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Introduction

Osteoporosis is defined by the World Health Organization as a reduction in bone mass of more than 2.5 standard deviations below the mean for a young adult (i.e., a T score of $<-2.5$).

In osteoporosis patients, even simple falls can result in fragility fractures, although—in other incidents—they may suffer high-energy fractures as well.

Patients with osteoporosis who fall and suffer a fragility fracture represent a major public health challenge in countries with aging populations.

Every year, approximately 200,000 osteoporotic fractures occur in Great Britain (population 60 million). Most fractures of the hip and radius are caused by falls. Because of this strong correlation, the consensus view is that falls, osteoporosis, and fractures must be addressed together. Several measures have been suggested for the prevention of falls in the elderly including strength and balance training, home hazard assessment and modification, vision assessment, medication review, cardiac pacing when necessary, and cognitive behavioural interventions. Medical management of osteoporosis is directed towards administration of anabolic agents, antiresorptive agents, calcium, vitamin D, and hormone replacement.

The surgical management of fractures in patients with osteoporosis is difficult due to poor bone quality. In particular, fixation of fractures affecting the metaphyseal region of long bones can be associated with an increased rate of complications. For example, there can be implant subsidence or cut-out, failure of fixation, nonunion, malunion, and the need for reoperation. This chapter focuses on the issues and strategies a surgeon should use to optimize fixation of fractures in osteoporotic bone.

Epidemiology of osteoporosis

Osteoporosis is a common disease in the elderly. 40% of women and 14% of men over the age of 50 years will suffer fractures related to this disorder [1].

Worldwide, 100–200 million people are at risk of osteoporotic fracture annually [2]. With an ever increasing number of elderly people, it is anticipated that osteoporosis will become epidemic in the years to come.

Women of all ethnic groups seem to be prone to both osteopenia and osteoporosis. Bone mineral density (BMD) declines with age in all women. Men are also at considerable risk of developing osteoporosis as they age. In the USA, more than 2 million men are estimated to have osteoporosis at present and another 12 million are estimated to have low bone mass.

The most frequent fractures in men aged between 50 and 54 occur in the ribs, spine, and wrist. In women in this age group, the common fracture sites are wrist, spine, ribs, and humerus. After the age of 50, most fractures are 2–3 times more common in women, but the likelihood of fracture increases with age in both sexes [3].

The most important socioeconomic impact of osteoporosis is the rising incidence of proximal femoral fracture in the elderly. In the year 2000, there were an estimated 424,000 hip fractures worldwide in men and 1,098,000 in women. Based on changing demographics and the increase in life expectancy, by the year 2025 hip fractures in men are expected to rise by 89%, resulting in 800,000 hip fractures per year, while the number of hip fractures in women will rise by 69% and reach 1.8 million [4].
Global, there is considerable geographical variation in the incidence of hip fractures [5].

Rates are highest in Caucasians living in northern Europe, followed by Caucasians living in North America. The rates are lowest in African populations, whereas the rates in Asians are in between. The low incidence of osteoporosis in developing countries may be partly due to the lower life expectancy of people. However, by the year 2050, more than half of all hip fractures in the world will occur in Asia.

3 Osteoporotic bone

3.1 Densitometry and fracture detection

Accurate diagnosis and assessment of osteoporosis is important for the treatment of fragility fractures in the elderly. Bone mineral density (BMD) describes the amount of bone contained within a particular structure of the musculoskeletal system. It is either measured as the density on an area in units of g/cm², or as a true volumetric density in g/cm³. The two values cannot be compared as the area density depends on bone size and composition, while the volumetric does not. Bone mineral content (BMC), measured in units of grams, is less useful for interindividual comparisons because it is influenced by bone size.

