to the Hospital (S. Mears)

In the most typical model of care, a patient with an acute hip fracture is unable to walk, is seen in the emergency department, and is admitted to the hospital, and then the fracture is surgically repaired. Despite the seeming simplicity of this pathway, many roadblocks stand in the way of optimal care.

The first potential roadblock is that, for some patients, the time between injury and when it was found can be extensive; in this period, patients are often unable to move, may become considerably dehydrated or even develop rhabdomyolysis with renal failure, and may experience increased pressure that can lead to pressure ulcer development even before transport. When initially seen by emergency medical service personnel, the patient will complain of hip or groin pain. Patients with suspected hip fractures are usually transported to the emergency department by ambulance on a back board or stretcher; these devices are hard and can lead to additional pressure on the sacrum and thereby potentially to pressure ulcers. Thus, the hip fracture patient is at particular risk for pressure ulcers from the time of fracture to arrival at the emergency department and, indeed, throughout care.

The next potential roadblock is the emergency department itself. In the United States, emergency room overcrowding is epidemic, and the patient with a hip fracture is often lost within the system. Lack of appropriate triage will lengthen the stay in the emergency department, especially for an elderly patient who does not appear to require acute care. In addition, the environment is frequently loud, seemingly chaotic, and often frightening for the elderly patient. This environment promotes the development of delirium in many patients.[11]

The initial step in evaluating the patient with a hip fracture is obtaining a problem-focused history and performing a physical examination. The clinician may need to obtain information from a family member, medical records, or a nursing home (most often via a call to the nursing supervisor) in addition to questioning the patient. The nature of the fall must be determined to see if there were a contributing event such as a stroke. Other potential causes for fracture should be sought, including a history suggestive of metastatic cancer. Other acute medical problems such as myocardial infarction must be ruled out. A medicine list and accurate medical history are critical. An evaluation of the patient's mental status is necessary. An abbreviated mini-mental examination will help determine if the patient has memory loss. A social history that discovers the patient's preinjury level of activity and independence is also important. In addition, the family of the patient must be located (if not present with the patient) and notified, and the advanced directives must be determined and documented prominently in the medical record.

The physical examination should be guided by the emergency department practitioner, who should inspect for other injuries. Basic laboratory studies and an electrocardiogram should be ordered. Typically, a trauma patient now undergoes a whole-body computed tomography (CT) scan to rule out other injuries. However, a whole-body CT scan is not required for the patient with a fragility fracture and should be avoided unless specifically indicated because of concern about more extensive injury or illness.

The physical examination should focus on the injured hip. Most often, a patient with a hip fracture has groin pain and pain with hip motion. If the fracture is displaced, the leg will be shortened and rotated (Figure 1). The hip should not be excessively moved on examination because it is painful and may increase bleeding. Conventional radiographs, the standard method for diagnosing a hip fracture, are then ordered: anteroposterior (AP) and tube lateral (cross-table) views of the involved hip and an AP view of the pelvis (Figure 2). An AP view with gentle traction can be very helpful in determining the pattern of the fracture. If radiographs are negative despite hip pain, a magnetic resonance imaging (MRI) scan is the best way to confirm a hip fracture. If metastatic cancer is the cause of the fracture, additional conventional radiographs and advanced imaging studies will likely be needed to evaluate the entire femur, and consideration should be given to additional imaging to find the primary lesion, if not already known.

Pain management must be started in the emergency department as part of the initial orders given for emergency care. Proper pain management is humane, will reduce the likelihood of the patient developing delirium,[12] and is best accomplished with small doses of narcotic medicine—for example, 1- to 2-mg doses of intravenous morphine (because of the accumulation of active metabolic products, merperidine should not be used in seniors) that can be titrated to achieve the desired effect. If available, a peripheral nerve block can help with pain relief. The use of traction does not seem to be helpful in terms of pain relief for patients with hip fractures and may contribute to pressure ulceration. In the emergency department, it is important to achieve effective pain control without excessive sedation.

At this point, the type of hospital admission is determined. The medical stability of the patient must be ascertained: the first question is, does the patient need critical care? If so, this should be rapidly obtained. If there is no obvious need for critical care, the patient should be admitted to an orthopaedic surgeon or medical service, depending on the care model of the institution. Clear benefits exist to streamlining this process and admitting patients to a hospital floor as quickly as possible.[13,14]

Low-pressure mattresses should be used to avoid pressure sores, and nurses should be experienced in recognizing and preventing pressure ulcers. To prevent skin inflammation and pain in female patients (or in men with incontinence or voiding difficulties), a Foley catheter should be placed while the patient is in the emergency department. Urinalysis should be performed, and urinary tract infections should be documented and treated. Although chronic urinary tract infections or colonization may not be symptomatic, patients who are undergoing surgical procedures with implantation of hardware require treatment of all with significant bacertiuria before surgery. In the emergency department, hydration of the patient should be started. Patients with hip fractures are typically dehydrated. Isotonic (normal) saline should be started at 100 to 200 mL/h, and the fluid status should be carefully followed with assessment for urine output, vital signs, and hydration every 4 to 8 hours. Caution is needed to avoid volume overload because many seniors have cardiac disease and are predisposed to heart failure.

The goal is to correctly diagnose the hip fracture, stabilize the patient medically for any acute needs, and admit the patient to the hospital. These goals must be accomplished quickly and in a thoughtful and caring manner.[13,14]

Preoperative Medical Assessment (S. Mears)

The preoperative medical assessment should be started in the emergency department. The goal of the preoperative medical assessment is to make surgical repair as safe as possible in a timely manner. The ideal timing of surgery is within 24 hours after fracture.[15] Early surgical repair improves results by decreasing initial pain, length of stay, and complications.[15-17] The preoperative medical assessment is meant to risk-stratify the patient, improve reversible acute medical abnormalities, and prevent complications common in the geriatric patient.[14] The use of an interdisciplinary team approach (including orthopaedics, geriatrics or internal medicine/family medicine, anesthesiology, nursing, and therapists) to fracture care and the level of experience of the providers are very important factors in achieving the best outcomes.[13,14] It is important that the anesthesia team be involved in this process to avoid delay in surgical intervention. The goals of the team must be to achieve early surgical repair. Coordination and cooperation among surgeons, anesthesiologists, and others are critical. This team approach should minimize unnecessary preoperative tests and consultations, which can add expense and cause delay.[13,14] The goal of early surgery should always be kept in mind, and any test that is ordered should have a clear and immediate benefit to the patient. Evaluation or procedures that are not needed for a surgical decision should be avoided.

For patients arriving from a nursing home, an efficient method of transition to the inpatient hospital setting is essential. When the patient is transferred from a nursing home, a transfer summary listing the patient's most recent history and physical examination and medication list is needed. Attention to mental status, including dementia and delirium, is important. A confusion assessment method and some form of mental status testing will help to determine this status. It is important to recognize cognitive problems because they can predict the development of delirium during the hospital stay.[12]

When intravenous access is established, standard laboratory tests, including a basic metabolic profile, complete blood count, prothrombin time (INR), and partial thromboplastin time, should be obtained. If the electrolytes are abnormal, these abnormalities should be corrected. The hematocrit level should be checked to make sure that the patient does not need a blood transfusion before repair of the hip fracture. Blood transfusion should be considered if the preoperative hematocrit level is below 30% because it likely represents a risk to a patient who will incur surgical blood loss, leading to an additional decrease in the hematocrit level. The prothrombin time/INR should be checked because the patient may be on chronic anticoagulant therapy or have a condition affecting coagulation. The treatment for patients with a markedly elevated INR is controversial, with options ranging from watchful waiting to the use of oral vitamin K or fresh-frozen plasma.[18] If the INR is less than 1.5, surgical intervention may proceed. The treatment for an elevated INR is complicated by the acute need for the patient with a hip fracture to undergo surgical fixation. Although not emergent, quick fracture repair has been shown to improve outcomes.[15] Therefore, waiting for 4 or 5 days for the INR to gently drift down is not optimal. The use of oral vitamin K may expedite this process. The fastest reversal is with the use of fresh-frozen plasma; however, this use is not recommended by official guidelines for this blood product.[18]

Figure 1. Clinical photograph of the lower extremities of a patient with a left hip fracture. The left side is shortened and externally rotated.

The electrocardiogram should be reviewed to rule out abnormalities and compared with a previous tracing, if possible. New or acute changes should be followed with analysis of serum troponin level to rule out myocardial infarction. Rate and rhythm should be assessed. The use of additional testing, such as echocardiograms or stress testing, should be kept to a minimum and used only in compelling circumstances—for example, for the patient with severe aortic stenosis or pulmonary hypertension, for whom the anesthesiologist may need the results of an echocardiogram to enable appropriate care during surgery. Low-dose beta blockade should be considered for patients with hip fractures and at high cardiovascular risk because it may decrease morbidity. This is referred to as the Perioperative Cardiac Risk Reduction protocol.[19]

- **Preoperative assessment should be driven by the goal of optimizing the patient for early surgery.**

Anesthesia Management (F. Sieber)

When examining all types of surgical procedures, meta-analysis suggests that, compared with general anesthesia, regional anesthesia is associated with decreased mortality, incidence of thromboembolism, myocardial infarction, bleeding complications, pneumonia, respiratory failure, and renal failure.[20] A meta-analysis of patients with hip fracture has shown that, compared with general anesthesia, regional anesthesia is associated with reduced incidence of deep vein thrombosis and decreased early mortality, but longer operative times.[21]

A recent review examined whether general or regional anesthesia is associated with a greater risk of postoperative delirium.[22] Most studies examining elective surgery suggest

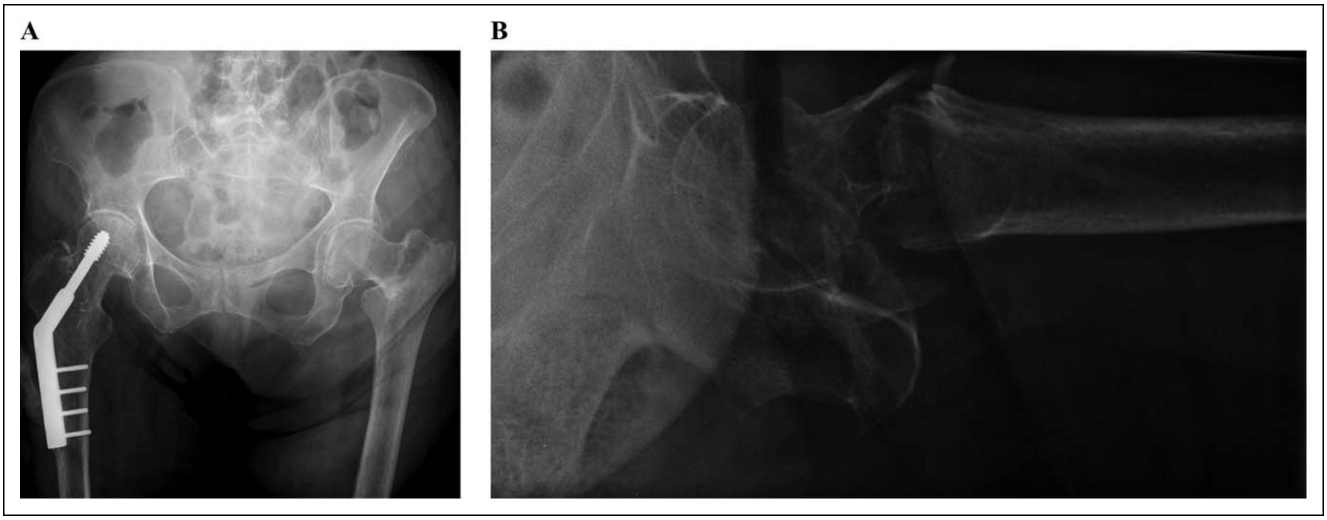

Figure 2. Intertrochanteric hip fracture. (A) An anteroposterior (AP) radiograph of the pelvis showing an intertrochanteric hip fracture on the left side and a healed fracture of the right hip that had been repaired with a sliding hip screw device. (B) A tube lateral radiograph of the fractured left hip shows anterior displacement of the femoral neck fragment.

no difference between regional and general anesthesia in terms of postoperative delirium. In contrast to elective procedures, however, evidence suggests that type of anesthesia influences postoperative delirium after the urgent surgery of hip fracture repair. A Cochrane review compared outcome differences in patients with hip fracture who received regional and general anesthesia.[23] Based on 5 randomized controlled trials, the number of patients who experienced a postoperative confusional state (delirium) was 11 of 117 (9.4%) in the regional anesthesia group and 23 of 120 (19.2%) in the general anesthesia group (relative risk [RR], 0.50; 95% confidence interval, 0.26-0.95; overall effect, $z = 2.12$, $P = .03$). The authors concluded that with hip fracture surgery, regional anesthesia, compared with general anesthesia, is associated with a 2-fold reduced risk of acute postoperative confusion.

Controlling the level of sedation during regional anesthesia has been shown to prevent delirium in high-risk populations. A recent randomized double-blind trial examined whether light or deep sedation could decrease the incidence of postoperative delirium.[24] Elderly patients undergoing hip fracture repair with spinal anesthesia were randomized to receive either light or deep sedation with propofol and then were followed postoperatively for delirium. The study showed that in this high-risk population, patients with light sedation had a 50% lower incidence of postoperative delirium than did those with deep sedation. The effect was associated with a mean reduction of almost 1 day of delirium for the light-sedation group. This study points to the role of excessive sedation during the perioperative period as a risk factor for delirium in patients with hip fracture.

There is no clear consensus as to whether intraoperative hemodynamic management prevents postoperative delirium. A large retrospective analysis of geriatric populations has found no association between intraoperative hypotension or hemodynamic complications and increased delirium incidence.[25] In a randomized trial, hypotensive epidural anesthesia in elderly patients was not associated with an increased incidence of postoperative delirium.[26] In contrast, hypotension may play a role in the development of delirium with select subpopulations. Yocum et al[27] showed a relationship between intraoperative hypotension and postoperative cognitive decline in patients with preoperative hypertension. Intraoperative hypotension may also predispose patients to cardiac and renal ischemia. Until additional studies are available, no recommendations for hemodynamic management can be made concerning the prevention of postoperative delirium.

Surgery (S. Mears)

The type of surgery for a hip fracture is determined by the fracture type (femoral neck, intertrochanteric, or subtrochanteric) (Figure 3) and the needs of the patient. Femoral neck fractures may be stable or unstable, depending on the fracture's pattern, displacement, and angulation. Stable fractures are nondisplaced fractures or valgus-impacted fractures with no angulation on a lateral radiographic view. Some nondisplaced fractures may require MRI for visualization.

