Best Practice & Research Clinical Rheumatology 33 (2019) 236–263

Contents lists available at ScienceDirect

Best Practice & Research Clinical Rheumatology

journal homepage: www.elsevierhealth.com/berh

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Non-hip/non-vertebral fractures – How to treat best?

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Keywords:
Extremity fractures
Arthroplasty
Osteosynthesis
Rehabilitation

A B S T R A C T

Fractures of the extremities in the elderly constitute more than two-thirds of all fragility fractures befalling frail, osteoporotic and sarcopenic patients. Although treatment controversies abound, consensus exists. Upper extremity fractures hinder activities of daily living and are debilitating. Open fractures or displaced fractures will need surgical intervention. Wrist fractures treated operatively allow early use of the hand. Most pelvic fractures are treated conservatively. In the lower extremities, fractures of the long bones, tibia and femur need surgical intervention. Non-displaced fractures around the foot may be treated with immobilisation and avoidance of full weight-bearing. As a rule, fractures take four months for consolidation. Individually tailored solutions are needed for frail patients with comorbidities. Maintaining joint mobility and muscle strength preserves mobility and autonomy. Caring for extremities trauma is team work, involving family and health care providers. Prevention efforts are mandatory.

Introduction

Although the care of fragility fractures remains a serious challenge, considerable progress has been made in the field, allowing for an optimistic future outlook [1,2]. Non-hip and non-vertebral fractures

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https://doi.org/10.1016/j.berh.2019.03.019
1521-6942/

make up for a large bulk of fractures, up to 59% of all fractures after the age of 80 years, and inflict considerable suffering and subsequent handicap on frail elderly, osteoporotic and sarcopenic patients [3]. The combined efforts of gerontologists, bone specialists, rheumatologists, rehabilitation experts and orthopaedic surgeons, to name only some of the team players of this multidisciplinary approach, have transformed the care offered worldwide to an increasingly frail and elderly population [4,5]. These patients have numerous comorbidities, necessitating multiple medications. It is only through increased awareness that complications may be avoided. In this context, it is necessary to be aware particularly of patients on oral anticoagulants with long reversal times before dealing with fracture treatment, regardless of whether conservative or interventional. Conservative, i.e. non-operative, treatment of fractures has made leaps and bounds in recent times, offering today lightweight and strong material for splints, casts and orthoses and hence replacing the bulky and heavy contraptions of the past that were a burden for these fragile patients [6]. Rehabilitation has evolved into a dynamic speciality encouraging motion, activity and strength in contrast to rest and immobility [7]. Medical and anaesthesiological progress in care during the pre-, intra- and post-operative phases has made possible surgical interventions in situations earlier held as impossible. Improvements in surgical technique, such as locking plates (i.e. plates where the heads of the screws are screwed into threaded holes in the plate to obtain an angular stable fixation [8]), minimally invasive surgery [9], personalised guidance templates for arthroplasties [10], emerging biologics [11] and new implantable biomaterials [12], have allowed more rapid recovery times for patients who were, in the not-so-distant past, condemned to long periods of bed rest or limb immobilisation accompanied by the unavoidable parade of complications [13] including painful stiffness, functional loss, cardiopulmonary disorders and bedsores, to name a few.

Proximal humerus

Proximal humerus fractures represent 5% of all fractures or 66/10,000 person-years population/year [14]. The incidence increases with age and is linked to sex, with a great majority of fractures occurring in females older than 60 years of age [15]. In younger patients, the male-to-female ratio is equal, and as age increases, this ratio reaches 3:7 [16]. The mechanism is generally a low-energy fall from the patients' own height in older adults, frequently associated with osteopenia or osteoporosis. A dysfunctional shoulder causes serious handicaps in everyday life, and simple tasks such as insuring bodily hygiene, dressing oneself or cutting meat when partaking in a meal become difficult and consume an inordinate amount of time and energy for an older person. Even walking ability is diminished with an abnormal arm balance due to a painful and stiff upper extremity, and this can be the reason behind increased falls and further injuries. Use of walking aids such as crutches, walkers or wheelchairs may be most difficult if not impossible with an impaired, painful and stiff shoulder [17].

Fractures of the proximal humerus are particularly serious because of their intra-articular nature with consequences on shoulder motion and strength [17]. Additionally, these fractures alter the perfect natural sphericity of the humeral head and cause damage to the cartilage coverage. This leads to post-traumatic arthritis and joint stiffness with loss of range of motion. The fracture lines also run through the tuberosities, both lesser and greater, causing varying degrees of displacement. More than 10 mm of linear displacement or more than 45° of angular displacement of the tuberosity and head main fragments will lead to poor results with loss of range of motion and strength if no remedial measures are taken [18]. These criteria are applicable to an elderly low-demand population, although these are not firmly determined as demonstrated by the ProFHER trial [19]. Reasons for this loss of function and strength are the disturbed geometry of the rotator cuff tendons, inserted on the displaced tuberosities, altering the lever arm action of the scapulo-humeral muscles and tendons. Finally, the combination of unsatisfactory fracture healing associated cartilage damage and chronic tendon tearing will lead to a chronic inflammatory condition, causing painful stiffness. The clinical diagnosis of the injury is straightforward with immediate pain and loss of function of the shoulder following a fall. One should look for deformity and ecchymosis and evaluate the neurovascular status, as neurological and vascular injuries have been, although rarely, seen to be associated with this injury. Plexular injuries may occur and are generally reversible. It is more concerning that vascular injuries such as tears or occlusions of the axillary vein or of the axillary artery have been reported [20].

Definitive diagnosis relies on examination of plain true antero-posterior X-rays and axillary views. No attempt at manipulation should be undertaken before radiological diagnosis, as a dislocation may be present and untimely manipulations may dislocate an otherwise undisplaced fracture, thereby further worsening the situation. Some specialists advocate CT scanning with 3D reconstructions to better ascertain the relative positions of the fracture fragments and to allow a more accurate classification of the fracture; this has a direct bearing on the operative technique and prognosis [21]. MRI, in certain cases, may prove useful to identify soft tissue injuries such as concomitant rotator cuff tears [22].

Prognosis is related to the position of the main fragments at the onset of the fracture. If the main fragments bearing the articular surface of the humeral head are tipped into varus, the functional prognosis is ominous with expected loss motion and stiffness. If the fragments are positioned into valgus, a better prognosis is to be expected. If a greater tuberosity fragment is wedged in the subacromial space, the situation will require surgical attention to avoid painful stiffness. High fracture lines occurring at the level of the head and neck junction will cause interruption of intraosseous blood flow and lead to aseptic necrosis and collapse of the humeral head ending in post-traumatic arthritis. Fracture dislocations are of very poor prognosis if the humeral head remains dislocated. In case of doubt, the patients should be referred to the surgeon for definitive evaluation and surgical treatment. It is to be noted, however, that more than 80% of fractures of the proximal humerus will require only conservative treatment. Immobilisation for three to six weeks in a shoulder immobiliser or in a Velpeau type bandage is followed by physiotherapy. It is important to begin early rehabilitation, perhaps 10 or 15 days after the occurrence of the fracture. In the beginning, the exercises should focus on isometric muscle strengthening tasks and not in trying to improve shoulder motion. After one month, the fragments are sufficiently sticky, through the production of callus, so that passive and assisted active exercises may be initiated [23].

In case of surgery, such as in displaced fracture patterns, two major approaches dominate current thinking. In the first approach, the fracture is reduced and fixed using an armamentarium of implants, ranging from sutures, k-wires and intramedullary nails to sophisticated locking plates [24]. In the second approach, prosthetic replacement is performed. The fractured humeral head is replaced using an anatomic or an inverted prosthesis depending on the state and reconstructibility of the tuberosities and of the rotator cuff [25].

