4.8 Fragility fractures and orthogeriatric care

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1 Introduction

Life expectancy is dramatically increasing globally and the population is aging at an unprecedented rate. By 2050, people aged 60 years or older will exceed the number of younger people. This worldwide trend is believed to be irreversible and is coupled with lower birth rates and lower fertility.

The fastest growing demographic of the world population is those older than 80 years and in some countries more than 10% of patients with hip fracture are older than 90 years. In many orthopedic trauma departments, patients with fragility fractures now represent the largest group of patients (30%).

Fragility fracture was defined by the World Health Organization in 1998 as "a fracture caused by injury that would be insufficient to fracture normal bone; the result of reduced compressive and/or torsional strength of bone".

From a clinical perspective, a fragility fracture is defined as a fracture that occurs as a result of a minimal trauma, such as a fall from a standing height or less [1].

Osteoporosis is defined as "a systemic skeletal disease characterized by low bone mass and microarchitectural changes with a consequent increase in bone fragility and susceptibility to fracture" [2].

The most common fractures associated with osteoporosis are those at the hip, spine, distal radius and proximal humerus. Many other fractures after the age of 50 years are associated with low bone mass and should therefore be regarded as osteoporotic [2]. Over the years, many patients sustain multiple fractures (**Fig 4.8-1**), so osteoporosis can be considered a chronic disease with intermittent acute episodes (fracture).

The two major pillars in the treatment of fragility fractures are:

- Orthogeriatric comanaged care in the acute phase (30–35 days) including the rehabilitation process
- Lifelong secondary fracture prevention

1.1 Epidemiology

Osteoporosis is a major public health problem, affecting hundreds of millions of people worldwide.

It is estimated that an osteoporotic fracture occurs every 3 seconds worldwide. One in two women and one in five men aged 50 years and older will suffer a fracture in their remaining lifetime. The average lifetime risk for a 50-year-old adult of suffering an osteoporotic fracture has been estimated at 40–50% for women and 13–22% for men [3]. Approximately 50% of people with one osteoporotic fracture will have another, with the risk of new fractures rising exponentially with each fracture [4].

In general, the incidence of fragility fractures increases with age. However, the proportion of fractures at any site also varies with age. For example, the median age for distal radial fractures in women is 65 years and for hip fractures is 80 years [3].

1.1.1 Hip fracture

Hip fracture incidence has been shown to increase exponentially with age and the worldwide hip fracture incidence has been predicted to increase dramatically during the next three decades, mainly due to the increasing number of older people [5].

Estimates suggest that there are approximately 0.6 million hip fractures per annum in the European Union and about 0.3 million hip fractures in the US [6, 7].

Fig 4.8-1a–n An 88-year-old woman weighing 46 kg sustained a pertrochanteric fracture. Comorbidities were osteoporosis, heart failure, hypertension, depression, mild cognitive impairment, and problems swallowing. She lived alone and independently on low income with some help from her neighbors and a son. She used stairs to get to her second floor flat.

a–b Preoperative x-rays.

c A medial proximal tibial fracture was detected, most probably sustained at the same accident as the hip fracture and treated conservatively.

d–e The fracture healed after fixation with a proximal femoral nail antirotation (PFNA).

f Due to severe coxarthritis, total joint replacement was performed.

Fig 4.8-1a–n (cont)

g–i During her stay in the hospital, she fell and sustained a proximal humeral fracture that was treated nonoperatively with a typical varus malunion.

j–m Some time later, she suffered a periprosthetic fracture at the level of the tip of the stem ("problematic fracture") and at the site of the PFNA locking screw. Despite the rigid fixation and a remaining gap, the fracture healed eventually. At the time of this fracture, teriparatide was administered.

n Three years before the proximal femoral fracture, an osteoporotic spine fracture had been diagnosed. Unfortunately, no action had been taken with regard to secondary fracture prophylaxis.

In a recently published systematic review [8], it was shown that there is a greater than 10-fold variation in hip fracture risk and fracture probability among countries (**Fig 4.8-2**). The low incidence of osteoporosis in developing countries may be partly due to the lower life expectancy. However, by the year 2050, more than half of all hip fractures in the world will occur in Asia (**Fig 4.8-2**).

1.1.2 Vertebral fracture

Vertebral fractures are the most common osteoporotic fracture. However, the incidence of vertebral fractures is not well documented due to the fact that only approximately 30% of these fractures come to clinical attention, so-called clinical vertebral fractures [9]. Most vertebral fractures are asymptomatic and may be only detected on x-rays (radiographic or morphometric vertebral fractures).

1.1.3 Distal radial fractures

In contrast to hip or vertebral fractures, the incidence of distal radial fractures appears to increase rapidly during the early postmenopausal period and there is evidence of a plateau in the incidence of fracture during the mid-60s [10]. The average lifetime risk in a 50-year-old caucasian adult of suffering a distal radial fracture has been estimated at 20% for women and at 5% for men [3].

1.1.4 Proximal humeral fracture

The average lifetime risk for a 50-year-old white adult of suffering this type of fracture has been estimated at 13% for women and at 4% for men [11, 12]. In populations with sufficient epidemiological data on different fracture types, the overall age-adjusted incidence of humeral fractures is approximately 50–60% of hip fracture incidence rates.

2 Etiology

Bone strength reflects the integration of two main features: bone density and bone quality:

- Bone density is expressed as grams of mineral per area of volume and in any given individual is determined by peak bone mass and amount of bone loss.
- Bone quality refers to architecture, turnover, mineralization and damage accumulation, eg, microfractures. A fracture occurs when force exceeds the strain tolerance of bone and osteoporotic bone has a much lower strain tolerance than normal bone. In severe osteoporosis, even normal physiological strain may exceed this tolerance and result in fracture, eg, many vertebral fractures.

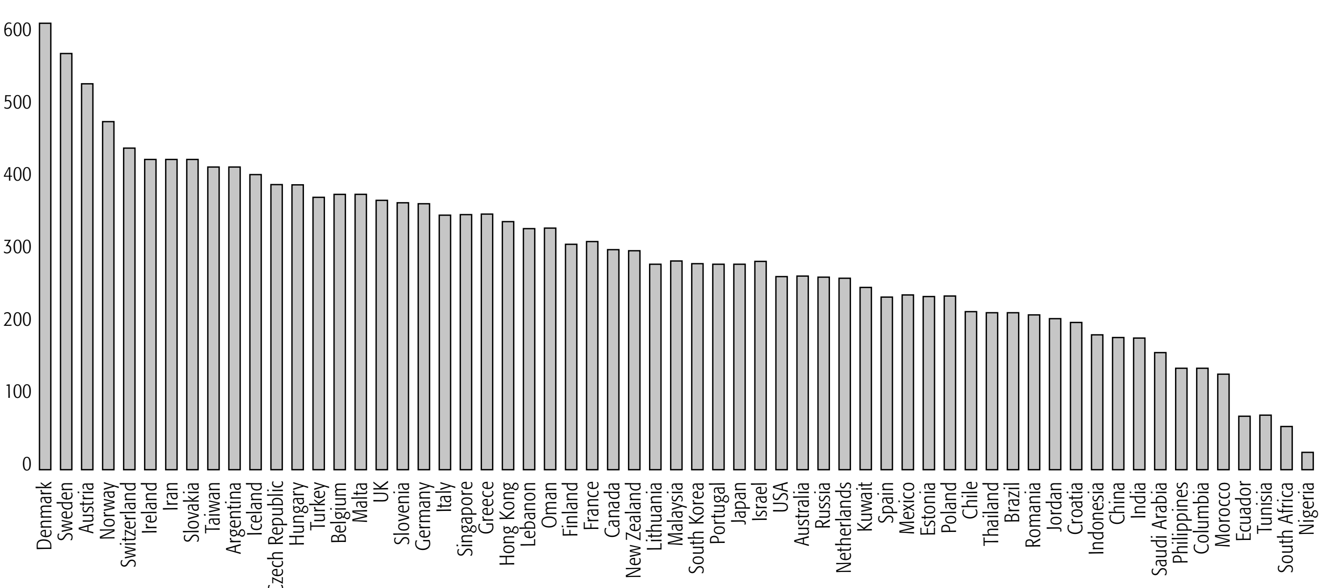

Fig 4.8–2 World standardized annual hip fracture rates for women (per 100,000). Adapted from Kanis, 2012 [8].

Osteoporosis influences both strength and stiffness of bone. Both decrease with age and degree of demineralization. This is true for cortical and cancellous bone. Osteoporosis involves a loss of bone mass, reduction in bone quality by deterioration of microarchitecture and reduced ability of bone to withstand loading. It is important to understand the difference between bone mineral density (which reflects the calcium content) and the deterioration of bone quality measurable in reduced resistance to loading. Usually, the quality of bone reduces much more with age in cancellous bone than in cortical bone.

2.1 Cortical bone

Cortical bone in a 25-year-old adult is dense, thick, and strong. The pattern of age-related cortical bone loss involves loss of cortical thickness that is more marked at the endosteum with an increase in medullary diameter; particularly in women (**Fig 4.8-3**).

The changes in outer and inner cortical diameter affect the bending and torsional characteristics of the whole bone. If we assume a diaphyseal bone is a tube, the formula $\Pi/4(R4\text{-}r4)$ describes the calculation of the bending stiffness of a tube (R, r = outer and inner radii of a tube). Bending stiffness depends on the inner and outer radius of the tube.

2.2 Cancellous bone

In cancellous bone, the change in bone structure is due to decreasing trabecular thickness, interruption of the trabecular network, reduction in the number of trabeculae, and reduction of trabecular connectivity. As well as age and hormonal changes, reduced physical activity also leads to deterioration of bone. There is vast evidence that mechanical usage influences bone mass (Wolff's law) but, unfortunately, exercise only leads to a minimal increase in bone mass.