Nondisplaced fractures are treated with surgery because there is a 20% chance of displacement with nonoperative treatment.[28] This risk increases to 79% when the patient is older than age 70 years.[29] Surgery typically involves fixation with 2 to 3 cannulated screws (most typically, 3), with the patient on a fracture table. The use of washers seems to improve fixation in osteoporotic bone. The position of screws is important: they should be spread apart and placed next to the cortex of the femoral neck inferiorly, superiorly, and posteriorly. The bottom screw must be above the level of the lesser trochanter to prevent a stress riser in the subtrochanteric areas that can result in subtrochanteric fracture.[30] The screw threads should not cross the fracture line and should be placed as deeply into the head as possible without head penetration. The results of screw fixation for stable fractures are satisfactory with revision rates approximating 10%; the more stable the fracture, the better the results.[31] Some patients may later develop limb shortening, osteonecrosis, nonunion, or screw cutout.

If the fracture is unstable, the choice of treatment is based on an algorithm that uses information about the patient and the surgeon. The basic choices are reduction and internal fixation, hemiarthroplasty, or total hip arthroplasty: open reduction and internal fixation should be reserved for very young patients. Hemiarthroplasty is an excellent choice for the older or medically infirm patient with a relatively normal acetabulum, and total hip arthroplasty has been shown to give the best outcomes for the active elderly patient.[32] The choice of surgery should also be tempered by the surgeon's skill. For instance, those less familiar with total hip replacement will achieve better results with hemiarthroplasty.

For total hip arthroplasty, there is much debate about which type of femoral prosthesis should be used. Although uncemented stems are used commonly, the role of the cemented stem in very elderly patients (older than age 85 years) with hip fracture should not be forgotten.[33] Excellent long-term results with cemented stems should ensure that a well-placed stem will last the length of the patient's life.[33,34] The cemented stem has the advantage of a lower fracture rate and easier use in the patient with advanced osteoporosis and the stovepipe or Dorr type C anatomy of the femur.[34] Cemented stems have the potential disadvantage of acute intraoperative hypotension at the time of cement insertion. Uncemented stems can be used in osteoporotic bones, but their placement is difficult, especially for the surgeon who performs hip replacements infrequently, such as may be the case when an on-call surgeon performs the hip fracture procedure. If an uncemented stem is selected, many designs have been shown to be effective in Dorr type C bones, including those with proximally coated, rectangular, or fully coated designs. Uncemented stems have a higher risk of intraoperative fracture.[34] The experience of the surgeon in using the stem most familiar to him or her is the most important factor for success.

If a hemiarthroplasty is selected, a uni- or bipolar type of head may be used. In the past, a unipolar head was associated with poor femoral fixation, which leads to poor results. With the use of a well-fixed stem, there seems to be no advantage to the use of a bipolar construct in terms of range of motion or pain level.[35] The hemiarthroplasty does leave the patient susceptible to wear of the articular cartilage or pain in the hip secondary to mismatch of the size of the selected head and the native acetabulum. This potential disadvantage has led to the use of total hip arthroplasty for patients who are active or physiologically young. Several randomized controlled trials have shown that, in such patients, total hip arthroplasty has proven superior for pain relief and functional outcomes.[32,34,36,37]

Intertrochanteric fractures have been classified by several systems,[38] but they are more practically termed stable or unstable (Figure 4). Stable fractures typically have 2 or 3 parts with intact medial and lateral buttresses and should be treated with sliding hip screw fixation. The lateral buttress allows for a firm endpoint to the sliding of the screw.[39] The sliding hip screw works by having a firmly anchored screw in the femoral head. The screw slides in the barrel of the side plate, allowing for compression of the neck of the femur against the greater trochanter. Over time and with weight bearing, the screw may slide, further compressing the fracture. The key factor in the success of the hip screw is the placement of the screw within the femoral head. The screw should be as deep as possible and centered with the head. The importance of the position has been quantified by the tip-apex distance, that is, the distance between the tip of the screw and the apex of the femoral head on the posteroanterior and lateral views. When this distance is <25 mm, the chance of success and healing is excellent. If the tip-apex distance is >25 mm, the rate of failure is increased.[40]

Unstable fractures are characterized by comminution, a reverse obliquity fracture line, or extension into the shaft of the femur. In these cases, the lateral buttress is not intact and will not provide an endpoint to sliding, so a sliding hip screw has a higher rate of failure in these fracture patterns.[41] The unstable fracture is best treated with an intramedullary nail because it provides the buttress for the proximal fragment. A fixed-angle device, such as an angled blade plate, may also be considered.

There are 3 important technical points concerning the insertion of an intramedullary nail. First, the fracture must be reduced before nail insertion and open reduction performed if necessary. Second, the proximal part of the nail must be medialized during insertion to prevent additional iatrogenic fracture. Third, the nail must be held still in the femoral canal during hip screw insertion so that the screw does not migrate proximally, a step that is critical in ensuring a low tip-apex distance.

A short or a long intramedullary nail may be used. Although the long nail may protect more of the femoral shaft, the bone can be at risk for fracture distally around the end of the nail above the knee. The nail may also cause an intraoperative fracture at the anterior cortex of the distal femur because of a mismatch between the anterior bow of the nail and that of the femur. Care must be taken during nail insertion to avoid fracture. Good evidence does not exist for the choice of a short vs long nail for unstable intertrochanteric fractures.[42]

The goal of hip fracture surgery is to permit the patient to bear weight as tolerated after surgery.[43] Elderly patients usually cannot limit their weight bearing or follow mobility restrictions. Allowing patients to bear weight will help with mobilization and recovery and is recommended when stable surgical repair has been achieved.[44] The surgeon should choose a procedure that will allow full weight bearing immediately postoperatively.

Postoperative Considerations

Many factors are involved in the postoperative care of the fragility fracture patient. In general, care is best delivered by a protocol-driven, patient-centered approach. In addition to lessening the variations in care, protocols improve outcomes.[14] Protocols should address the following areas: pain control, wound care, pressure sore prevention, thromboprophylaxis, fluid and blood management, nutrition, delirium prevention,

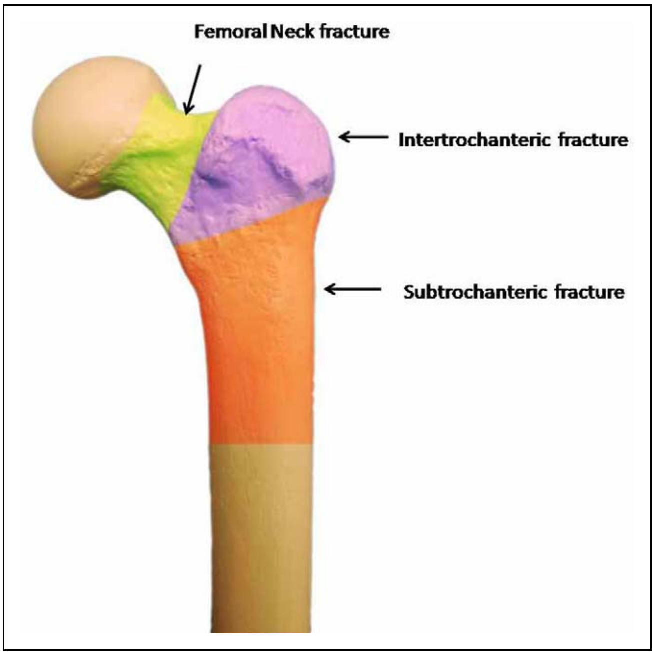

Figure 3. This image shows the 3 typical locations of hip fractures: femoral neck, intertrochanteric, and subtrochanteric regions.

and rehabilitation. Although these topics are interrelated, they are addressed individually below.[14]

Pain Management (F. Sieber). Assessment of postoperative pain in the elderly can be complicated for several reasons. There appears to be both an age-related increase in pain threshold[45] and a tendency for elders to underreport pain.[45,46] Cognitive impairment can also make pain assessment and treatment difficult. In general, pain intensity scales may be used for assessment. Numerical rating scales and verbal descriptor scales have been used successfully in cognitively intact elderly patients, whereas visual analog scales may lead to frequent unscorable responses with the elderly.[46] In patients with mild to moderate dementia, the 0 to 10 pain assessment scale and the verbal descriptor scale have been found to have adequate, but not perfect, reliability and validity.[47] In patients with severe dementia, pain assessment may be performed with one of several pain assessment tools available for seniors with limited verbal communication secondary to the presence of dementia.[47]

Little evidence exists regarding the best means of providing analgesia for the hip fracture population. Many patients with hip fracture have underlying coronary artery disease. Studies have suggested that epidural anesthesia instituted preoperatively reduces perioperative myocardial ischemia more effectively than does the use of parenteral narcotics.[48,49] Currently, there is insufficient evidence to determine if the use of nerve blocks for postoperative analgesia confers any substantial benefit compared with other analgesic methods.[50]

The control of postoperative pain is important in preventing delirium. Higher pain scores at rest during the first 3 postoperative days are associated with postoperative delirium in patients undergoing noncardiac surgery.[51] Increased levels of preoperative and postoperative pain are risk factors for the development of postoperative delirium.[52] In the hip fracture population, Morrison et al[53] found that cognitively intact individuals with poorly controlled pain were 9 times more likely to become delirious.

When selecting narcotics for pain management, there is no difference in cognitive outcome when comparing fentanyl, morphine, and hydromorphone[54]; meperidine is the only narcotic that has been definitively associated with delirium, and it should be avoided.[55,56] With regard to the mode of narcotic administration, there is no difference in cognitive outcome between intravenous and epidural administration.[54] There is no evidence that postoperative delirium limits the use of on-demand patient-controlled analgesia,[57] but 1 prospective case series showed an association between oral opioid administration and a decreased risk of developing delirium compared with intravenous patient-controlled analgesia.[52] To summarize the relationship between postoperative delirium and pain management with narcotics in hip fracture patients, the strongest evidence supports avoiding meperidine, and there is only weak evidence that the mode of administration is an important factor.

Opioids themselves may induce delirium, and elderly patients may have increased cerebral sensitivity to them.[58] To circumvent these effects, nonopioid analgesics are increasingly used as a part of a multimodal pain management regimen. Two randomized studies have shown that nonopioid-based analgesics decrease postoperative pain and the need for opioids.[59,60] In addition, a meta-analysis has shown that nonsteroidal anti-inflammatories (NSAIDs) are associated with a 30% to 50% decrease in opioid consumption and decreased morphine-associated side effects.[61] Therefore, a multimodal approach to pain management using NSAIDs or other nonopioids, such as acetaminophen, allows lower doses of medications to be used, thus helping to reduce potential side effects.[62]

- **Good control of postoperative pain reduces delirium and improves a patient's ability to participate in rehabilitation.**

Wound Care and Infection Prevention (S. Kates). There is considerable variation in the management of postoperative wounds. In many institutions, the problem has become more challenging with the emergence of resistant organisms.

Most patients with lower extremity fragility fractures receive an anticoagulant postoperatively that can result in the formation of a wound hematoma. Avoidance of the hematoma is desirable and is assisted with accurate fracture reduction, meticulous intraoperative hemostasis, the application of ice, and the careful use of anticoagulants. Dressing the wound with an occlusive dressing can help avoid contamination with urine or feces. To avoid skin blistering that can occur with postoperative swelling, it is essential when applying the dressing to avoid putting any tension on the skin, and to avoid the introduction of resistant organisms to the healing incision, the wound should be touched as little as possible. Hand washing and careful

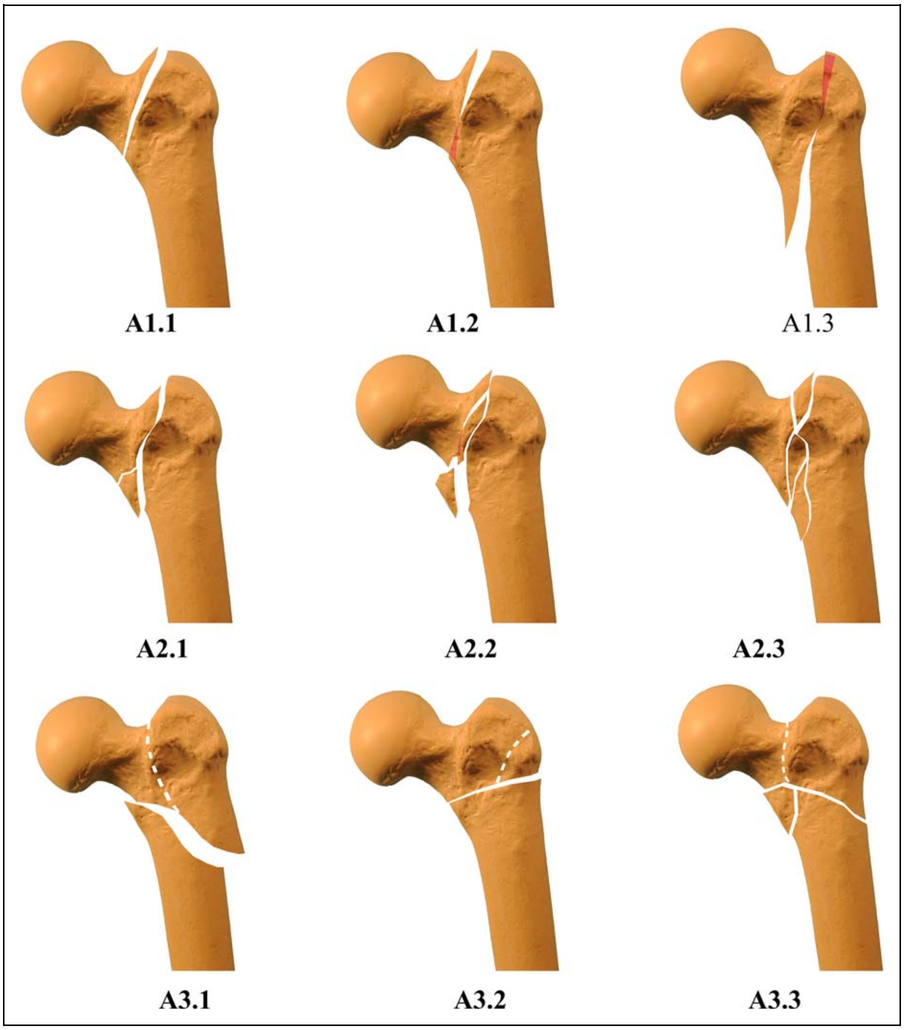

Figure 4. The AO/OTA classification of the extracapsular proximal femur fractures (intertrochanteric-subtrochanteric region). According to this classification system, the femur is labeled bone 3, and the proximal femur segment is labeled 1. The "A" types are extracapsular fractures. Types A1.1 to A2.1 are generally considered to be stable patterns. Types A2.2 to 3.3 are usually considered unstable fractures.

dressing change techniques are essential. Drains have not been shown to reduce infections or hematoma formation[63,64] and should be avoided whenever possible.

