Geriatric Orthopedics

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By the year 2020 about 20% of the population, or an estimated 60 million people, will be aged 65 years or over. Increasing age leads to increasing vulnerability in the musculo-skeletal system through injury and disease. Approximately 80% of those older persons will have musculoskeletal complaints.

Significant osteoarthritis of the hip or knee will be reported by 40% to 60% of older persons. Disabling osteoarthritis of the weight-bearing joints commonly leads to joint replacement surgery, which was performed an average of 648,000 times annually from 1993 to 1995. [1] In 1996, 74% of the total knee replacements and 68% of the total hip replacements were performed on patients aged 65 and older. [1] As the number of elders in the population increases, so will the need for joint replacement surgery. Joint arthroplasty is expected to increase by at least 80% by 2030. [1]

Age-related changes in bone and soft tissue are commonly associated with disabling fractures. In the first 5 years following menopause, women lose up to 25% of their bone mass. In the United States, osteoporosis affects approximately 20 million persons, and every year 1.3 million fractures are attributed to this condition. Muscle strength decreases on average by about one third after age 60, which can lead to difficulty maintaining balance and predispose a person to falls. By the age of 90, one third of women and one sixth of men will experience a hip fracture. About two thirds of those who fracture a hip do not return to their prefracture level of functioning. The cost of treating all osteoporotic fractures was estimated to be $13.8 billion in 1995 and is expected to double in the next 50 years. Most of this cost can be attributed to the treatment and postoperative care of hip fractures. [1]

Thus, it is vital at this time to evaluate the agenda for research on orthopedic management of geriatric patients. We approached this task by surveying the orthopedic literature to assess the status of knowledge and the quality of research on which present practice is based. By detecting areas where research has been lacking or of poor quality, or where results have been inconsistent or controversial, we have identified research studies that are urgently needed.

Methods

The searches were conducted on the National Library of Medicine's PubMed database in March 2001. Eleven topics were searched: demographics, arthritis, and fractures; impact of musculoskeletal conditions on overall function; joint replacement; rotator cuff and surgery; spinal stenosis and surgery; fracture care, in general; hip fracture care; wrist fracture care; spine fracture care; proximal humerus fracture care; and amputation surgery.

For epidemiology, the search strategy was to combine terms for aged, arthritis epidemiology, and fractures epidemiology with terms for demography, male or female, social class, and ethnic groups. This search yielded 1129 references.

For overall function, the search strategy combined terms for aged, musculoskeletal diseases, or fractures with terms for function, recovery of function, and activities of daily living (ADLs). This search uncovered 1656 references.

On joint replacement, the search combined terms for aged and arthroplasty, replacement, and statistics and numeric data with terms for utilization, cohort studies, physicians' practice patterns, incidence, indicators, postoperative complications, treatment outcome, risk factors, follow-up studies, recovery, predict, prognosis, functional status, indication, complications, etiology, forecast, or length of stay. This search yielded 1272 references.

The search strategy for rotator cuff surgery was identical except *rotator cuff surgery* was substituted for *arthroplasty, replacement*. This search generated 110 references.

When *spinal stenosis surgery* was substituted, the search yielded 235 references.

For fracture care, the search strategy was to add terms for aged, fractures, osteoporosis, and risk factors and then merge them with terms for treatment and fracture fixation or complications, bone transplantation, bone substitutes, or casts. This search produced 1592 references.

For the care of hip fractures, the search strategy was long and complex. It is available from the author. The number of items retrieved was 2449.

The search strategy for wrist fractures was simpler: it used terms for aged and fractures and wrist injuries and excluded several terms that had been used in the general fracture care search (see above). This search found 153 references.

The search strategy for spine fractures used terms for aged and fractures and spinal fractures, and it excluded a host of terms used in the searches above. It retrieved 764 titles.

The search strategy for proximal humerus fractures was exactly the same, except for substituting *shoulder* for *spinal*. It led to 140 references.

Finally, the search strategy for amputations included terms for aged, amputation, and energy metabolism, combined with terms for wound healing, prostheses, implants, rehabilitation, or utilization. This search yielded 272 references.

Normal Musculoskeletal Aging and the Aging Athlete

A comprehensive review of the literature did not find any studies identifying normal ranges of motion of the extremities in older persons. No articles were found addressing the treatment of the otherwise healthy elderly patient who sustains a sports-related musculo-skeletal injury. It is not currently known whether treatments recommended for younger patients with musculoskeletal injuries are applicable in part or at all to the older patient with a similar problem.

To prepare for the care of an increasingly active and vigorous older population, research is needed to define normative and incidence data.

> ***Ortho 1 (Level B)***: **Observational studies are needed to define the normal range of motion of the extremities in older people without musculoskeletal disease. Such studies should also examine the range of motion necessary for activities of daily living and instrumental activities of daily living.**
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> ***Ortho 2 (Level D)***: **Observational studies of older athletes are needed to define the incidence and nature of sports-related injuries in older athletes and to examine the utility of arthroscopy in the treatment of knee and shoulder injuries.**

Factors That Influence Postoperative Outcome

Age alone does not appear to be a prognostic factor for outcome following orthopedic surgical procedures. Pre-existing medical condition, however, plays a significant role in postoperative outcome; medical comorbidities influence physiologic reserve, postoperative complications, and capacity for rehabilitation. Many patients require treatment of a medical condition prior to elective joint replacement surgery. [2]

Following hip fracture, host factors, not injury severity, are the primary determinants of long-term survival. [3] One-year mortality following hip fracture can be predicted on admission by the number of medical conditions: with no other medical conditions, mortality is 0%; with one or two, mortality is 14%; with three or more, the mortality is 24%. [4]

Malnutrition is common in older patients. The incidence of malnutrition among orthopedic patients is thought to be 20%. Many studies have shown that weight loss in older persons is a major predictor of mortality. In addition, poor nutrition can lead to weakness, fatigue, and decreased muscle mass, muscle strength, and bone mineral density. Poor nutrition is, therefore, a risk factor for poor outcome following surgery because of wound-healing complications, delayed recovery, and increased infection rate. Low preoperative serum albumin has been correlated with decreased postfracture quality of life [5] and increased postfracture mortality rate. [6]

On the other hand, good nutrition is associated with decreased fracture risk. In a cohort study of women aged 55 to 69 who were assessed with a food frequency questionnaire and followed up 2 to 3 years later, a reduced risk of hip fracture was shown in those with increased dietary protein consumption. [7] (See also Chapter 13, section on preoperative nutrition.)

The outcome of elderly patients who have undergone surgery for hip fracture [8-11] and joint arthroplasty [12] improves with dietary supplementation. Older patients with a hip fracture demonstrate an increase in serum insulin-like growth factor 1 (IGF-1) in response to increased dietary protein. [10,13] IGF-1, which normally decreases in the aging process, may be responsible for the improvement seen in bone quality and outcome following fracture. It may be difficult, however, to improve nutrition in those hospitalized with a hip fracture. Many hospitalized elderly patients receive inadequate calories during their hospital stay. [14] Even if adequate calories are provided in the postoperative period, the nutritional status of malnourished patients does not improve. [15]

Pre- and perioperative medical conditions and nutrition clearly influence long-term outcome; interventions to influence those outcomes are critical and should be examined.

> ***Ortho 3 (Level B)*: Observational and case-control studies are needed to determine the elements of preoperative evaluation and treatment that are associated with reduction in mortality in older orthopedic surgery patients.**
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> ***Ortho 4 (Level B)*: Case-control studies are needed to compare the incidence of malnutrition among older hip fracture patients to that in the general population of older adults. Databases examining risk factors for hip fracture should be expanded (when possible) to include detailed nutritional measures.**
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> ***Ortho 5 (Level B, A)*: Observational studies using multivariate regression analysis are needed to identify which nutritional deficiencies (eg, calcium, protein) appear to be predictive of bad outcomes following hip surgery in older patients. Randomized controlled trials based on these findings are then needed to determine the type and duration of nutritional supplementation that would most effectively improve surgical outcome and fracture healing.**

Degenerative Joint Disease

Osteoarthritis (OA, degenerative joint disease) is the most common articular disease among those aged 65 and older. It commonly leads to decreased function and loss of independence. Although the joints of the hand are the most commonly affected, they are less likely than the knee or hip to be symptomatic.