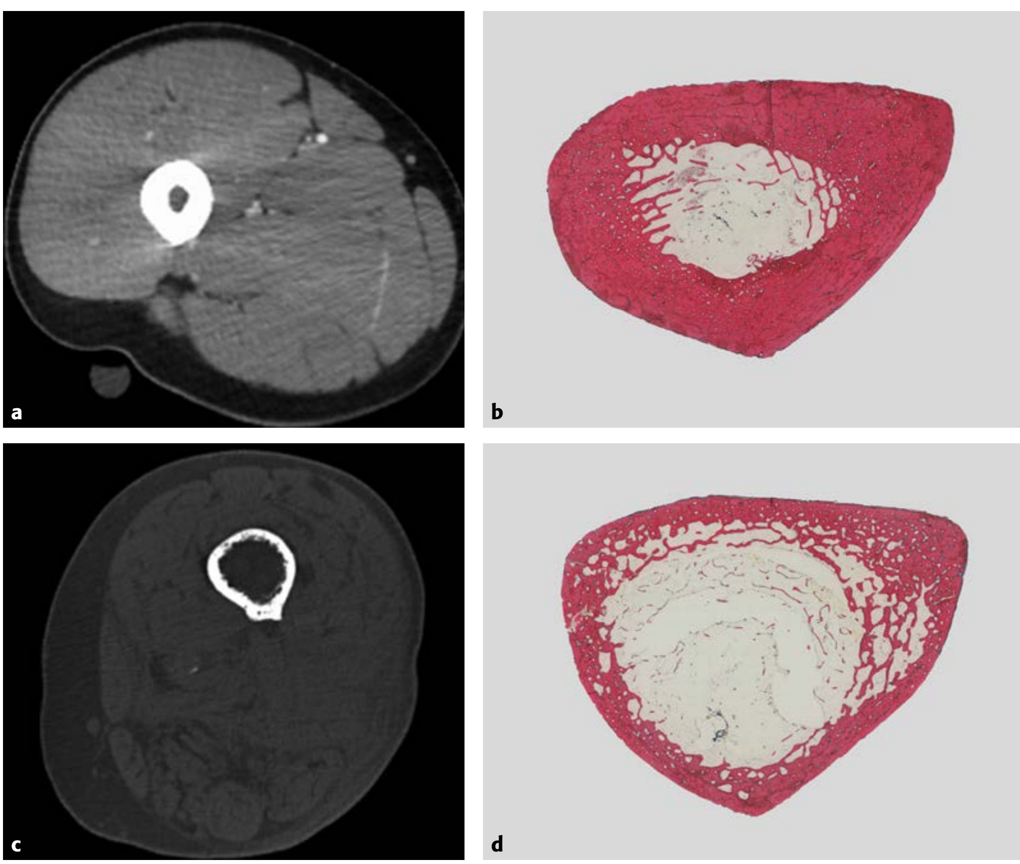

Fig 4.8-3a–d Age-related changes in cortical bone quality. Cortical bone loss between 30 and 80 years of age, with 8% decrease in elastic modulus, 11% decrease in ultimate strength, and 34% decrease in toughness.
a–b Cross-section images of cortical bone from a 30-year-old woman.
c–d Cross-section images of cortical bone from an 80-year-old woman.
(Images of histological sections (**b**, **d**) courtesy of Beat Schmutz, Davos, Switzerland.)

With aging, the bone trabeculae change in shape from flatter structures to more rod-like structures. These changes weaken the internal architecture of the cancellous bone making it more likely to fracture with minor trauma (**Fig 4.8-4**).

2.3 Significance for fracture fixation

Biomechanical studies have demonstrated that osteoporotic changes reduce implant anchorage. Decreased cortical thickness significantly affects the holding capacity of screws.

2.4 Measurement of osteoporosis

Dual-energy x-ray absorptiometry (DEXA) has become the standard method for measuring bone mineral density as a proxy measure and accounts for approximately 70% of bone strength. The World Health Organization operationally defines osteoporosis as bone density 2.5 standard deviations below the mean for young caucasian adult women. It is not clear how to apply this diagnostic criterion to men, children, and across ethnic groups.

Indications for obtaining a DEXA scan include:
- Long-term steroid use
- Early surgical menopause
- Postmenopausal women with alcoholism, heavy tobacco use, a body mass index < 18.5, or a family history of fragility fractures
- Baseline measurement for monitoring bone-protection therapy
- Follow-up measurement after bone-protection therapy

Clinically, in the acute fracture situation, the degree of osteoporosis should be estimated by consideration of preoperative x-ray imaging, intraoperative haptics while drilling or fixing bone and additional parameters such as gender, age, and comorbidities.

2.4.1 Falls

Most fractures are caused by falls. Therefore, falls, osteoporosis, and fractures must be addressed together. Several measures have been suggested for the prevention of falls in older patients including strength and balance training, home hazard assessment and modification, vision assessment, medication review, cardiac pacing when necessary, and cognitive behavioral interventions.

Risk factors for falls are similar to those for fracture: previous falls, weakness, poor balance, gait disorders, and taking certain medications, such as psychoactive drugs, anticonvulsants, and antihypertensive drugs.

2.4.2 Other mechanisms of injury

High-impact trauma has increased as people have become more active during their retirement, continuing to drive and enjoy outdoor activities more than was seen in the past. Falls down stairs are a particular hazard and can result in frail patients suffering high-energy and complex trauma.

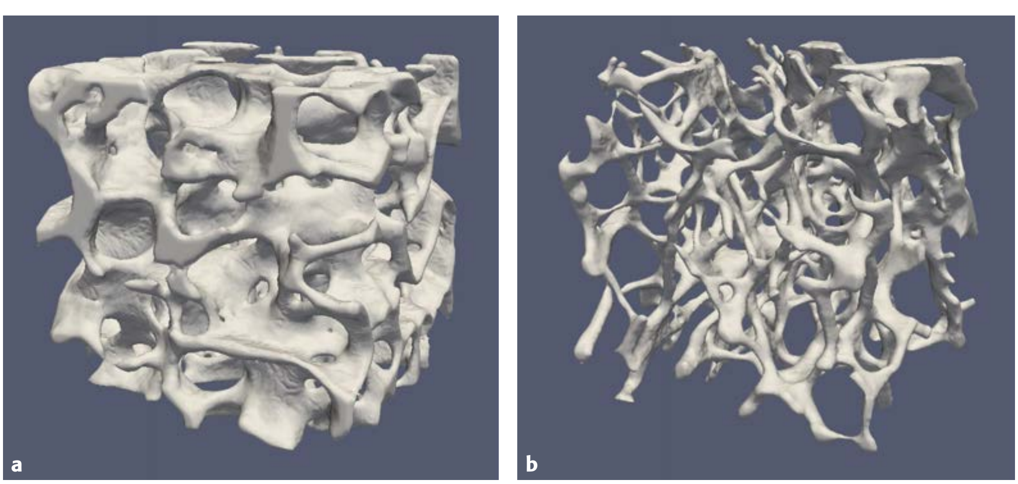

Fig 4.8-4a–b Age-related changes in trabecular bone quality. Besides drastic loss in bone mass, plate-like structures change into rod-like structures with aging as shown by these micro-computed tomographic images at age 35 (**a**) versus 73 (**b**) years. (Images by courtesy of Prof. Dr. Ralph Müller, Institute for Biomechanics at the ETH Zurich, Switzerland).

For care of the older patient with polytrauma, trauma centers have shown significantly better outcomes than acute care hospitals [12]. Injury patterns differ from younger patients with higher Injury Severity Scores and mortality, as well as more pelvic and upper extremity injuries [13]. Trauma registries have demonstrated that increased age is an independent variable for death in polytrauma with significant risk increases in patients older than 64 and 89 years (**Fig 4.8-5**).

3 The fragility fracture patient

A clinical definition of a fragility fracture patient is:

- Acute injury caused by a low-energy trauma
- Older than 70 or 80 years with reduced general health status

Factors that contribute to a reduced general health status include the number of comorbidities (two or more), cognitive state and functional disabilities that result in reduced mobility and increased need for social support. One of the common factors for many of these patients is that they are frail and have sarcopenia due to complex medical and rehabilitation problems. They have a higher need for specialist medical care.

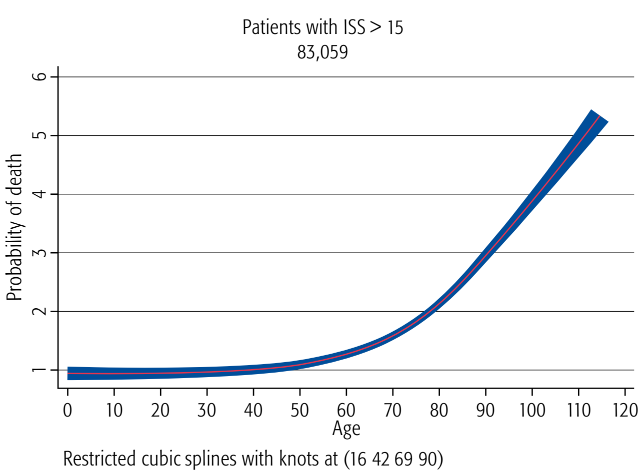

Fig 4.8–5 The impact of age on the probability of death following multiple trauma (ISS > 15). An analysis of 83,059 cases from the UK National Trauma Data Bank.
(Data supplied by the Trauma Audit and Research Network).

3.1 Relevant comorbidities

Fragility fractures are much more common in patients with preexisting medical conditions—comorbidities. Preexisting comorbidities also have a significant impact on outcomes of older trauma patients. While some of these comorbidities are apparent, others might remain unrecognized yet cause complications and result in an unfavorable outcome. Therefore, comorbidities should be assessed systematically and treatment goals should be set.

Established and helpful tools to assess the morbidity burden of an older patient are the Charlson Comorbidity Index with 19 items and the Cumulative Illness Rating Scale. Comorbidities should be documented at admission when the relevant information may be easiest to collect.

> Common comorbidities in patients with fragility fractures include cardiac disease, dementia, renal dysfunction, pulmonary disease, hypertension, diabetes, and malignant disease.

Often, multiple comorbidities lead to the problem of polypharmacy. Each of these conditions is likely to be treated with at least one medication. The number of medications increases the risk of adverse drug reactions and unexpected drug-drug and drug-disease interactions. A special problem is the high prevalence of anticoagulation drugs in older adults.

> These problems are best managed with an orthogeriatric team approach.

3.1.1 Preexisting conditions

Preexisting conditions cannot be changed fundamentally; they are common in fragility fracture patients and have to be recognized. The preoperative evaluation of geriatric patients should aim to identify all preexisting conditions but recognize that delay to treat most of these conditions is unlikely to reduce the risks of surgery. The key is to identify those that require immediate medical measures to lower the risks of surgery (see section 3.1.2 in this chapter). However, if the risk of surgery cannot be altered, surgery should be performed without further delay. Delaying surgery usually adds unnecessary risk [14]:

- Cardiac diseases: Hypertension, coronary heart disease, heart failure, atrial fibrillation, and valve disease are frequent among fragility fracture patients. In a stable patient, they present a higher risk for surgery but are not a contraindication. The challenge for the orthogeriatric team is the management of the medication, especially anticoagulation.

- Pulmonary diseases: Patients with severe pulmonary disease need strong collaboration with the anesthesiologist. Blood gases may help to estimate the pulmonary status. In cases where neuroaxial anesthesia is not feasible, severe pulmonary disease may be a contraindication for surgery.
- Renal dysfunction: 40% of patients with a hip fracture have chronic kidney disease (defined as an eGFR < 60), but all patients are at risk of acute kidney disease in the perioperative period. Inappropriate fluid management, nephrotoxic medication or computed tomographic scans with contrast agent increase the risk for acute kidney injury, which is also more common with increasing age, two or more comorbidities, and in those with chronic kidney disease.
- Diabetes: Hypoglycemia is more dangerous than hyperglycemia; nevertheless, blood glucose level should be lower than 200 mg.
- Dementia is an important risk factor for delirium and an independent risk factor for mortality. Patients should have a formal assessment of cognitive function on admission and there are a number of validated scoring systems, such as the abbreviated mental test score, that can be used.