Wound infection is a serious complication. Preventive best practice beyond careful sterile technique includes the use of appropriate first-generation cephalosporin or vancomycin for penicillin-allergic patients. Antibiotics should be administered within 1 hour before skin incision and discontinued by 24 hours after surgery. Additional measures that have been shown to reduce infections include maintaining a normothermic state intraoperatively and serum glucose between 100 and 180 g/dL in the perioperative period.[65] Infections superficial to the deep fascia are typically treated with antibiotics. An early deep infection, which can frequently result in a disastrous outcome in the elderly patient with a fracture,[66] may be treated with appropriate antibiotics and surgical debridement. A late deep infection requires implant removal, debridement, and long-term antibiotic therapy. In some cases where an abscess cavity or dead space is present, antibiotic beads may be used. Consultation with an infectious disease specialist is frequently helpful in the case of serious infections.

- **Deep wound infection involving the implant is uncommon but devastating in its impact: approximately half of such patients die, and few survivors regain mobility.[6]**

Fluid and Blood Management (S. Kates). In the postoperative period, careful fluid management is essential for a good outcome. It may prove difficult to determine if the patient is normovolemic, dehydrated, or fluid overloaded. Maintaining the patient's urine output without diuretics at a rate of 30 to 35 mL/h or 250 mL/8 hours is usually an acceptable indication of normovolemia. The experienced medical consultant following the patient regularly is usually in the best position to provide advice on this issue. It is generally best to use an isotonic saline solution to ensure volume adequacy while monitoring serum electrolyte laboratory values for hypokalemia, hyponatremia, or bicarbonate changes. To our knowledge, there currently is no evidence as to the appropriate hematocrit level required for the elderly patient with a fracture; this area is under study in the National Institutes of Health–sponsored FOCUS trial. However, most experts now agree that a discharge hematocrit level of 27% to 30% in combination with normal vital signs is desirable. In the absence of evidence, determination of the transfusion threshold is left to the decision of the physicians caring for the patient.

Pressure Sore Prevention (S. Kates). Pressure sores have a very negative impact on the recovery of the elderly patient with a fracture. They are often painful and interfere markedly with the patient's rehabilitation. Pressure sores take months to heal and often become infected, which may result in wound infection, readmission to the hospital, additional surgery, or death. The patient should be checked, especially around the buttocks, hips, heels, and elbows, at least daily for the development of redness or blisters, which indicate a beginning pressure sore. The Braden Scale for assessment of pressure sore risk is a commonly accepted measurement tool.[67] This scale assesses risk level based on a point system for sensory perception, moisture level, activity level, mobility, nutrition, friction, and shear.

A pressure sore can be staged[67,68] by determining whether it has partial- or full-thickness skin loss or by grading it on a 1 to 4 Braden scale: stage 1, nonblanching erythema of the skin; stage 2, partial-thickness skin loss, such as a blister or shallow ulcer; stage 3, a deep ulcer not penetrating the fascia and with no undermining; and stage 4, extensive soft tissue loss with exposure of tendon, muscle, or bone and undermining of the skin.

Treatment of a pressure sore is based on staging and involves relief of pressure and shearing stresses on the skin, debridement of any necrotic tissues, and dressing changes; rarely, surgical coverage with a muscle flap is required.

Avoiding the pressure sore is the best approach. Early surgery for the fracture, frequent repositioning, and early mobilization postoperatively all are essential. Pressure-reducing mattresses and avoidance of pressure sources such as use of compression stockings in bed or braces are also useful techniques. Avoiding or minimizing delirium (see previous discussion) will reduce the likelihood of developing a pressure sore.[68]

- **All patients with hip fractures should be assessed and cared for with a view to minimizing their developing a pressure ulcer.**

Thromboprophylaxis (S. Kates). The development of a perioperative thrombosis is a common event in the elderly patient with a fracture. It has become a standard of care in most hospitals in the United States to use a prophylactic strategy for hospitalized patients with a lower extremity fracture.[18] However, currently there is no one accepted standard of prophylaxis, and controversy exists. For example, one method is to use mechanical means such as sequential pneumatic compression devices placed on the legs; these devices are somewhat effective in the reduction of thrombosis.[69,70] However, mechanical devices may serve to tether the patient to the bed and thus increase the risk of falls and delirium. Compression stockings are of limited benefit and must be carefully applied and removed to prevent skin injury. To avoid the development of a pressure sore, such stockings should not be left on the elderly patient with a fracture while in bed. Early surgery and early mobilization have been shown to reduce the likelihood of thrombosis and should be instituted whenever possible.[18]

Pharmacologic Prophylaxis. Pharmacologic means commonly used to prevent venous thromboembolism include unfractionated heparin, low molecular weight heparin, warfarin, and factor 10A inhibitors.

Unfractionated heparin and low molecular weight heparin. Heparins significantly reduce the risk of venous thrombosis and embolism, but they also increase the incidence of bleeding into the wound and at other sites. Considerations for use of the low molecular weight heparins include its high cost and the need to inject the medication subcutaneously. Weekly platelet counts are required to check for development of heparin-induced thrombocytopenia. Low molecular weight heparins such as dalteparin and enoxaparin have been shown to be very effective as prophylaxis of venous thromboembolism after hip fractures.[18] Unfractionated heparin is typically used as a twice-daily subcutaneous injection and is inexpensive. It is also effective as a prophylactic agent, particularly in the inpatient setting where the twice-daily administration is less problematic. It carries the risk of heparin-induced thrombocytopenia.

Warfarin. Warfarin inhibits the production of vitamin K–dependent coagulation factors in the liver. It has a long half-life, and dosing is often troublesome in the elderly. Effects of the dose are not seen until 48 hours after the dose is taken orally. Although warfarin is inexpensive and easy for the patient to take, it requires frequent, often inconvenient, and expensive laboratory testing (INR) to monitor and adjust dosage. It may cause bleeding complications, particularly if the INR values are greater than 3. The effects of warfarin are reversible with the administration of vitamin K orally or parenterally.

Factor 10A inhibitors. This newer class of medications inhibits activated factor 10 and thereby anticoagulates the patient. Fondaparinux sodium is very effective for thromboprophylaxis, but it also can result in bleeding complications. It is currently available in a subcutaneous form and is costly. Despite these limits, fondaparinux is recommended as the best primary choice for venous thromboembolism prophylaxis by the National Institute for Health and Clinical Excellence (NICE) in the United Kingdom.[71]

Summary. Pharmacologic prophylaxis for venous thromboembolism should be undertaken postoperatively for all patients with a hip fracture. Because the available evidence is mostly based on consensus statements from various organizations, the choice of therapy is the clinician's preference. Fondaparinux or low molecular weight heparin for 28 to 35 days after surgery seems to be the best evidence-based recommendation at this time.[18] Warfarin is an alternative reasonable choice for therapy and is almost always used in patients who were on warfarin therapy before their fracture.

- **All patients with a major lower extremity fracture should receive prophylactic anticoagulation for pharmacologic postoperative prophylaxis unless strongly contraindicated.**

Nutrition (S. Kates). Nutrition is an essential part of care of the elderly patient with a fracture. Proper nutrition allows for uneventful wound healing and, ultimately, better recovery. The patient who is unable to eat postoperatively has a very poor prognosis. Malnutrition is a part of the geriatric syndrome known as "frailty."[72] A serum albumin level less than 3 g/dL has been associated with poor outcomes after hip fracture.[73]

Generally, the patients should be fed orally and may require assistance from others to accomplish this goal. Nasogastric feeding is uncomfortable, likely a precipitant of delirium, and associated with aspiration pneumonia, and it should be avoided.[74]

The diet should consist of small portions with high caloric content. This diet should comprise easily chewed foods because many elderly patients have impaired dentition. Nutritional supplementation, consisting of liquid oral supplements between or with meals, may be useful for decreasing complications, improving rehabilitation, reducing pressure sores, and improving muscle strength. Some high-caloric drinks or shakes may not be well tolerated by the elderly, and assistance from a dietician is often very useful.

- **Proper nutrition of the patient with a fragility fracture is an essential element for a successful recovery.**

Rehabilitation (S. Kates). The goal of rehabilitation after fracture is to restore the patient to the preinjury activity status.

In most cases, rehabilitation should begin immediately after surgery. The patient should be mobilized to stand and then walk with a walker as soon as possible after surgery but always within 24 hours. The preinjury activity status is the therapeutic target and should be the basis of planning the rehabilitation program.

Appropriate pain control will allow the patient to participate effectively in his or her rehabilitation. In many cases, however, delirium and dementia interfere with rehabilitation. Delirium should be prevented to allow rehabilitation to progress.

Weight bearing as tolerated should be recommended for patients with hip fractures. In addition, most elderly patients cannot comply with limited weight-bearing restrictions. Currently, there is no consensus on the best method for the rehabilitation of the patient with a fragility fracture, and this area requires additional study.[75]

- **All patients with hip fractures should be weight bearing as tolerated after surgery.**

Models of Care in Current Use in the United States (S. Kates)

There are several different models of care in current use in the United States, and there is some evidence to suggest that improvements in the system of care will improve patient outcomes and costs of care.[5,13,14,76] When considering how to care for a patient with a fragility fracture, there are several models of care to be considered, each of which represents a different system or approach to the delivery of care. The common models in use in the United States are traditional care, closed-panel health maintenance organization (HMO), and comanaged (Rochester model).

Traditional Care. In this model of care, the patient with a fragility fracture admitted to the hospital enters through the emergency department and is evaluated. This evaluation is often delayed because elderly patients tend to suffer quietly and are thus perceived as low-acuity problems to assess. The diagnosis may be quite apparent to the nurse triaging elderly patients, but they are frequently placed in the hallway or back of the emergency room. When a decision is being made to admit the patient to the hospital, there is frequently a dispute that occurs between the medical and surgical physicians as to who should accept the patient onto their hospital service. This type of "turf war" is unfortunately common, and the patient becomes the victim in such a case. Such a situation must be avoided in all institutions.

Nonetheless, once admitted, the patient must be seen by a surgeon and often by a medical physician for "clearance" for surgery. Many medical physicians feel uncomfortable with this role of giving clearance for surgery, and they request specialty consultations and additional testing before surgery is approved. The result is a delay in surgical intervention that can be especially detrimental for an elderly patient.

When the patient has been cleared for surgery, the anesthesiologist becomes involved. An unclear clearance note or a perceived lack of diagnostic testing may result in surgery being delayed or canceled.

In most cases, postoperative care is dependent on the surgeon. The comorbid conditions may present substantial challenges medically in the postoperative period. Often, patients are restricted to "non-weight-bearing" status by the surgeon, which interferes with their ability to participate in rehabilitation and typically relegates them to a bed-to-chair activity status.

Discharge to a skilled nursing facility is common, and the patient may or may not recover from the injury. In most cases, there is no treatment prescribed for osteoporosis upon discharge, nor is a referral made for treatment of the osteoporosis.

Closed-Panel HMO. The patient is admitted to his or her participating facility for care or transferred there if originally admitted to a nonparticipating hospital. The patient is usually admitted to the hospitalist and assessed medically. Surgery is typically mandated within 24 hours of admission. Postoperative care is provided primarily by the hospitalist, with the orthopaedic surgeon as the consultant. At the 72-hour point, the stable patient is transferred to inpatient rehabilitation, which is also operated by the HMO. This procedure results in a very short length of stay and very orderly care. Follow-up care is arranged by the closed-panel HMO and may not be with the operating surgeon.

This model of care has resulted in a very successful rate of postfracture osteoporosis management. Kaiser Permanente's "Healthy Bones Program" is one such system that has published successful outcomes.[77]

Comanaged Care (a Care Model Used at the University of Rochester and Other Institutions). In this model of care, an emphasis is placed on the rapid admission of the patient through the emergency department or as a direct admission to the floor from other facilities. A fast-track approach is undertaken in the emergency department, with rapid admission after assessment of medical stability. The patient is admitted by agreement to the orthopaedic surgery service. The patient is seen by the orthopaedic surgeon, and then a consultation is obtained from the geriatric medicine hospitalist service. The emphasis of this consultation is to ensure medical optimization for early surgery. A detailed assessment of the comorbid conditions and medications is also obtained. The patient is risk-stratified for the appropriate operative risk level. Additional consultations and diagnostic testing are rarely obtained.

Early surgery, typically in less than 24 hours, is provided for all optimized patients. The risk stratification and comprehensive assessment is reassuring to the anesthesia physician, and thus cancellation of surgery is a rare event.

Postoperatively, all patients are comanaged by medicine and surgical services, and care is by standard protocol. All patients are advised to bear weight as tolerated so they may participate effectively in their rehabilitation. The stable patient is discharged on the third hospital day. This model of care has been shown to result in reduced length of stay, reduced complication rates, and lower costs than that of usual care.[5,13,14]

Summary. The system or model of care used has a profound impact on the quality of care and outcomes for the patient with a fragility fracture. Standardizing care will provide better care to such patients. Attention to details and avoidance of adverse events should be important goals when instituting such a system. Physician leadership and collaborative interdisciplinary care are fundamental concepts in such a system. Improvements in quality will directly result in improvement in costs of care.[5]

- **An organized and standardized system of care for the patient with a fragility fracture will afford a better outcome for that patient and be of benefit to the health care system.**

Nonhip Fractures

Proximal Humerus Fractures (H. Hoyen and S. Kates)

The proximal humerus fracture is a fragility fracture frequently seen in late middle-aged and older adults. A 65-year-old white woman has a 5% risk of developing a proximal humerus fracture by the age of 90 years.[78] Risk factors for proximal humerus fracture include low bone mineral density, frequent falls, diabetes, difficulty walking in dim light, poor vision, and low dietary calcium intake.

The fracture usually occurs as a result of a fall onto an outstretched arm or directly onto the shoulder, most commonly from a standing height or less. A careful history should be taken to obtain the critical information: injury specifics (other painful sites, loss of consciousness, and the specific mechanism of injury); history of previous injury, surgery, or rotator cuff dysfunction; and previous functional status (preinjury living situation, ambulatory status, use of ambulatory aids, and frequency of falls). Patients who require their upper extremities for ambulation and transfers will have different needs than those without preexisting ambulation difficulties.

Pathophysiology. Osteoporosis affects the proximal humerus because this bone is composed primarily of cancellous bone: the microarchitecture deteriorates with the loss of bony trabeculae and decrease of their interconnections. These changes weaken the metaphysis more than the diaphyseal bone and lead to a propensity to fracture in the metaphyseal area of the proximal humerus. Although nearly all proximal humerus fractures result from falls, occasionally a spontaneous fracture will occur through a metastatic lesion in this area; this possibility should be excluded before treatment. The many different positions of the shoulder at the time of injury help explain the wide variety of fracture patterns seen. The attachments of the rotator cuff tendons onto the greater and lesser tuberosities represent commonly fractured areas, and the tensile forces on those fragments influence treatment in many cases. For many fractures, the vascular supply to the proximal humerus also influences the choice treatment.[79]

Classification. The most commonly used system for classifying proximal humerus fractures is that described by Neer[80,81] in 1970 (Figure 5). This system incorporates Codman's 4 parts of the proximal humerus: the anatomic head, the lesser tuberosity, greater tuberosity, and the humeral shaft (Figure 5 and 6).[82] Displacement of more than 1 cm or angulation of the part by 45° or more allows the fragment to be counted as a part. Thus, a nondisplaced fracture would be zero parts, and a fracture with displacement of more than 1 cm of all 4 parts would be a 4-part fracture.