Clinically, OA is diagnosed by pain that worsens with activity and lessens with rest. Joints may feel as though they are locking or giving way. Older adults with OA demonstrate decreased flexibility [16] and decreased quadriceps strength. [17] Impairment in mobility often leads to difficulty with ADLs. Painful ambulation and disturbances in gait, as are commonly seen in arthritic joints, may predispose an older person to falling. [18] A self-reported history of arthritis and painful or limited motion is predictive of recurrent nonsyncopal falls by older adults. [19] There are many other factors that contribute to falling, including lower-extremity muscle weakness; deficits in balance; impaired visual, proprioceptive, and cognitive function; sedative medications; and comorbid medical conditions. The contribution of a single factor such as hip or knee OA to falling is difficult to estimate and should be a topic of further research. [20]

Pharmacologic management of OA usually begins with acetaminophen, the recommended analgesic for symptomatic OA in adults. In cases where acetaminophen at full dosage (3000 to 4000 mg per day) does not control symptoms, nonsteroidal anti-inflam-matory drugs (NSAIDs) may be used. These medications exert their anti-inflammatory and analgesic effects by inhibition of prostaglandin synthesis via inactivation of the COX enzymes. Reduction of prostaglandin synthesis can have a negative impact on the kidneys and stomach, leading to renal impairment and gastric ulceration. These agents are also associated with sodium retention that can lead to hypertension or edema. Elderly patients taking NSAIDs are particularly vulnerable to these side effects; 20% to 30% of all hospitalizations and deaths due to peptic ulcer disease in this age group are attributable to NSAID therapy. [21]

Selective COX-2 inhibitors, celecoxib and rofecoxib, have been studied in patients with OA. Celecoxib has been found to be more effective than placebo and comparable in efficacy with naproxen in patients with hip or knee OA, and rofecoxib has been shown to be comparable to ibuprofen and diclofenac in patients with hip or knee OA. [21] Endoscopic studies have demonstrated a lower incidence of gastroduodenal ulcers than with conventional NSAID therapy and comparable to that of placebo. [21]

Local treatments include topical capsaicin and methylsalicylate creams as adjunctive agents. Intra-articular injections of cortisone may be effective when there are effusions or local inflammatory signs. [22]

Intra-articular injections of hyaluronate and hylan are now often being used for the treatment of symptomatic knee osteoarthrosis. A randomized controlled clinical trial of three (hylan) or five (hyaluronate) weekly intra-articular injections showed that they provided sustained pain relief and improved function, at least as effectively as continuous treatment with NSAIDs, with fewer side effects. [23,24] It is not currently known how this substance exerts its therapeutic effect.

Exercise benefits elderly persons, improving symptoms in those with arthritis and preventing hip fracture by increasing bone density [25] and muscle strength [26] and thereby decreasing falling. [27] Other studies have shown that resistance training in older adults increases muscle mass [28] and improves neural coordination and strength. [29]

OA is a common and morbid problem in later life, and painful arthritis of the hip or knee is a risk factor for falls. Further research is needed to define the importance of OA of the knee or hip as an independent risk factor for falls and to examine the risks and benefits of surgical and nonsurgical therapies on risk reduction.

Surgical Treatment of Degenerative Joint Disease

Older patients may be more vulnerable to joint disease because of age-related changes in the musculoskeletal system. The surgical management of joint disease consists largely of joint replacement. Joint replacement surgery can significantly improve patients' health and well-being. An outcome study found that following hip or knee replacement, those patients who were 75 years of age and older had improved their preoperative scores on the Medical Outcomes Study 36-item Short Form Health Survey (SF-36), becoming similar to population norms for this age group. [30] A review of 99 consecutive elective hip and knee arthroplasties in patients aged 80 years and older found significantly improved postoperative knee and hip scores with no increased complication rate when they were compared with a younger, otherwise matched control group. [31] Postoperative outcome has been demonstrated to be predominantly dependent on preoperative function, [32] and not age. Surgical management of joint disease can improve physical function, which could positively influence comorbidities, improve strength and balance, and reduce the rate of injurious falls.

DEGENERATIVE DISEASE OF THE HIP

Surgical treatment of osteoarthritis of the hip in the older patient is limited to total joint arthroplasty. Advanced age alone does not appear to be a contraindication to joint reconstruction. Poor outcomes appear to be related to comorbidities rather than age. The best outcomes for total hip arthroplasty have, however, been shown in those younger than 75. [33] Total hip replacement in patients aged 80 and older results in more complications than in younger patients, including increased rates of dislocation and femoral fractures. [34] However, total hip replacement improves pain and physical activity [35] and increases independence and function. [36]

Fixation of the components in total hip arthroplasty is a topic of considerable debate. A cementless acetabular component is most commonly used. Concern about the increased cost of porous coated implants and the ability for bony ingrowth in the older patient have generally led to the use of a cemented femoral stem in the older patient. However, Konstantoulakis et al reviewed hip arthroplasties in patients aged 65 and older and found that uncemented hip arthroplasties in this age group showed no signs of subsidence or osteolysis after 4 years of follow-up. [37] An autopsy study by Lester et al of cementless femoral components, with an average time in situ of 22 months, in patients with an average age of 87 years found that the implants were well fixed and stable. [38] It would seem from the literature that age has no bearing on the success of different fixation methods, cement versus bony ingrowth. Cost, however, may be a significant issue.

Wear debris may lead to implant loosening. The atrophy of bone and muscle may also be a contributing factor in implant loosening. However, pelvic osteolysis, which can result from polyethylene wear debris, was not found in patients older than 70 years followed for a minimum of 5 years. [39] The influence of age on cellular response to wear debris has not been studied. Aging affects cell number and most likely affects cellular response. This is potentially an interesting area of study.

When implants become loose, they often become painful, necessitating revision surgery. Revision hip surgery in patients over age 75 has been found to improve function and relieve pain, although the complication rate (death 13.3% and dislocation 20%) was higher than in patients younger than 75. [40]

The incidence of dislocation of total hip components is 1% to 2%. The most common causes of recurrent dislocation, reported in a study conducted by Joshi et al, are component malposition (58%) and failure of the abductor mechanism (42%). [41] Ekelund et al found a higher dislocation rate for total hip replacements performed for complications from proximal femoral fractures. [42] Treatment may consist of revision surgery or repair of the abductor mechanism, if possible. Revision of a total hip replacement to bipolar arthroplasty (large head with no acetabular component) has been shown to be helpful as a salvage treatment for instability of the hip. [43]

Hip disease is a problem that limits the quality of life and functional independence of older persons. Advances will depend on studies to address areas of uncertainty in treatment, such as optimal techniques for fixation, outcomes after hip revision, the effect of age on wear debris, and prevention of periprosthetic fracture.

DEGENERATIVE DISEASE OF THE KNEE

Surgical options for the arthritic knee include arthroscopy and arthroplasty. Arthroscopic debridement of the arthritic knee has been shown to improve function, decrease pain, and decrease need for total joint replacement. [44] However, patients with angular malalignment of the knee do poorly following arthroscopic debridement, [45,46] and this is a more significant factor than age in outcome. [46] Results of a recent randomized controlled clinical trial have shown no difference in outcome between placebo and arthroscopic debridement and arthroscopic lavage of osteoarthritic knees. [47]

End-stage osteoarthritis of the knee is generally treated with total knee arthroplasty that reliably provides significant and persistent relief of pain and improved physical function. Age does not appear to have a negative impact on patient outcomes. [48] Patients over the age of 80 followed for 12 months after total knee replacement demonstrated improved pain, emotional reaction, sleep, and physical mobility. [49] Those older than 85 had significant improvement in pain and function after total knee replacement, although most still required the use of a cane for walking outdoors. [50,51] Successful knee replacement surgery has been demonstrated in patients 90 and older. Although no surgical complications occurred in this age group, there were several nonsurgical complications, including confusion, urinary retention, atrial fibrillation, atrial flutter, gallstone retention, and gastroin-testinal bleeding. [52]

All total knee components are generally cemented, especially in elderly patients. Cemented, all-polyethylene tibial components have been recommended for patients older than 75 because the component is less expensive, [53] and studies have shown a high rate of survivorship without the need for revision surgery and without symptomatic loosening. [54] In recent years, patellar resurfacing has been controversial. Studies have shown, however, that patellar resurfacing results in better stair-climbing ability and improved overall function. [55]

Interestingly, after total knee arthroplasty, bone mineral density of the proximal femur improves. [56] This increase in bone density may be related to an increase in loading of the proximal femur as a result of improved mobility. This improvement in bone density could prevent or lessen the likelihood of an injurious fall.