Patients' needs for sustained high levels of activity will tip the scales in favour of anatomical reconstruction. Frailty, osteoporosis and low-activity demand will, on the other hand, encourage a choice of treatment based on joint replacement. Technically, motivations behind choosing reconstructive or arthroplasty surgery are guided by the anatomy of the fracture and by the state of the rotator cuff. In some cases, manipulation under anaesthesia under image control will lead to an acceptable reduction, which may then be fixed in place using percutaneous pins. This is not recommended for highly displaced or dislocated fractures occurring in osteoporotic bone, as the pins will not resist redisplacement. In some cases, where an acceptable reduction is obtained, a nail may be inserted through the humeral head and fixed in the humeral shaft through a minimally invasive approach. When closed reduction is not feasible, an open approach is favoured and the reduction is obtained under direct vision, and with the aid of the image intensifier, it is then possible to fix the reduced fracture with a plate. The latest development is the locking plate, whereby the heads of screws lock into the metallic plate, and therefore, a rigid construct is obtained. Anatomic reconstruction and strong fixation will allow good results for motion, strength and pain. Anatomic reconstruction is usually the method of choice for young active patients, and the technique should be impeccable (Fig. 1 A,B). In osteopenic or osteoporotic patients, the fixation may not be strong enough and the fracture will re-displace or collapse [26]. The worst-case scenario is when the screws of the locking plate perforate the collapsing head, leading to rapid deterioration of the articular surface with painful post-traumatic arthritis as the end result.

When considering prosthetic replacement, a decision will have to be made whether to use an anatomical head replacement (hemiarthroplasty) or whether to use an inverted prosthesis. In the first case, the rotator cuff must be intact and the tuberosities re-attachable to the prosthesis with heavy sutures [27]. Care must be taken in planning the intervention, with emphasis on the choice of head sizing (diameter and thickness), head height in relation to the glenoid and the tuberosities and proper retroversion (Fig. 2 A,B). It is recommended to obtain radiographs of the intact opposite shoulder to

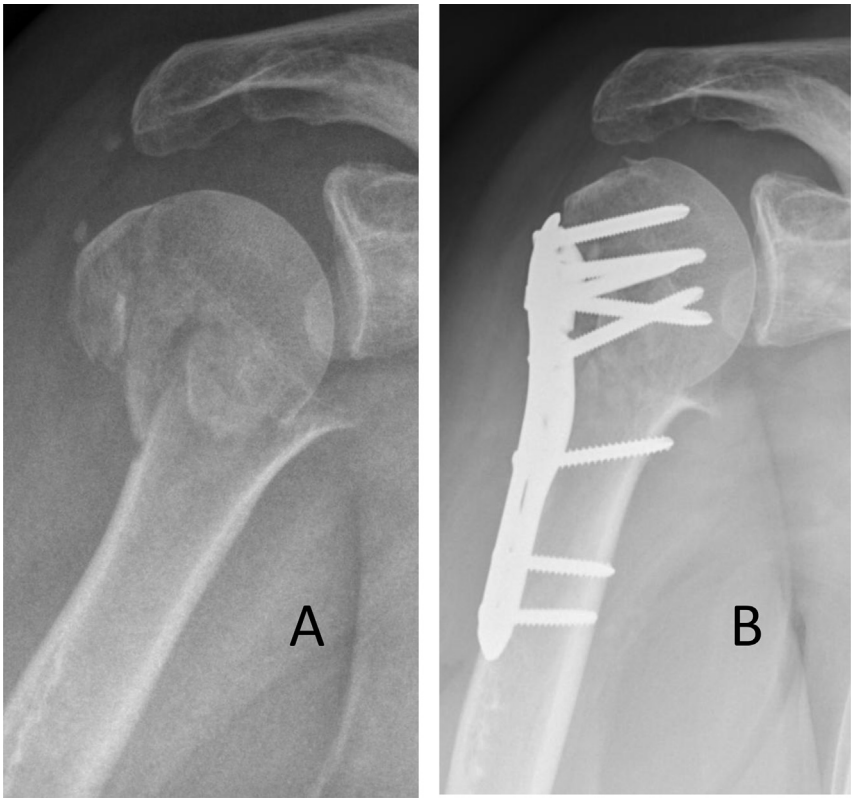

Fig. 1. Displaced fracture of the proximal humerus (A), reduced and fixed with a plate with locking screws (B).

plan accurately. The stem may be press-fitted, but often, because of bony fragility due to osteoporosis, a cemented technique will be preferred. The glenoid, being generally intact in this situation, is not as a rule, resurfaced. Hemi-arthroplasty, although a time-tested intervention, with the first implantations going back to the 1950s, has drawbacks: Often, the shoulder remains relatively stiff with loss of motion due to heavy scarring and malfunction of the rotator cuff. Furthermore, the metallic head may wear through the cartilaginous layer of the glenoid with time or glenoiditis, leading to stiffness and pain. In addition, the tendons of the rotator cuff may be eroded and thinned by the metallic head. Finally, the tuberosities may displace posteriorly or even disappear entirely due to insufficient fixation and disuse. All these conditions cause a stiff, painful and sometimes unstable shoulder joint, leading to, in many instances, difficult revision surgery [28].

The choice will be made towards an inverted prosthesis if the tuberosities and rotator cuff are irremediably damaged and non-reconstructible [28,29]. The inverted prosthesis has its sphere fixed to the glenoid, and the cup is placed on a stem fixed in the humeral shaft. Motion and strength of the shoulder are possible because of a distalised and medialised centre of rotation upon which the deltoid muscle will act. The rotator cuff is not necessary for function in this implant, but the subscapularis should be intact, as this muscle provides stability to the inverted prosthesis. The learning curve is steep, and surgeons should be specifically trained in the technique before attempting to implant an inverted prosthesis. Again, technical details such as a down-facing glenosphere, proper retroversion and prosthetic height all play a role in the success of the operation. Stability is a major issue and must be secured by proper tensioning and placement of the implants. The patient can expect a satisfactory function that is related to elevation and abduction of the shoulder, but limitations occur in internal rotation and, to a lesser degree, in external rotation. This is related to the function of the deltoid and to

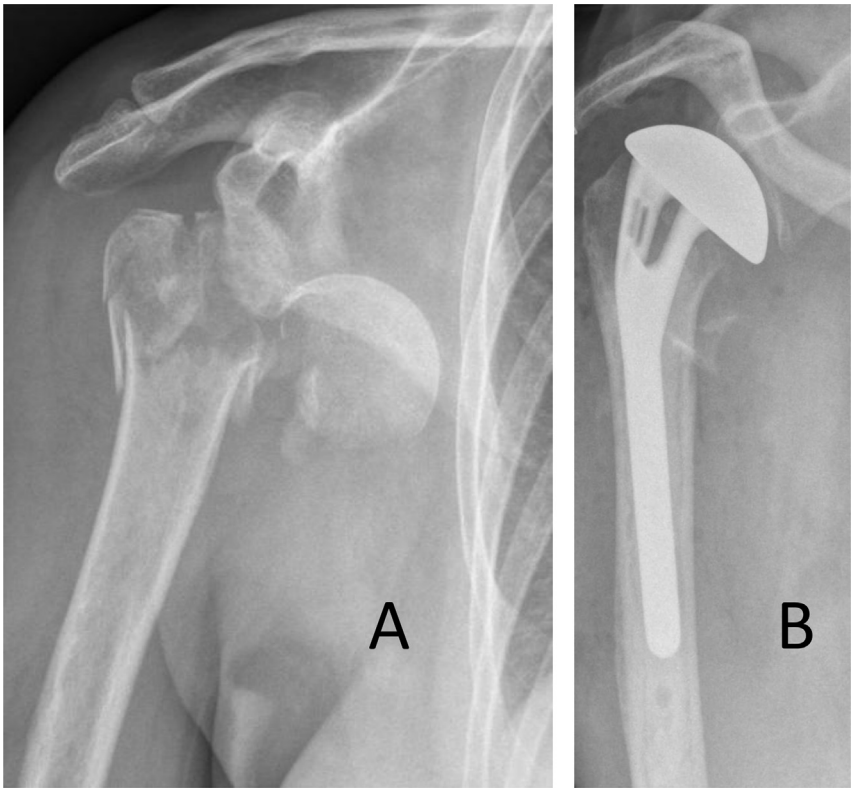

Fig. 2. Displaced fracture dislocation of the proximal humerus (A). The humeral head is replaced with a cemented hemi-arthroplasty (B).

the bony impingements inherent to the prosthetic design (Fig. 3 A, B). The inverted prosthesis may also be used when revising failed osteosynthesis or hemi-arthroplasties (Fig. 4 A, B) [28,29].