3.1.2 Active conditions

Conditions that need medical stabilization before surgery are active geriatric medical conditions:

- Decompensated heart failure, acute cardiac ischemia
- Acute stroke
- Acute infection, such as pneumonia or septicemia
- Unstable angina
- Severe hypotension
- Acute bleeding, eg, gastrointestinal
- Rhabdomyolysis
- Acute kidney injury

Comorbidities, especially cardiopulmonary and renal conditions and medication, such as anticoagulants, may influence the type of anesthesia and timing of surgery. An anesthetist should be involved as early as possible to avoid any unnecessary delay.

As a rule, the time needed for medical stabilization should not exceed 72 hours. Any delay of surgery for more than 72 hours causes significant increase in complications. The team should define clear goals for the optimization, determine the responsibility, and set a time frame.

3.2 Functional disabilities

Beside medical comorbidities, older patients suffer from functional disabilities. They can be assessed systematically by using a standardized geriatric assessment. Functional needs and resources are helpful in terms of goal setting. Older adult patients often require the use of their upper extremities to assist with ambulation by using a cane or walker. It is impossible for older adult patients to limit their weight bearing on an injured extremity.

3.3 Frailty and sarcopenia

Frailty is a common clinical syndrome in older adults that results in an increased risk for poor outcomes including falls, disability, hospitalization, and mortality. In frail patients, the physiological reserve is limited and so the ability to compensate for poor medical or surgical management is drastically reduced.

Frailty is defined as a clinically recognizable state of increased vulnerability resulting from an aging-associated decline in reserve and function across multiple physiological systems, such that the ability to cope with every day or acute stressors is comprised [15].

At admission, frailty cannot be influenced. Nevertheless, it is important to assess it. Frail patients have a higher risk of complications and in-hospital death. Their functional outcome is drastically limited. All goals and treatment decisions should be considered carefully. The overall goal should be “not to harm these patients”.

Sarcopenia is a syndrome characterized by progressive and generalized loss of skeletal muscle mass and strength that result in a risk of adverse outcomes, such as physical disability, poor quality of life, and death.

Depending on the definition used for sarcopenia, the prevalence in people 60–70 years of age is reported as 5–13% and ranges from 11–50% in people older than 80 years [16]. Usually, sarcopenia is a part of frailty. Nutrition, vitamin D3, and mobilization may help to avoid further progression of sarcopenia during a hospital stay.

3.4 Immobilization

Older adult patients do not tolerate prolonged bed rest either before or after surgery. This predisposes to problems, such as thromboembolism, decubitus ulcers, urinary tract, and chest infections.

Immobilization leads to a loss of 0.5% of muscle mass and up to 4% of muscle strength per day [17]. Nutrition and mobilization are the cornerstones in preventing sarcopenia due to immobilization.

3.5 Facilities

Older adult patients have specific needs and requirements that need to be met by specialized facilities to protect them from harm:

- Patient rooms, therapy rooms, bathroom facilities, and the floor must be accessible without obstacles and offer enough space and safety, eg, handrails to help patients with their personal hygiene.
- A therapy room located on the ward helps to avoid patient transportation.
- Facilities should be designed to avoid the development of delirium.
- Good lighting, contrasting colors, and other visual characteristics.
- Low beds, large clocks, and large windows for sufficient day light.
- Common areas where patients can meet, eat, and talk with each other.

4 Orthogeriatric comanagement

4.1 The Comorbidity Construct

The Comorbidity Construct [18] is a helpful tool to provide a better overview of older patients (**Fig 4.8-6**):

- The index disease leads to hospital admission.
- Comorbidities always have a strong relationship to the index disease.
- Gender is an issue, especially in terms of social and psychological conditions.
- The impact of age is not significant.
- The biological age of patients and estimated life expectancy are more relevant for the outcome.
- In older adult patients, intrinsic factors are a major contributor to falls.
- In older adult patients, morbidity burden is not only described by the comorbidities but also by the functional disabilities and geriatric syndromes.
- The complexity of these older adult patients result from a combination of their health problems and their nonhealth-related individual attributes.

4.2 Goal setting

Therapeutic decision making is much more complex in older adult patients. Fragility fracture patients are not homogeneous and the benefits and risks of treatment are not as clear as in younger patients. It is essential to find agreement for the treatment goals from all team members.

It is useful to set short-term as well as long-term goals. The long-term goal is the expected outcome in several weeks, eg, to live independently or to walk without using a walking aid. The goals may be changed due to medical complications or if a patient were to become unwilling or unable to continue or if they progress more slowly or quickly than expected.

4.3 Team approach and co-ownership

Comanagement requires that all core team members, ie, surgeons, anesthesiologists and geriatricians, are equal. Decisions are taken jointly. Leadership is not regulated by hierarchical structure but by medical qualification. Based on the knowledge and the expertise in the involved disciplines, leadership changes and depends on the clinical situation. However, each member has a specific role and expertise within the team.

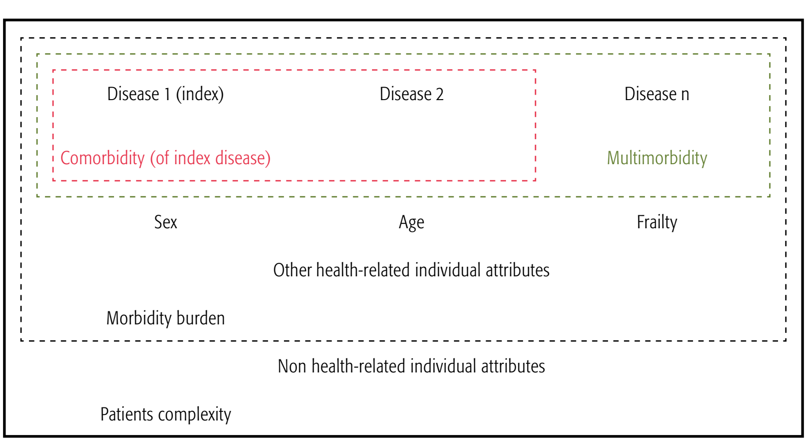

Fig 4.8-6 Comorbidity Construct.

All team members play their role at different phases of the treatment and even in different facilities. But they all must agree on the basic principles of treatment according to the guidelines and they all must feel responsible, in a sense of co-ownership, for the patient. They should know each other well and meet and communicate on a regular basis.

4.3.1 Orthopedic trauma surgeon

- Decides if an older patient requires treatment in a geriatric fracture facility or not according to the type of trauma, age, and relevant comorbidities.
- Starts the multidisciplinary process by contacting the geriatrician and anesthesiologist.
- Initiates the diagnostic workup regarding injuries.
- Takes part in the process of goal setting in cooperation with the geriatrician and anesthesiologist.
- Plans and performs surgery, and should choose the appropriate technique and implant to allow immediate full weight bearing following surgery.
- Cares for anticoagulation management, in cooperation with the geriatrician and the anesthesiologist.
- Cares for pain management, starting immediately after admission and including local anesthesia, enteral and parenteral drug treatment and nonpharmacological measures.
- Plans antibiotic management in the perioperative period.
- Responsible for rehabilitation plans together with a physiotherapist and geriatrician. Range of motion, assisted or active motion, and weight-bearing status need to be determined.
- Active management of wound infection.
- Takes part in the multidisciplinary ward round and team meetings.
- Together with other team members must audit the treatment process and adjust goals as necessary.

4.3.2 Geriatrician or medical leader

- Should be involved as soon as possible, ideally in the emergency department.
- Perform a physical examination, particularly focused on the cardiopulmonary, neurological and renal status. Collects medical history, especially comorbidities and medication. Cognitive function must be assessed using a tool such as the abbreviated mental test score. Basic assessment tools, like the Parker Mobility Score or CAM-Score, should be part of the clinical examination. Indicates further examinations, like laboratory tests, electrocardiography, chest x-ray or consulting other specialists based on this information.
- If surgery is required, the most important task is to identify and treat conditions that require preoperative optimization.
- Arranges preoperative fluid management.
- Must consider the patient's needs and living will. Both are essential aspects in terms of goal setting.
- Postoperatively, the geriatrician is in charge of medical treatment, particularly of the comorbidities.
- The geriatrician has an important role in the prevention and management of delirium.
- Management of medication.
- The geriatrician initiates calcium and vitamin D3 supplementation and considers specific osteoporosis drug treatment for every patient, eg, bisphosphonates.
- Assess risk factors for falls and develop a specific treatment plan to reduce the risk of subsequent falls and fractures.

4.3.3 Anesthesiologist

- Should be involved as soon as possible.
- Involved in acute pain relief in the emergency department, eg, local anesthesic nerve blocks.
- Clears (with the multidisciplinary team) the patient for surgery.
- Determines the type of anesthesia.
- Responsible for the immediate postoperative care of the patient.
- Benefits from cooperation between surgeons and geriatricians.

4.3.4 Orthopedic nurses

- Spend the most time with the patient. Therefore, the nursing staff have a major role in the multiprofessional team and stimulate patients in activities of daily living.
- Assess risk factors for falls, pressure sores and wounds, malnutrition, delirium and infections, manage incontinence and catheters. A specialized orthopedic nurse may be involved in secondary fracture prevention. They choose the appropriate walking aid, counsel their patients and relatives about fall risk factors and osteoporosis.
- Are involved in discharge planning together with families, carers, and social workers.

4.3.5 Physiotherapist

- Should mobilize the patient from bed on the first postoperative day.
- Helps to encourage recovery through mobilization.

- Trains older adult patients to use walking aids in the correct way.
- Helps with breathing therapy to decrease the risk of pulmonary infections.

4.3.6 Occupational therapist

- Trains patient in activities of daily living, the use of walking aids and special devices.
- Evaluates the home circumstances; this may involve a home visit.
- Prescribes tools and aids that help with activities of daily living.
- Should also be involved in the treatment of delirium. They have different options to work with confused patients and to help them to recover earlier from delirium.

4.3.7 Speech therapist

- Provides treatment, support and care for older adult patients who have difficulties with eating, drinking, and swallowing. Swallowing disturbances are more frequent in older adults. An assessment of swallowing should be integrated in the treatment process.

4.3.8 Medical social worker

- Stays in contact with the relatives, nursing homes, and rehabilitation centers.
- Evaluates home environment and social support of the patients.
- Is extremely important in terms of discharge planning.

4.3.9 Dietitian

- Malnutrition is frequent among older adult patients with fragility fractures.