In the Neer classification, there may be multiple fracture lines within each of the main fragments. In general, the greater tuberosity externally rotates to a posterior and superior position secondary to the supraspinatus and infraspinatus forces, the lesser tuberosity fragment internally rotates to a medial position because of the pull of the subscapularis, and the surgical neck component may be angulated in the valgus/impacted position or in the varus/depressed position with an apex anterior angulation as a result of the pectoralis and deltoid forces on the shaft. The surgeon should determine if there is disruption of the medial calcar hinge.[83]

In addition, the Neer classification has several special proximal humerus fracture types, such as the fracture associated with a shoulder dislocation and one with a splitting of the articular surface. These special fractures have unfavorable prognoses, especially for osteonecrosis or traumatic arthritis.

There are other good classification systems (such as the AO/OTA system[84]), but they are less commonly used than the Neer system in the United States.

Clinical Features. The proximal humerus fracture is dramatic, and patients typically seek help soon after injury. Presenting complaints are pain, swelling, tenderness, and diminished ability to move the arm. Crepitus is often present, and ecchymosis may be impressive if the patient is not seen early. Displaced fractures or fractures associated with a dislocation have some deformity in addition to the swelling.

Some patients present with a neurologic deficit (such as decreased sensation or axillary nerve palsy) or a brachial plexus injury. A neurologic examination should be performed and documented for all patients, even those without pronounced symptoms. The most frequently injured structures are the axillary nerve and components of the lateral cord; because they are usually nerve-in-continuity injuries, observation is recommended. Resolution of the neurologic symptoms typically occurs within the first 3 months.

In addition, attention should focus on assessing the glenohumeral joint for shoulder dislocation associated with a fracture (a commonly missed injury[85]) and assessing for rib and chest trauma that may be associated with a proximal humerus fracture.

Radiographic Evaluation. Conventional radiographs are essential for diagnosing a proximal humerus fracture. The views commonly needed are a true shoulder AP view, a scapular lateral "Y" view, and an axillary lateral view (Figure 7). Most fractures can be diagnosed with these 3 views. The relationship between the humeral head and glenoid should be carefully studied to avoid missing a dislocation associated with a fracture, and the 4 anatomic parts of the humeral head should be assessed with respect to displacement and/or angulation. In situations involving extreme comminution, a CT scan may be necessary to fully diagnose the extent of the injury.

Nonoperative Treatment. Nondisplaced, valgus-impacted, and minimally displaced fractures are best treated with nonoperative care. Use of a sling or shoulder immobilizer followed by early gentle mobilization has historically had a high success rate.[86] If the patient is in severe pain, a plaster coaptation splint can be useful for several days to a week until the initial pain level subsides. It is helpful to advise the patient to maintain a powdered soft cloth in the axilla to prevent skin maceration. Sling immobilization for 10 to 14 days is typically needed before beginning gentle exercises for range of motion. It is very important that the rest of the upper extremity is mobilized and attention is given to edema reduction because the shoulder is immobilized for 3 to 4 weeks.[83] Physical or occupational therapists should be involved early in helping the patient gain function with range-of-motion exercises as the fracture heals and becomes less painful.

For a proximal humeral fracture, closed reduction alone is not usually successful. However, for simple patterns of fracture-dislocation, such as a displaced greater tuberosity fracture or a minimally displaced surgical neck fracture, closed reduction may be the definitive treatment. Reduction may be achieved with intravenous sedation or general anesthesia, depending on the patient's needs. Healing typically takes 3 to 4 months.

Surgical Treatment. Displaced fractures are not always treatable with nonsurgical interventions. Attention must be given to the type, angulation, and degree of displacement when choosing a plan of treatment.

Fractures in a valgus alignment with an intact medial hinge (humeral calcar) tend to have a better prognosis with nonoperative treatment than do those with varus alignment or medial hinge disruption.

For 2-part surgical neck fractures with displacement, closed reduction and percutaneous pinning or nailing are good options. Open reduction and plate fixation is another treatment option. The 2-part fracture with a displaced anatomic neck fracture is best managed with prosthetic replacement because of the loss of blood supply to the articular surface.

Three-part fractures may be fixed with open reduction and plate fixation, tension band wiring, or percutaneous reduction and terminally threaded wire fixation.[87] Attention must be given to accurate reduction of the greater and lesser tuberosities with sutures or wires to allow for acceptable postoperative function. Attention must also be paid to restoration of medial bony contact to prevent varus collapse and screw penetration into the joint. In some cases, restoration of the medial bony apposition may not be possible, and intraoperative impaction of the shaft into the humeral head may allow for improved stability.[88] The best remaining bone in the humeral head is typically within 1 cm of the articular surface. Placement of screws or pins into this bone gives the best purchase but carries with it the highest risk of intra-articular screw penetration.[89-91]

Four-part fractures and head-splitting fractures are best managed with prosthetic replacement. Because the tuberosity healing is not reliable and humeral height may not be reestablished properly after arthroplasty, the actual effect on the arthroplasty may be compromised.[92,93] The height of the humeral head should be 5 mm inferior to the greater tuberosity. For extremely comminuted 4-part fractures with nonreconstructable tuberosities, some surgeons have found good results with the reverse shoulder replacement.[94]

Rehabilitation. Once a stable construct has been achieved, shoulder range-of-motion exercises can begin. During the

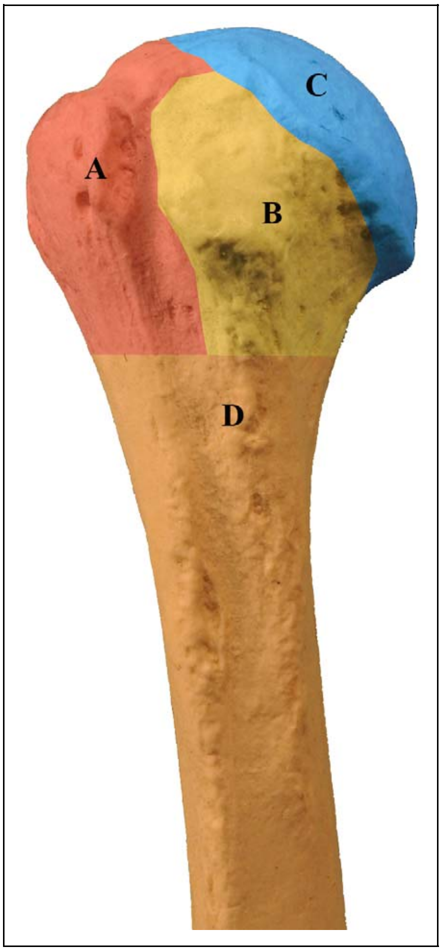

Figure 5. The 4 parts of the proximal humerus as described by Codman[82]: (A) greater tuberosity, (B) lesser tuberosity, (C) anatomic head, and (D) humeral shaft.

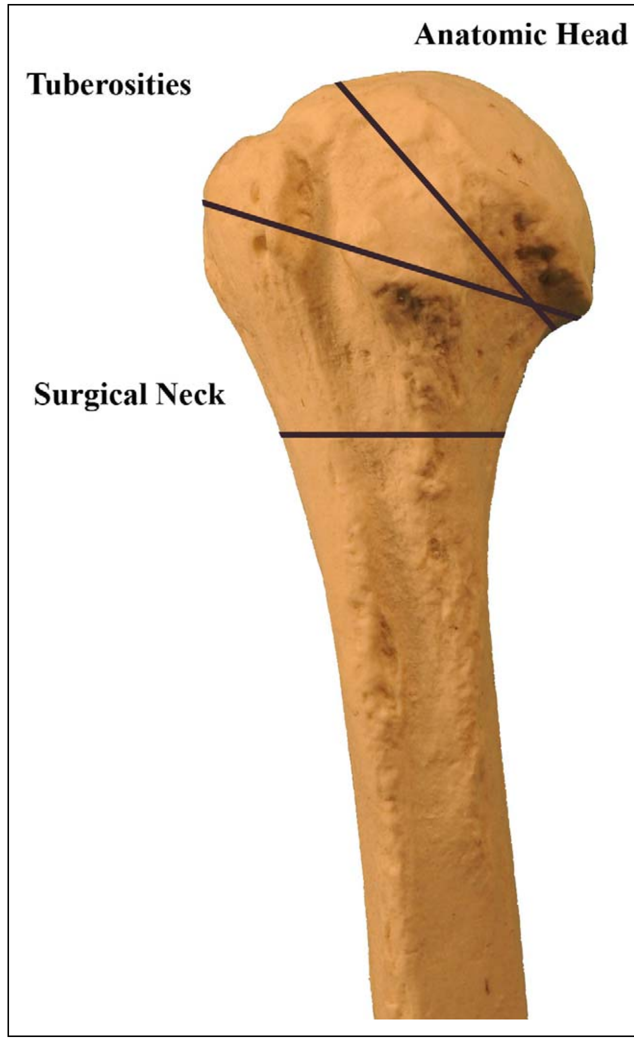

Figure 6. The common zones of injury in the humerus: the anatomic head, tuberosity region, and surgical neck area.

period of convalescence, physical therapy should include elbow, wrist, and hand motion. Even if return to full shoulder motion is not expected, a functional remaining extremity may aid in daily activities. Scapular plane motion may substitute for some lost glenohumeral motion for activities that involve the hand-to-head function. Good strength within the limited motion arcs is often an acceptable outcome. The most appropriate tools used for functional assessment are the Disabilities of Arm, Shoulder, and Hand (DASH) and the Short Form 6D.[95]

Summary. There are many challenges in treating proximal humerus fragility fractures. Treatment must be individualized for the patient. Accurate diagnosis of the injury, as well as consideration of the patient's preinjury function and needs, will allow for acceptable outcomes for most patients.[83,93]

- **Treatment of the proximal humerus fracture is complex and should be uniquely designed to provide for the best functional outcome for each patient.**

Distal Radius Fractures (H. Hoyen and S. Mears)

Distal radius fractures are a very common injury in patients with reduced bone quality. Approximately 200 000 distal radius fractures occur in the United States each year, and women are approximately 4 to 6 times as likely to sustain a distal radius fracture as are men.[96] The incidence of distal radius fractures begins to increase around age 50 years.[97] Care of the patient with a distal radius fracture is also costly: a cost of $7788 (between 2000 and 2005) has been estimated for a Medicare patient with a distal radius fracture.[98]

Pathophysiology. Fractures of the distal radius most commonly occur from a fall onto the outstretched hand from a standing height. The most typical fracture pattern is with dorsal displacement of the distal radius, and it may or may not be accompanied by comminution of the radius, injury to the ulnar side of the wrist, or other wrist injuries such as injury to the scapholunate ligament. Distal radius fracture may also be open injuries.

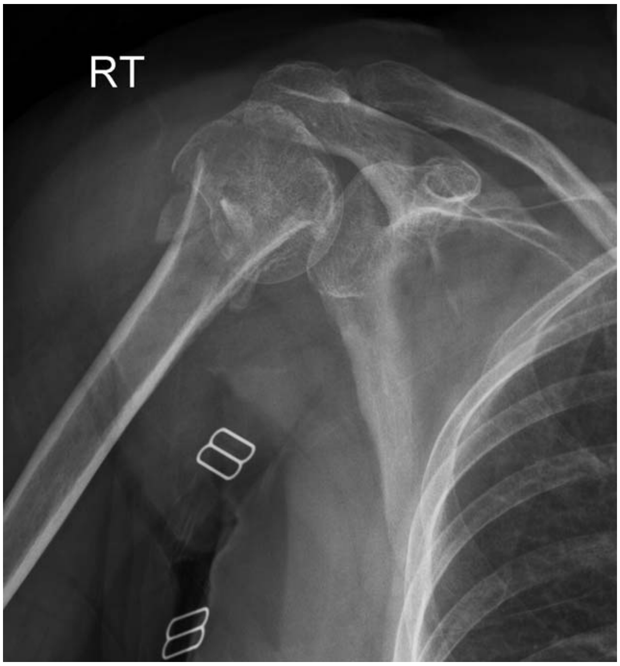

Figure 7. This conventional anteroposterior radiograph shows a comminuted 2-part proximal humerus fracture.

Fractures are associated with diminished bone quality in the distal metaphysis of the radius.

Classification. Many different fracture classification systems have been developed but, in general, have poor interobserver reliability. When evaluating radiographs of the broken distal radius, several measurements can be helpful, including apex volar angulation, radial length, and radial inclination. Most classification schemes distinguish between fractures with and without intra-articular extension and the amount of intra-articular involvement and comminution. Measurement of fragment depression or intra-articular "step-off" should be made because depression larger than 2 mm is associated with development of traumatic arthritis.

Clinical Features. Fracture of the distal radius is usually obvious, with deformity of the wrist, pain, and swelling. Occasionally, a fracture may be nondisplaced and less painful. A skin examination should rule out open injury, particularly near the ulnar styloid. A thorough neurovascular examination should be performed to rule out concomitant nerve or vascular injury. The patient should be questioned to ascertain the dominant hand and the preinjury functional status. Treatment plans may be different in a patient with a poor functional status than in one who is very active. The clinician should assess the patient's activity level and goals after the fracture has healed.

Radiographic Evaluation. Dedicated AP/lateral/oblique views of the wrist should be obtained. Radiographs of the remaining forearm/elbow and potentially the shoulder should be obtained after joint-specific examinations. Other disabling conditions of the hand, such as thumb basal joint arthritis, wrist instability, preexisting deformity, and other posttraumatic conditions, should be identified. These problems may cause a greater impact on hand function than does the distal radius fracture.[99,100] A traction view can be helpful in determining the fracture pattern and stability.

Nonoperative Treatment. All displaced distal radius fractures should be reduced and splinted. Reduction is often aided with the use of a hematoma block. With this block, the fracture site is infiltrated with lidocaine via a dorsal approach. Additional intravenous medication may also be needed for reduction. Although such anesthesia may decrease pain, it is not associated with the quality of reduction. A traction radiographic view should then be obtained, and the wrist should be reduced and splinted. Reduction is performed with re-creation of the displacement followed by translation of the carpus volarly with traction. The goal is a reduced fracture without excessive palmar flexion of the wrist.

A well-padded sugar-tong splint or cast should be then placed. For fractures that require reduction, a sugar-tong splint or cast maintains the reduction better than a slab splint. The splint must be carefully placed to allow the patient to have range of motion of the metacarpophalangeal joints and thumb. A splint that is too long will result in hand stiffness. The splint or cast must be molded using a 3-point technique to allow for fracture reduction maintenance. A splint or cast should not have a cylindrical shape; it should appear deformed—otherwise, the molding is insufficient. Postreduction radiographs are then scrutinized to assess fracture reduction. The mold should be visible on the radiographs.