Drawbacks of using an inverted prosthesis are the difficulty of obtaining a well-balanced shoulder, entailing a risk of dislocation [28,29]. The average life expectancy of the inverted prosthesis is not known, although current evidence shows that this has very much improved due to progress in implantation technique and prosthetic design. The failed inverted prosthesis is a major challenge for which a good solution remains to be identified. If the prosthesis needs to be definitively removed for intractable instability, loosening with major bone loss or infection, a flail and painful shoulder will ensue.

Fractures of the humeral shaft

Fractures of the humeral shaft can occur after a fall from the patients' own height [30]. Careful clinical examination is warranted, with special attention paid to the function of the neurovascular structures and more specifically of the radial nerve [31]. Immediate radial nerve palsy signifies neurapraxia or axonotmesis, and very seldom neurotmesis. Evolving neurapraxia, appearing in minutes or hours after a fall, points to an expanding haematoma or to the effect of pressure exerted upon the nerve by the fracture fragments, and in very rare cases, the nerve may be severed. Plain X-ray examination will ascertain the diagnosis. In more than 90% of cases, the treatment will be non-operative, with application of a shoulder immobiliser for the first few days, and when the swelling decreases, an arm brace may be applied (Fig. 5 A, B, C, D) [32]. Depending on fracture type, healing will occur after 8–12 weeks. During that time, the musculature of the arm must be kept active with isometric exercises, thereby insuring a stabilising effect from continuing muscular function.

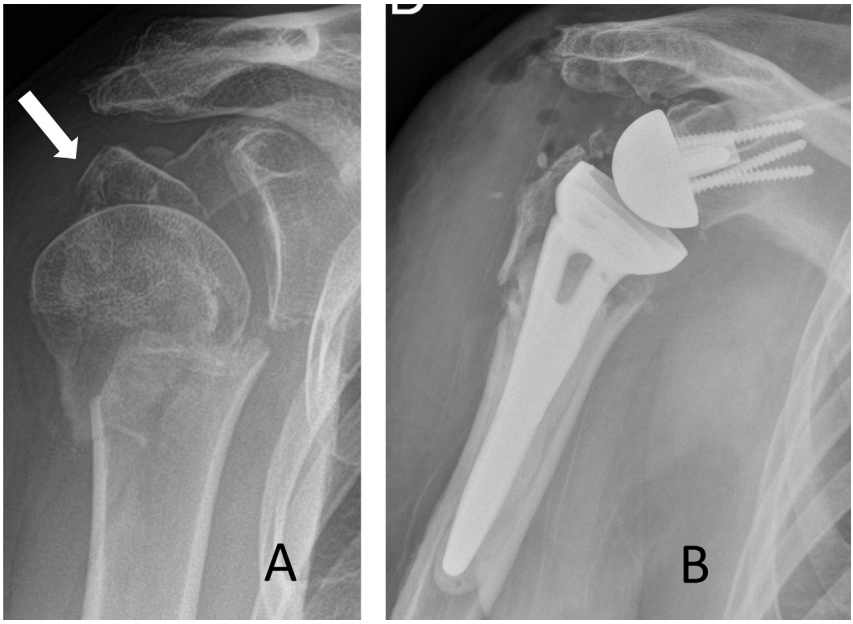

Fig. 3. Displaced fracture of the proximal humerus with a very displaced greater tuberosity (arrow) (A). The humeral head is replaced with a cemented reverse arthroplasty (B).

For some cases such as obesity, open fractures or polytrauma, an operative approach will be chosen (Fig. 6 A, B) [33]. Non-return of radial nerve function after 30–60 days may also be a reason for surgical intervention. In that case, the radial nerve needs to be explored and repaired, if necessary, and the fracture fixed with a plate. In the acute phase, some surgeons prefer introducing a locking nail by an antegrade manner through the humeral head or by a retrograde manner through opening an entry hole in the distal humerus. When using humeral nails, bone quality should be sufficient so that the locking screws have sufficient purchase to inhibit rotatory displacements. Healing takes 8–12 weeks, and during that time, the humerus should not be stressed by the use of walking aids or carrying items. During the healing phase, carrying loads of more than a few kilograms will distract the fracture, and driving is not recommended, as turning the wheel induces torsional forces in the humeral shaft, which are deleterious to callus formation and consolidation.

Elbow Fractures

The elbow is a complex set of joints (ulno-humeral, radio-humeral and radio-ulnar) that allow harmonious motion and positioning of the upper extremity. A stiff elbow or a damaged elbow will hamper everyday movements and severely curb the use of the hand. Elbow range of motion is 0° of extension, 150° of flexion, 75° of pronation and 85° of supination. A functional range has been defined as 100° of flexion/extension and prono-supination [34]. Normal elbow flexion and extension are necessary for reaching objects and bringing them towards the body, and the pro-supination motion is indispensable for grasping and directing objects. An impaired elbow with a loss of function will impact on daily life and create handicaps [35].

Distal humerus fractures

Fractures of the distal humerus occur in the older women population, and osteoporosis is most often associated with this injury. The fracture mechanism is a low-energy fall from the patient's height [36,37]. Clinical diagnosis is straightforward, with exquisite pain on motion, functional deficit, ecchymosis and, in

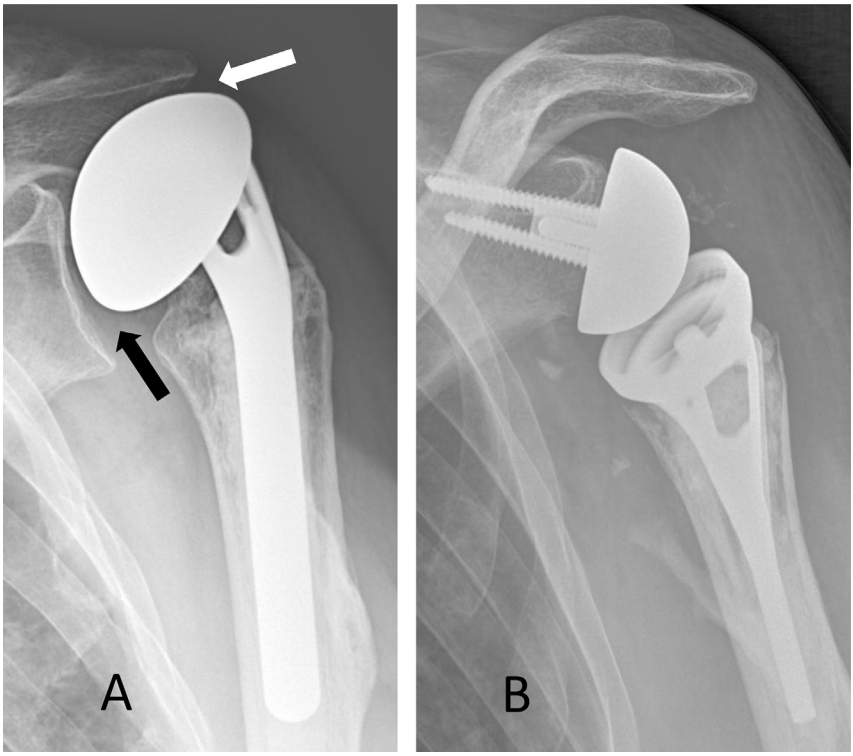

Fig. 4. Displaced fracture of the proximal humerus replaced with a hemi-arthroplasty. Some years later, the cuff has thinned (white arrow) and the prosthetic head has subluxed upward (black arrow) causing painful loss of function (A). The humeral head is replaced with a cemented reverse arthroplasty (B).

severe cases, deformity. It is important to assess the vascular status, as collateral circulation may hide a complete blockage of the brachial artery at the elbow; any difference in the contralateral pulse needs to be investigated. The median nerve is the most frequently injured neural structure, followed by the ulnar and radial nerves [38]. Careful clinical assessment is always indicated. Definitive diagnosis relies on AP and lateral X-ray examination, and although infrequent, if there is strong clinical suspicion in the face of non-informative X-rays, further imaging is recommended such as CT scanning.