4.3.10 Care coordinator or case manager

- Organizes team meetings and stays in contact with general practitioners (primary care physicians), nursing homes and rehabilitation centers.

4.3.11 Pharmacist

- Polypharmacy is a widespread phenomenon among older adult patients with a fragility fracture.
- Interactions and adverse drug reactions are strongly associated with the number of drugs. A pharmacist helps to reduce the risk of adverse effects caused by medication.

4.3.12 Psychiatrist

- Delirium is a frequent complication. A well-trained orthogeriatric team can care for patients suffering from delirium. However, there are some severe cases of delirium where a psychiatrist should be involved.
- Depression and fear of falling are other frequent symptoms. Older fragility patients often fear losing their autonomy.
- Patients with dementia may develop psychosis that requires expert psychiatric management.

4.3.13 Cardiologist or other specialists

In addition to the core team, other specialists should be involved as indicated. Examples include cardiologists for advice on the management of endovascular stents and anticoagulation and renal physicians when patients receiving long-term dialysis suffer fragility fractures.

4.4 Guidelines and protocols

"A Guide to Improving the Care of Fragility Fractures" [19] and BOA/BGS Blue Book (2nd edition, 2007) [20] may offer guidance. Protocols, checklists and clinical pathways are a practical part of guidelines and professional audit standards are also helpful to improve care.

4.5 Fast-track and urgent surgery

A well-organized "fast-track system" should limit the time in the emergency department to a maximum of 2 hours. Healthcare systems must ensure that sufficient operating room capacity is dedicated to fragility fractures and older adult patients with fractures. Delays to surgery increase health care economic costs and time to surgery has been shown to be an excellent measure of how well comanagement works.

4.6 Lifelong assistance

Several topics should be addressed during an open discussion involving the patient, relatives, home-care nursing, and nursing homes:

- Prescription of walking aids
- Adapting the home environment
- Secondary fracture prevention
- Mobility, exercises, and social integration
- Nutrition

One of the most important and most difficult discussions is about end-of-life care. Although the long-term prognosis for many patients with fragility fracture is good, some groups have a poor prognosis: 90% of patients with dementia who are admitted to a long-term nursing home survive for less than 1 year. It is important that their relatives are aware of this so that appropriate plans and advanced-care directives can be put in place.

5 Principles of medical treatment

5.1 Preoperative optimization

The standard evaluation process follows a predefined and consented pathway. Typical actions are:

- Proper hydration
- Strict hemoglobin, coagulation, and bleeding control
- Strict glucose control
- Correction of hyper and hypotension
- Avoidance of chronic obstructive pulmonary disease exacerbation with bronchodilators
- Management of cardiac dysrhythmias, such as atrial fibrillation
- Warming up in cases of hypothermia
- Monitoring the patients' psychological status to avoid delirium and subsequent complications
- Checking skin condition

5.2 Delay to surgery

The best way to avoid delay to surgery is agreed local guidelines. Regular multidisciplinary meetings are needed to streamline opinions and behaviors.

5.3 Fluid and electrolyte management

Electrolyte imbalance, especially hypokalemia and hyponatremia, are common in the both the preoperative and postoperative periods and reflect the limited reserve of the patients. This situation may worsen with diuretics and inappropriate administration of intravenous fluid and can also cause delirium. Isotonic fluids should be used exclusively and electrolyte management should be monitored regularly and adjusted appropriately.

5.4 Pain management

Adequate pain management enhances mobilization, lowers delirium rates, and may shorten the length of hospital stay. It may also be associated with reduced cardiovascular, renal, respiratory, and gastrointestinal tract morbidity [21]. Early onset of sufficient pain control—ideally at the scene of the injury—is of paramount importance and has been shown to reduce the rate of delirium by 35%.

Pain assessment is much more difficult in older adult patients, especially those suffering from cognitive dysfunction: undertreatment of patients with dementia is well documented.

Nonsteroidal antiinflammatory medications should be avoided because of potential adverse effects like acute kidney injury, worsening of heart failure, or peptic ulcers.

Paracetamol, dihydromorphine, morphine, metamizole, and piritamide are used as first-line therapy intravenously. Opiates must be carefully administered and titrated against response to reduce the risk of respiratory depression. Patients should be switched to oral administration of paracetamol, metamizole or hydromorphone as soon as possible. Opioids should only be used in low dosages, particularly in patients at high risk of delirium. When patients are cachectic or sarcopenic, dosages should be generally reduced. This is also true for patients with impaired renal function.

5.5 Regional anesthesia

There is evidence for adequate pain relief by regional anesthesia using femoral nerve blocks preoperatively [22–24]. Nerve blocks reduce the requirement for opiates and significantly reduce the incidence of pulmonary complications.

5.6 Fracture immobilization

Fractures of the lower extremity should be immobilized preoperatively by positioning the leg in a foam splint or by using pillows [25]. Skeletal or skin traction for fractures of the lower extremity tethers and confuses older adult patients and should only be applied in exceptional cases of neurovascular or soft-tissue problems caused by malalignment. In terms of pain relief, ease or quality of reduction at the time of surgery, no evidence of benefit from traction has been demonstrated [26]. The initial application of skeletal traction was noted as being more painful and costlier.

5.7 Anticoagulation

5.7.1 Clopidogrel (eg, Plavix) and "dual antiplatelet therapy"

- Surgical aspects:
  - The administration of clopidogrel is usually suspended during the perioperative period.
  - Hip fracture surgery should not be delayed for patients taking clopidogrel.
  - Meticulous surgical hemostasis is essential.
- Anesthesiological aspects:
  - Dual antiplatelet therapy with clopidogrel is a contraindication to neuroaxial anesthetic techniques because of the risk of epidural hematoma.
  - The anesthesiologist must be aware of the increased risk of bleeding and potential for blood transfusion.

  - Patients who have recently had a coronary artery stent inserted should not have clopidogrel stopped. Consultation with a cardiologist and an individual, multidisciplinary risk-benefit analysis is recommended because of the high risk of life-threatening complications like stent thrombosis.
  - If clopidogrel is suspended, regional anesthesia can be performed only after an interval of 7 days during ongoing therapy with aspirin.

5.7.2 Vitamin K antagonists (VKA, coumarins)

- Surgical aspects:
  - Anticoagulation with warfarin (eg, Coumadin), acenocoumarol (eg, Sintrom), and phenprocoumon (eg, Marcumar) should be reversed by vitamin K, until the coagulation parameters are in a subtherapeutic to normal range (INR ≤ 1.8–1.5).
  - Depending on the initial INR, urgency for surgery and actual bleeding risk, 2.5–5 mg and up to 10 mg of vitamin K are administered preferably intravenously. INR should be checked again after 4–6 hours.

5.7.3 Direct oral anticoagulants

- Surgical aspects:
  - The administration of direct oral anticoagulants (DOAC) are usually suspended during the perioperative period.
  - Urgent pre- and perioperative monitoring should include activated partial thromboplastin time for dabigatran, antifactor Xa and prothrombin time for rivaroxiban, as well as rotation thrombelastometry (ROTEM).
- Anesthesiological aspects:
  - If DOACs are suspended neuraxial anesthetic techniques can only be performed after > 24 hours depending on drug, dose and creatinine clearance.
  - Specific antidotes are eg, idarucizumab for reversion of dabigatran and andexanet alfa for reversion of the factor Xa inhibitor activity.
  - In the case of an increased bleeding prothrombin complex concentrate, activated prothrombin complex concentrate, fresh frozen plasma, fibrinogen concentrate, recombined factor VIIa, erythrocytes and thrombocytes are available.

6 Postoperative management

6.1 Dementia and delirium

Many older patients have difficulties being compliant with instructions because of frailty and/or cognitive dysfunction caused by dementia or delirium. Dementia and delirium are common comorbidities in the fragility fracture population.

Dementia is a chronic illness with relentless decline in cognitive status and is ultimately fatal.

Delirium is an acute illness and is potentially reversible, with a state of confusion related to an acute medical condition or disorientation due to a sudden change in environment.

It is important to recognize that patients with dementia may also get delirium with an increase in confusion and sudden decline in cognitive function from an acute medical condition that can be treated. Delirium is much more common in patients who have dementia and up to 60% of patients with a hip fracture have delirium in the perioperative period [27].

Delirium is an independent risk factor for length of hospitalization, an increase in functional impairments, complications, and admission to a nursing home [28]. Delirious patients cannot effectively participate in their rehabilitation following fracture and may be unable to follow instructions. Thus, surgery that allows immediate full-weight bearing is essential.

There are four key features that characterize delirium [28]:

- Disturbance of consciousness with reduced ability to focus, sustain, or shift attention.
- A change in cognition or the development of a perceptual disturbance that is not better accounted for by a preexisting, established, or evolving dementia.
- Disturbance develops over a short period (usually hours to days) and tends to fluctuate during the course of the day.
- There is evidence from the history, physical examination, or laboratory findings that the disturbance is caused by a medical condition, substance intoxication, or medication adverse effects.

The mortality rate is high (up to 30%). Only one-third of patients fully recover from delirium, the other two-thirds retain a decline in cognitive function.

Delirium is always an acute medical emergency. It requires an adequate diagnostic process. The best treatment for delirium is prevention. Guidelines for diagnosis of delirium can be useful when an experienced clinician is not available.

Common causes and risk factors for delirium are:
- Older age
- Brain disorders, eg, dementia, subdural hematoma, Parkinson disease
- Metabolic derangements, eg, hypoglycemia, hyponatremia
- Organ failure, eg, heart failure, renal failure
- Toxic agents, eg, alcohol, prescription medications
- Physical disorders, eg, trauma with systemic inflammatory response system, hypothermia
- Sensory deprivation and impaired perception of the environment, eg, taking away glasses and hearing aids
- Noisy and unfamiliar environment, frequent changes of environment, eg, trips to hospital
- Major fractures, eg, hip fracture
- Triggers like physical restraints, eg, traction, bed grids, splints, urinary catheters, and drains
- Medical complications and polypharmacy, eg, more than three medications
- Malnutrition
- Dehydration and derangement of electrolytes
- Pain
- Anesthesia
- Withdrawal of benzodiazepines or alcohol

6.2 Prevention of delirium

Treatment strategies are less effective than preventative measures.

Prevention is based on the following principles [28]:
- If possible, avoid triggers and worsening factors.
- Identify and treat possible causes.
- Provide optimal early rehabilitation to avoid further physical and cognitive decline.
- Early surgery and proactive geriatric treatment are crucial.