Current densitometric methods include plain-film radiography and absorptiometry, single and dual x-ray absorptiometry (SXA, DXA), quantitative computed tomography (QCT), quantitative ultrasound (QUS), and quantitative magnetic resonance imaging (QMR) [6]. Plain-film x-rays should not be used for densitometry, because exposure time, tube voltage, anode characteristics, beam filtration, film/screen properties, film processing, etc influence readings. It has been estimated that 20–40% of bone mass must be lost before a decrease can be seen on x-rays [7]. Olschewski et al [8] assessed the bone density of patients with a unilateral distal radius fracture using standard x-rays, and found a specificity and sensitivity of only 61%. This is not enough to predict the osteoporosis status.

QCT measures true volumetric density and therefore is able to discriminate between cortical and trabecular bone, but its precision is not better than DXA. Cross-sectional bone loss measured by QCT is typically 1.2% per year. Accurate radiographic diagnosis of fractures is often difficult. Delmas et al [9] investigated vertebral fractures in a multicenter, multinational, prospective study. A false negative rate of 34% and a false positive rate of 5%, independent of geographic regions, were found. Lill et al [10] compared five different fracture classifications for distal radius fractures with the failure loads and fracture patterns in a laboratory study. The Cooney and AO classifications were found to have a better correlation with fracture severity than others, but radiography in general led to an underestimation of the true severity of the fractures. Some femoral neck fractures are also difficult to diagnose from x-rays. Lee et al [11] submitted 28 patients to additional magnetic resonance imaging and found undetected neck fractures in 50%, equaling 4% of all femoral neck fractures.

MRI has become the investigation method of choice for hip pain in elderly patients suspected of having a fracture but who have a normal hip x-ray.

3.2 Structure and properties

Osteoporosis influences both strength and stiffness of bone. Both decrease with age and degree of demineralization. This is true for cortical and cancellous bone.

In cortical bone, the decrease of stiffness and strength is in the region of a few percent per decade. Endosteal diaphyseal
resorption and medullary expansion occur in men and women, but only men seem to exhibit concurrent subperiosteal bone apposition in the femur and tibia [12]. Thus, men show little change in cortical area and some increase in strength, whereas women show a decrease. The changes in outer and inner cortical diameter affect the bending and torsional characteristics of the whole bone. In addition, decreased cortical thickness greatly affects the holding capacity of screws [13]. There is also a decrease of density in cortical bone due to an increase in porosity.

In cancellous bone, the change in bone structure is due to decreasing trabecular thickness, interruption of the trabecular network, reduction of trabecular number, and reduction of trabecular connectivity. As much as age, bone loss and reduced activity also lead to deterioration of bone. There is vast evidence that mechanical usage influences bone mass (Wolff’s Law), but, unfortunately, exercise only leads to minimal increase in bone mass. Running as a high-impact exercise has been shown to be more efficient in this respect than walking or cycling.

3.3 Healing

- Fracture healing in osteoporotic bone comprises the normal stages and concludes with fracture union. However, the healing process may be prolonged [14].

There is evidence of this from animal models of osteoporosis. Lill et al [15] performed in vivo bending stiffness measurements and found a delay of 2 weeks in the osteoporotic sheep model (ovariectomy, low calcium diet, and steroids), but no difference in final strength when compared to healthy sheep. Even though delayed fracture healing is not obvious in patients, the decreased healing capacity in osteoporosis may be reflected in a dramatically increased failure rate of implant fixation [16]. There are several explanations possible for this effect. Mesenchymal stem cells from osteoporotic individuals may be fewer in number and have a lower proliferative response [17], which might explain the age related decrease in the number of osteoblasts [18]. Mesenchymal stem cells of postmenopausal women differ to those of premenopausal women in having a lower growth rate and exhibiting a deficiency to differentiate along the osteogenic lineage [19]. Bone cells from osteoporotic patients may also be impaired in their long-term response to mechanical stress [20].