Arthroscopy of osteoarthritic knees has been shown to be unsuccessful in the management of symptoms. The role of knee arthroscopy in the older patient with knee pain is unclear. Although the potential benefits of knee replacement are clear, there remain several unanswered issues: patient selection for various procedures, issues of optimal hardware, and the outcomes related to gait and balance.

DEGENERATIVE DISEASE OF THE SHOULDER

Degenerative disease of the shoulder is fairly common. Out of 100 randomly chosen people aged 65 and older, 34% were found to have significant shoulder pain and 30% had disability related to decreased shoulder movement. [57] Rotator cuff disease is the major cause of shoulder disability. The degenerative change in the rotator cuff that occurs as a result of overuse can lead to a tear with minimal trauma. Large tears in the rotator cuff are more common in the older population. [58] Tears of the rotator cuff may result in the loss of the primary stabilizers of the glenohumeral joint, leading to articular wear and arthritis.

Treatment of rotator cuff disease generally begins with rotator cuff strengthening exercises and anti-inflammatory medication. In a review of 124 patients with rotator cuff tears treated conservatively, those with well-preserved motion and strength did well with nonoperative treatment, in contrast to those with limited motion and strength on first evaluation. [59] Patients who experience significant sleep loss due to shoulder pain are unlikely to be satisfied with nonoperative treatment. [60]

Rotator cuff repair is usually associated with an acromioplasty and occasionally a distal clavicle resection. Surgery is often performed in an open manner through a standard approach, with the deltoid removed from the acromion and distal clavicle. In general, the larger the rotator cuff tear, the poorer the results. [58,61] A follow-up study nearly 7 years after open rotator cuff repair in 72 patients found that age was not a factor in functional outcome. [61] Retrospective reviews of 92 patients aged 62 and older [62] and 69 patients aged 70 and older [63] found, with standardized scoring, improved function, decreased pain, and satisfactory results more than 2 years following open rotator cuff repair.

Rehabilitation after rotator cuff surgery is important. The greatest improvement in strength occurs in the first 6 months after surgery, but strength continues to improve 12 months after surgery [64] and can ultimately equal that of the nonoperative shoulder. [65]

Symptomatic, failed repairs of massive rotator cuff tears can be managed with muscle transfer as a salvage procedure. The latissimus dorsi [66] or central quadriceps tendon can be used as a free tendon graft. Harvest of the central quadriceps tendon in elderly patients was found to be associated with significant reduction in knee reliability and function. [67]

Significant degenerative change of the glenohumeral joint is initially treated with anti-inflammatory medication and function-maintaining exercise. Surgical management may consist of total shoulder arthroplasty, hemiarthroplasty, or bipolar hemiarthroplasty.

Shoulder arthroplasty is commonly performed for end-stage glenohumeral arthritis. Total shoulder arthroplasty involves resurfacing of the glenoid in addition to replacement of the humeral head. The indications for resurfacing the glenoid have not been clearly defined, but generally resurfacing is reserved for cases with an intact rotator cuff. Total shoulder arthroplasty demonstrated significantly greater pain relief and improved internal rotation than that achieved with hemiarthroplasty. [68] Hemiarthroplasty is often utilized to eliminate the problem of glenoid loosening, which can occur in total shoulder arthroplasty as a result of proximal humeral migration due to a torn rotator cuff. Improvement in function and comfort has been demonstrated following hemiarthroplasty performed in patients with massive rotator cuff tearing. [69,70] Bipolar hemiarthroplasty is also used to treat glenohumeral arthritis associated with rotator cuff tearing. It has been theorized that the oversized humeral head would increase the stability of the joint, increase the abductor lever arm, and power and prevent impingement of the tuberosities. Concerns have been raised regarding the potential for overstuffing the glenohumeral joint and the generation of polyethylene wear debris. A review of the literature did not find any reports comparing bipolar hemiarthroplasty with standard hemiarthroplasty in the rotator cuff-deficient shoulder.

Although shoulder disease is common and disabling, much remains to be learned on its optimal surgical management. Changes in the aging shoulder and in potential tissue donor sites will likely influence possible surgical approaches. The goals for improved function from total knee arthroplasty are readily identified, but range and function goals for the shoulder may be more subtle.

COMPLICATIONS OF JOINT REPLACEMENT SURGERY

Thromboembolism

Venous thromboembolism occurs in 40% to 70% of patients who undergo hip or knee replacement without postoperative thromboprophylaxis. Patients who have total knee arthroplasty are 3.2 times more likely than patients who have total hip arthroplasty to develop deep-vein thrombosis (DVT). [71] Patients aged 65 and older who have had total hip arthroplasty and who have an increased body mass index have an increased risk of rehospitalization for thromboembolic events. [72]

With thromboprophylaxis, the incidence of DVT is 15% in those having hip replacement and 30% in those with knee replacements. [73] The risk for thromboembolism continues for at least 1 month postoperatively, [74] with the rate of proximal DVT 2.4% at 1 week after surgery and increasing to 8.2% at 1 month after surgery. [75] The risk of fatal pulmonary embolism after total knee arthroplasty without thromboprophylaxis is 0.4%. [76]

Those with hip fractures demonstrate a high rate of DVT, and, if surgery is delayed more than 48 hours, 62% of patients have venographic evidence of DVT. [77] Autopsies performed on patients with surgically treated hip fractures demonstrate that the incidence of fatal pulmonary embolism is between 0.37% and 3.3%. [78]

A variety of medications and mechanisms have been proposed to decrease the rate of thromboembolism. The safest and most efficacious method of prophylaxis remains controversial. Mechanical modalities include external pneumatic compression sleeves and foot pumps. These work by decreasing stasis in the gastroc-soleus complex, by improving venous return, and also by increasing fibrinolysis. They are placed on the patient prior to and worn throughout surgery. It is recommended that the sleeves be discontinued when the patient is more ambulatory. Pneumatic compression has been shown to be effective after total hip arthroplasty only in patients with body mass index (weight in kg / height in meters ^{2}) of less than 25. [72] The arteriovenous impulse system has been shown to be effective in reducing thromboembolic events after hemiarthroplasty of the hip [79] and comparable to enoxaparin in preventing DVT following total hip replacement. [80]

Aspirin has long been used for thromboprophylaxis. In the Pulmonary Embolism Prevention (PEP) trial, [81] 17,444 randomized patients undergoing surgery for hip fracture or elective arthroplasty received 160 mg of aspirin daily for 35 days after surgery. The study concluded that this regimen reduced pulmonary embolism 43% and symptomatic DVT 29%. In this study, thromboembolic events were not recorded if they were not symptomatic. With this protocol there was no significant increase in bleeding complications. Aspirin has been shown to effective for thromboprophylaxis in doses of 160 mg [81] and 375 mg. [79]

Warfarin has been shown to be protective against DVT after total hip and knee arthroplasty. The goal is to keep the INR between 2 and 3. Warfarin used in combination with pneumatic compression results in a prevalence of DVT of 5% and a prevalence of bleeding complications of 0.9%. [82] A meta-analysis of thromboembolic prophylaxis following elective total hip arthroplasty [83] found that warfarin and pneumatic compression were the best prophylactic agents in terms of safety and efficacy. Sensitivity to anticoagulant effects is enhanced by age 80 years or greater, hip fracture fixation, and weight greater than 180 pounds. [84]