Rarely, these fractures are undisplaced, requiring conservative treatment that consists of relative immobilisation in a protective sling at 90° of flexion and in neutral pro-supination [39]. After three to four weeks of immobilisation, mobilisation should be started, beginning with flexion exercises and progressing to extension. Most frequently, the fractures are displaced. The fractures may be partial involving only the articular surface such as isolated fractures of the capitellum. These fractures must be accurately reduced and fixed, or definitive stiffness or locking will ensue if fragments are left free in the articular space. Displaced fractures, which may be articular, extra-articular or a combination of both, need surgical treatment. If left to conservative treatment, poor results follow with a severe deficit in strength and mobility. The choice is reconstruction using specifically designed plates or articular replacement.

Reconstruction with locked plates is indicated in active patients with a strong bone. The ulnar nerve must be well protected throughout the procedure. Adequate reduction must be obtained and supplemented for added stability with a bone graft if necessary. The upper extremity is placed in a padded splint. Active mobilisation is encouraged in the days following the reconstruction, and the fracture is followed clinically and radiologically until healing, which usually takes place two to three months after the open fixation. As peri-articular ectopic bone formation is always a risk, a course of non-steroidal anti-inflammatory drugs is administered during the first post-operative days to avoid stiffening [40] (Fig. 7 A, B).

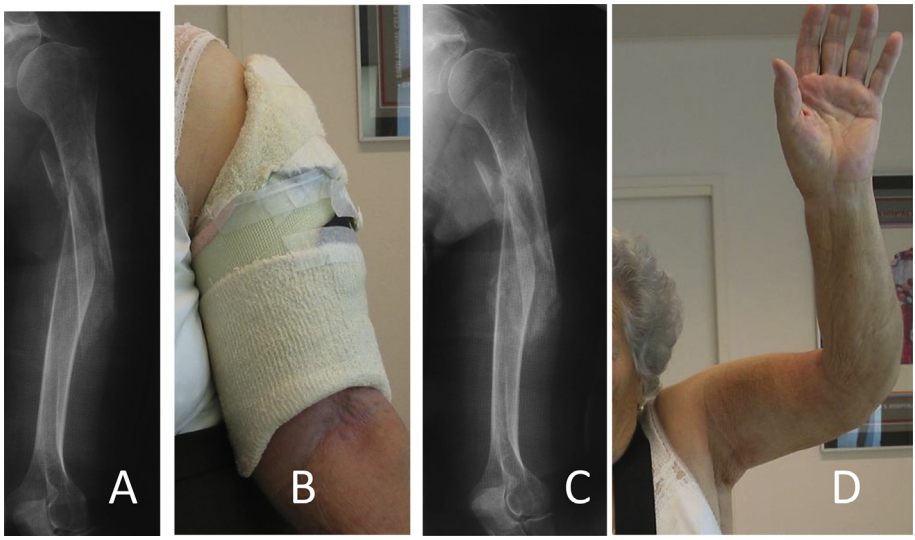

Fig. 5. Displaced fracture in an osteoporotic humeral shaft (A). Treatment with a functional Sarmiento splint (B). Consolidation obtained after 12 weeks (C). Adequate function (D).

In elderly, low-demand patients with severe osteoporosis, osteosynthesis and reconstruction using plates and screws are neither reliable nor technically feasible because of poor purchase of the screws in the weak bone. A solution for this issue is the use of a hinged cemented arthroplasty, which provides immediate stability and return to motion [41]. Post-operatively, the elbow is placed in a well-padded splint, and early mobilisation is encouraged. Function is restored quickly, and after skin suture removal, the patient may resume activities of daily living. Complete healing occurs at 6 weeks when the partially detached extensor triceps tendon becomes well fixed to the ulna (Fig. 8 A, B).

Olecranon fractures

Olecranon fractures occur most often in patients with a fragile bone after a fall on the elbow from their standing height. The incidence increases with age, and both males and females are equally affected [42]. The diagnosis relies on plain X-ray examination. Because of the pull of the triceps tendon, these fractures tend to displace, and most fractures will therefore need to be reduced and fixed operatively. Non-operative treatment may be an option for the low-demand patient, with the elbow splinted in slight extension [43]. If non-union occurs, a severe loss of extension strength ensues. Patients are handicapped in this situation because they cannot keep their arm in the air and have no control over extension except passively, which is a hindrance to overhead activities. The best options for operative treatment are still under discussion [44]. K-wire fixation and tension band wiring can be used for a strong bone and plates with locking screws for a weakened osteoporotic bone. In rare cases, simple fragment excision may be an option. Rapid active motion is encouraged after fracture fixation, but lifting is avoided for the first three months depending on the extent of fracture healing (Figs. 9 A, B and 10 A, B). Fractures related to radial head dislocations and proximal ulnar fractures (Monteggia fractures) will, as a rule, necessitate surgical treatment; usually, reduction and fixation of the ulna will suffice to reduce the dislocated radial head [44].

Radial head fractures

Fractures of the radial head are relatively infrequent in the elderly frail population. The mechanism is a fall on the outstretched hand, and if the fracture is severely displaced, it may be necessary to perform open reduction and osteosynthesis [45]. If the fragments are too comminuted or the bone too

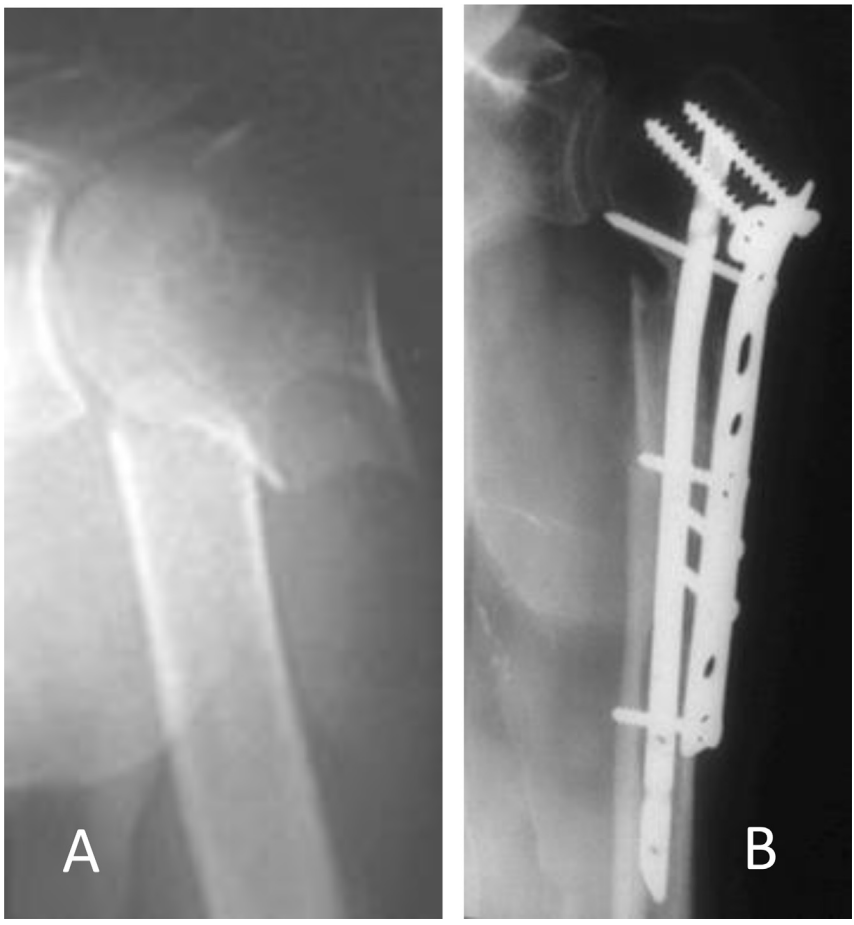

Fig. 6. Displaced fracture of an osteoporotic subcapital humeral shaft (A). To obtain stability in an osteoporotic situation, plating and nailing were combined (B).

weak for reconstruction, the surgeon has a choice between radial head excision, which is a good option if the elbow is stable, or insertion of a radial head prosthesis in case of an associated dislocation or an otherwise unstable elbow joint. Adequate functional results may be obtained with both options. In cases of highly comminuted or displaced fractures of the radial head, with tearing of the interosseous membrane, such as the Essex-Lopresti fracture, there may be repercussions on the distal radio-ulnar joint because of shortening of the radius relative to the ulna. In these cases, an arthroplasty is indicated to preserve length and wrist function and preserve strength. Heterotopic bone formation leading to stiffness is a risk after any surgery to the elbow joint, and non-steroidal anti-inflammatory drugs should be given to all patients for a period of one week post-surgery [40].