4 Internal fixation in osteoporotic bone

Osteoporosis increases resorption and decreases calcium deposition resulting in thinner cross-link connections in the trabecular bone framework. The overall diameter of the long bones may remain the same but the ratio of cancellous to cortical bone is increased. The thinner layer of cortex is weaker and predisposes to low-energy or fragility fractures, which often have a complex fracture pattern.

- The major technical problem the surgeon faces is the difficulty to produce secure fixation of the implant to the bone. There is less cortical and cancellous bone for the screw threads to gain purchase and the pullout strength of implants is significantly lower in 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 high rate of complications has encouraged extensive research into the development of implants that improve the
bone-implant interface by preventing high bone strain and distributing the force to the bone in a load-sharing rather than load-bearing configuration.

- **Internal fixation must take the local bone mineral distribution into account. This varies with fracture location, age, and gender.**

Proper preoperative planning, implant choice, fixation technique, and understanding of the biomechanical principles are essential [21].

The general principles of fracture management are applicable to most fragility fractures, but the decrease in bone strength requires some adaptations in surgical technique for these cases. To decrease the risk of failure at the bone-implant interface the following is recommended:

- techniques of relative stability including bridging and buttress fixation;
- devices providing angular stability;
- intramedullary nails;
- controlled bone impaction;
- bone augmentation;
- joint replacement.

- **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.**

Thus, internal fixation techniques that provide absolute stability through interfragmentary compression are usually not appropriate. Intramedullary nails are load sharing and provide relative stability. They seem to be the most efficient method of reducing strain at the bone-implant interface but often are not able to maintain alignment because of a wide medullary cavity. Plates are load bearing: Due to their eccentric position, very long implants fixed with few locking head screws should be applied to distribute the stress. Short plates with every screw hole filled will cause concentration of forces, which may exceed the strain tolerance of osteoporotic bone. The holding power of conventional plates is based on preload and friction at the plate-bone interface as the plate is pressed against the bone surface. Failure of fixation starts at the screw, where strain is greatest (Fig 4.8-1). Mechanical failure at this screw then puts additional strain on the next screw and there is progressive failure of the implant.

- **Sequential screw pullout always starts at the end of the plate where motion (and strain) is greatest.**

Fixed-angle devices, such as the angled blade plate, DHS, and DCS, are very useful in osteoporotic bone. The internal fixator principle (chapter 3.3.4) is based on the angular stability of the

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*Fig 4.8-1a–b  Examples of failure of conventional plates in osteoporotic bone with sequential screw pullout.*
locking head screws (LHS). In addition, these screws have a larger core diameter than conventional screws, which results in a higher pullout strength and overall strength. This is especially helpful in metaphyseal bone, where intramedullary nails may fail. The holding power of the LHS can further be increased by orienting them in different directions: This method is used with the PHILOS for the proximal humerus and the LISS for the distal femur and proximal tibia.

- **Bone impaction is a key element in the surgical management of osteoporotic fractures as it reduces the risk of implant failure.**

In many cases, like, for example, in the valgus impacted fracture of the femoral neck, impaction is created by the trauma itself. Controlled impaction can be attained by tensioning internal fixation devices. Implants, such as the dynamic hip screw (DHS), allow controlled impaction of the fracture while preventing penetration of the joint by the hip screw.

Fixation strength can also be improved by bone augmentation using bone autograft or allograft, bone cement, or bone substitutes. This is discussed in chapter 4.8:4.2.

Joint replacement may be a good option in articular fractures and some metaphyseal fractures where the complication rate of internal fixation is high. It may also be considered for patients with preexisting osteoarthritis. It is commonly used in the proximal femur and, in rare cases, the distal and proximal humerus.

### 4.1 Implant based solutions

Most implants for fracture treatment have been developed for use in young, healthy bone. Not all of these implants have shown equal success when applied in osteoporotic bone. This is particularly true for the application of implants to the metaphysis, where loss of bone density is more pronounced. Curtis et al [22] provided an overview of the different principles and devices based on an analysis of patents: Not all of those devices found their way into the clinic, but knowledge of the limiting elements of each of these devices in poor bone is helpful in patient treatment.