The following steps can be taken in clinical practice:
- Early volume and electrolytes repletion
- Avoid hypoxemia and hypothermia
- Provide sufficient pain therapy
- Review medication; look for inappropriate drugs
- Management of bowel and bladder function
- Adequate nutrition
- Early mobilization
- Minimize use of physical restraints for patient with limited mobility
- Early detection and treatment of postoperative complications
- Environmental modification and nonpharmacological sleep aids for patients with insomnia
- Orientation protocol and cognitive stimulation for patients with cognitive impairment
- Managing disruptive behavior, particularly agitation and combative behavior
- Monitoring high-risk patients with validated scores, like the confusion assessment method
- Therapy for delirium

There is no true treatment for delirium itself although acute medical conditions must be treated appropriately. Symptom control may be necessary to prevent harm or to allow evaluation and treatment. Delirium symptoms are still managed empirically and at this time there is no evidence in the literature to support a change to current practice.

In older hospitalized patients after hip surgery, low-dose haloperidol did not reduce the incidence of delirium but did reduce the severity and duration of episodes [29].

Medication must be reduced or discontinued as soon as possible and should be accompanied by the following measures:
- Protecting patients from falling by low beds, bed rails, alarms and close observation
- Providing contact to relatives

6.3 Blood transfusion management

The individual indication for transfusion of erythrocytes is derived from the hemaglobin (Hb) concentration, compensatory abilities, and risk factors:
- Transfusion is indicated if:
  - Hb ≤ 6 g/dL or 3.7 mmL/L
  - Hb 8–10 g/dL or 5.0–6.2 mmoL/L with signs of anemic hypoxia
- Transfusion is not indicated if:
  - Hb > 10 g/dL or ≥ 6.2 mmoL/L

6.4 Thromboprophylaxis

Venous thromboembolism is one of the leading causes of perioperative mortality in older adult patients with a fracture. Thus, perioperative thromboprophylaxis should be a routine aspect in the care of older adult patients with a fracture.

Commonly, low-molecular-weight heparins are used. Prophylaxis should be initiated either preoperatively or postoperatively, depending on time to surgery and type of anesthesia, eg, neuraxial.

Thromboprophylaxis should be continued at least until the patient is mobile. Some guidelines recommend extended thromboprophylaxis for up to 35 days postoperatively for patients with hip fracture although there is no clear evidence from randomized controlled trials. The risks and benefits for extended thromboprophylaxis should be assessed for each individual patient.

6.5 Malnutrition

The nutritional status should be checked for all patients with fragility fractures on admission. The most common problem is protein deficiency. For malnourished patients with hip fractures, oral supplements are recommended and may reduce unfavorable outcomes [30, 31], and may also influence mortality [32].

The following symptoms help to diagnose poor nutritional status:

- Weight loss: > 5% within 3 months or > 10% within 6 months
- Body mass index < 20 kg/m²
- Albumin level < 3.5 g/dL
- Mini-Nutritional Assessment

Step-by-step approach to treating malnourishment:

- Identify and treat possible causes
- Focus the nursing staff on malnourishment
- Assisting patients with eating
- Dietary supplements
- Parenteral nutrition or feeding tube, if enteral feeding is impossible

Recommendations for older adults:

- Calories: 1,500–2,000 kcal/day
- Protein: 12–14% of overall feed charge (0.9–1.1 g/kg body weight/day)
- Fat: maximum 30% of overall feed charge
- Carbohydrate: minimum 50% of overall feed charge
- Dietary fiber: minimum 30 g/day
- Fluids: 1.5–2 L/day

If malnourishment is identified, liquid dietary supplements should be given early. Oral dietary supplements are known to decrease mortality in older adult patients. In addition, postoperative oral dietary supplements may reduce complications in older adult patients with a hip fracture.

6.6 Rehabilitation

An acute geriatric unit with rehabilitation seems to be the most effective way to reintegrate patients into society following acute treatment in an orthopedic department. A multidisciplinary rehabilitation program improves physical outcomes, quality of life, and daily activities, reduces readmission rates and depression, and may also be associated with fewer falls [33, 34].

6.7 Secondary fracture prevention

Up to 40% of patients with hip fractures have previously suffered another osteoporotic fracture. Yet, undertreatment of osteoporosis is widespread, even among patients with fragility fractures.

A systematic approach, based on the fracture triangle—osteoporosis, falls, and force impact—is useful. All patients suffering a fragility fracture, including vertebral body fractures, should be identified and have access to a dedicated service that evaluates their risk of osteoporosis and gives appropriate advice on lifestyle measures, such as diet and exercise, falls prevention as well as medication if required.

6.7.1 Fall prevention

Each year, one in three people older than 65 years experiences at least one fall. And 9% of the falls result in an emergency department visit and 5–6% cause a fracture. Therefore, fall prevention has become a public health goal.

> Older adults tend to neglect their falls. They are often afraid that their relatives and their physicians will challenge their autonomy.

A previous fall is the strongest predictor for the next fall. Thus, from the clinical aspect, it is important to inquire about falls.

The reasons for falls are multifactorial. A standardized assessment may help to detect different risk factors. A comprehensive falls assessment program is recommended for all patients with falls in their history or fragility fractures, as it represents an essential tool for prevention of subsequent fractures. An excellent review of falls prevention in community-dwelling people was published by Tinetti and Kumar [35]. Common reasons for falls include the home environment, alcohol, medications, poor vision, balance issues, footwear, and cardiovascular problems.

6.7.2 Nonspecific treatment—vitamin D and calcium

All older adult patients with fragility fractures should be suspected of having a low level of vitamin D. Serum 25-hydroxy vitamin D levels below 32 ng/dL are considered insufficient, and below 10 ng/dL are considered deficient.

Vitamin D deficiency is typically accompanied by elevated levels of parathyroid hormone and a low-serum calcium level, ie, secondary hyperparathyroidism.

Fractures may not heal with low vitamin D levels as the body is unable to mineralize the osteoid deposited at the fracture site. Dosage of vitamin D3 for maintenance is 1,200–2,000 IU per day orally.

Calcium should only be consumed with vitamin D for proper absorption. Oral calcium supplementation: 500–1,000 mg/dL daily is recommended.

6.7.3 Specific medication for osteoporosis

Oral bisphosphonates can usually be started immediately after fracture repair. The fracture prevention effects of these medications are not reached until at least 6 months of therapy [36]. Oral bisphosphonates will not interfere with secondary bone healing but may interfere with primary bone healing and bone remodeling as they inhibit osteoclast function, which play a key role in this process.

Compliance with medication is reported to be low after 6 months with oral bisphosphonate therapy. This is due to upper gastrointestinal tract being upset and osteoporosis being an asymptomatic condition. Compliance can be improved with patient follow-up, including telephone calls, to encourage them to continue taking their tablets.

Intravenous treatment should be delayed at least 3 weeks postoperatively to prevent uptake of the drug at the fracture site. Intravenous therapy assures compliance and has an immediate onset of fracture protection but is costly and requires medical personnel to infuse the dose.

Orthopedic surgeons should be familiar with the basics of osteoporosis treatment:

- First choice: oral bisphosphonates, either alendronate or risidronate, from 3 weeks after the fracture. These can be switched to intravenous, eg, zoledronic acid 5 mg once a year.
- If osteoporotic fractures occur after treatment with bisphosphonates, the anabolic hormone teriparatide should be considered.
- Renal failure is the most important contraindication for drug treatment with bisphosphonates and teriparatide. Denosumab 60 mg sc every 6 months is another option. The antiresorptive effect is comparable with bisphosphonates.
- Following a fragility fracture, the diagnosis of osteoporosis and recommendations of how to proceed should be communicated in writing to the patient and primary care physician.

6.7.4 Reduction of the force effect

In the nursing or residential care setting, the use of hip protectors leads to a marginally significant reduction in hip fracture risk. However, the beneficial effect is not constant and lack of compliance remains a problem. For hospitals, nursing homes, or residential homes, a softer floor is an option. This floor surface can reduce the force of a fall by 50%.

7 Anesthesia

The geriatric and anesthetic preoperative assessments have a lot in common and both must work in synergy to speed up time to surgery and to avoid redundancies.

7.1 Risk stratification

Decision making about the type of anesthesia is based on the type and duration of the surgery proposed, preoperative anticoagulation, likelihood of delirium, and feasibility of neuroaxial anesthesia.

If there is a contraindication for spinal anesthesia, progression to general anesthesia is superior to a prolonged wait. In general, the intraoperative mortality risk is low. However, for high-risk cases it is useful for the surgical and anesthetic teams to discuss in advance the response to sudden cardiovascular collapse so that the teams are prepared.

7.2 Neuroaxial anesthesia

- Reduces the risk of delirium, thromboembolic events including fatal pulmonary embolism, myocardial infarction (tendency) and hypoxic complications [37].
- Increases the risk of intraoperative hypotension [38].
- Antiplatelet agents, such as clopidogrel, may interfere with neuroaxial anesthesia.
- Critical aortic stenosis is a contraindication for spinal anesthesia.
- Femoral or supraclavicular nerve blocks provide excellent anesthesia and postsurgical analgesia.
- Regional anesthesia can improve the overall outcome in the right patients and the right situations [37].

7.3 General anesthesia

- Lower incidence of hypotension and a tendency toward fewer cerebrovascular accidents [37].
- Respiratory diseases and general anesthesia are significant predictors of morbidity in patients with hip fracture.
- Sufficient preoperative hydration reduces the risk of hypotension during surgery.
- Chronological age is of lesser importance than is biological age (frailty) as far as the risks for perioperative complications are concerned.

8 Principles of surgical treatment

8.1 Time matters

Most studies recommend performing surgery within the first 24–48 hours of admission, which decreases the number of complications and mortality. Delays longer than 72 hours are associated with an increased risk of multiple complications and mortality risk [14].

The system of care must be optimized to avoid delay and iatrogenic illness. This guiding principle is often violated because of the general condition and compliance of the patient or because patients with fragility fractures are often given lower priority within healthcare organizations.

Keeping the operating time as brief as possible may also reduce the stress of surgery and its physiological burden on the patient.

8.2 Soft-tissue concerns

The musculoskeletal system of older adult patients is more vulnerable and less tolerant to stress of any kind:

- Skin may be thin and less elastic due to atrophy or malnutrition. This makes pressure sores and degloving more common. During positioning and draping, the surgeon must remember that the older adult patient's skin is fragile and can tear or be avulsed with minimal shear stresses. Shear forces during manual traction, removal of surgical drapes and localized pressure from splints and traction devices must be avoided (**Fig 4.8-7**).
- Trophic changes are common in arterial disease, which may result in ischemic changes and poor healing while venous hypertension produces edema, ulcers, and chronic skin changes in the lower legs.