Based on the postreduction radiographs, patient goals, and patient activity levels, a plan for treatment can be developed. If the fracture is well reduced or the patient is very nonfunctional, closed treatment can be attempted.[101] This treatment should include a weekly radiograph in the splint or cast to ensure maintenance of the reduction. After 3 weeks, the splint or cast may be removed and a short-arm, well-molded cast can be placed. At 6 weeks, the patient usually can be transitioned into a Velcro-applied wrist splint.

Restoring motion and reducing swelling is critical during this period. Elderly patients with distal radius fractures are susceptible to stiffness of the hand, wrist, elbow, and shoulder. Hand edema can be severe, and all rings must be removed at the time of initial evaluation. The patient and caregivers must be counseled to elevate the hand and to use a sling initially. They must be told to remove the arm from the sling frequently and to move the elbow and the shoulder. Stiffness, pain, swelling, and skin temperature changes may represent onset of a complex regional pain syndrome. Early recognition of this condition is essential to allow for early treatment with therapy and sympathetic blockade. Physical or occupational therapy can be instrumental in maintaining range of motion. The splint or cast must be checked to make sure it does not impede range of motion.

If fracture reduction is not obtained with closed reduction or if the reduction is later lost, additional decisions must be made. If the fracture alignment is unacceptable when considering the needs of the patient, operative treatment should be considered. Repeated attempts at reduction are unlikely to result in improved final fracture alignment. The radiographic parameters for failed reduction are controversial but include radial shortening, >2 mm of intra-articular depression, volar tilt of >20°, or dorsal tilt of >0° to 10°.

It has long been thought that fragility fractures do not require operative intervention. The parameters described for younger patients in relation to radial tilt, dorsal angulation, and ulnar variance are often in reference to the development of carpal instability patterns, posttraumatic arthritis, ulnar abutment, and long-term effects. The manner in which these factors affect carpal kinematics is less understood in the elderly population. These radiographic guides must be matched with the activity level and goals of the patient. Fractures of the palmar lip or palmarly displaced fractures are typically unstable and not easily managed with closed reduction and immobilization. Similarly, if the fracture is comminuted, operative treatment may be considered. In select cases, a CT scan may be helpful for planning surgical intervention.

Surgical Treatment. If operative intervention is selected, the treatment options include percutaneous Kirschner-wire (K-wire) fixation, intrafocal K-wire fixation, external fixation, intramedullary fixation, osteobiologic supplementation, arthroscopic reduction, dorsal or volar plate stabilization, or combinations thereof.

The literature does not provide a guide for the best method of fixation, and the choice and success of the modality depend on the experience and skill of the surgeon. With so many different methods of fixation, it is unlikely that an individual surgeon will be skilled in multiple fixation methods. Well-done fixation with one method is much more likely to achieve a good result than poorly done fixation with a perceived (but less frequently used) superior method. Interestingly, the rate of fixation of distal radius fracture is dramatically different in different areas of the United States.[102] No information is available for determining if results are better in the geographic areas with more surgical intervention. In general, each of these methods may be successful, and each has different risks associated with it. Certainly, pin infection can be a risk of K-wire fixation and external fixation that is not associated with internal fixation.

The goals of surgery are to maintain reduction and improve wrist function. The objective measures are consistently better with internal fixation, but the outcome measures are very similar between operative and nonoperative treatment groups.[99,103-105] A more specific outcome measure for fracture treatment is needed and is a potential for further study. The DASH outcome measure may not be appropriate for distal radius fractures in the older patient population. Volar fixed-angled plates are becoming increasingly popular for the treatment of these fractures. The osteopenic bone is directly supported with the locking screws for volar stabilization. Risk factors of plate fixation are plate failure, fracture subsidence, and tendon irritation or rupture.

Patients with complex articular fractures often present with separate dorsal and volar segments. Axial load causes complete shortening of both segments and flattening of the articular disk. This articular incongruity is better tolerated in this population than in younger individuals. In the scaphoid-lunate facet region, articular fractures displaced >3 mm may lock the scaphoid and lunate from rotating with each other. This fracture type may require open reduction, and the metaphyseal angulation may also dictate the necessity for internal fixation.[105,106] Fixation of the ulnar side of the wrist is debated. Although it can be achieved with K-wires or screw or wire fixation, it is unclear how much this improves wrist function, particularly in the elderly patient.

Clearly, further research is required to determine an appropriate treatment algorithm for the treatment of distal radius fractures in the elderly. This algorithm will require careful attention to standardized outcome measures, comorbidities, the needs of the patient, the skill of the surgeon, and cost.[107]

Rehabilitation. After casting or surgery, early finger motion is essential to prevent edema and stiffness. When immobilization is discontinued, aggressive finger and hand motion is necessary to allow for the best possible outcomes. Hand and occupational therapists are an essential part of the patient's recovery.

Summary. Distal radius fracture in the elderly patient should be first treated with closed reduction and immobilization. The decision for operative management should be made with consideration of the radiographic assessment of the fracture, and the type of reduction should be based on the needs of the patient and the skill of the surgeon.

Vertebral Compression Fractures (W. Tyler)

Osteoporosis of the spine is a progressive disease process that can lead to functional morbidity and severe pain, even in the absence of an acute fracture. Approximately 750 000 vertebral compression fractures (VCFs) occur yearly in the United States. These numbers will likely increase as the US population continues to age. Seventy thousand of those VCFs ($\sim$10%) will result in a hospitalization lasting, on average, 8 days.[108] Once a person has sustained a VCF, there is a 5-fold increased risk of sustaining a second VCF and a 4- to 5-fold increased risk of a subsequent hip fracture.[108-110] In 2005, the estimated direct cost of osteoporotic fractures in the United States was $18 billion a year, and if little changes in the epidemiology of these fractures over the next 30 to 40 years, that cost will likely double.[111]

Pathophysiology. The causes of osteoporosis can be explained in the vast majority of cases as a result of decreased circulating estrogen (in the case of rapid-turnover postmenopausal osteoporosis) or the natural aging process (as in the case of low-turnover age-related osteoporosis). In either case, as the bone quality and quantity decrease throughout the body, the spine is often one of the most affected areas. As the cortical and trabecular bones of the vertebral bodies begin to decline in thickness and connectivity, the risk of fracture from physiologic compressive forces increases. Simple activities, such as standing from a sitting position, can lead to fracture through the weakened bony trabeculae. Some fractures occur as a gradual microfracture process that leads to progressively worsening anterior vertebral compression and wedging. These gradual fractures can often be asymptomatic. Other fractures may occur as an abrupt catastrophic failure of the trabeculae, which may be immediately painful. Once a person has a compression fracture, it alters the spine's biomechanics, predisposing it to more compression fractures. A weak vertebral body bone is also representative of a more systemic process taking place throughout the entire body, which is why VCFs are often ominous signs of future fractures.

Classification. There are 2 main types of VCF: acute and chronic. Acute VCF may present with back pain after minimal activity, as mentioned above; this pain can be extremely debilitating. The chronic form of VCF is often detected incidentally when the patient is being examined by a physician and is noted to have a decreased standing height or kyphotic deformity. Chronic VCF may also present with new-onset pain or postural fatigue as the normal biomechanics of the spine become further compromised by the fractures. Some fractures may also be detected when radiographs of the lumbar or thoracic spine are obtained for unrelated reasons (such as abdominal radiographs to assess intestinal gas patterns or routine screening chest radiographs). The identification of the fracture type as acute or chronic can affect the type of medical care and surgical management (if any) chosen for the patient (see below for the management of acute and chronic VCFs).

Although 2 common classification systems address the specific anatomic features of VCFs,[112] neither has been universally accepted. In general, when relaying information about the fracture pattern, it is acceptable to describe the percentage of collapse seen on conventional lateral radiographs.

Clinical Features. Two-thirds of VCFs will not be noticed initially, usually because the patient has minimal symptoms at the time of the event. Patients who are initially asymptomatic may present with loss of height, kyphotic deformity in the thoracic and lumbar regions, and functional declines. The patient's osteoporosis may go untreated because of the lack of acute symptoms, which may lead to a subsequent catastrophic fracture, such as a hip fracture. The other third of patients with VCFs often present with symptoms that are detected close to the time of the initial fracture. The most common presenting symptom is acute onset of back pain after an atraumatic event, such as sneezing or standing from a sitting position. Other acute findings can include lose of height and kyphotic deformity in the spine. Patients with VCFs can also experience neurologic symptoms, such as weakness or radiating pain down the leg or across the chest wall. If such symptoms are present, one should suspect retropulsion of a fracture fragment into the spinal canal or compression of a nerve root in the neural foramen. Neurologic compromise can be a serious complication and can lead to permanent weakness or disability.[113]

Radiographic Evaluation. If a VCF is suspected, conventional radiographs are a useful starting point for workup (Figure 8). AP lateral and flexion/extension views can be helpful. The fractures are often most easily seen on the lateral view. A decrease of 4 mm or more than 20% in vertebral height compared with the baseline height of the vertebral bodies (using the normal vertebra above or below the suspected fracture site) is diagnostic of a VCF.[114] Evaluation of the posterior vertebral line can also be helpful in detecting retropulsion of fracture fragments. If retropulsion or nerve compression is suspected, an MRI or CT scan should be requested. Flexion and extension views can be helpful if instability is suspected.

MRI is helpful in the setting of VCF for several reasons. Unlike conventional radiographs, MRI can often illustrate the acute nature of the fracture (Figure 9). The presence of marrow edema and surrounding soft tissue edema is strongly suggestive of an acute or acute-on-chronic VCF (Figure 10). MRI can also help to delineate the presence of a retropulsed fracture fragment or foraminal narrowing, which may be helpful in explaining the patient's symptoms and in determining treatment.

Finally, in some cases, when an MRI cannot be performed or is indeterminate, a bone scan can sometimes be helpful in detecting the presence of an acute fracture versus a chronic, older fracture. Bone scans may not become positive at the fracture site until about 10 days after the initial injury, and if the bone scan is obtained too early in the process, a false-negative result may occur.[115]

Nonoperative Treatment. Most patients with VCFs can be treated with nonsurgical options. There are several categories of such interventions: treatment of the underlying osteoporosis, pain management, and bracing.

Treatment of the underlying osteoporosis that led to the fracture can be achieved with the use of several different medications such as calcium and vitamin D, along with calcitonin, bisphosphonates, parathyroid hormone analogue, raloxifene, or denosumab (see the section on osteoporosis for the indications for use of such medications). Pain control, maintenance of function, and correction or stabilization of the deformity are also important components in the treatment of VCF.

Pain control is a paramount part of the medical treatment of VCF. Without adequate pain control, patients cannot rehabilitate appropriately, which will lead to permanent functional declines and other complications frequently seen in immobile elderly individuals (eg, pressure ulcers, venous thromboembolism, and pneumonia). NSAIDs and acetaminophen are good starting points for control of pain. However, NSAIDs should be used with caution, especially in older women and in patients with a history of hypertension, gastrointestinal bleeding, ulcers, or renal disease, and acetaminophen should be used with caution in patients with advanced liver disease. If NSAIDs are unsuccessful, a short course of narcotic medications can be considered. However, although narcotics can work well for pain control, they can cause confusion, delirium, and constipation in elderly patients. Some medications that are used to treat the underlying osteoporosis have also been shown to improve pain related to VCFs.[116,117] Calcitonin, in particular, has been associated with improvement in pain through its ability to influence beta-endorphin levels.[117] Teriparatide and bisphosphonates have also been found to be associated with lessened bony pain in patients with VCF.[116]

Bracing can serve several functions. One is to help with pain relief by reducing the amount of continued compression and micromotion at the fracture site. Bracing can also act as a supplement to muscle support for patients who experience early muscle fatigue. Bracing improves the biomechanics of the spinal column after fracture.[118] Extension bracing can prevent additional collapse in the setting of an acute fracture and can help the fracture heal in a more anatomic position,[118] which may in turn prevent subsequent additional fracture and pain. The Jewitt brace and the CASH brace are 2 frequently used types of braces for VCFs. They both function to provide 3-point stability to the spine and prevent flexion at the thoracic and lumbar regions.[118] Both can be worn under regular clothing. The major problem with bracing is that many elderly patients are unable to tolerate it for lengthy periods of time. The braces can cause skin irritation and pressure sores. Bracing can also lead to decreased mobility if the brace is too bulky for the patient's body type. In addition, it may also be difficult to obtain a brace that adequately fits an obese patient. The braces may contribute to further muscle atrophy. These factors, along with individual patient needs and body geometry, need to be taken into account when bracing is being considered.

Surgical Treatment. Surgery should be reserved for patients with painful VCFs for whom nonoperative treatments have failed and those who have been shown to have an acute VCF on MRI or bone scan. The 2 procedures that have been approved for intervention for VCF are vertebroplasty and kyphoplasty. Vertebroplasty is the injection of polymethylmethacrylate bone cement through a posterior transpedicular approach into the collapsed vertebral body. Like vertebroplasty, kyphoplasty uses polymethylmethacrylate to stabilize the fractured vertebral body, but it differs in that before the cement is injected, a balloon is inserted into the vertebral body and inflated to allow the vertebral body to be expanded more closely to its prefracture position. After the balloon is withdrawn, the polymethylmethacrylate is then injected into the expanded space and allowed to harden. Both procedures are thought to improve pain and function in patients with acute VCF[119] but to have limited utility in patients with chronic back pain and chronic VCFs.

Surgical intervention for VCF is somewhat controversial, and the choice between vertebroplasty and kyphoplasty is still very much a debated topic. Advocates of kyphoplasty argue that it more accurately restores the natural anatomy of the spine (Figure 11).[120,121] Advocates of vertebroplasty argue that the balloon effects on restoring the anatomy are minimal and that the pain relief experienced from both procedures is secondary to stabilization of the fracture with cement.[122] Vertebroplasty advocates also argue that the risk of iatrogenically induced fracture fragment retropulsion is less with vertebroplasty.[123,124] Retropulsion can lead to neurologic deficits and spinal cord compromise and is a major complication of either procedure.[125]

Three recently published randomized placebo-controlled trials have called into question the efficacy of vertebroplasty in improving pain in patients with VCF.[126-128] Kallmes et al[127] found a trend toward improved pain scores over baseline in the vertebroplasty group at 1-month posttreatment, but it was not a statistically significant difference. Buchbinder et al[126] found that at 6 months, there was no difference between groups in pain or functional scores. Critics of these studies point out that the analysis included patients with fractures up to 12 months old, which many would consider beyond the window of the acute fracture period and therefore would have limited improvement from the procedure. Wardlaw et al[128] specifically assessed the efficacy of kyphoplasty and found that patients treated with kyphoplasty had statistically significant improvements in the SF-36 scores at 1 month.