Dislocation of the elbow

Dislocation of the elbow is a rare occurrence in the frail patient, and as a rule, the fall will lead more often to a bony fracture in the osteoporotic elbow. Diagnosis by X-ray examination must always precede attempted reduction. The neurovascular status must be well evaluated so as not to overlook lesions to the nerves and vessels around the elbow. Reduction is usually performed under light sedation

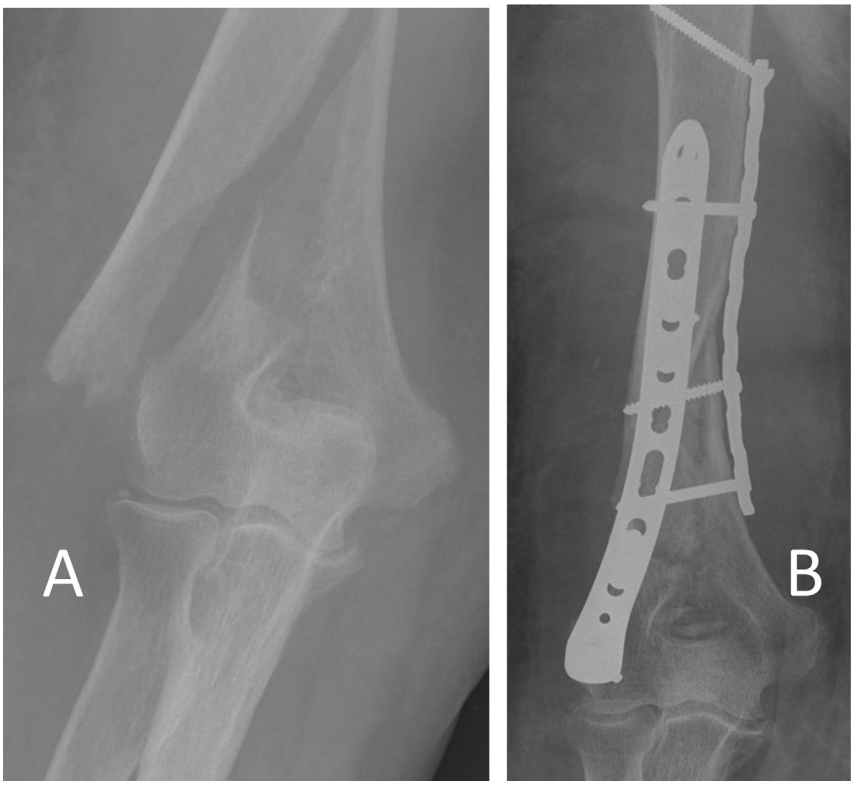

Fig. 7. Displaced fracture of the distal humerus extending into the humeral diaphysis (A). Open reduction and internal fixation with contoured anatomical plates (B).

and rarely necessitates a loco-regional or a general anaesthetic. Once reduced, the elbow should be immobilised at 100° of flexion in a well-padded splint. After seven days, the elbow needs to be actively mobilised with active-assisted flexion/extension, and at three weeks, prono/supination should be started if stiffness is to be avoided [46]. A short course of non-steroidal anti-inflammatory drugs will help to avoid ectopic bone formation. In case of recurring instability, one should look for coronoid fracture or severe ligamentous lesions. Surgical solutions such as fixation of the coronoid or suture of the ligaments may be indicated. The procedure may necessitate to be protected with a hinged external fixator for a period of 6 weeks. In some rare cases, a total elbow arthroplasty may be needed [47].

Fractures of the coronoid can be encountered in frail patients, although this is an uncommon occurrence usually associated with dislocations of the elbow. Plain X-ray examination is not always sufficient for diagnosis, and hence, other modalities such as CT scanning may be necessary. Displaced fractures involving more than two-thirds of the coronoid need to be fixed surgically so as to avoid an unstable elbow. The reconstruction may involve specially contoured plates and bone grafts [48].

Forearm diaphyseal fractures

Forearm diaphyseal fractures in elderly frail and osteoporotic patients are due to falls from standing height [49]. Some authors have reported diaphyseal fractures of the forearm occurring in patients on long-term bisphosphonates [50]. With its unique anatomy combining a straight ulna and a bowed radius articulated together by joints proximally and distally, the forearm may be considered a joint and provides the hand with its essential pronation-supination mobility. The forearm may be considered to function as

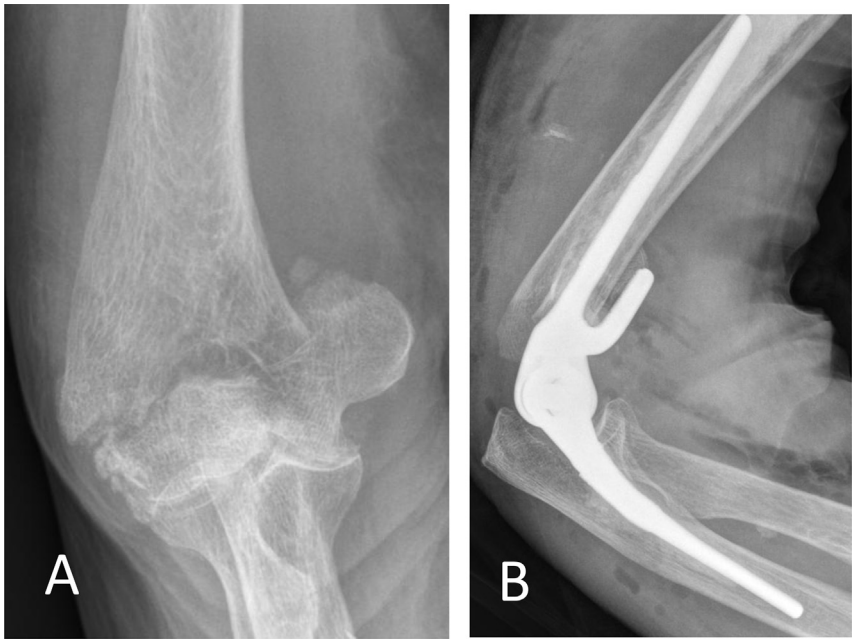

Fig. 8. Displaced fracture of the distal humerus extending into the articular surface (A). Treatment with Coonrad-Morrey hinged elbow prosthesis (B).

a joint procuring supination and pronation. The neurovascular status must be carefully assessed clinically before surgery. Diagnosis relies on plain X-ray examination. Fractures usually involve both bones of the forearm. These must be accurately reduced and fixed with plates and or intramedullary nails if physiological motion is to be restored [51] (Fig. 11 A, B). Forearm fractures are at risk of developing a compartment syndrome, and care must be taken to avoid this ominous complication that, although rare in the elderly, can cause major disability if left undiagnosed and untreated [52].