Enoxaparin, a low-molecular-weight heparin (LMWH), is commonly used for throm-boprophylaxis. In elderly patients with hip fracture, a 40 mg once daily dose of enoxaparin was found to be effective in prevention of DVT without major bleeding complications. [85] The rate of thromboembolic event during and after prophylaxis with enoxaparin has been reported to be 2% and the rate of major hemorrhage 2.9%. [73] Bleeding complications are reported by 23.7% of individuals over the age of 65 receiving enoxaparin but by only 16.5% of control persons; [86] the result is a lower hemoglobin level and a higher transfusion rate in the enoxaparin group. The complication rate was lower if the first dose of enoxaparin was given more than 10 hours postoperatively. A meta-analysis revealed that LMWH may be more protective against thromboembolism following total joint arthroplasty but that there was a slightly greater risk of clinically important bleeding. [87] A study of 263 patients who had undergone total knee arthroplasty found an 11.3% incidence of bleeding complications in those patients using enoxaparin but only a 4.6% incidence in patients using warfarin, with no significant difference in the rate of DVT between the groups. [88] The bleeding complications reported with the LMWHs may be attributed to the fact that these medications are cleared by renal excretion. Patients with decreased renal function may develop accumulation of the drug and hemorrhagic problems. [89]

There are several effective therapies for the prevention of thromboembolism in older patients who have undergone hip and knee procedures. Most of these are associated with some risk of bleeding and some residual risk of thromboembolism. The optimal regimen for older patients and for specific procedures remains to be determined. For further discussion of thromboembolism and surgery, see Chapter 13.

Periprosthetic Fracture

Periprosthetic femur fractures have been estimated to occur in 2.5% of patients following total hip arthroplasty. [90] The cause is usually loosening of the implant due to osteoporosis [91] or osteolysis secondary to wear debris. [92] The incidence of these fractures is likely to increase the longer the implant is in place. Treatment can consist of plate fixation if the implant is stable or stem revision with or without cerclage wiring and bone strut grafts if the initial stem is loose. [93-95]

Fracture around a total knee arthroplasty generally occurs around the femoral component. Treatment may consist of open reduction and internal fixation [96] or intramedullary rodding, [97] that is, placing the rod in the intercondylar notch, between the medial and lateral femoral condyles of the femoral component. If the fracture is comminuted, treatment is difficult. Tani et al have described intramedullary fibular grafting as a means for reconstructing large segmental defects. [98]

Risk factors for periprosthetic fractures resemble those for osteoporotic fracture (old age or poor bone quality). Development of and risk for these fractures are also likely influenced by the site (hip or knee) and possibly by the nature of fixation for the device (cemented or noncemented). Further research is needed to understand causes and to design and test preventive strategies.

Infection

Infection of a joint after total hip or knee arthroplasty may be the result of hematogenous seeding. Treatment is generally removal of the implant and placement of a block of cement that has been mixed with antibiotics to act as a cement spacer. A relatively new technique is to cement total joint components loosely in place with antibiotic-impregnated cement as an "articulating" spacer. Treatment with debridement and retention of joint components and antibiotic therapy is usually successful if the infection is caught within 2 weeks of symptoms. [99] The success of these techniques in the older patient has not been established.

> ***Ortho 6 (Level B)*: Basic studies are needed to determine the mechanism of action of hylan and hyaluronate injections in providing long-term pain relief from knee arthritis. Additional clinical studies are needed to examine the long-term effect on cartilage in older persons during repeated courses of treatment.**
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> ***Ortho 7 (Level A)*: A randomized clinical trial is needed to examine if hylan and hyaluronate injections delay or reduce the likelihood of total knee arthroplasty in elderly patients.**
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> ***Ortho 8 (Level B)*: Existing databases should be examined (or expanded) in an effort to determine the independent contribution that hip or knee osteoarthritis holds as a risk factor for falls by older people.**
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> ***Ortho 9 (Level B)*: Databases examining the effects of joint replacement surgery should**

assess baseline and postoperative rates of falling to determine the effects of replacement on falls risk in older persons.

Ortho 10 (Level B): **Further laboratory and clinical studies of COX-2 inhibitors should examine the effects of these agents in older persons on fracture healing, tissue healing (eg, after rotator cuff injury), and on bony ingrowth (into joint replacements).**

Ortho 11 (Level B): **Case-control studies should examine the surgical and functional outcome in older patients for various methods of fixation and various surgical approaches in total hip replacement. Such studies should examine the outcomes for cementless components in osteoporotic bone.**

Ortho 12 (Levels B, A): **Observational studies are needed to define the outcome of revision hip surgery in elderly patients. Careful reporting of factors associated with outcome would help define future level A studies to further define the optimal approach to this problem.**

Ortho 13 (Level D): **Basic laboratory studies are needed to define the influence of age on the cellular response to wear debris.**

Ortho 14 (Level B): **Observational studies are needed to define the type of hip procedure (cemented or uncemented) that is associated with the lower incidence of periprosthetic fractures in elderly patients. Additional observational studies are needed to generate information on the outcomes of various treatments for periprosthetic fractures in preparation for hypothesis-testing studies.**

Ortho 15 (Level B): **Observational studies are needed to define the subpopulation of older patients who might respond to arthroscopy or meniscectomy.**

Ortho 16 (Level B): **Observational studies are needed to identify older patients at risk for less than optimal outcome after total knee arthroplasty, for example, those with peripheral vascular disease or neuropathy.**

Ortho 17 (Level B): **Additional observational studies focused on patients aged 85 years and over who undergo total knee arthroplasty are needed to identify risk factors for postoperative morbidity and to begin to define interventional strategies to reduce that risk.**

Ortho 18 (Level D): **Case-control studies are needed to determine whether metal-backed or all-polyethylene tibial components should be used in arthroplasty for elderly patients and whether there are indications for each.**

Ortho 19 (Level B): **Observational studies of older patients undergoing treatment for comminuted distal femur fractures are needed to examine the possible utility of total knee arthroplasty as a reconstructive procedure in this setting.**

Ortho 20 (Level B): **Observational studies are needed to further define those benefits of total knee arthroplasty (eg, increased range of motion, increased strength, decreased pain), which serve to improve gait and balance. Ultimately, such studies may begin to determine whether or not total knee arthroplasty helps to reduce the risk of hip fracture.**

Ortho 21 (Level B): **Case-control or focused cohort studies are needed to compare functional outcomes in older people with shoulder disease who do not undergo surgery with those who undergo rotator cuff surgery, hemiarthroplasty, or total shoulder replacement. Key outcomes for comparison include improved function and decreased pain. Such studies**

should address how the desired outcomes may change with age, from those aged 65 to 75 years to those aged 90 years and over.

Ortho 22 (Level A): **Randomized controlled clinical trials are needed of the various preventive regimens (alone or in combination) to identify the safest and most effective treatment strategy for preventing thromboembolism after joint replacement surgery in older patients. Such studies should also address how long deep-vein thrombosis prophylaxis should continue in elderly patients who have had recent total joint replacements or hip fracture.**

Ortho 23 (Level B): **Further retrospective studies are needed to examine risk factors beyond age and poor bone quality for periprosthetic fractures. Case-control studies could possibly suggest protective factors, such as the nature of the implant (cemented or uncemented) and the use of antiresorptive therapies.**

Ortho 24 (Level A): **Randomized controlled trials are needed to determine with certainty whether specific prostheses or antiresorptive therapies would be effective at minimizing the risk of periprosthetic fracture.**

Ortho 25 (Level B): **Observational studies and subgroup analyses are needed to determine if features of periprosthetic infections are different in elderly patients and to examine differences in outcome for elderly patients when specific established or emerging approaches are used.**

Degenerative Spine Disease

Degenerative disease of the spine (spondylosis) includes spondylolisthesis, which is characterized by the forward displacement of one vertebral body on another, disc herniation or degeneration, facet joint degeneration, osteophytes, foraminal stenosis, and radiculopathy. Degenerative spondylosis and radiculopathy may occur in the cervical or lumbar spine. These conditions are usually managed conservatively.