The advantages of angular-stable implants have been discussed and developments to provide angular stability for the interlocking screws of intramedullary nails have recently been introduced. Treatment of unstable, proximal humeral fractures using such nails has demonstrated that stable osteosynthesis in elderly patients can be achieved [23]. An alternative element in intramedullary nail fixation is the spiral blade, which is stronger and stiffer than conventional interlocking screws and better suited for osteoporotic bone [24].

### 4.2 Augmentation based solutions

Fixation in osteoporotic bone can be improved by changing the principles and techniques of hardware application or by augmenting the bone with a substitute. The substitute can improve the purchase of the implant, in particular of screws, and prevent hardware pullout. It can also be used to support the bone structure, for example, of a vertebral body or the tibial plateau, and prevent it from collapsing.

- **Cancellous or corticocancellous bone autografts to assist fracture healing are probably still the best. However, availability, quality, and quantity, especially in case of osteoporosis, are limited and morbidity at the harvesting site may be considerable.**

An alternative is to use allograft bone, which has good mechanical properties but less osteogenic potential. Allograft fibular struts can be used in severely osteoporotic diaphyseal fractures; they act as an augmentation device outside or within...
the medullary canal. They can also be combined with plates, screws, or cables to enhance fixation of periprosthetic fractures. The struts improve local bone stock for screw purchase and can be incorporated to span regions of diaphyseal deficiency. Femoral head allograft can be cut to shape and used to support the articular surface in case a metaphyseal defect has resulted after reduction of an articular impaction.

Polymethylmethacrylate (PMMA) cement is a synthetic substitute material that has been used successfully, especially in supracondylar fractures of the femur. Both laboratory and clinical studies have demonstrated that screws in osteoporotic bone have increased resistance to pullout when PMMA is used [25]. Eriksson et al [26] compared conventional PMMA and calcium phosphate cement in laboratory tests and found PMMA to be superior in torque and pullout, irrespective of the type of implant. Injectable calcium phosphate cement proved more useful in low-density bone (Fig 4.8-2). The advantage of calcium phosphate cement appears to be its ability to bioabsorb and remodel into bone. This cement can also be used to fill bone defects. However, large volumes may impair fracture healing.

- Resorbable bone cements, made of calcium phosphate and calcium sulphate, have been developed to fill bone defects in metaphyseal fractures and to complement hardware fixation in osteoporotic patients. They improve the interface between screws and bone and have the advantage of being resorbed and replaced by bone.

Hip fractures due to osteoporosis have been treated using the dynamic hip screw and calcium phosphate cement [27]. These cements (chapter 1.3) are used to fill voids caused by comminution or severe osteoporosis.

**Fig 4.8-2a–b** Treatment of osteoporotic distal radius fracture with the supplementary use of calcium phosphate cement for bone augmentation in combination with a plaster cast.
4.3 Biology based solutions

It is generally believed that fixation in osteoporotic bone is mainly a question of mechanics and primary stability. However, the importance of biological processes in the vicinity of implants, ie, postoperative bone neoformation, needs to be clarified (chapter 1.4). The bone-implant interface has been shown to be influenced by hydroxyapatite coatings and a comparative study of osteoporotic wrist fracture patients who received hydroxyapatite-coated versus standard external fixator pins [28] concluded that the patients with hydroxyapatite-coated pins had better pin fixation and less pin-track infections. Such coatings may also be used as drug delivery systems for bisphosphonates [29]. Surfaces could also be used to deliver growth factors (eg, BMP-2, BMP-7, TGF-β, or FGF), which influence bone formation and may improve implant fixation locally [30]. However, their benefit in osteoporosis remains unproven.