Fractures of the distal radius

Fractures of the distal radius are frequent, with an incidence rate of 278 per 100,000 population per year in Southern Sweden as reported by Jerrhag et al. [53]. In elderly, osteoporotic and frail patients,

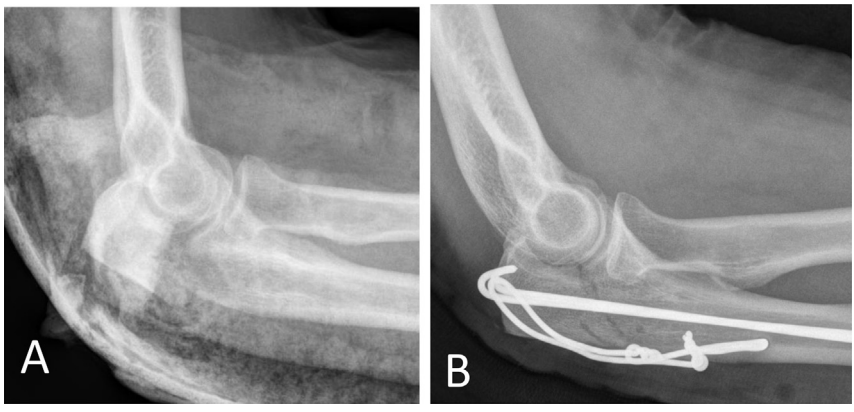

Fig. 9. Displaced fracture of the olecranon (A). Treatment with a tension band wiring technique (B).

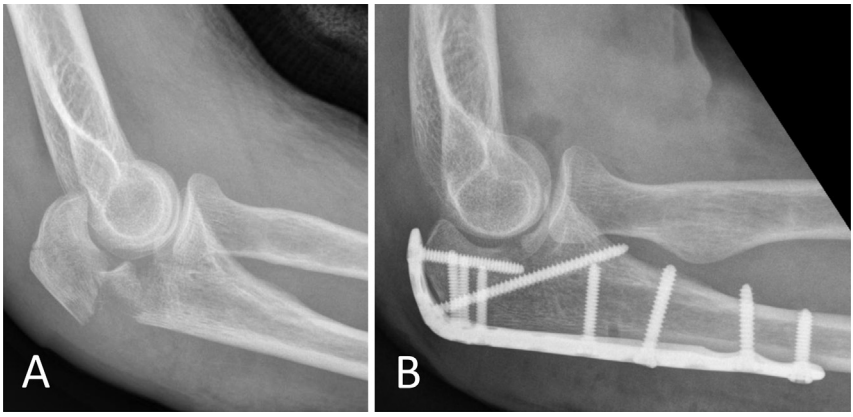

Fig. 10. Displaced fracture of the olecranon with intra-articular fragment (A). Operative treatment with a locked plate technique (B).

fracture occurs after a fall from standing height on the outstretched hand. Classically, the fracture occurs at the junction between the diaphysis and the metaphysis of the radius where the cortical bone is the thinnest, approximately 2 cm above the articular space. The displacement of the distal fracture fragment is in extension with comminution dorsally. The advocated treatment was closed reduction and application of a cast in flexion and ulnar inclination. The wrist was held in this position for three to four weeks and then changed to a position of neutral flexion and inclination for another three to four weeks. Results were often disappointing with recurrence of the deformity in the cast, leading to a shortened swan neck wrist and a sometimes painful prominent ulnar styloid because of the collapse of the radius fracture. Despite these aesthetic shortcomings, most patients had a satisfactory return to function accepting some degree of loss of mobility and strength and a relatively high incidence of complex regional pain syndrome (CRPS) [54]. Other treatment methods include pinning the fracture in place and applying a cast or using an external fixateur to immobilise the fracture. Although somewhat controversial, many surgeons currently agree that the optimal treatment of a fracture of the distal radius occurring in elderly, osteoporotic and/or frail patients is surgery with open reduction and internal fixation using a volar locking plate [54,55]. The operation may be accomplished under locoregional anaesthesia such as a plexular nerve block. This allows early mobilisation and rapid return to function. Results in the literature have been found satisfactory in the long term and are dependent as much on fracture pattern as on socioeconomic status [56]. Complications of plating of distal radius fractures include carpal tunnel syndrome, trigger finger and tendon rupture. Patient rehabilitation will allow return to useful function [54,57] (Fig. 12 A, B).

Fractures of the carpals, metacarpals and phalanges

Fractures of the carpals, metacarpals and phalanges are usually associated with younger age and high levels of activity. Some authors point to a diminishing incidence of these fractures with age, and for the metacarpal fractures, there is a bimodal distribution in women, with a peak of frequency in the 20–30 years age bracket and a second peak in the 70–80 years age bracket [58]. The mechanism is unclear, and various activities and falls may cause these injuries [59]. Diagnosis is made by plain X-ray examination, but more sophisticated imaging tools such as computed tomography or MRI may be necessary for occult fractures such as those occurring in scaphoid or carpal bones [60]. In the frail population, treatment depends on displacement, and if this is minor, generally, conservative treatment modalities will be chosen. For displaced or open fractures, surgical treatment is required. After fractures of the carpals, metacarpals or phalanges, long periods of rehabilitation are necessary for the patient to regain a painless functional flexibility of the hand [61].

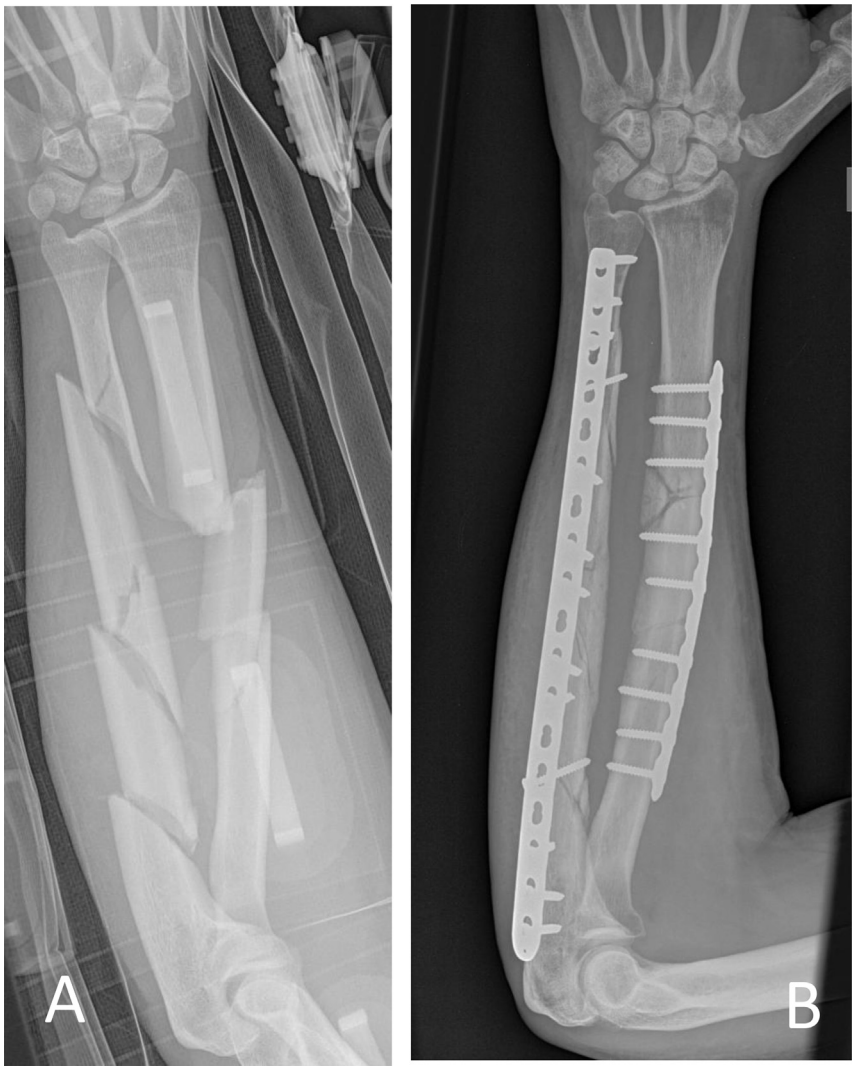

Fig. 11. Displaced fracture of both bones (radius and ulna) of the forearm (A). Treatment with open reduction and fixation with locking plates (B).