Surgical intervention is reserved for those with progressive neurologic deficit or severe functional incapacitation. Surgical decompression in cervical spondylotic myelopathy is usually anterior decompression and fusion in patients with three or fewer levels or in patients with kyphosis; a posterior decompression is used for those with more extensive disease. [100] Elderly patients can benefit from decompression; [101-103] however, incomplete recovery is more likely in patients older than 70, and outcome has been found to be related more to the clinical picture and the duration of the symptoms than to age. [103]

Surgical treatment of lumbar spinal stenosis generally consists of decompressive laminectomy plus fusion with or without instrumentation. Patients aged 65 and older have outcomes that are as good as those for younger patients. [104] The complication rate may be higher for patients aged 75 and older [105] and has been reported to be 6% [106] to 10%. [107] After 4 years of follow-up, patients aged 60 years and over who had surgical treatment for spinal stenosis were found to have better outcomes than those who had nonsurgical treatment. [108] In a meta-analysis, patients suffering from degenerative spinal stenosis for up to 8 years were found to have responded best to decompression without fusion, whereas those with symptoms of 15 years or more had better results with decompression and fusion with instrumentation. [109] These studies suggest that earlier intervention is more successful, possibly because of better overall health and functional reserve and fewer medical comorbidities in younger patients. This is supported by the finding that the most powerful predictor of a good outcome was the patient's report of good or excellent health before surgery. [110] Shorter duration of symptoms may be associated with less nerve degeneration and atrophy. This is supported by the results of a study that revealed that the outcome following surgically treated lumbar spinal stenosis was better when there was a shorter preoperative duration of symptoms. [111] A 10-year follow-up study found that more than half of the patients evaluated their postsurgical results as excellent or good. [112]

Stenosis can recur within a few years following decompression, and the rate of recurrence has been reported to be from 18% to 27%. [111,113,114] This may be attributed to vertebral levels that had unrecognized stenosis and were, therefore, not decompressed or stabilized in the initial surgery. Bone regrowth has also been demonstrated following decompression. [115] Bone regrowth may be associated with postoperative spinal instability. [116]

Fusion with instrumentation is associated with a better outcome than fusion without instrumentation if there is instability after surgical decompression. [117] Instrumentation in an osteoporotic spine can, however, be difficult. Larger screws can be used in the pedicle, but these can cause the pedicle to fracture. The pedicle can fracture if the screw diameter is greater than 70% of the outer diameter of the pedicle in cases were bone mineral density is low. [118]

Patients with osteoporosis have less bone to harvest for fusion, and the bone is commonly of poor structural quality. A decreased number of osteoprogenitor cells in the autogenous bone graft often necessitates supplemental material to encourage osteoinduction and osteoconduction.

Advanced age does not appear to preclude benefit from cervical-spine decompressive surgery, although recovery of neurologic function may be less complete in older than in younger patients. Available studies suggest that a longer duration of symptoms prior to surgery reduces the eventual degree of recovery. Benefit is also seen from lumbar surgery, although at the risk of higher complication rates. Osteoporosis makes surgery more difficult and reduces the quality of bone harvested for grafts. These issues raise several significant research problems.

> ***Ortho 26 (Level B)*: Observational studies are needed to examine the impact of aging on bone fusion or fracture healing and to begin examining strategies to augment the bone healing response after fusion or fracture. Candidate strategies include growth factors.**

> ***Ortho 27 (Level B)*: Case-control or focused cohort studies are needed to refine understanding of which patients benefit (in terms of symptom control and function) most from spinal decompression versus conservative management. Important covariates include duration of symptoms and degree of neurologic deficits and perhaps the degree of osteoporosis. Such studies should attempt to clarify when elderly patients should be referred for spinal decompression in order to experience maximum benefit.**

Degenerative Disease of the Foot and Ankle

There is a high incidence of foot problems in the elderly age group. If older persons are to remain ambulatory, foot care is essential. Foot deformity resulting from aging or degenerative disease can lead to gait and balance disturbance. A comprehensive review of the literature found very few articles addressing foot-related issues in the elderly population.

Shoe wear is an important factor in maintaining balance. A randomized controlled trial of twenty-five patients to evaluate balance while barefoot and in different types of shoe wear determined that bare feet and walking shoes maximize balance and that high heels create a balance hazard. [119] (See also Chapter 13, section on falls prevention.)

Onychomycosis is a common problem affecting 2% to 13% of all persons. Treatment is oral antifungal agents. The efficacy and side effects of these medications in elderly patients have not been well established.

A review of the literature did not find any articles pertaining exclusively to the elderly age group.

Posterior tibial tendon insufficiency and hallux valgus often lead to severe deformity of the foot. Treatment can range from conservative care with shoe wear modifications and orthotics to extensive reconstruction and fusion. A review of the literature, however, found no articles evaluating reconstruction in the older patient.

Fractures of the ankle are relatively common. Of all ankle fractures, 20% to 30% occur in elderly persons. [120] A study comparing operatively treated and nonoperatively treated ankle fractures in patients aged 65 and over found better outcomes in the nonoperatively treated group. [120]

The treatment of ankle arthritis is either fusion or total ankle arthroplasty. The results of ankle fusion can deteriorate over time as a result of transverse tarsal or subtalar degenerative joint disease. Elderly patients are thought to be good candidates for total joint replacement because degenerative changes in other areas of the foot are most likely and because older patients may be less active than younger ones. A review of the literature found no articles dealing with this procedure exclusively in the elderly patient.

Relatively little is known about the effect of foot and ankle problems on gait and balance in older people, even though these would appear to be important outcomes when assessing the utility of surgery for such disorders in this population. Research needs to define indications for surgery and orthotics in the treatment of disorders of the foot and ankle in the older person.

> *Ortho 28 (Level B)*: **Observational studies examining how foot and ankle deformity influence gait and balance in the older person are needed. Those deformities that are associated with significant gait problems should be the focus of research on surgical and nonsurgical approaches to these conditions. Appropriate outcome measures (eg, healing, gait improvement) from specific techniques of foot and ankle reconstruction need to be defined. In addition, more study is needed to identify characteristics of footwear that maximize balance.**
>
> *Ortho 29 (Level C)*: **Controlled trials are needed to identify safe and effective treatment for fungal disease of the foot.**

Bone Insufficiency and Falls

Bone loss is commonly associated with aging. Significant bone loss, which results in skeletal fragility, is termed *osteoporosis*. (See also Chapter 9, section on Osteoporosis.) Osteoporosis is a major health problem, affecting 10 million people in the United States. Another 18 million are at risk for developing the disease. [121] Low bone mineral density predicts fracture risk but cannot identify individuals who will have a fracture. Therefore, an understanding of the factors that result in a fall and the subsequent fracture is essential. At least 30% of individuals fall at least once in their life. Only 5% of falls result in fracture. Most fractures occur in the home. [122] The nature of the fall determines the type of fracture, and bone density and factors that increase or attenuate the force determine whether a fracture will occur. [123] A prospective case-control study demonstrated that a fall to the side, decreased bone density in the hip, and impaired mobility were all-important risk factors for hip fracture. [124] Neuromuscular and visual impairments, as well as femoral neck bone mineral density, are significant and independent predictors of hip fracture in elderly mobile women. [125-127] Balance is a prerequisite for mobility and ADL function [128] and is affected by medical comorbidities. Herndon et al reported on chronic medical conditions in patients aged 65 and older, finding that a self-reported history of anemia or stroke increased risk of a fall. [129] A comprehensive review of risk factors for falls summarizes 11 separate risk factors and reviews studies that demonstrate that the greater the number of risk factors, the greater the likelihood of falls. [130] This report also summarizes the strategies that have, in controlled trials, been shown to reduce the incidence of falls, although none has been sufficiently powered to demonstrate a reduction in fractures. (See also Chapter 13, section on falls prevention.)