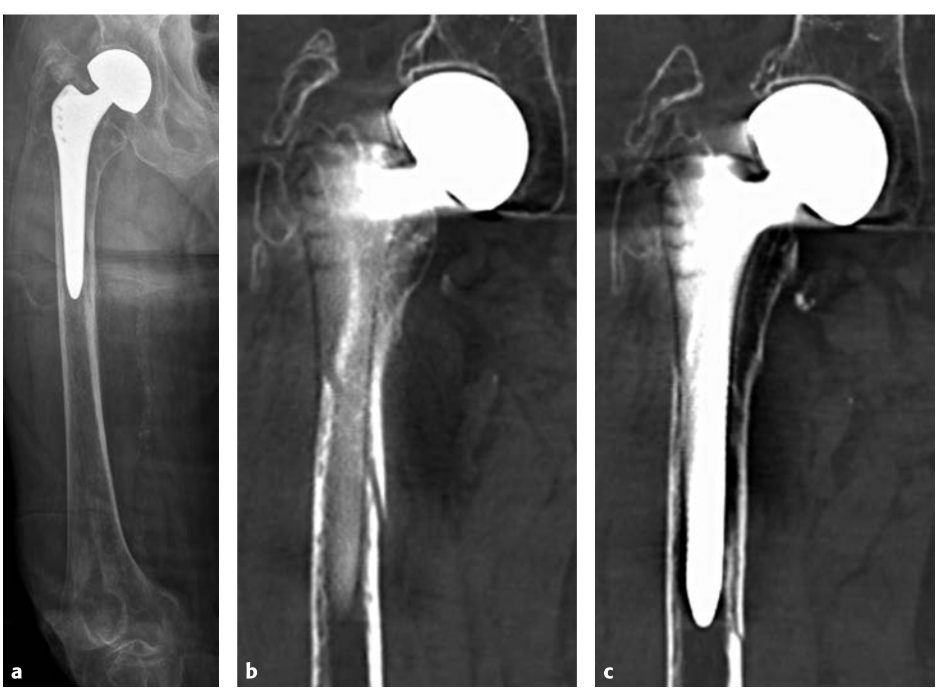

Fig 4.8-7a–i
a–c An 88-year-old woman with type B2 periprosthetic femoral fracture.

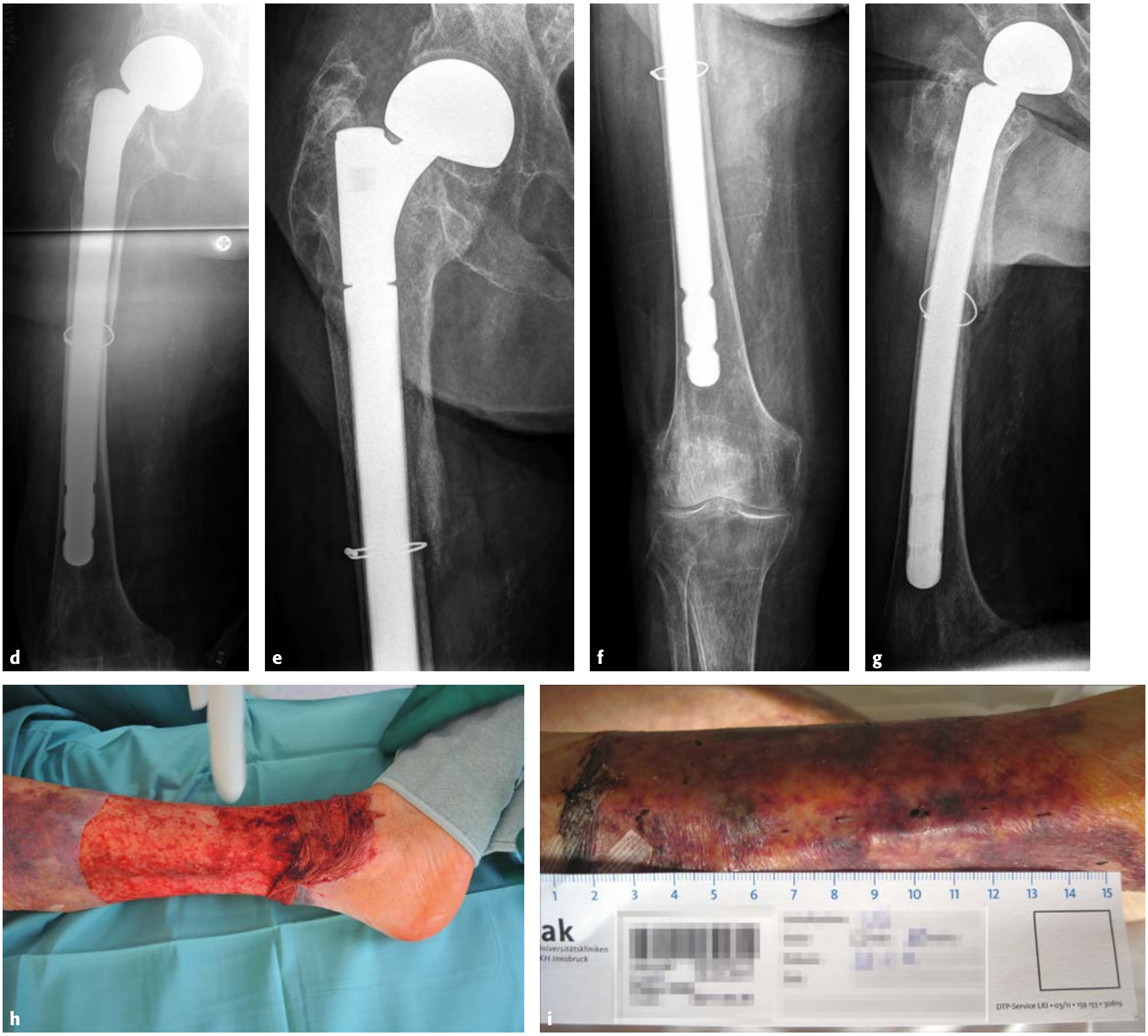

Fig 4.8-7a–i (cont)
d Revision hemiarthroplasty.
e–g Follow-up x-rays at 2 months.
h After removing the covers, a degloving of the lower leg skin by gentle traction for intraoperative reduction became apparent.
i Uneventful healing after 10 days.

8.3 Bone quality

Bony quality may vary substantially from the typical wide, osteoporotic tube with thin cortices to a thickened but brittle cortex in atypical femoral fractures in patients who have received bisphosphonates. Cortex perforation or bone fragmentation during application of clamps or lag screws is more likely to occur than in normal bone (**Fig 4.8-8**). Forceful reduction maneuvers and aggressive handling of bone may result in extension of the fracture beyond the original pattern. Clamps must be used with caution to avoid iatrogenic damage (**Fig 4.8-9**). Fracture patterns are often complex, with impaction occurring despite low-energy trauma.

8.4 Bone deformation

Bowing of the femur into varus and antecurvatum has a clinical impact in older adult patients with fractures and may make it challenging to use standard intramedullary and extramedullary implants [39]. Increased bowing of the femoral shaft is an important risk factor for fracture [40].

Geriatric bowing of the femoral shaft may be increased under the following conditions:

- Older adults with decreased bone mineralization
- Osteoporosis or osteomalacia may induce genu varum or bowing of the femur

8.5 Atypical femoral fracture

Atypical femoral fractures occur through abnormal bone and typically have thickened cortical bone, a simple transverse pattern and a periosteal reaction (beaking) on the tension side (lateral). They occur in both the subtrochanteric region and the femoral shaft following minimal or no trauma and many patients have prodromal pain for a few weeks before fracture [41]. They are associated with the long-term use of bisphosphonates but the same radiological appearance can occur with sclerotic metastases (usually breast or prostate cancer) and it has also been observed without bisphosphonate use, especially in patients of Asian ethnicities.

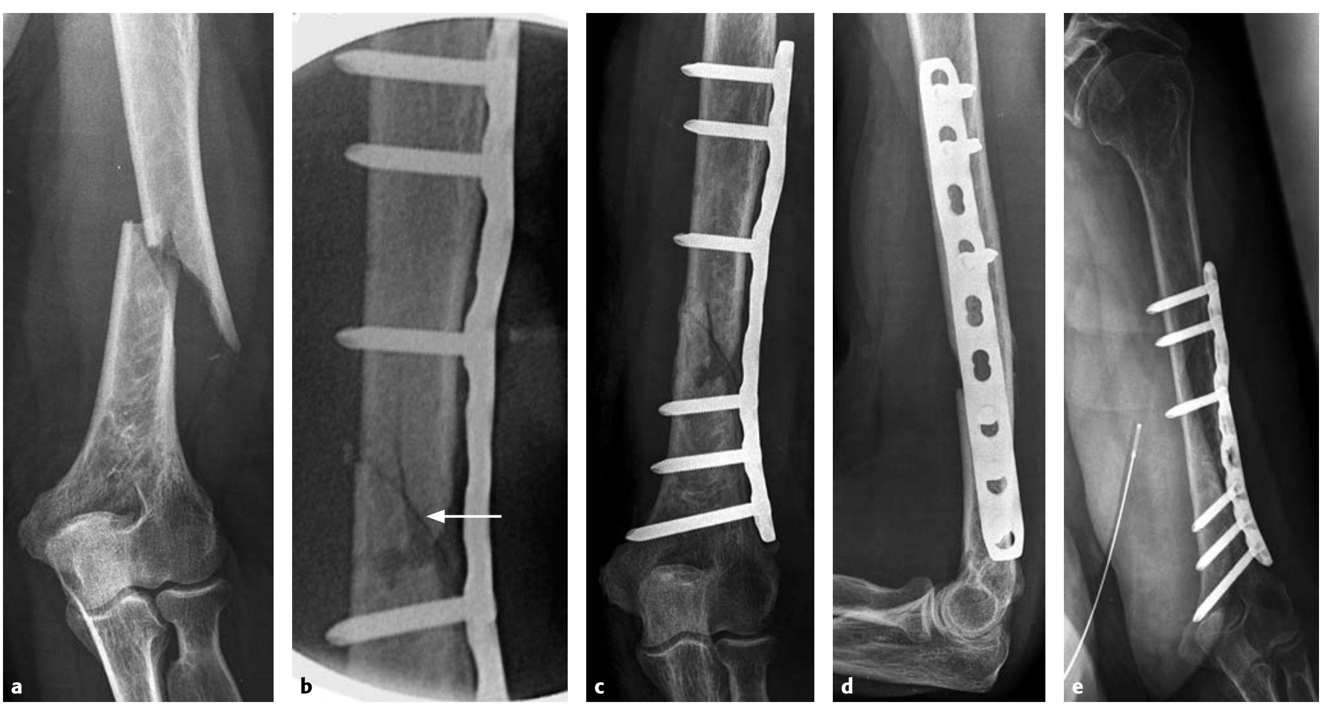

Fig 4.8-8a–e A 76-year-old woman with a simple 2-part fracture of the left humerus (**a**). After anatomical reduction, a 3.5 mm titanium lag screw was used to provide absolute stability (not displayed). After tightening the screw just a bit too much, a multifragmentary situation emerged (arrow) (**b**). The reduction was challenging and a bridging type of construct was chosen. Uneventful healing after 2 months (**c–d**) and 5 months (**e**). The patient did not have osteopenia (T-score L1-L4 0.4 and T-score femoral neck -0.9). DEXA scan describes the deterioration of bone quality only to a certain extent.