Fractures of the pelvic ring

Fractures of the pelvic ring in the elderly and osteoporotic patients result from benign low-energy falls or from osseous insufficiency [62,63]. This is in contrast with the high-energy trauma fractures that are becoming commoner in the older population and more active population, mostly involving motor vehicle accidents [64]. It must be noted, however, that these fragility fractures do not involve only the pubic rami readily diagnosed by a-p X-ray examination of the pelvis. The pelvis is a rigid ring, and if the anterior part of the ring is fractured (rami fractures), it follows that a posterior break (Sacral fracture) must also exist. Little displaced sacral fractures are difficult to be diagnosed by plain X-ray examination because the intestinal gases are superimposed in front of the sacrum on an a-p view. With the advent of computerised tomography (CT) and, more recently, magnetic resonance imaging (MRI), it has become possible to accurately examine the sacral region. Sacral fractures are readily identified now,

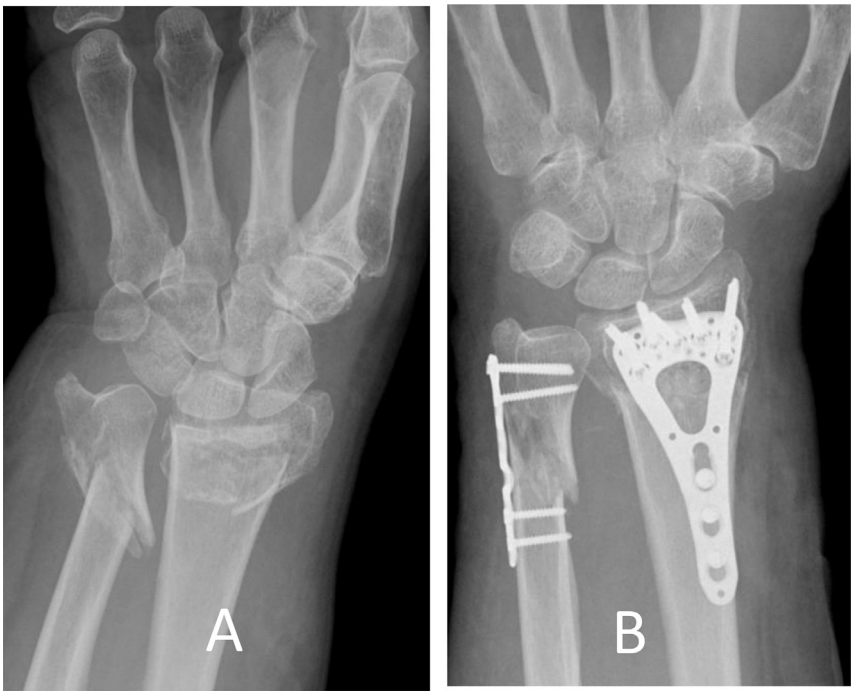

Fig. 12. Displaced fracture of both bones (radius and ulna) of the wrist (A). Treatment with open reduction and fixation with locking plates allowing immediate movement (B).

and in some cases of unstable patterns of pelvic ring fractures, some authors will advocate surgical fixation even in very elderly patients, as an unstable pelvic fracture will render ambulation impossible. In certain circumstances, injections of intraosseous calcium-based bone cements may enhance stability and healing [65]. Sacral fractures may also occur as insufficiency or fatigue fractures. These are serious

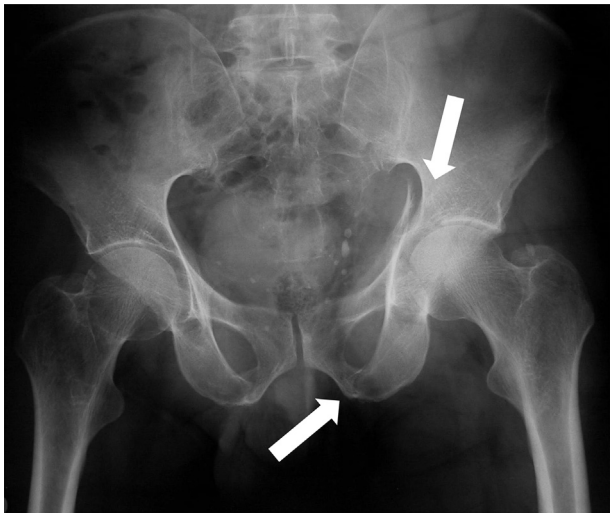

Fig. 13. Fractures of the pelvic ring involving both rami (arrows). Because of minimal displacement, conservative treatment was chosen. Bed rest until alleviation of symptoms and protected weight bearing on crutches for 8 weeks.

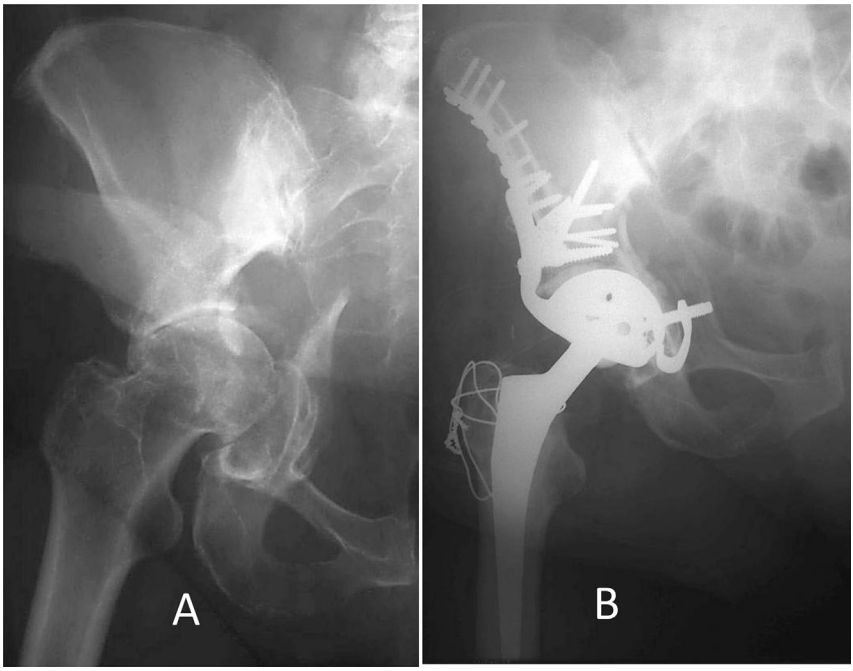

Fig. 14. Massively medially displaced transverse fracture of the acetabulum (A). Prosthetic replacement of the hip was chosen after prior reduction and fixation of the fracture fragments with plates and screws (B). (Courtesy Professor RE PETER).

injuries, and studies show that patients with insufficiency fractures of the sacrum have a heightened risk of mortality (Fig. 13) [66].

Fractures of the acetabulum require specialised treatment. In the frail and osteoporotic patient, a fall from standing height on the greater trochanter acting as a battering ram will suffice to provoke an acetabular fracture [67]. Diagnosis is made by plain radiography, and CT is an obligatory adjunct to accurately characterise and define the fracture pattern. Conservative treatment relies on long periods of immobilisation, up to 8 or 12 weeks of bed rest in traction. This may not be an option for fragile patients with multiple comorbidities. If the surgical option is chosen, it needs to be performed by specialised operative teams in a well-equipped environment. In some cases, osteosynthesis with plates and screws will be possible, but in some patients with profound osteoporosis or if the fracture is highly comminuted, a combination of bone grafting with the use of specially designed prosthetic hip implants will be necessary [68,69] (Fig. 14 A, B).