Nursing-home residents are at particular risk for injurious falls. Institutionalized fallers have low serum 25-hydroxyvitamin D and high serum parathyroid hormone levels. [131] Minimal trauma fractures are common, usually with no clear precipitating factors other than severely impaired mobility. [132] Extreme weight loss and poor health have been shown to increase the risk of hip fracture. [133,134]

With aging, decreased muscle strength and impaired coordination are common, which results in an increased likelihood of falling and a decreased ability to break the fall. Physical activity throughout life has been found to reduce the risk of falling. [135-138] Fractures of the hip, wrist, and spine are a significant cause of morbidity and mortality among elderly persons. The cost of treating these fractures is $14 billion annually, and this is expected to increase to $60 billion by the year 2020. [1]

Fractures occur in osteoporotic bone, but osteoporosis per se does not predict who will fracture. Falls are the result of cumulative risk factors, and there is good evidence for strategies that reduce falls in community-dwelling older persons who have fallen. Whether those same strategies reduce fractures has not been determined (sample size inadequately powered). Risk factors for minimal-trauma fractures are being developed, although intervention studies have not been undertaken. Studies are generally lacking on the best surgical approaches, such as using joint replacement for fractures that occur close to a joint and using techniques or materials that provide the best fixation in osteopenic bone.

> ***Ortho 30 (Level A)*: Adequately powered randomized clinical trials are needed to determine if falls-prevention strategies for older persons will translate into fracture reduction for treated patients.**

> ***Ortho 31 (Level A)*: Cohort studies or randomized controlled trials are needed to compare the functional recovery of patients whose fractures occur close to a joint and who are treated with either total joint replacement or standard care.**

> ***Ortho 32 (Level B)*: Methodologic studies are needed to describe outcomes with various approaches to fixation in osteopenic bone.**

Fractures of the Hip

The number of elderly persons with hip fractures will double to 2.6 million by the year 2025. [139] The lifetime risk of hip fracture is 11.1% for men and 22.7% for women. [140] Almost half of all hip fractures occur in patients aged 80 or over. An estimated 18% to 28% of older hip fracture patients die within 1 year of their fracture. [140]

There are many determinants of hip fractures. The two main factors are falls and decreased bone density. Increased fracture risk has been demonstrated with lifestyle factors, such as weight loss or low body weight, [133,134,141-143] decreased physical activity, [143,144] increased tobacco use, [145,146] and poor socioeconomic status. [147] Increased fracture risk has also been found to be associated with medical comorbidities such as stroke, [148] end-stage renal disease, [149,150] and visual impairment. [151]

There has been considerable debate as to which came first, the fall or the fracture. Most studies report that the fall precedes the fracture. In fact, over 90% of all fractures are the result of falling [152-156] Hip fractures typically result from falls that result in direct impact on the hip, typically a fall to the side. External hip protectors have been found to prevent hip fractures. [157,158] A controlled study [159] and a randomized controlled clinical trial [160] found the rate of hip fracture to be significantly lower when hip protectors are worn. However, one study found only 44% adherence in wearing the device. [159] Reasons cited for not wearing the protector included skin irritation and being bedridden. (See also Chapter 13, section on falls prevention.)

For all but the very sick, operative treatment of hip fractures is recommended. Mortality rates following nonoperative treatment for hip fractures has been found to be high. [161] The timing of surgery following hip fracture is critical. The sooner the better, but medical stabilization before surgery is required. Once the patient is medically stable, surgery is recommended, if possible within 24 hours. Operative delay more than 2 calendar days has been found to be associated with higher mortality within 1 year in patients who were independent, cognitively intact ,and able to walk prior to fracture. [162] There is a significant increase in mortality in those patients whose surgery is delayed more than 24 hours. [163,164] The choice of regional or general anesthesia does not influence outcome. [165]

Fractures of the hip include intertrochanteric fractures and femoral neck fractures. There may be some differences in the patients that sustain each type of fracture. In a prospective study of elderly patients admitted for hip fracture, patients with intertrochanteric fractures were found to be slightly older and sicker and to have longer hospital stays; they were less likely at 2 months postfracture to have recovered ADLs than were patients with a femoral neck fracture. [166] Recovery at 1 year following hip fracture did not differ between fracture types. Patients with an intertrochanteric hip fracture had higher mortality rates at 2 and 6 months after fracture than did those with a femoral neck fracture.

The basic principle of treating hip fractures is secure fracture fixation to promote healing and early mobilization. Intertrochanteric hip fractures are generally treated by open reduction and internal fixation. A sliding hip screw-plate construct (compression hip screw) or a cephalomedullary nail (gamma nail) may be used for treatment. Although there has been shown to be less femoral shortening with the gamma nail, [167] no difference between the two treatments with respect to functional recovery has been found. [168] An increased complication rate has been shown with the gamma nail. [168] The gamma nail may, however, be a more versatile implant, useful in treating a variety of fracture patterns. [169] As there is currently no literature to suggest that use of this device improves outcome in routine intertrochanteric hip fractures, the sliding hip screw is thought to be the implant of choice for treating intertrochanteric hip fractures. For peritrochanteric fractures or fractures with subtrochanteric extension, the gamma nail is superior in stability and decreases operative blood loss, [170-172] and complications can be minimized by attention to surgical technique. [173]

Hemiarthroplasty has been proposed for treating unstable intertrochanteric hip fractures in debilitated elderly patients. [174,175] Hemiarthroplasty can also be used to salvage an intertrochanteric hip fracture that has had a failure of internal fixation. [176]

Femoral neck fractures may be fixed with internal fixation if nondisplaced. However, Hudson et al found higher revision and mortality rates in patients who had internal fixation than in those who had hemiarthroplasty for femoral neck fracture. [177] Internal fixation for femoral neck fracture has been associated with greater readmission and reoperation than hemiarthroplasty, without improvement in function. [178] In a review of 312 commu-nity-dwelling ambulatory patients admitted for femoral neck fracture, the choice of hemiarthroplasty or internal fixation also was found to have no impact on recovery of physical ADLs or instrumental ADLs. [179]

Hemiarthroplasty is performed when femoral neck fractures are displaced or the quality of the bone is poor. Cement may be used as a grout to improve stem fixation. There is no difference between the use of a bipolar or unipolar hemiarthroplasty for the treatment of femoral neck fractures. [180-182] Furthermore, the bipolar prosthesis has been shown to have increased polyethylene wear because of impingement of the metal shell notching the femoral component. [183] Patients with cemented implants have been found to have a higher perioperative mortality than those in which no cement was used. [184] However, in a randomized prospective trial comparing cemented and uncemented bipolar hemiarthroplasties in 53 patients with femoral neck fracture, the patients with cemented stems were found to fare better with less pain and need for fewer walking aids than did those with uncemented stems, and there was no difference in complications. [185]

Total hip arthroplasty may also be used to treat femoral neck fractures. Better outcome following femoral neck fracture has been reported with total hip arthroplasty than with hemiarthroplasty [186] or with internal fixation. [187,188] Revision rates have been shown to be lower for total hip arthroplasty (2.2%) than for cemented hemiarthroplasty (7.9%) and uncemented hemiarthroplasty (13%). [189] An increased rate of operative complications (17%), [190] dislocations (12%), [188] and implant loosening [191] has been shown if total hip arthroplasty is performed for femoral neck fractures than if the replacement is done for osteoarthritis.

Immediate postoperative weight bearing to tolerance following hip fracture fixation has not been shown to result in hardware failure or loss of fixation. [192]

Delirium is a common problem following operative treatment of hip fractures. Stromberg et al in a randomized clinical trial found a 13% incidence of delirium postoperatively in patients with hip fractures. [193] Postoperative delirium is more likely to occur in patients aged 80 and older, those with prefracture cognitive impairment, and ADL functional impairment or high medical comorbidity; if the delirium persists more than 1 month following hip fracture, there is poor functional recovery. [194] Following hip fracture, patients with dementia, delirium, or depression are more likely to remain in the hospital longer. [195] For further discussion of delirium in surgical patients, see the chapter on cross-cutting issues (Chapter 13).