8.6 Indications for fixation

Almost all fractures of the femur and displaced fractures of the tibial shaft should be surgically managed. Ambulatory patients may benefit from ankle fracture fixation but nonoperative treatment remains an option [42] and most foot fractures can be managed without surgery in this age group. Most fractures below the knee can also be managed without surgery in nonambulatory patients. In this instance, carefully applied, well-padded splints or casts will suffice.

In the upper extremity, the need to preserve function to help the patient accomplish activities of daily living like eating, self-care, grooming, and ambulation should be considered. Surgical treatment must make a difference in terms of functionality to be indicated. In proximal humeral, olecranon and distal radial fractures, nonsurgical management often leads to acceptable, subjective functional results [43-46].

Nonsurgical management in older adult patients is less well tolerated than in younger individuals. Casts interfere with functionality and increase the risk of falls. Immobilization renders older adult patients dependent for basic activities like eating and grooming. Casts may prevent a patient from accomplishing daily activities and the patient may therefore require placement in a nursing home. Casts and braces tend to exacerbate delirium in this age group. Thus, the surgeon should always consider the option of nonoperative treatment if surgical fixation will not be sufficient to allow immediate full weight bearing without the additional support of a cast or splint.

Complete return to all activities after trauma is the general goal of treatment for those younger than 60 years. This does not apply to patients with fragility fractures. In this age group, the focus is on the restoration of individual functional demands.

8.7 The need for careful single time surgery

Hemiarthroplasty instead of fracture fixation for displaced intracapsular fractures of the hip and other primary joint replacement operations are good examples.

In a small group of bedridden, preterminal patients (6–10%), nonsurgical palliative management of hip and other lower leg fractures may be appropriate. These decisions should be team decisions involving the multidisciplinary team, the patient (if possible), and always the family.

Fig 4.8-9a–e
a A 70-year-old woman with a humeral shaft wedge fracture.
b Open reduction and reduction with multiple clamps.
c More manipulation led to an iatrogenic multifragmentary situation that was difficult to align and fix with a locking plate.
d–e Three-month result with excellent clinical function.

8.8 Weight bearing as tolerated and functional after treatment

Early postoperative mobilization and unrestricted weight bearing as tolerated are important principles for various reasons in this patient group. Prolonged bed rest or "sitting mobilization" are not good options. The daily loss of muscle mass while staying in bed is dramatic. Current surgical procedures and implants permit immediate unrestricted weight bearing. Reasons for immediate weight bearing include:

- Loss of muscle mass
- Restriction of weight bearing inflicts a significant physiological burden on older adult patients. The energy expenditure for ambulation without full weight bearing increases fourfold and leads to rapid exhaustion [47].
- Patients with fragility fractures are often physically unable to perform partial weight bearing due to sarcopenia, lack of proprioception, and weakness in the arms.
- Dementia and delirium make many patients noncompliant.
- Partial weight-bearing protocols are not evidence based.
- Pain, even when taking analgesia, will guide a patient to use the appropriate amount of load and safe progression with ambulation.
- Early weight bearing can promote fracture healing and union of the fracture without increasing loss of fixation [48, 49].

8.9 Fixation techniques

The major technical problem the surgeon faces is the difficulty in securing fixation of the implant to the osteoporotic bone. Bone mineral density correlates linearly with the holding power of screws. If the load transmitted at the bone-implant interface exceeds the strain tolerance of osteoporotic bone, microfracture and resorption of bone with loosening of the implant and secondary failure of fixation will occur. The common mode of failure of internal fixation in osteoporotic bone is bone failure rather than implant breakage.

The principles of fracture management are applicable to most fragility fractures, but the decrease in bone strength requires some adaptions to decrease the risk of failure.

Important techniques include:

- Relative stability, including bridging and buttress fixation
- Angular stability
- Intramedullary nails
- Controlled bone impaction
- Bone augmentation
- Joint replacement

8.9.1 Positioning

It is essential to carefully position the patient on the surgical table. Avoidance of pressure sores is of importance as sores significantly interfere with recovery. In most cases, the supine position is preferred in the elderly to allow for overall care by the anesthetist. When under regional anesthesia, the patient can breathe easier when supine.

8.9.2 Minimal invasive surgery

The main advantages of minimal invasive surgery techniques, including reduced soft-tissue dissection and less bleeding, apply even more in older adult patients.

8.9.3 Relative stability

In osteoporotic bone, it may not always be possible to obtain and maintain anatomical reduction and compression with absolute stability because the weakened cortical and cancellous bone may fail under compression.

As a simple rule, intramedullary devices should be preferred to extramedullary ones if fracture morphology and soft tissues allow this option.

Short plates with every screw hole filled will cause concentration of forces, which may exceed the strain tolerance of osteoporotic bone. Osteoporosis demands basic rules for the safe use of internal fixation [50, 51]:

- Simple transverse fractures are best addressed by intramedullary implants. If this is not possible, the fracture gap must be closed as much as possible. If plates are used, compression should be obtained with the plate and three to four holes should be left free and three to four bicortical locking head screws in each main fragment are needed after compression is obtained.
- Spiral 2-part fractures should be reduced as much as possible and preliminarily fixed with suture or cerclage wire or cables with minimal soft-tissue stripping. If screws are used, they should be tightened with caution as "reduction screws". The first plate screw should be inserted at the end of the fracture line. Again three to four bicortical locking head screws in each main fragment are necessary (**Fig 4.8-10**).
- Multifragmentary fractures require the first screws to be placed adjacent to the fracture zone. Long plates are used with four bicortical screws in each main fragment.

Fig 4.8-10a–f A 77-year-old woman with a pertrochanteric fracture (**a**). Fixation with a proximal femoral nail antirotation (**b**). The nail was removed 1.5 years later because of lateral thigh pain. Three years later, she sustained a spiral diaphyseal fracture (**c–d**). Minimally invasive reduction in lateral position and preliminary fixation with suture wire was performed. Definitive fixation with relative stability and distal femoral plate was performed, with the first proximal screw starting at the end of the fracture. Uneventful healing with a little callus formation (**e–f**). Ideally, a longer plate to protect the whole femur could have been used. A reasonable alternative was a long cephalomedullary nail.

8.9.4 Splinting the whole bone

Subsequent fractures adjacent to the end of plates, nails or prosthesis occur due to the stress riser between the stiff implant and the osteoporotic bone. If possible, the whole bone should be protected with the first fixation including the femoral neck in femoral diaphysis and periprosthetic fractures (**Fig 4.8-11**).

8.9.5 Implants

Locking implants (fixed or variable angle) as well as angular stable locking options for intramedullary nails all have biomechanically proven superior stability in bone with reduced cortical thickness.

Locking head screws cannot be overtightened and rendered unstable (because the thread gets destroyed). They should always be used in a bicortical mode because of the reduced working length with a single thin cortex.

These screws also have a larger core diameter than conventional screws, which results in higher pullout strength and overall strength. This is especially helpful in metaphyseal bone, where intramedullary nails may fail. The holding power of the locking head screws can further be increased by orienting them in different directions. This method is used with PHILOS, the screw-in-screw concept of the Multilock nail for the proximal humerus, and the anatomical distal femur and proximal tibia LCPs.

A blade for fixation of pertrochanteric fractures or distal femoral fixation is more stable than a screw. Inserting a blade condenses the bone around the implant while screw insertion always produces some bone loss.

Fig 4.8-11a–c A 92-year-old woman with a periprosthetic fracture (**a**). Open reduction and fixation with cerclage wires and revision arthroplasty with a long-stemmed implant with locking options was performed. The distal femoral plate protects the bone between the two prostheses (**b–c**).

8.9.6 Alignment

Correct anatomical alignment represents an important prerequisite for uneventful bone healing. Fixation of osteoporotic bones is less tolerant of any deviation than younger bone. Specifically, varus malalignment should always be avoided in femoral and tibial fractures.

8.9.7 Impaction

Bone impaction is a key element in the surgical management of osteoporotic fractures as it reduces the risk of implant failure. In many cases impaction is created by the trauma itself, eg, the valgus impacted fracture of the femoral neck. Controlled impaction can be attained by tensioning internal fixation devices. Implants, such as the dynamic hip screw, allow controlled impaction of the fracture while preventing penetration of the joint by the hip screw.

8.9.8 Augmentation with bone cement

Fixation in osteoporotic bone can be improved by augmenting the bone with a substitute. Augmented purchase of screws prevents hardware migration, cut out, cut through and pull out. It can also be used to support the bone structure and prevent it from collapsing, eg, vertebral body or tibial plateau fracture.

Polymethylmethacrylate bone cement still seems to be the material of choice and is used to fill voids that mainly result after reduction of fractures through cancellous bone that was impacted by the trauma. A typical example is vertebral body compression fractures treated after closed reduction with vertebroplasty. The same principle is applied around proximal tibial fractures and prevents them from collapsing.

In standardized implant augmentation, the cement is typically injected with specific cannula through perforated implants to improve the bone-implant interface by preventing high bone strain and distributing the force transmission to the bone in a load-sharing rather than load-bearing configuration (**Fig 4.8-12**). In nonstandardized implant augmentation, the cement is applied via the screw hole before the implant is inserted.

Fig 4.8-12a–d An 82-year-old man with a proximal femoral fracture (**a**). Closed reduction with a traction table was performed. After insertion of nail and blade, the decision was taken to augment the blade because of severe osteoporosis and very low resistance while inserting the blade. An intraoperative contrast dye test demonstrated no arthrogram, ie, no perforation into the hip joint (**b**). Polymethylmethacrylate (4 cc) was injected through a special cannula. Result after mobilization with center-center position of the head-neck-element and equally distributed cement (**c–d**).

Autografts

Cortical-cancellous bone autografts to assist fracture healing and to fill gaps can also be harvested in older adult patients, but because of osteoporosis they may have limited mechanical properties and there may be limited amounts of bone at the donor sites. Unless they are used to fill voids, grafts should be fixed to the bone with cortical screws or cables. As well, adjuncts such as bone cement can be used (**Fig 4.8-13**).

Allografts

Allograft bone has good mechanical properties but less osteogenic potential. In osteoporotic conditions, allografts are used to fill metaphyseal voids and prevent articular and other fragments from displacing. This can be helpful in fractures of the proximal and distal humerus, distal radius, and proximal tibia.

Strut allografts are also used in periprosthetic femoral fractures with poor bone quality to enhance the mechanical strength of the construct (**Fig 4.8-14**).