5 Surgical treatment in specific, fractured, osteoporotic bones

5.1 Special aspects of treatment of elderly patients

The treatment of fractures is determined by the fracture type and location, the soft tissues, and the general condition and compliance of the patient. These factors determine the “personality” of the injury. In the elderly, each of these factors may present particular problems. Soft tissues and skin may be thin due to atrophy or malnutrition and this makes degloving injuries more common. Arterial disease may result in ischemic changes and poor healing while venous hypertension produces edema, ulcers, and chronic skin changes. Fracture patterns are often complex, with impaction occurring despite low-energy trauma.

Patient factors are often complex in the elderly as the majority of patients have medical comorbidities, which require careful assessment (chapter 2.1). Preinjury mobility may be reduced and impaired cognitive function may render a patient unable to participate actively and reliably in rehabilitation. Elderly patients do not tolerate prolonged bed rest as this predisposes to problems such as thromboembolism, decubitus ulcers, urinary tract and chest infections. It is essential that these patients are mobilized early in the postoperative period, and an important goal of fracture management, including implant selection, should be to permit immediate weight bearing; partial weight bearing is often impossible in the elderly.

- Elderly patients have complex preinjury functional, medical, and cognitive problems. A team approach including geriatricians, anesthesiologists, and other appropriate specialists is essential for providing optimal care.

5.2 Fractures of the proximal humerus

Proximal humeral fractures, particularly in osteoporotic patients, remain a very difficult problem. Fractures are often complex and associated damage to the rotator cuff muscles results in poor shoulder function. In osteoporotic patients, the small size and the poor bone stock of the humeral head fragments do not allow good purchase for internal fixation devices. Conventional plate osteosynthesis has been associated with high complication rates due to loss of fixation, screw pullout, and collapse of the head fragment. Tension band wiring offers the potential to provide better stability but often requires valgus impaction of the head fragment. This may result in shortening, with laxity of the deltoid muscle and subsequent subluxation of the shoulder joint. Less invasive methods, such as closed reduction and percutaneous pinning, require advanced surgical skills and are not always successful due to painful wire migration. Joint replacement may be a reasonable option and provides good pain relief.
However, function remains poor because of rotator cuff problems.

Intramedullary devices theoretically have biomechanical advantages and have been developed for fixation of proximal humeral fractures. Their central location is considered beneficial by providing a uniform load distribution.

The proximal humeral locking plate (PHILOS), with angular-stable locking head screws that enter the humeral head at various angles, appears to provide satisfactory purchase in osteoporotic bone. Additional plate holes allow sutures to anchor the rotator cuff. The anatomical design allows for an easier or possibly minimally invasive application of the plate and reduces subacromial impingement (Fig 4.8-3).

5.3 Fractures of the distal radius

Small degrees of malunion in the distal radius are well tolerated in the elderly and cause little functional impairment. However, radial shortening of more than 5 mm or dorsal angulation of more than 10° are associated with reduced grip strength, restricted forearm rotation (due to distal radioulnar joint dysfunction), and increased pain. Nonunion is rarely a problem in the distal radius and so the main aim of surgery is to reduce the incidence of malunion. Although there have been a number of small randomized trials, the best fixation technique in the elderly is still open to debate. Closed reduction and percutaneous K-wire fixation, intralocal pinning (Kapandji technique) and external fixation—using bridging or nonbridging fixators—are minimally invasive, but results are often marginal. Bone graft or calcium phosphate cements have been used alone (with plaster cast) or to augment all of these fixation techniques (Fig 4.8-2). Alternatively, ORIF with dorsal or palmar plates of different designs and dimensions has been recommended.

Fractures with dorsal angulation often have a zone of comminution and impaction on the dorsal side of the radius. Thus, the best mechanical fixation is a buttress plate on the dorsal surface of the radius. This technique maintains the axis and allows safe fracture healing, but impingement of the plate on the extensor tendons often results in poor functional outcome. The introduction of plates with angular-stable locking head screws offers the possibility of plate fixation on the palmar aspect of the radius even in cases with dorsal angulation and comminution (Fig 4.8-4). This should reduce soft-tissue complications associated with the plate; however, there are still some indications for dorsal plate fixation.