Bone mineral density decreases in the operative side following femoral neck fracture. [196] A decline in bone mineral density has also been demonstrated in the contralateral hip in the year following hip fracture. [197,198] Bone mineral density does, however, increase in the following 5 years, in most cases replacing the loss from the first year. Those patients who do not regain bone density in the contralateral hip are at risk for a second hip fracture. [199] Patients with a history of hip fracture have a greater risk for developing another hip fracture. A review of orthopedists and internists found that neither specialty adequately addresses the prevention of a second hip fracture. [200]

The primary determinants of long-term survival following hip fracture are host factors and not injury severity. [3] The mortality following hip fracture has been found to be predictable on admission by the number of medical conditions: with no other diagnosis, mortality is 0%; with one or two, mortality is 14%; and with three or more, the mortality is 24%. [4] Following a hip fracture, medically ill and functionally impaired patients demonstrate an immediate increase in mortality, but those with no comorbidities and few impairments have a gradual increase in mortality that continues for 5 years postfrac-ture. [201] Increased mortality has also been demonstrated in those with mental impairment [195,202] and decreased postoperative ambulatory level. [203] Age at the time of fracture is also predictive of mortality. [204] The 1-year mortality of nonagenarians is 46% [205] and of centenarians is 56%. [206] Men in general appear to have a higher mortality rate after hip fracture than women. [204,207] Poor et al attributed this to interaction of the fracture with serious underlying medical conditions. [208]

Following hip fracture, there is a dramatic decline in physical function at 2 years that is independent of the effects of increasing age, pre-existing medical conditions, and disabilities. [209] Prefracture mobility is the most significant factor in predicting continued ability to live at home. [210] By 1 year, only 41% of hip fracture patients are back to their prefracture ambulatory ability, 40% of those ambulating require assistive devices, 12% go from community ambulation to household ambulation, and 8% become nonfunctional ambulators. [211] Patients aged 85 and older who live independently and alone before a fracture are at high risk for nonrecovery of ADLs and instrumental ADLs. Recovery of ADLs occurs in only 73%, and only 48% recover instrumental ADLs. [212] The chance that a patient with a hip fracture will make any further recovery after 4 months is minimal, and that recovery is directly influenced by increasing age, coexisting diseases, and complications. [213] Only 17% of institutionalized elderly patients regain their overall functional ability, and only 13% return to their pre-injury ambulatory status.

Hip fracture is a disorder of late life and one that is too often associated with substantial long-term disability. Although surgical techniques have progressed and pre- and perioperative care have improved, long-term outcomes have failed to keep pace. Surgical advances include improved devices for fixation, better understanding of the importance of timing (best if in the first 24 hours), and weight bearing as tolerated for most repairs. Further advances can be expected as other key issues are addressed: whether or not cement should be used with hemiarthroplasty; comparisons of available techniques for repair of intertrochanteric fracture to identify the optimal approach; and techniques or interventions to reduce hardware failure. Reducing 1- and 2-year mortality and improving long-term functional outcomes for patients is a more daunting task and will likely require approaches to reduce perioperative delirium, to improve continuity between care settings (hospital, rehabilitation setting, and home), to optimally manage medical comorbidities (including osteoporosis), and to provide effective (perhaps extended) rehabilitation and nutritional support services.

> *Ortho 33 (Level B)*: **Observational studies are needed to examine the effect of shortening of the fractured limb on gait and balance.**
>
> *Ortho 34 (Level B)*: **Observational studies are needed to learn whether modalities such as electrical stimulation or ultrasound can speed the fracture healing response in the older patient and therefore decrease fracture collapse or hardware failure.**
>
> *Ortho 35 (Level B)*: **Methodologic studies are needed to identify elderly patients with hip fracture who are at high risk for operative intervention and postoperative complications and to devise clinical pathways for their care. Database analyses of the pre-hospital, in-hospital, and rehabilitation periods of elderly orthopedic patients should be performed to identify clinical management strategies that result in decreased morbidity and improved functional recovery.**
>
> *Ortho 36 (Level A)*: **Controlled trials are needed to compare outcomes using cement and noncemented hardware for hemiarthroplasty. Additional controlled trials are needed to compare techniques for repair of intertrochanteric hip fractures.**
>
> *Ortho 37 (Level B)*: **Current clinical databases should be expanded to include long-term and functional outcomes of older orthopedic surgical patients recovering from hip fracture.**

Fractures of the Wrist

Wrist fractures are a common consequence of osteoporosis. Wrist fractures are more likely to occur in women with low bone mineral density who are healthy and active and have good neuromuscular function, when they put out the hand to break the fall. [214] As common as distal radius fractures are in the elderly age group, there is a paucity of research regarding treatment and outcome. The expert consensus seems to be that most of these fractures do well in the elderly patient, regardless of treatment. However, this assumption has not been well studied. Fractures may require either closed manipulation and immobilization or surgical treatment.

Older patients with low levels of activity have been found to be satisfied with wrist fractures treated nonoperatively; 88% are able to return to their prefracture activities. [215] Up to 30 degrees of dorsal angulation and 5 mm of radial shortening have been found to be acceptable in elderly patients. [216]

More active individuals may be candidates for operative stabilization. Surgical treatment may consist of closed reduction and pinning, open reduction and pinning, open reduction and internal fixation with plate and screws, or external fixation alone or in combination with wiring or plating. Percutaneous pinning is simple and has been shown to give results superior to those of manipulation and casting alone. [217] If the fracture is extensively comminuted, however, reduction may be lost.

Plate fixation [218,219] is advantageous because it may be used in combination with bone grafting to restore structural integrity, and plate fixation allows for earlier motion. Plates are commonly placed on the dorsal aspect of the wrist and as a result can interfere with extensor tendon activity.

External fixation is commonly used to address the concern of radial shortening and comminution. This procedure uses an external device that applies pins proximally and distally to the fracture and applies traction to keep the fracture out to length. Bone grafting of the fracture site is commonly carried out to supplement the fixation. [220] Unfortunately, because the fracture is at the end of the bone, the external fixator needs to span the wrist joint, which can result in wrist stiffness. Also, because the distal pins are placed in the metacarpal and this bone is small, fractures can result. Frame loosening can occur as a result of placement of the pins in osteoporotic bone. Bone graft or bone substitute is commonly used for filling in the void after an impacted fracture is brought back out to length. Options for bone void filler include autograft, allograft, and bone void fillers. Autograft is often not a good choice for the elderly patient, as the number of mesenchymal cells in the host bone may be limited. In addition, because many of these patients are osteoporotic, the structural integrity of the graft material is not adequate. Allograft bone is commonly used instead. Additionally, there are many bone substitutes. An injectable, remodellable bone cement has been developed, but its use for elderly patients has not been studied. However, Sanchez-Sotelo et al have shown it to provide good results in comparison with conservative treatment. [221]

Outcome 10 years following distal radius fracture was shown by Warwick et al to be satisfactory. [222] Radial shortening and finger stiffness were found to be related to less satisfactory outcomes.

Wrist fracture is common in older women, and although it is not well studied, most patients appear to have a good outcome. However, for those fractures requiring operative intervention, issues regarding osteoporosis and whether autograft or allograft is better require further study.

> ***Ortho 38 (Level B)*: Observational studies are needed to compare operative with nonoperative management to suggest which method is better with regard to outcome (time to union and function) following wrist fracture in the older patient.**
>
> ***Ortho 39 (Level D)*: Descriptive studies are needed to determine the range of motion and strength of the wrist necessary for good activities of daily living function in older persons.**
>
> ***Ortho 40 (Level D)*: Case series describing outcomes with various fixation methods are needed to suggest the best fixation method for wrist fractures in older patients.**
>
> ***Ortho 41 (Level C)*: Controlled trials of various graft materials are needed to determine the best graft material to supplement wrist fracture internal fixation in older patients.**

Fractures of the Spine

Osteoporotic vertebral compression fractures are very common, affecting 25% of women aged 70 years and older and 40% of women aged 80 and older. [223] Vertebral fractures are associated with significant performance impairments in physical, functional, and psychosocial domains [224] and increased risk of mortality [225] and hospitalization. [226]