Joint replacement

Joint replacement (total or hemi) plays an important role in older adult patients. It is commonly used in the proximal femur, mainly with femoral neck fractures. The indication for replacement arthroplasty is not so clear in proximal humeral fractures. Studies of C3 fractures of the distal humerus show that a total elbow replacement is superior to open reduction and internal fixation in terms of functional results but there are no long-term (5-year plus) follow-up studies available yet. There are not yet enough comparative studies to give general recommendations in all periarticular areas.

9 Outcome

9.1 Bone healing

Fracture healing in osteoporotic bone comprises the normal stages and concludes with fracture union. However, the healing process may be prolonged and it seems obvious that there are differences in fracture healing in older age groups. Even though delayed fracture healing is not apparent in patients, the decreased healing capacity in osteoporosis may be reflected by an increased failure rate of implant fixation. Fracture healing is believed to require the migration of mesenchymal stem cells into the fracture callus. Mesenchymal stem cells from osteoporotic individuals may be fewer in number and have a lower proliferative response [52]. The number of stem cells is reduced in older adult patients, which might explain the age-related decrease in the number of osteoblasts. Bone cells from patients with osteoporosis may also be impaired in their long-term response to mechanical stress [53]. The periosteum itself is also less responsive with aging.

9.2 Mortality

After a hip fracture, mortality rates range from 12% to 35% in the first year, and is higher in men than in women. Mortality rates increase with age, the number of comorbidities, and low prefracture mental and physical function. Low bone mineral density is also a risk factor.

9.3 Orthogeriatric care

Comparison of a comprehensive medical and nursing approach to older adult patients with fracture against usual orthopedic care revealed dramatic improvements in time to surgery, length of hospital stay, readmission rates, and numerous complications. Rates of delirium are reduced, as are bleeding complications and infection rates. This approach seems to offer many benefits to patients and healthcare systems [54].

In a recent systematic review and metaanalysis based on 18 studies, Grigoryan et al [55] aimed to determine if orthogeriatric collaboration models improve outcomes. The overall metaanalysis found orthogeriatric collaboration was associated with a significant reduction of in-hospital mortality and long-term mortality. Length of stay was significantly reduced, particularly in the shared care model.

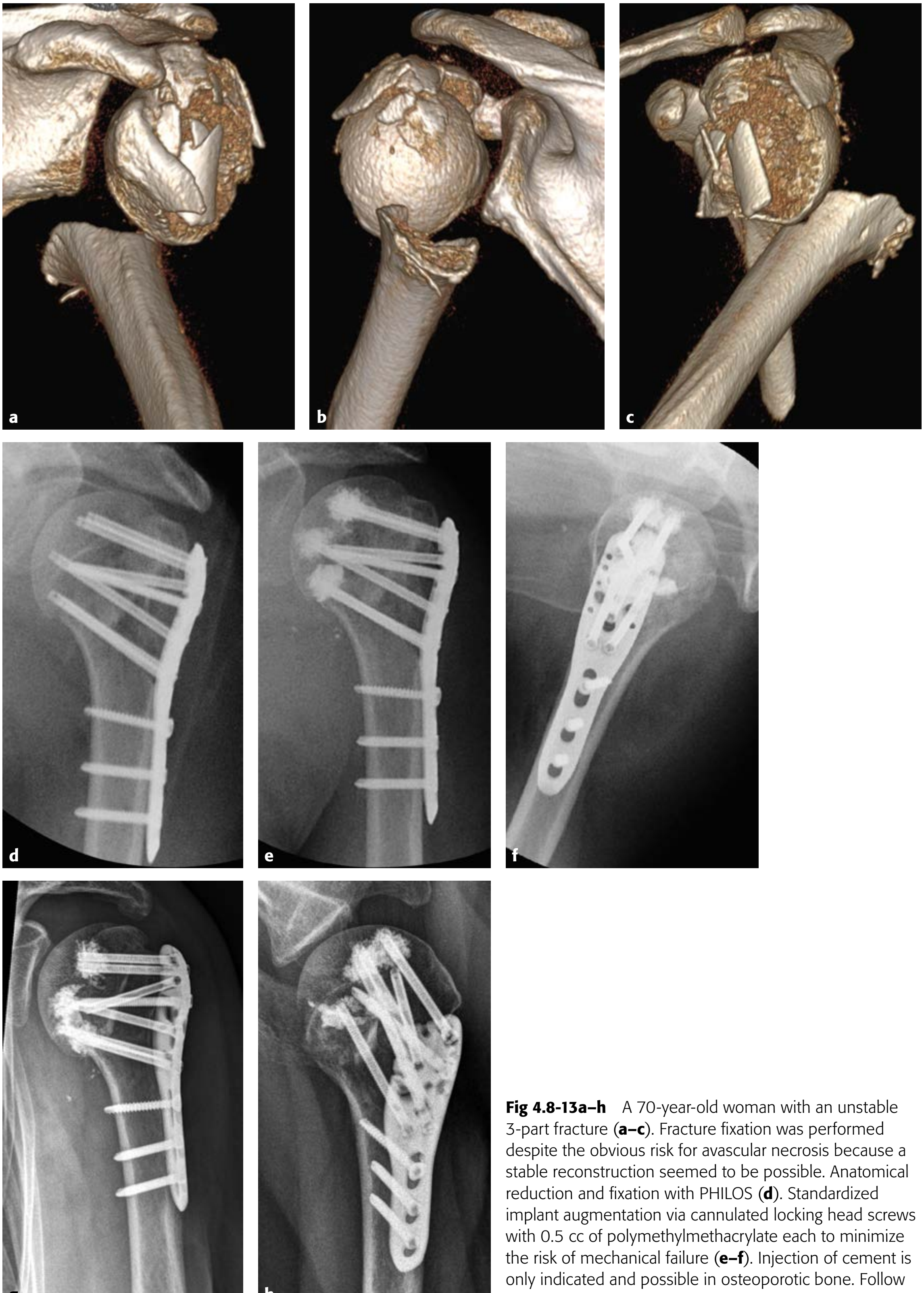

Fig 4.8-13a–h A 70-year-old woman with an unstable 3-part fracture (**a–c**). Fracture fixation was performed despite the obvious risk for avascular necrosis because a stable reconstruction seemed to be possible. Anatomical reduction and fixation with PHILOS (**d**). Standardized implant augmentation via cannulated locking head screws with 0.5 cc of polymethylmethacrylate each to minimize the risk of mechanical failure (**e–f**). Injection of cement is only indicated and possible in osteoporotic bone. Follow up after 3 months (**g–h**).

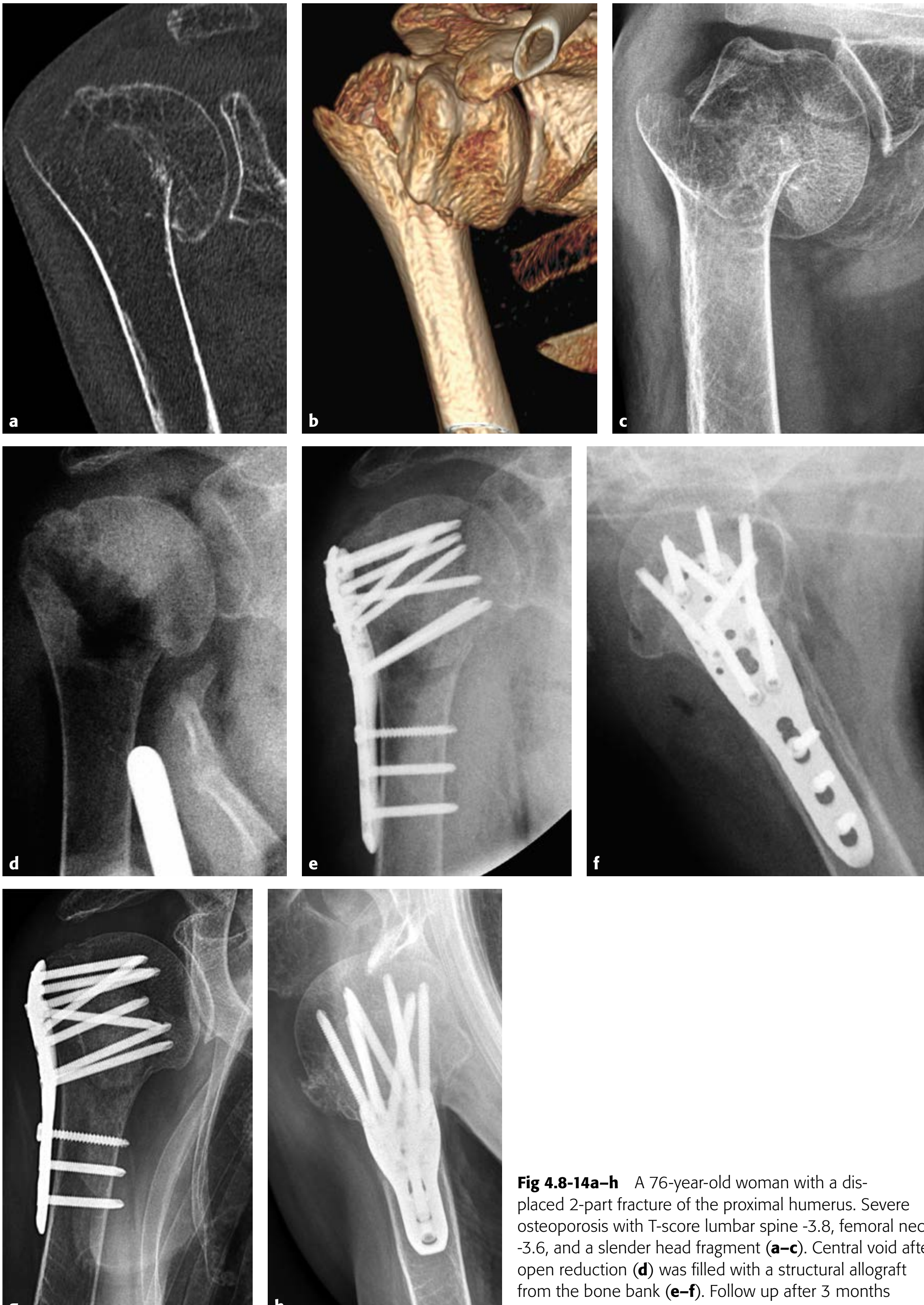

Fig 4.8-14a–h A 76-year-old woman with a displaced 2-part fracture of the proximal humerus. Severe osteoporosis with T-score lumbar spine -3.8, femoral neck -3.6, and a slender head fragment (**a–c**). Central void after open reduction (**d**) was filled with a structural allograft from the bone bank (**e–f**). Follow up after 3 months (**g–h**).

Classic references | Review references

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11 Acknowledgments

We thank Norbert Suhm, Tobias Roth, and Chang-Wug Oh for their contributions to the third edition and Peter Giannoudis and Erich Schneider for their contributions to the second edition of the *AO Principles of Fracture Management.*