5.4 Hip fractures

Hip fractures are associated with high morbidity and mortality in the elderly. Up to 10% of patients will die within 30 days of surgery and 30% will be dead within one year. Multiple factors will influence decision making with intracapsular hip fracture surgery. In general, age is not important, but preinjury mobility, residential status, and cognitive function all affect prognosis and are key factors.

Nondisplaced, intracapsular fractures usually require internal fixation with lag screws or a DHS to prevent fracture displacement. The consensus now is that displaced intracapsular fractures are best treated by femoral head replacement. A cemented hemiarthroplasty is recommended for those with impaired motility or cognitive state but a cemented total hip replacement should be considered for fit, elderly patients who remain mobile and independent.

Extracapsular fractures usually require reduction and internal fixation. The major technical problem is secondary fracture collapse. Therefore, the key element of hip fracture fixation is that controlled impaction along the axis of the hip screw is
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Fig 4.8-3a–b Osteoporotic fracture of the proximal humerus stabilized with the PHILOS plate utilizing locking head screws in different directions to provide angular stability.

Fig 4.8-4a–d Application of a palmar LCP for a distal radial fracture with dorsal angulation and comminution.
possible. Accurate placement of the hip screw in the femoral head, as measured by the screw tip-apex distance, determines the performance of the device, particularly in osteoporotic bone. Fixation failure rates of stable fractures should be under 5%, even in patients with osteoporosis. Unstable fracture patterns—31-A2–3 and 31-B or fractures with subtrochanteric extension and a lack of bony support—are best fixed with an intramedullary hip screw device. Different options for fixation such as PFN, PFNA, TFN, or the buttressing side plate for the dynamic hip screw are available. The advantage of intramedullary devices with a sliding hip screw or helix is that they allow controlled impaction of the fracture. They are stable, thus permitting early weight bearing while the intramedullary implant prevents excess collapse of the fracture (Fig 4.8-5).

5.5 Periprosthetic fractures

Periprosthetic fractures are associated with two types of implants:
- internal fixation devices (eg, plates or nails);
- joint replacements.

In both cases, osteoporosis is a major risk factor for complications [31]. Fractures associated with plates often have a transverse pattern. The required surgical approach to remove the old implant will be an important factor in decision making. Intramedullary nailing may be a good option; however, if it is necessary to leave the old implant in situ, implants should overlap to minimize the stress riser effect. Occasionally, it may be possible to couple the two implants by passing a screw through a plate and the locking hole of a nail.

Approximately 1% of total joint replacements will be complicated by a periprosthetic fracture.

- As a first step, the surgeon must determine if a joint prosthesis is loose and if there is evidence of infection.

Both of these conditions result in local osteolysis and predispose to periprosthetic fracture. In general terms, a loose prosthesis will require revision joint replacement surgery using a long stemmed prosthesis that also provides fracture fixation. This may be augmented by interlocking screws through the stem, cerclage wires, or struts of allograft bone. If the joint replacement is not loose, the treatment will depend upon the site of the fracture and its complexity. Nondisplaced metaphyseal fractures and fractures around the stem may unite. Nonoperative management is an option if alignment and rotation can be maintained. Displaced fractures require reduction and internal fixation or revision joint replacement (if the prosthesis is loose). The presence of an intramedullary stem will limit the possibility of using a plate with screws through both

Fig 4.8-5a–b Proximal, femoral, osteoporotic fracture stabilized with a proximal femoral nail (PFN).
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cortices. Monocortical locking head screws with angular stability appear to provide good purchase. The new generation of locking compression plates may be appropriate in this situation, especially as they may be inserted with minimal exposure of the fracture site (eg, LISS) (chapter 3.1.3; 3.3.4). For LISS, special blunt-ended monocortical screws are available that can be placed through cement and right up to the intramedullary stem of the prosthesis. Fixation can be augmented with cables plus strut allografts.