Vertebral fractures typically occur in the lumbar and thoracic region and result in loss of normal alignment of the spine. Kyphosis can cause severely deformed posture, which commonly leads to a reduction in pulmonary capacity [227] and decreased physical mobility. [228,229] These fractures typically result from very minimal trauma, such as sneezing, lifting, bending, or coughing. Conservative treatment is generally indicated. Rest, physical therapy, and occasionally bracing are used for treatment. Nasal calcitonin has been reported to have an analgesic effect when used following compression fractures. [230]

In situations where there are persistent neurologic symptoms, surgical treatment may be indicated. Lee and Yip evaluated 497 patients with compression fractures and found a 2% incidence of spinal cord compression. [231] Treatment consisted of anterior decompression and iliac crest bone graft. The authors found incomplete recovery, but in general the results were satisfactory. Vertebroplasty is a relatively new technique involving percutaneous administration, under fluoroscopic guidance, of polymethylmethacrylate into the vertebral body. Improvement in symptoms following treatment has been reported by up to 90% of patients. [232,233] Of those with compression fractures due to metastatic disease, only half of those treated with vertebroplasty report good relief of symptoms. [233]

Complications of vertebroplasty have been reported in 6% of cases. Cortet et al found no adverse effect from the procedure, and at 6 months, no vertebral fracture had occurred. [234] With open or surgically controlled placement of the polymethylmethacrylate under fluoroscopic guidance, the potential risk of chemical, compressive, or thermal effects of cement leakage on the neural structures is eliminated. [235] Fracture adjacent to vertebrae augmented with cement has been shown as a late complication. [236]

Vertebral fractures are common and often cause severe acute and chronic pain. Surgical therapy is reserved for those with neurologic deficits. Vertebroplasty is a relatively new and promising therapy for the pain of fracture, but much remains to be learned about its indications, the timing of the procedure, and its benefits and complications.

> ***Ortho 42 (Level A)***: **Randomized controlled trials are needed to compare vertebroplasty with current usual care (no treatment) in older patients. The studies should compare indications (acute and or chronic pain) for vertebroplasty, complications, benefits, and long-term effects of each approach, and they should also examine the effects on adjacent vertebrae (eg, fracture, deformity) following vertebroplasty.**

Fractures of the Proximal Humerus

The proximal humerus commonly fractures when there is a fall directly onto the shoulder by persons whose bone quality is poor. The proximal humerus may fracture into two, three, or four parts. Treatment includes a sling with range of motion started when the patient is comfortable, internal fixation, or humeral head replacement. Nonoperative treatment of three- and four-part proximal humerus fractures has shown good results. In a 10-year follow-up of nonoperatively treated three- and four-part proximal humerus fractures, despite poor reduction and decreased range of motion, most patients were satisfied with their outcome. [237] A randomized controlled trial demonstrated that patients treated with open reduction with internal fixation had no better outcome than did patients treated nonoperatively. [238] The complication rate was higher in the operatively treated patients.

Operative treatment of proximal humerus fractures is considered when the reduction is poor. The indications for open reduction and internal fixation have generally been limited to two- and three-part fractures and some types of four-part fractures if the bone quality is adequate. Plate fixation and indirect reduction have been associated with a low rate of avascular necrosis and nonunion. [239] The valgus-impacted four-part proximal humerus fracture has been treated with open reduction and internal fixation; 74% of those treated were satisfied with their result. [240] Complications of open reduction and internal fixation include nonunion, malunion, subacromial impingement, and adhesive capsulitis.

Hemiarthroplasty has been the mainstay of treatment for significantly displaced three- and four-part proximal humerus fractures in older patients. Better results are seen if the decision to perform hemiarthroplasty is made early after the fracture. [241] After hemiarthroplasty performed for three- and four-part proximal humerus fractures, several authors have noted in their patients decreased range of motion but good pain relief. [242-244] Others have found their patients to have decreased range of motion and continued pain. [245,246] Complications of hemiarthroplasty include infection, nerve injury, intraoperative fractures, instability, and tuberosity nonunion.

The results of operative repair for three- and four-part proximal humeral fracture are conflicting. Results for nonoperatively treated patients are probably not worse than those undergoing surgical repair, yet there are substantial limitations in shoulder range and functional abilities. Substantial additional study is needed on this topic.

> *Ortho 43 (Level B)*: **Observational studies are needed to more clearly define what constitutes a good outcome following a proximal humerus fracture in the older patient.**
>
> *Ortho 44 (Level A)*: **Controlled studies are needed to compare operative with nonoperative repair of proximal humerus fractures in older patients.**
>
> *Ortho 45 (Level A)*: **Controlled studies are needed to compare various operative repairs for proximal humerus fractures in older patients.**

Key Research Questions in Geriatric Orthopedics

The morbidity related to musculoskeletal disorders in the elderly patient is significant. Degenerative joint disease and fractures of the spine and extremities have a tremendous impact on function, especially in the oldest individuals. Research is needed in many areas, particularly in ways to decrease the amount of fall-related trauma, to improve implant fixation in osteoporotic bone, to enhance fracture healing in the aged patient, and to optimize outcomes following fracture. Outcome studies should be performed to evaluate treatment, but what defines a successful outcome in this age group remains to be established.

> *Ortho KQ1*: **How can implant fixation in osteoporotic bone be improved?**
>
> Hypothesis-generating research studies should focus on the technical aspects of specific fixation techniques (eg, cemented, noncemented implants) and postoperative care (eg, antiresorptive agents, calcium, vitamin D, exercise). Database analyses and observational studies of specific implants currently used in operations on elderly patients should elucidate risk factors (eg, degree of osteoporosis) and technical contributions to implant fixation. Further hypothesis-generating research should focus on the development of widely acceptable measures and timeframes for healing and fixation to be used as benchmarks in the evaluation of elderly patients after implant fixation.
>
> Hypothesis-testing research may start with cohort studies to compare fixation rates according to implant type. Multivariate analyses for such studies may clarify the role of device characteristics versus the presence of specific diseases in predicting successful fixation in older patients. Finally, randomized trials of specific implants alone or in combination with specific therapies to treat the underlying bone disease may be required.
>
> *Ortho KQ2*: **How can fracture healing in the aged person be enhanced?**
>
> Hypothesis-generating research should include studies to identify risk factors for poor healing

and the effects on healing of commonly prescribed therapies for osteoporosis. Basic research needs to examine growth factors and other modalities that may enhance healing for future clinical trials. Further hypothesis-generating research should focus on the development of widely acceptable measures and timeframes for healing to be used as benchmarks in the evaluation of elderly patients after fracture.

Hypothesis-testing research may include randomized trials of specific therapies to enhance fracture healing. Cohort studies should compare healing rates under different strategies for fracture management. Multivariate analyses from such studies may clarify the role of patient-level characteristics versus the management of specific fractures in predicting optimal healing in older patients.

***Ortho KQ3*: How can the outcomes after fracture be optimized in elderly patients?**

Hypothesis-generating research should include methodologic studies to identify high-risk elderly patients and devise clinical pathways for their care. Database analyses of the pre-hospital, in-hospital, and rehabilitation periods of elderly orthopedic patients should be performed to identify clinical management strategies that result in decreased morbidity and improved functional recovery. Hypothesis-generating research should also include the expansion of current clinical databases to include long-term and functional outcomes of older orthopedic surgical patients. Observational studies and database analysis should focus on refinement of risk factors for poor outcome in surgically versus nonsurgically treated elderly patients (eg, for humerus, wrist, vertebral fractures) and describe outcomes in various settings (eg, acute rehabilitation, skilled nursing facility, home) and with various approaches (eg, organized fracture service, weight bearing as tolerated after hip repair) used to manage specific high-priority fractures (eg, hip).

Hypothesis-testing research studies to address this question would be aimed at defining the benefits of specific interventions in older patients. Randomized trials of elderly patients treated for specific fractures (eg, vertebrae, wrist, humerus) are needed to clarify the role of operative therapy in improving function and quality of life. Case-control or randomized studies of clinical pathways to elucidate the benefit of pathways in obtaining better functional outcomes and reducing in-hospital adverse events and optimizing long-term recovery are needed. The aim of these studies would also be to identify treatment strategies that reduce the incidence of perioperative complications, wound-related problems, and deep-vein thrombosis, which are especially prevalent in older orthopedic patients.

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