Both vertebroplasty and kyphoplasty have potential complications, including the risk of cement extrusion into the spinal canal, retroperitoneal space, or thoracic cavity[124,125]; intravascular extrusion of cement[124,125]; fat embolism syndrome, which should be considered when pulmonary compromise is noted during or after the procedure[124,125]; and neurologic deficits from cement causing injury to local nerve roots or the spinal cord (rare)[124,125] or from subdural and epidural hematomas. Patients with bleeding disorders or on blood-thinning medications should have their coagulations restored to normal before proceeding with either procedure. Patients should also be off aspirin and clopidogrel bisulfate for 1 week before either procedure. In addition, retropulsion of fracture fragments into the spinal canal from the pressure from the cement entering the enclosed space has been reported[129] and can be a devastating event. Therefore, most advocates of these 2 procedures would argue that they should not be performed in people who already have evidence of retropulsion of the posterior vertebral body wall or an incompetent posterior vertebral body wall on MRI or conventional radiographs.

Summary. VCFs frequently occur in patients with osteoporosis and often involve complicated presentations and complex treatment decisions. Combinations of medicinal, functional, and sometimes surgical treatment options need to be considered. The vast majority of patients can be treated with medical management options, which include pain medications and bracing, but a small subset will benefit from surgical intervention. Because surgical treatment carries substantial risks, special training is suggested for those surgeons performing vertebral augmentation.

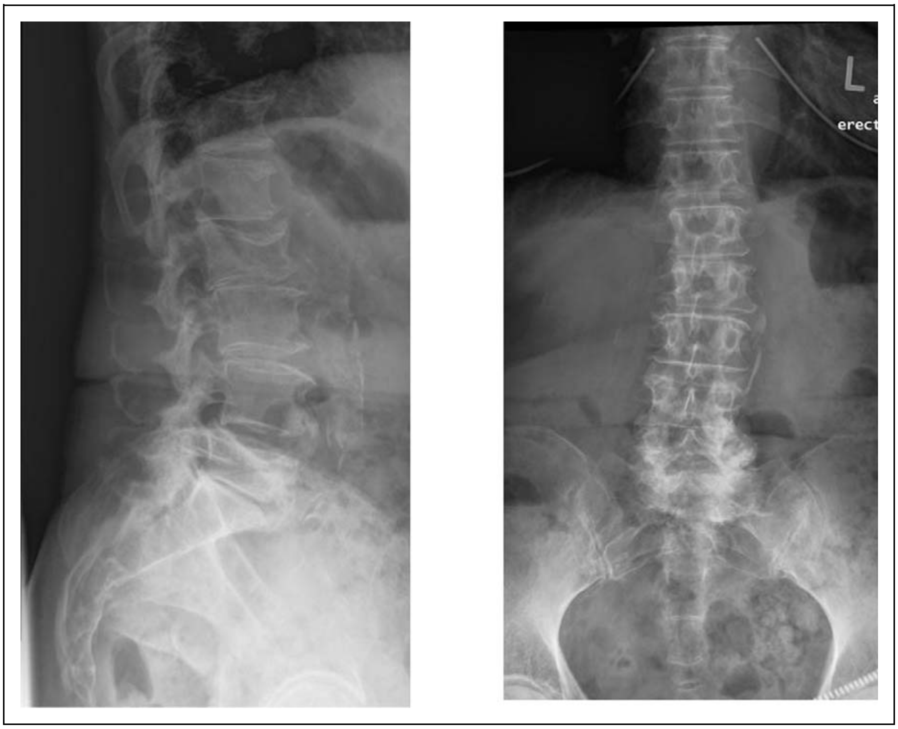

Figure 8. These lateral (left) and anteroposterior (right) conventional radiographs show healed vertebral compression fractures at T12, L2, and L5.

Fragility Fractures of the Foot and Ankle (B. DiGiovanni and F. Serna, Jr.)

Foot and ankle injuries—including fractures—are among the most common orthopaedic complaints, with a published pooled incidence for ankle fractures of up to 184 fractures per 100 000 person-years; 20% to 30% of those fractures occur in the elderly.[130] They can be the result of high- or low-energy mechanisms, with low-energy trauma (slips, falls from a standing height, etc) being the far more common cause in the elderly population. In recent years, the incidence and severity of ankle fractures (more unstable supination-eversion injuries) in the elderly have been increasing.[131,132] The incidence of foot and ankle fractures in elderly, nonblack women has been reported to be 3.0 and 3.1 per 1000 woman-years, respectively, with fractures of the fifth metatarsal and distal fibula being the most common.[133] The incidence of fragility fractures increases even in middle age.[134]

Risk Factors. The risk factor profiles for foot and ankle fragility fractures differ between middle-aged and older men and women.[134] For men, the most commonly associated risk factors include diabetes and hospitalization for mental health problems; for women, diabetes, a previous fracture, and high body mass index (BMI) (specifically for ankle fractures) are the most commonly associated risk factors.[134]

Risk factor profiles for ankle vs foot fractures differ in elderly women.[133,135] Those sustaining ankle fractures tend to be younger; to have a higher BMI; to have participated in more vigorous physical activity, gained weight since age 25 years, and fallen within the previous 12 months; and to self-report osteoarthritis, have a sister who sustained a hip fracture after age 50 years, and get out of the house one time or less per week. Male and female patients sustaining foot fractures had lower distal radius and calcaneal bone mineral density values, were less physically active, and were more likely to have had a previous fracture, be on benzodiazepines, have insulin-dependent diabetes mellitus, and have poor far-depth perception.[136]

An increasing rate of falls (from baseline) continues to be a risk factor for hip and proximal humerus fractures—the classic fragility fractures—but not for foot or ankle fractures.[137] However, risk factor profiles for foot and ankle fractures are similar to those of other fragility fractures in that they have been shown to be largely related to low bone mass.[135] Although ankle and foot fractures in the elderly are commonly categorized as osteoporotic fragility fractures, a recent clinical study has shown that the incidence of such fractures rises until age 65 years and then plateaus or decreases thereafter, calling into question the relationship between these injuries and bone quality.[138] Therefore, the increased incidence of ankle fractures may result more from an increasing number of active elderly patients rather than the aging process and the presence of osteoporosis.[138]

Treatment of Foot Fractures. Fragility fractures in the foot occur most commonly in the metatarsals and tarsals. Fifth metatarsal fractures, reported as the most common site for foot fracture,[133] are seen primarily in an acute/traumatic setting. Stress fractures

Figure 9. This sagittal fat-suppressed T2-weighted magnetic resonance imaging scan shows healed vertebral compression fractures at T12, L2, and L5.

Figure 10. This sagittal fat-suppressed T2-weighted image shows a nonhealing L2 fracture and a developing L4 fracture.

are the most common type of foot fractures; they can affect the talus, navicular, great toe sesamoids, and other metatarsals and are defined as injuries resulting from excessive, repetitive, and submaximal loads resulting in an imbalance between bone resorption and formation, most often in the setting of intrinsic (eg, metabolic bone disease) or extrinsic (eg, muscle fatigue) factors.[139] Initial conventional radiographs are often unrevealing, but a high clinical suspicion and physical examination findings supporting the diagnosis should prompt adequate treatment. Repeat radiographs obtained at 10 to 14 days postinjury/onset of symptoms often show evidence of fracture lines and/or apparent callus formation that were not present initially.

Nonoperative treatment. The mainstay of treatment for all foot fractures is nonoperative intervention. Rigid cast immobilization for 6 to 8 weeks, with avoidance of weight bearing and aggressive treatment targeted at the causative intrinsic or extrinsic factors, allows for successful healing in most cases. However, the treating clinician must be vigilant for progression to complete fracture, delayed union, and nonunion and skin ulceration.

Surgical treatment. Fractures that are displaced or with chronic radiographic findings such as intramedullulary sclerosis or cystic changes frequently require operative intervention with percutaneous pinning/screw fixation, open reduction and internal fixation, or sesamoidectomy.

Treatment of Ankle Fractures. The primary goals in treating these injuries are to (1) provide a functionally stable ankle joint, (2) return the patient to activities of daily living and preinjury functional levels, and (3) avoid the risks of prolonged immobilization and bed rest. Despite clear indications for nonoperative and operative treatment of such fractures in the young, there continues to be controversy regarding their optimal treatment, particularly of ankle fractures, in the elderly. For the elderly, conventional treatment modalities can be difficult because of such patients' poor bone quality, poor soft tissue integrity, intrinsic instability, and difficulty in complying with nonoperative or postoperative weight-bearing limitations.

Nonoperative treatment. For nondisplaced fractures in the elderly, nonoperative management with splint or cast immobilization and serial radiographic follow-up can provide satisfactory results without the inherent risks of surgical intervention,

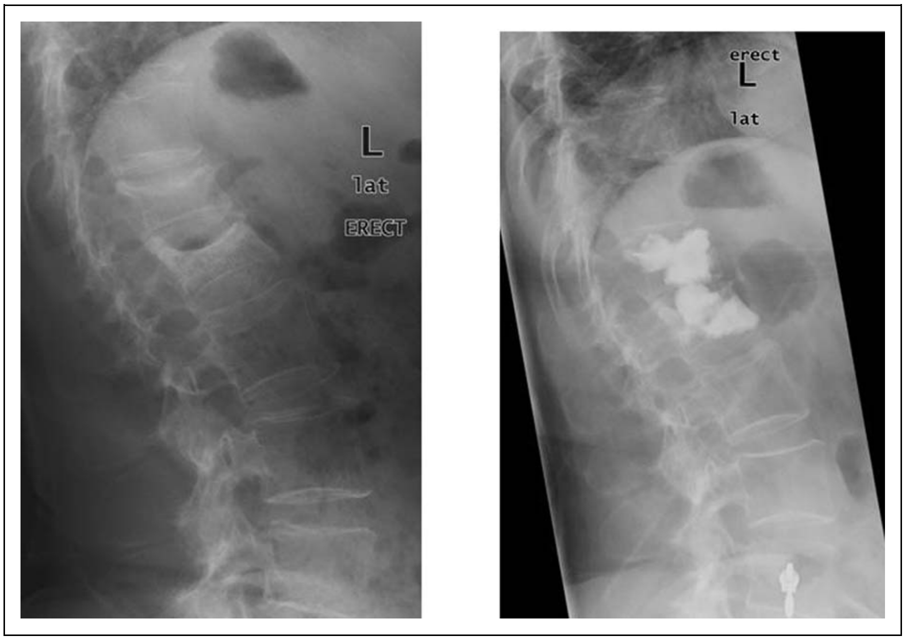

Figure 11. These conventional lateral radiographs show vertebral compression fractures at L21 and L2 before (left) and after (right) treatment with kyphoplasty.

including those related to poor bone and soft tissue quality. Reported data also indicate that even displaced but well-reduced fractures in elderly patients can be managed successfully with nonoperative treatment methods.[130]

Surgical treatment. Operative management should be considered for fracture-dislocations and other unstable fracture patterns. Contrary to early studies recommending against this approach in the elderly because of high complication rates and poor functional outcomes, a recent study has shown increasingly positive results.[138] These results can be attributed, in part, to improved postoperative rehabilitation, the introduction of fixed-angle devices used in internal fixation techniques, and an increased awareness of potential complications.

Special Considerations in Patients With Diabetes Mellitus. Compared with patients without diabetes, individuals with diabetes mellitus have a higher risk of complications with either surgical or nonoperative management of their foot or ankle fractures. Vasculopathy and neuropathy with impaired proprioception and nociception (loss of protective sensation) may play a role in predisposing diabetic patients to further injury, loss of reduction, delayed union, malunion, nonunion, infections, and soft tissue or wound complications. The following is the method for testing plantar sensation using Semmes-Weinstein 5.07/10-g monofilament:

- The filament should be pushed against the plantar surface of the foot (in multiple areas to map out the entire footprint).
- Just enough pressure should be exerted for the filament to start bending.
- If a patient cannot sense this pressure, the loss of protective sensation should be documented.
- The result should be compared with that of the contralateral foot (although this step may not be helpful because of the bilateral nature of diabetic neuropathy).
- An assessment should be made based on how much of the plantar surface is affected.

Nondisplaced fractures can be treated nonoperatively with prolonged cast immobilization in a well-padded, non-weight-bearing cast. However, such patients with diabetes often have difficulty with cast immobilization and weight-bearing restrictions, and close clinical and radiographic follow-up is necessary for optimal outcomes. Early and aggressive operative stabilization has been recommended for displaced unstable fractures in this population.[140] Such fractures, when treated nonoperatively, have a high rate of progression to malunion or nonunion[141] and are likely to require surgical intervention at a later time. A meta-analysis of 140 diabetic ankle fractures showed an overall operative cohort complication rate of 30%, with an infection rate of 25%, a Charcot arthropathy rate of 7%, and a Charcot amputation rate of 5%.[142] There are trends toward using supplemental fixation, multiple syndesmotic screws, and larger/stronger implants (locking constructs) in patients with diabetes, comorbidities, and neuropathy; however, in those without comorbidities, results of operative management similar to those in patients without diabetes can be expected.[143] Medical management of the patient's diabetes should be supervised by the primary physician or endocrinologist.

Investigators have suggested and recommended a longer period of postoperative immobilization and subsequent protected weight bearing and bracing than for patients without diabetes.[143,144] Increased vigilance for complications such as loss of reduction, wound breakdown, plantar ulceration secondary to loss of protective sensation, and Charcot neuroarthropathy is recommended.

Summary. Foot and ankle fractures are common injuries in the elderly population. Identifying the risk factors for such injuries, knowing which injuries are amenable to nonoperative or operative management, and having a strong focus on prevention of these injuries combined with appropriate medical management directed at any underlying comorbidities (eg, conditions such as osteoporosis, diabetes, peripheral vascular disease, and mental health disorders) are paramount to the successful overall management of these patients.

Pelvic and Acetabular Fractures (S. Mears)

Pathophysiology. Fractures of the pelvis are common injuries in the elderly patient. The most common cause is a low-velocity fall, often from a standing position. The vector is most commonly thought to be on the side of the greater trochanter, resulting in a compression injury to the pelvis. Acetabular fractures in the elderly, which may also be the result of a low-velocity fall, are becoming more common. Both of these types of fractures may also occur from higher velocity forces.

Classification. In the elderly, a pelvic ring fracture typically involves 2 or more bony areas, most commonly the sacrum and 1 or both pubic rami. Another pattern of injury is the sacral insufficiency fracture. These may result in nonunion and may be bilateral or involve a horizontal component. Acetabular fracture in the elderly may approximate the injury patterns seen in younger patients. Some patterns are more common, such as anterior wall fracture and associated both column fractures.

Clinical Features. Patients with pelvic or acetabular fractures have pain in the hip or groin region. It may be difficult to distinguish pelvic fractures from a hip fracture. Patients with sacral insufficiency fracture present with low back pain. Both pelvic and acetabular fractures may result in bleeding, especially in the anticoagulated patient. Retroperitoneal hematoma may cause critical bleeding, and the hematocrit level should be monitored.