Nonunion is common if the fracture occurs at the tip of the stem of the joint replacement. These injuries require surgical treatment. Revision with insertion of a longer stemmed replacement is an option. These fractures often have a simple fracture pattern (transverse or short spiral) and if plate fixation is used, anatomical reduction and absolute stability will give the best chance of fracture union. Fractures distal to the stem do not require revision joint replacement. They can often be treated as independent fractures but the fixation technique often needs to be modified to allow for the intramedullary stem and avoid a stress riser between the stem and the fracture fixation.

5.6 Fractures of the spine

The spine is the most common site of osteoporotic fracture (Fig 4.8-6). The vast majority of patients will not require surgery but those with persistent pain and evidence of ongoing collapse may require treatment. Recent developments include vertebroplasty and kyphoplasty (chapter 6.11).

Vertebroplasty uses direct bone cement injection into the vertebral body. This is performed through a pedicular or extrapedicular approach and with control of an image intensifier (Fig 4.8-6). There is no reduction of the kyphotic deformity or restoration of vertebral height and the aim is to prevent further collapse and relieve pain. In contrast, kyphoplasty uses a balloon, which is introduced into the vertebral body and inflated to reduce the fracture and restore vertebral height. The resulting cavity is then injected with low-pressure cement. Vertebroplasty and kyphoplasty lead to good pain relief in a high percentage of patients. Major complications are uncommon but may occur due to cement entering the spinal canal, the spinal root canal, or major vessels.

6 Medical treatment

The aim of treatment of osteoporosis is to decrease the frequency of fractures, especially of the hip and spine, which are responsible for severe morbidity and mortality. Results of large placebo controlled trials have shown that alendronate, raloxifene, risedronate, the 1–34 fragment of parathyroid hormone, and nasal calcitonin, all greatly reduce the risk of vertebral fractures. Moreover, a large decrease of nonvertebral fractures has been shown for alendronate, risedronate, and the 1–34 fragment of parathyroid hormone. Data from a large trial of risedronate suggest a 40% reduction of the relative risk of vertebral fractures (95% confidence interval (CI) 30–50%, \( P < .01 \)) [32].

Hormone replacement therapy remains a useful option for the prevention of osteoporosis in perimenopausal women. Choice of treatment depends on age, smoking history, the presence or absence of prevalent fractures (especially at the spine), and the degree of bone mineral density measured at the spine and hip. Nonpharmacological interventions include calcium intake and diet, certain exercise programs, reduction of other risk factors for osteoporotic fractures, and reduction of the risk of falls in the elderly. To reduce the risk of subsequent fractures, investigation for and treatment of osteoporosis should be considered in all patients who have sustained a fragility fracture.
With the worldwide increase in the number of elderly people, it is anticipated that osteoporosis will become epidemic in the years to come. Low bone mass and excessive skeletal fragility will pose many problems for surgical management.

**Fig 4.8-6a–f**

*a–b* This 72-year-old female developed a collapse of T11 within 4 months ending with a nonunion. The standing x-rays show the severe collapse of T11. The MRI scan shows a noticeable, spontaneous correction of the segmental kyphosis.

*c–f* With vertebroplasty the segmental height is restored by levering the cannulas in the adjacent vertebrae (lordoplasty). The defect after height restoration is clearly visible. It is filled with PMMA and tension is released once the cement has set. The cannulas are then removed easily with a half turn when the cement has set.

(With permission by Paul Heini.)

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**7 Conclusion**

The principles of osteoporotic fracture management include fixation with techniques of relative stability:
- bridging and buttress fixation;
- angular-stable implants;
- intramedullary nails;
- controlled impaction;
- bone augmentation;
- joint replacement.
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Bibliography