Radiographic Evaluation. Standard AP pelvis and hip radiographs should be the first study ordered. If a pelvic fracture is recognized, inlet and outlet views will give better views of the pelvis. If an acetabular fracture is identified, oblique or Judet views are standard to determine the fracture type. The gull sign, seen on oblique views, has been characterized as a poor prognostic indicator for elderly patients with acetabular fractures.[145] This sign indicates substantial impaction and damage to the joint surface. For pelvic fractures, a CT scan facilitates recognition of posterior sacral injury that is often not apparent on conventional radiographs. For acetabular fractures, a CT scan provides better visualization of marginal impaction than conventional radiographs and can help the clinician classify the fracture. When a fracture cannot be visualized on radiographs or CT scans, an MRI scan can help determine if a hip, pelvic, or acetabular fracture is present. MRI scans also provide excellent imaging of sacral insufficiency fractures.

Nonoperative Treatment. Nonoperative treatment is used for most pelvic injuries in the elderly. Most fractures are stable injuries and can be treated with weight bearing as tolerated with an ambulatory aid. Pain control as needed is used, and thromboprophylaxis should be instituted.

Acetabular fractures in the elderly should be treated nonoperatively if the hip is reduced and there is congruency of the joint surface. Treatment involves limited weight bearing for 6 to 8 weeks followed by a progressive increase in weight bearing. In most cases, the pelvic or acetabular fracture will produce enough pain that hospitalization is required, and an acute rehabilitation stay may be needed before a patient can return home.[146]

Surgical Treatment. Surgery is rarely indicated for pelvic fractures in the elderly but may be necessary for cases of nonunion or sacral insufficiency fractures that do not respond to nonoperative interventions. Surgery may involve screw insertion or plate fixation.[147]

The exact treatment of each type of acetabular fracture is controversial, but displaced acetabular fractures may be treated by 1 of 4 general modalities: percutaneous fixation with screws, open reduction and plate fixation, immediate hip replacement, or delayed hip replacement. Each of these methods requires different skills and may be more or less indicated for different fracture patterns, and other factors can also affect method selection. For example, internal fixation may be made difficult by poor bone quality and the presence of marginal impaction,[148] percutaneous fixation requires great technical expertise,[149] and hip replacement is much more technically challenging in the acute hip fracture and may require a combination of fracture fixation and revision hip replacement skills.[150] For delayed hip replacement, standard arthroplasty techniques may be used and may not be required for years after the injury.

Rehabilitation. In most cases, rehabilitation for a pelvic fracture is started with ambulatory aids and weight bearing as tolerated. In cases of operative fixation, weight bearing as tolerated may not be possible, and patients may be limited to a bed-to-chair existence until fracture healing.

Summary. Pelvic and acetabular fractures are a common injury in elderly patients, and they often require hospitalization. Most pelvic fractures are stable and are treated with physical therapy, weight bearing as tolerated, pain control, and thromboprophylaxis. Treatment of acetabular fractures in the elderly is a controversial topic. Stable and congruent fracture should be treated nonoperatively. Displaced fracture may be treated with percutaneous or open fixation, or immediate or delayed hip replacement.

Secondary Prevention of Fragility Fractures (S. Bukata)

Basic Metabolic Bone Workup

Defining the Disease of Osteoporosis. Osteoporosis is characterized by low bone mass, deterioration of bone tissue, increased bone fragility, and higher risk of fracture. A bone's strength and ability to resist fracture depend on a combination of its mass and quality. Bone mass can be measured, but bone quality is more difficult to assess, and the elements that influence bone quality are still being defined.

Bone density is generally measured using a dual-energy X-ray absorptiometry (DEXA) scan. Low doses of radiation (1-3 mrem, which is approximately the exposure on a cross-country airplane trip [2.5 mrem][151]) are used to measure an individual's bone mass at the lumbar spine, each hip, and each forearm. Generally, 3 sites are chosen for assessment. Any location that contains hardware cannot be accurately assessed. In the spine, any level that has substantial arthritis, a compression fracture, or a laminectomy also cannot be assessed accurately. The patient remains clothed throughout the test, which takes approximately 15 to 20 minutes. Patients are scored against control values matched for race and sex. Bone mineral density (in g/cm^2) for each measured site is then matched to curves appropriate for race and sex to determine a patient's score for that site. A *z* score is used for children and young adults younger than 25 years old because they are still gaining bone mass and have not yet reached their peak; the *z* score is used to compare the patient's bone density to that of peers in the same age. For all other patients (ie, those >25 years old), a *t* score rates the patient's bone mineral density relative to the population at the time of peak bone mass (which occurs between the ages of 25 and 30 years). The World Health Organization defines a *t* score of –2.5 or lower as osteoporotic bone mass and scores of –1 to –2.4 as osteopenic bone mass.[152] A patient with a *t* score of –2.5 or lower or a patient who has suffered a fragility fracture (regardless of *t* score) is defined as having the disease of osteoporosis. Quantitative CT scan can also be used to generate *t* scores and *z* scores, but radiation exposure is substantially greater. Ultrasound can be used to evaluate superficially accessible bones (eg, tibia, calcaneus), but results are not highly correlated with DEXA measurements at the hip and spine.[153] Ultrasound for bone density determination is not recommended.

Bone quality is much more difficult to define and measure, but it relates to all the characteristics that contribute to bone strength besides the bone mineral density (ie, the architectural distribution of bone material and how those materials bond to one another). The rate at which the bone remodels, distribution of bone mineral and collagen, porosity of the cortex, shape of trabeculae within the bone, and other yet to be defined factors influence bone quality and are not easy to measure. For that reason, surrogate markers that include important risk factors for fracture are used to assess the influence these bone quality factors may have on bone strength. These factors include age, sex, BMI, personal history of fragility fracture, parental history of hip fracture, smoking, glucocorticoid use, rheumatoid arthritis, secondary causes of osteoporosis (type 1 diabetes, osteogenesis imperfecta, untreated hyperthyroidism, untreated hyperparathyroidism, hypogonadism or premature menopause [at <45 years of age], chronic malnutrition, malabsorption, chronic liver disease), or daily alcohol intake of more than 3 units.

Assessment of Fracture Risk With FRAX. FRAX (available at www.sheffield.ac.uk/FRAX) is a fracture risk assessment tool designed to predict an individual's 10-year probability of hip fracture or major osteoporotic fracture (spine, forearm, hip, or shoulder) by combining these determinants for bone quality with bone mineral density measurements. It takes 1 to 2 minutes to complete this assessment on the Internet and does not require a bone mineral density (BMD) value to predict fracture risk. Data entered are compared against country-specific data. Patients with a 10-year hip fracture risk of $\geq$3% or a $\geq$20% risk of major osteoporotic fracture should be treated for osteoporosis.

Fragility Fracture as a Major Risk for Future Fracture. One of the greatest risk factors for future fragility fracture is having a fragility fracture as an adult.[154] Regardless of bone mass, that individual's risk of future fragility fracture is increased. Of patients with 1 fragility fracture, 10% will have another within 1 year, and 17% to 21% will have another within 2 years.[154] Compared with an individual without a VCF, a patient with a VCF is immediately 5 times more likely to suffer another vertebral fracture and twice as likely to suffer a hip fracture.[155] Despite this knowledge, only approximately 20% of patients with hip and wrist fractures are assessed for osteoporosis.[4] Counseling should be provided to all patients to encourage weight-bearing activities, smoking cessation, fall prevention, and activity modifications to minimize the risk of future fracture.

Diagnostic workup for osteoporosis. Any adult patient who has had a fragility fracture should undergo assessment and treatment for osteoporosis. In addition, any patient with known risk factors for osteoporosis who has not yet experienced a fragility fracture should also have an assessment for osteoporosis. Current National Osteoporosis Foundation recommendations suggest that the following individuals should have a BMD test, such as a DEXA scan, and an assessment for fracture risk: women $\geq$65 years old, men $\geq$70 years old, men or women $\geq$50 years old who have had a fragility fracture, men between 50 and 70 years old with 1 or more risk factors for osteoporosis, and postmenopausal women <65 years old with 1 or more risk factors for osteoporosis.[156] It is estimated that 30% of patients with osteoporosis have a secondary cause that contributes to the disease.[157] The rate is even higher in men with osteoporosis and premenopausal women with osteoporosis (50%-60%) and in patients who have suffered a hip fracture (>80%).[158] Patients undergoing assessment for osteoporosis, particularly those who have had a fragility fracture, should have additional laboratory testing to assess for these secondary causes. Serum calcium, 25-hydroxy vitamin D, intact parathyroid hormone, thyroid-stimulating hormone, and 24-hour urine calcium levels should be a part of the osteoporosis assessment. For patients with known renal problems or those with a glomerular filtration rate <60, levels of 1,25-dihydroxyvitamin D should be added, which allows assessment of the renal 1-hydroxylation of vitamin D. For patients who have not experienced a recent fracture, markers of bone turnover such as serum alkaline phosphatase and urine N-telopeptide or serum C-telopeptide can be added. However, these turnover markers will be elevated in the setting of a recent fracture that is healing and can remain elevated for a few months after the fracture, limiting the usefulness of these markers at that time.

Importance of vitamin D. It is now being recognized that vitamin D insufficiency (defined as a serum 25–vitamin D level of <32 ng/mL[159]) or deficiency (defined as levels of <20 ng/mL[159]) is relatively common in the US population in all age ranges.[159] Patients with low-energy hip fractures have shown vitamin D insufficiency rates as high as 70% to 90%.[160] Vitamin D is important not only for bone strength and mineralization but also for lower extremity muscle strength, gait speed and performance, and balance in individuals older than 65 years old.[161]

Vitamin D is a fat-soluble hormone that is produced in the skin or obtained from the diet. It is then processed by the liver (hydroxylated at the 25th carbon) and finally processed by the kidney (additional hydroxylation at the first carbon) to produce 1,25 dihydroxyvitamin D. Recent evidence has shown that many other tissues are capable of processing vitamin D at the first carbon (using 1-α hydroxylase just as the kidney does) and that almost 85% of vitamin D is metabolized outside of the kidneys and used locally by the tissues that process it.[162] These tissues do not contribute to the serum levels of 1,25 vitamin D, so it is the serum level of 25–vitamin D that is relevant for the assessment of vitamin D status.

However, because vitamin D is a fat-soluble hormone, there is concern for accumulation and toxicity. Toxicity occurs rarely, but it is defined as hypercalcemia (serum calcium levels $\geq$10.5 mg/dL) and is accompanied by symptoms of anorexia, nausea, polyuria, polydipsia, weakness, and pruritis.[163]

Recommendations for vitamin D supplements are evolving (Table 1). Current recommendations for patients with osteoporosis or substantial risk factors for osteoporosis are 800 to 1200 IU of vitamin D_3 supplement if dietary intake and sunlight exposure are not adequate.[159] Increased age, obesity, darker skin pigmentation, certain medications, and malabsorption require an increase in the dose of vitamin D an individual needs. More aggressive supplement recommendations suggest that, for older adults, 2000 IU of vitamin D_3 daily is needed for maximal effect. More vitamin D is also needed in the winter and early spring than in the summer and fall because almost all areas of the United States have inadequate sun strength to produce optimal levels of vitamin D in the skin, even with extended sun exposure.[159] Two forms of vitamin D are available for supplementation: ergocalciferol–vitamin D_2 is derived from plant sources, and cholecalciferol–vitamin D_3 is derived from animal sources. Vitamin D_2 is not efficiently metabolized in humans (only 20%-40% as efficient as D_3). It is inexpensive and well tolerated in large doses given orally. Vitamin D_2 is available in larger prescription doses (50 000 IU) and can be helpful if rapid correction of vitamin D levels is needed, such as after a fracture or in the setting of hypocalcemia. Use of vitamin D_3 supplements (800-1200 IU/d) is encouraged for long-term maintenance dosing or if correction can occur over several months.[159] Vitamin D_3 is available as a low-cost over-the-counter supplement.

A supplementation/treatment algorithm (Table 1) can be used to correct vitamin D deficiency or insufficiency.

Assessment for osteoporosis. The following list represents the typical evaluation needed for the workup of a patient with fragility fracture

- DEXA scan for bone density
- Serum calcium
- 25-OH vitamin D
- Intact parathyroid hormone
- Thyroid-stimulating hormone
- Estimated glomerular filtration rate
- 24-hour urine calcium
- 1,25-OH vitamin D (if estimated glomerular filtration rate is <60)
- FRAX assessment (if never on previous therapy—available online: http://www.shef.ac.uk/FRAX/)
- All patients with a fragility fracture should have an assessment for osteoporosis and, if present, treatment and vitamin D supplementation when levels are insufficient.

Treatment of osteoporosis. Many different categories of medications are now available for the treatment of osteoporosis. The goal of all therapies is to maintain bone mass, limit bone loss, and decrease fracture risk. All therapies decrease the risk of vertebral fracture by at least 50%,[164,165] but decreases in hip fracture risk and other nonvertebral fractures vary from medication to medication. For example, risendronate has been shown to reduce hip fracture risk.[165] Currently, teriparatide is the only treatment that works as an anabolic agent, stimulating the osteoblast to produce bone.[166] Bisphosphonates are analogs of hydroxyapatite that deposit into the bone and affect the development and activity of osteoclasts—that is, they significantly slow the rate of bone loss.[167] Zoledronic acid, a bisphosphonate given by once-yearly intravenous infusion, has been shown to decrease bone loss and mortality after hip fractures.[168] Estrogen and estrogen with progesterone have been

Table 1. Vitamin D Supplementation

Parameter	Current Recommended Daily Allowance, IU	Probable Physiologic Need, IU Vitamin D_3	Aggressive Supplementation, IU[a]
Adults >50 years old	Vitamin D_3, 800-1200 daily	Vitamin D_3, 2000 daily	Vitamin D_3, 2000 summer/fall Vitamin D_3, 4000 winter/spring
Darker skin	No change	Add 1000 daily	4000 summer/fall 4000 winter/spring
Vitamin D insufficiency (levels <32 ng/mL)			Vitamin D_2, 50 000 weekly for 8 weeks; repeat dosing if vitamin D level remains <32 ng/mL
Vitamin D deficiency (levels <20 ng/mL)			Vitamin D_2, 50 000 twice weekly for 5 weeks; repeat dosing until levels are >32 ng/mL

[a] Patients with body mass index >27, with malabsorption, or on certain medications may need higher doses and longer duration of treatment.

used less frequently since the Women's Health Initiative studies raised concerns about increased heart disease, stroke, and rates of invasive breast cancer.[169] The use of estrogen does show reduced risks for vertebral and hip fractures, but current recommendations (because of long-term side effects) suggest that it be used only in patients who also require it for vasomotor or urogenital problems.[170] It is not recommended as a first-line therapy solely for osteoporosis treatment. Selective estrogen receptor modulators are not hormones, but they work through the estrogen receptor to produce some of the bone-sparing effects of estrogen.[171] Raloxifene is the only form of such agents available in the United States. It has been shown to reduce not only fracture risk but also the risk of developing invasive breast cancer.[171,172] Denosumab is a fully human monoclonal antibody to RANK ligand that works by inhibiting the development and activity of osteoclasts, decreasing bone resorption rates.[173]

Regardless of the treatment chosen for osteoporosis, all patients should receive adequate calcium and vitamin D intake, which usually mandates supplements or an increase in dietary intake. The National Academy of Sciences recommends a daily intake of 1200 to 1500 mg calcium for adults older than 50 years.[174] Most individuals get only 600 to 700 mg of calcium through their diet. Vitamin D supplements should also be given with the goal of maintaining a serum 25-OH vitamin D level of $\geq$32 ng/mL.

Compliance with osteoporosis medications is a problem.[175] This seems to be the case because osteoporosis is a silent disease until fracture, and there are some troublesome side effects of the medications used to treat it. Regardless of treatment type, one-third to one-half of patients stop taking their medications as prescribed within the first year, with persistence rates for bisphosphonates as low as 20% at 24 months.[176] Fracture protection is related to medication persistence, and patients should be reminded that they will not get the full benefit of their osteoporosis medication unless they take it as prescribed and continue to take the medication, even after the fragility fracture has healed. The appropriate duration of therapy is currently unclear, and patients require monitoring with DEXA scans and metabolic bone markers.

Falls Assessment (A. Kates)

Most nonvertebral fragility fractures result from a fall. The reason that a patient falls is not always apparent and may be the combination of several factors. Investigation into the cause of falling and attention to the correctable causes may lessen the likelihood of future falls and future fractures.

In an elderly patient, a fall is a sign of frailty.[177] About one-third of seniors living in a community setting will fall each year, women more so than men.[177] Approximately 5% of those falls will result in a fracture, and 1% will result in a hip fracture.[178] Falls are the third leading cause of accidental death in seniors in the United States.[179] The magnitude of this problem is quite clear.

Why Secondary Prevention Matters. There are many fall prevention studies, education programs, and programs to improve strength or balance, optimize medications, and modify the home environment.[180] Some address a single intervention, whereas others assess combinations. It is thought that individualized interventions, either a single intervention or a combination of 2 or more, are more effective than strategies that target only 1 factor.[180,181]

The reduction in fall risk may be associated with the number of risk factors improved or eliminated.[181] Another study found that a combination of education, home safety assessment, and exercise interventions reduced the rate of falls, although systematic review of the other trials did not find a reduction in the risk of falls.[180]

A multidisciplinary screening/intervention program (performed by a multidisciplinary team) should include the following[182]:

- Medical history, physical examination, and cognitive and functional assessment
- Falls risk assessment based on
  - History of falls
  - Medication review
  - Gait, balance, and mobility assessment
  - Visual acuity assessment

Neurologic examination, including cognitive testing
Cardiovascular status assessment, including postural blood pressure
Feet and footwear assessment
Environmental assessment

History of Falls. A history of falls is an important risk factor for future falls.[183] Clinicians need to ask patients about falls at each encounter. Falls will frequently go without clinical attention for a variety of reasons: the patient may not mention it without specific questioning, or there was no injury, and if there was an injury, there may not have been an investigation as to why the patient fell. Fear of falling is often a result of a fall and can lead a person to limit activities and exercise for the sake of "safety." Falls to the side are of particular concern because they are much more likely to lead to hip fracture than falls in other directions.[184]

Medication use is one of the risk factors that can be modified. In addition to specific types of medications, the total number of medications and recent dose changes are associated with an increased fall risk. Specific classes of medications, such as central nervous system active agents (eg, neuroleptics, benzodiazepines, and antidepressants), are the most common drugs associated with falls.[185] Vasodilators have also been associated with an increased risk of falling.[186]

Exercise and Balance. Exercise should be included as a part of any falls prevention program and may be considered a solitary intervention in some cases.[187] A program that targets strength, gait, and balance, such as tai chi or physical therapy, is recommended to reduce falls. In 2008, the Centers for Disease Control and Prevention developed "Preventing Falls: What Works"[187] and highlighted a group in Atlanta, Georgia, that studied a successful 15-week program of tai chi classes using simplified movements with a balance training program. In Australia, there is a "Stay Safe, Stay Active" program that also includes tai chi as part of its balance and coordination training along with strengthening exercises and aerobic exercises such as fast-paced walking with frequent changes in direction.[187]

Vision Impairment. Vision changes are a part of the normal aging process and should be considered as playing a role in the risk of falling. Changes in acuity, the development of cataracts, macular degeneration, and glaucoma are among the common vision problems associated with aging.[188] For patients with cataracts, expedited surgery for the first eye reduced the rate of falls; however, surgery for the second eye was not associated with the same decrease.[188] Vision correction with bifocal and trifocal lenses increases the risks of falls and fractures.[182,188]

Cardiovascular Problems Associated With Falls. Postural hypotension is associated with an increased incidence of falls and most commonly occurs from autonomic nerve function impairment, a result of dehydration or medications.[189] Medication reduction and/or modification have been shown to have a benefit for fall prevention.[189] Other cardiac disorders associated with falls include carotid sinus hypersensitivity, vasovagal syndrome, bradyarrhythmias, and tachyarrhythmias.[190] Experts have recommended that dual-chamber cardiac pacing should be considered for all those with cardioinhibitory carotid sinus hypersensitivity who experience unexplained, recurrent falls because one randomized controlled study showed a significant reduction in fall rates with this intervention in this select group.[190] This condition can be diagnosed by carotid sinus massage for 5 seconds with the patient supine and monitored for blood pressure and electrocardiogram. Asystole and/or systolic blood pressure reduction of 50 mm Hg during massage is diagnostic of this condition.

Feet and Footwear. Foot problems and inappropriate footwear in the elderly are associated with impaired balance and performance. Moderate or severe bunions, toe and nail deformities, and foot ulcers have been shown to predispose the elderly to falls.[191] Also implicated in higher risks of falls are inappropriate footwear or footwear in poor condition[192] and shoes that fit poorly, have high heels, or are not laced up properly.[192] Recommendations for use of appropriate shoes are indicated.

Environmental Assessment. Environmental hazards are any objects (throw rugs, furniture) or circumstances in the home environment that increase an individual's risk of falling, such as poor lighting, general clutter, and lack of handrails in bathrooms. A home environmental screening by a health care professional (visiting nurse, occupational or physical therapist) with follow-up regarding needed modifications is an effective intervention for people with a history of falls or other fall risk factors.[193] Attention to safety hazards in the home environment appears to be worthwhile, although a randomized study did not show a reduction in falls.[194]

Specific Patient Groups at Increased Risk for Falls. Patients with dementia of any type are at markedly increased risk of falls.[177] Such patients have gait abnormalities (eg, reduced gait velocity, variation in stride length, and increased width of their sway path) that worsen when the patient is multitasking, such as carrying an object and/or speaking. Patients with such gait abnormalities have a much increased risk for falls.[195] Patients with dementia associated with Parkinson disease are also noted to be very likely to fall,[196] whereas patients with Lewy body dementia and Alzheimer dementia are at increased likelihood of falls, but less so than patients with dementia associated with Parkinson disease.[196] The severity of dementia does not seem to influence the rate of falls.[196]

Summary. Many factors contribute to the propensity to fall. Falls cause most fragility fractures, and it is thus important to try to reduce the likelihood of falling as a part of secondary fracture prevention. Some of the risk factors for falls can be modified by a multidisciplinary approach to the patient with medication changes, exercise programs, environmental modification, shoe wear changes, and vision correction.

- **"All patients with a fragility fracture following a fall should be offered a referral for multidisciplinary assessment and intervention to prevent future falls."[6]**

The Role of Medical Specialists (D. Mendelson and S. Friedman)

At least 3 groups of medical specialists are important in the care of the patient with a fragility fracture: (1) primary care physicians, (2) hospitalist physicians, and (3) internal medicine subspecialists.

Primary Care Physicians. Primary care physicians are the coordinators and facilitators of the highest quality care. Their role is critical in primary and secondary prevention. It is also important to engage primary care physicians, who sometimes also hospitalize their own patients, during the immediate hospital care of the patient with a fragility fracture.

Primary prevention. The opportunity to improve bone health exists across the continuum of primary care, beginning with ensuring that all infants, children, adolescents, young adults, adults, and elderly receive the appropriate intake of calcium and vitamin D along with weight-bearing exercise and general fitness (see the section on osteoporosis for specific recommendations on osteoporosis evaluation and management).

Acute care. Primary care physicians are usually the best source of important history data that may have bearing on the patient's acute fracture care, including the patient's medical history, response to previous surgeries and hospitalizations, psychosocial and family issues, medication sensitivities, and advance directives and preferences. In the United States, it is now common that primary care doctors do not care for their patients in the hospital; therefore, the hospital providers must actively engage, via a telephone call or e-mail message, the primary care providers to render the most appropriate hospital care for a patient with a fragility fracture. For the highest quality care, it is critical that the primary care providers be notified of discharge and routinely receive the patient's discharge summary.[197]

Posthospital care and secondary prevention. Medical providers who typically are not the patient's primary care provider render most postfracture care in subacute rehabilitation facilities. Just as in the hospital, the primary care team is an important source of information for coordinating the most appropriate care and therefore should be engaged. Similarly, as the primary care providers will assume care after discharge from rehabilitation services, it is important that they receive an accurate and timely discharge summary.[197]

Primary care physicians are in the best position to provide osteoporosis management, monitor treatment and compliance, and assess the need for additional interventions. Primary care providers can identify complications and risks early and intervene or refer as appropriate. After a fragility fracture, the primary care provider should take responsibility to coordinate care with the orthopaedic providers.

Transitions in care. The Institute of Medicine[198] and many professional medical societies have noted that transitions in care are times when fragmentation of care occurs and errors in care are common. These interfaces between care environments create the risk of loss of information and missed steps in care. Medication reconciliation and communication with the primary care providers at each transition are one way of minimizing these risks. Documentation should be available that includes the type of procedure that was performed, care providers in the hospital and their contact information, complications encountered, weight-bearing status, expected course, a description of any unresolved issue, and specific plans for follow-up treatment and visits.

Hospitalist Physicians and Medical Complexity/Comorbidity. The hospitalist physicians are medical specialists for the acute hospital care of adults. Because they are hospital based, they are familiar with acute care policies, procedures, techniques, and routines and are often able to coordinate and manage hospital care better than primary care providers; they are often able to see the patient or their families more than once per day when needed and are more readily available in an emergency. To ensure that these advantages outweigh a fragmentation of care and the disadvantages of not knowing the patient as well as the primary care team, hospitalists must have excellent communication skills and routinely engage the primary care team.[199]

Fragility fractures occur more commonly in elderly frail patients who have substantial comorbidities. This level of medical complexity is usually beyond what orthopaedic surgeons comfortably manage. Most patients with a fragility fracture, therefore, will benefit from routine comanagement by medical physicians who specialize in the hospital care of frail elders. Comanagement with geriatricians or hospitalists has been shown to be associated with excellent outcomes.[13,14]

Internal Medicine Subspecialists. Appropriate medical subspecialty consultation can be critical in safely caring for complex patients with multiple comorbid conditions and fragility fractures. Coordination of consults by the general medical physician will ensure proper use of these services. Fragility fracture care often requires surgery, and delays in surgery result in less desirable outcomes.[15] Consultations that result in additional evaluations not necessary for a decision regarding surgery are not recommended. Comanagement with geriatrics hospitalists, wherever available, minimizes the use of subspecialty consultants. This model is associated with excellent outcomes in morbidity, mortality, and cost.

- **The primary care physician should be included in the process of care for a patient with fragility fracture, including coordination of secondary prevention measures.**

Data Collection, Quality Assurance, and Research (D. Mendelson and S. Friedman)

In all institutions, gathering and analyzing accurate data are essential steps in maintaining and improving the quality of the care of patients with fragility fractures. Analysis of clinical data is necessary to develop and promote an ideal fragility fracture program in an institution.

The Role of Data in the Development of a Fragility Fracture Program. Performance and outcome data are often critical in gaining and subsequently maintaining administrative support for special orthopaedic care programs. Before starting a program, there should be an assessment of baseline mortality, time to surgery, length of stay, complication rate, and readmission rate. This information should be compared with national benchmarks and/or other regional medical centers providing care to such patients. Only in this way can an institution gauge its starting point and develop realistic goals. Assessment of the yearly volume of admissions, types of procedures, costs, and reimbursement allows for financial planning and sets the stage for developing a realistic business plan. Documentation of changes over time provides evidence of program efficacy and sustainability. Data are also important for compliance and billing purposes.

The Role of Data in Quality Assurance. Quality of care can be improved by evaluation of individual cases, individual incidents, and trends. Regular morbidity and mortality review is important to identify clinical issues and to reinforce best practices. Program managers can use an individual provider's clinical outcome data to respond to incidents or to help educate and guide a provider whose performance falls below expectation; data can also be used to recognize and acknowledge individuals whose performance exceeds expectation.

Reviewing data allows program and institutional leaders to identify areas of strength and weakness and to look for opportunities for improvement. Data collected on process measures (such as time spent in the emergency room, pain assessment and management, time to start of physical therapy, intensity of comanagement, and time to indwelling urinary catheter removal) can be tracked relatively easily and compared with benchmarks. These data can in turn form the foundation for process improvement.

The Role of Data in Research. Clinical data may also be gathered to gain new, generalizable knowledge or, in other words, for research. Data gathered for purposes of answering a research question will need to be carefully collected and should be of the highest quality. Obtaining research data requires expertise in data collection and database management, which are often best done by a dedicated data manager or research associate. An operational definition for each data point is central to maintaining reliability of data. Because database integrity is of the utmost importance, integrity and validity checks need to be performed routinely.

National Databases. Several countries have developed national databases concerning fragility fractures, but such an entity is not available in the United States at this time. One robust source of information is the United Kingdom's Web-based National Hip Fracture Database (http://www.nhfd.co.uk/). This is a collaborative project led by the British Orthopaedic Association and the British Geriatrics Society. The core data set includes elements of case mix, process, and outcomes. The availability of this large, national database will enable important clinical questions, such as surgical timing, anesthetic choices, implant issues, and postfracture osteoporosis care, to be answered in the future. In the United States, registries have been successfully constructed on a more limited basis. For example, the Kaiser Permanente Healthy Bones Program has permitted high-quality fracture follow-up care of osteoporosis by use of a computer registry. The availability of this registry has permitted clinicians to improve patient safety, quality of care, and cost-effectiveness.[77] Research using this registry has focused on early secondary prevention and has reduced the incidence of subsequent fractures in the Kaiser health system.[200] The establishment of a national hip fracture database in the United States would be desirable for the above-stated reasons.

- **Outcomes data should be used to drive decision making for fragility fracture care at the hospital and national levels.**

Summary

This monograph is written as a guide for physicians, nurses, therapists, and students interested in ideal care for their patients with fragility fractures. The scope of fragility fractures in the United States is large and will grow over the next 20 years as the population ages. There is much that can be done currently to idealize the outcomes of these patients. Additional research in many areas is needed to further improve the quality of care for these patients. We plan to update this monograph as new information concerning the care of seniors with fragility fractures develops.

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