Femoral shaft fractures

Femoral shaft fractures are life-threatening injuries that can occur in the elderly and very frail patients, often in nursing homes due to a low-energy fall from a wheelchair or out of a bed, and also during a bed to chair transfer [70]. Fatigue or atypical fractures occur commonly in the subtrochanteric area of the femur in patients under bisphosphonates for the treatment of osteoporosis (Fig. 15 A, B) [71]. Diagnosis is by plain X-ray examination, and imaging such as CT or MRI may rarely be useful in suspected pathological fractures. Associated fractures of the femoral neck are known to occur, and therefore, a pelvic X-ray examination should always be performed, as well as knee X-ray examination, in the face of a femoral shaft fracture [72]. Operative fixation will be needed in all cases including fatigue fractures, and most surgeons will choose intra-medullary nailing whether antegrade (from the trochanter) or retrograde (from the intercondylar notch in the distal femur). To enhance stability and to

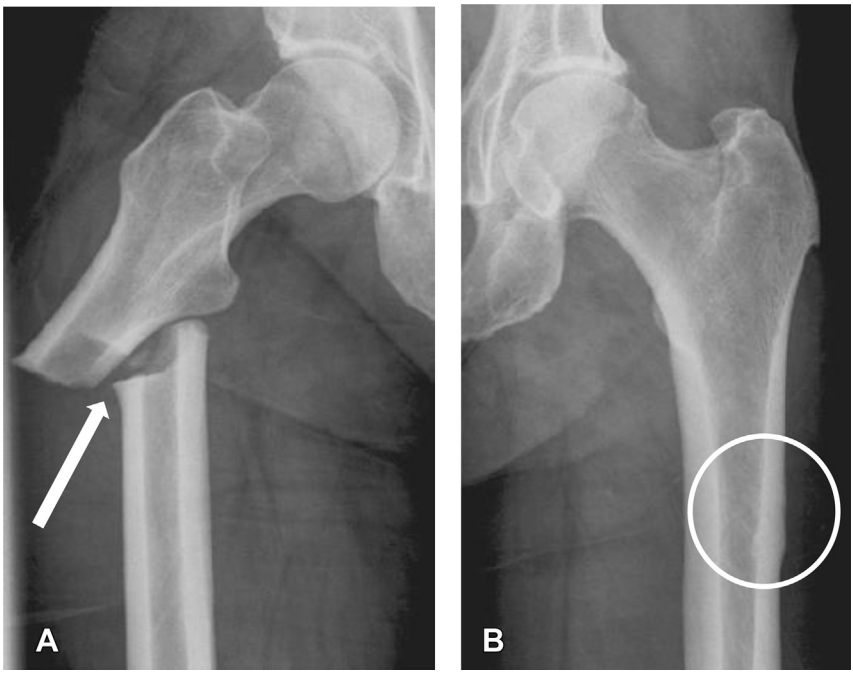

Fig. 15. Fatigue fracture after bisphosphonate treatment, notice cortical thickening (A) Impending fracture, notice cortical thickening (B).

avoid rotation, it is necessary to lock the nail with locking screws. In some cases, plating will be chosen, especially if there is a suspicion of preoperative pulmonary dysfunction such as fatty embolus. After performing the procedure, it is important to take into consideration the rotation of the femur, and if there is any uncertainty, it should be checked by CT scanning [73]. A malrotation of the femur in internal rotation will hinder walking ability at any age. External rotation deformity in the elderly is better tolerated but should be corrected if more than 15°. Complications after femoral shaft nailing or fixation include infection, pulmonary embolus, haemorrhage and non- or delayed union [74]. Rehabilitation and return to ambulation may take some time (3–4 months), but exercises must be encouraged to avoid muscle loss and weakness [75].

Distal femur fractures

Distal femur fractures are intra- or peri-articular fractures. They have a bimodal distribution and occur in the young after high-energy trauma (motor vehicle, high-velocity sports activities, and falls from heights); in the elderly and frail patient, a fall from standing height will suffice [76,77]. Diagnosis depends on examination of adequate X-rays, and CT scans are invaluable in assessing the intra-articular damage. 3-D reconstructions are often used as an aid in planning for the surgical intervention. Surgeons agree that treatment for these fractures is surgical. Conservative treatment with non-weight-bearing ambulation should be reserved for undisplaced fractures, and even in these cases, frequent X-ray evaluations are needed to detect secondary displacement. These fractures are best treated by open reduction and internal fixation with specifically designed plates with locking screws or nails. At times, if the medial aspect of the femur is comminuted, a medial plate may also be necessary. In some rare cases where patients present with severe osteoporosis or massive articular comminution, it may be necessary to use reconstructive arthroplasties to obtain a stable and mobile knee [78]. Rehabilitation will be important after the operative fixation to maintain mobility and permit resumption of independent walking ability in the months that follow the surgery (Fig. 16 A, B).

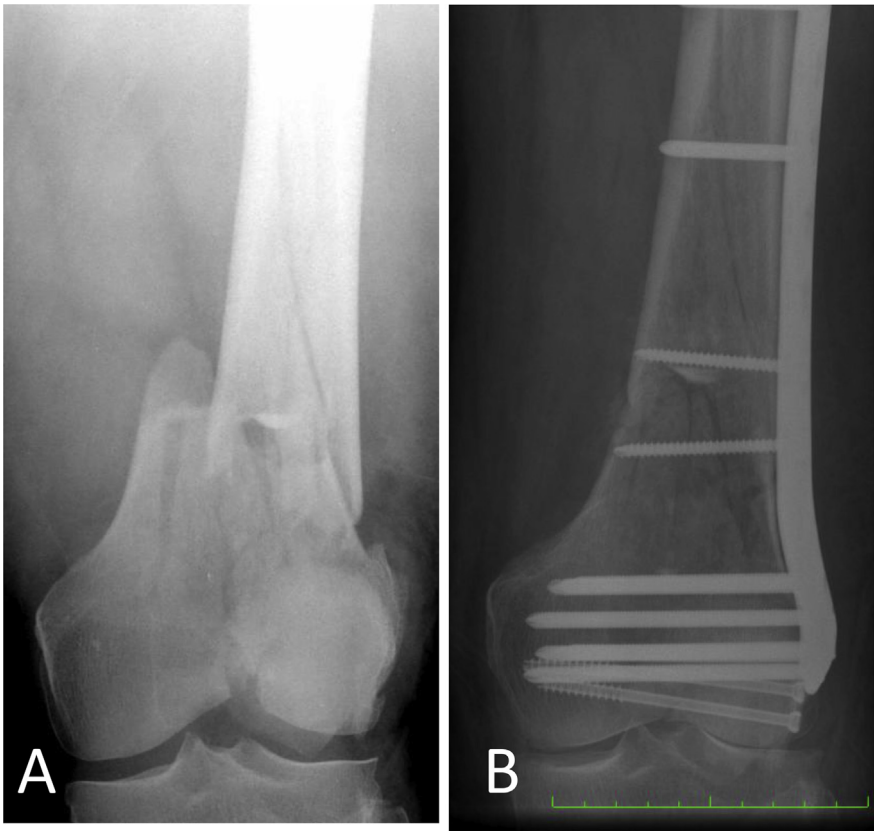

Fig. 16. Fracture of the distal femur (A). Fixation with locking plate (B).

Fractures of the patella

Fractures of the patella are most common in females in the 60- to 80-year age group [79]. It usually occurs after a fall on the flexed knee, with direct impact on the patella. Fractures of the patella may also occur after a total knee arthroplasty with or without patellar resurfacing [80,81]. X-ray examinations confirm the diagnosis. Partial lateral fractures may be treated conservatively or if displaced with screws alone, while transverse displaced fractures are fixed with a tension band construct using metallic or non-metallic implants [82]. Highly comminuted fractures may necessitate treatment by plates or even patellectomy [83,84].

Proximal tibial plateau fractures

Proximal tibial plateau fractures result from low-energy falls in the osteoporotic patient. The majority of these fractures tend to occur in elderly patients [85]. Diagnosis is made by plain X-ray and CT evaluation. MRI may be useful to delineate associated lesions to the soft tissues, menisci and ligaments, although definitive evidence is lacking [86]. Usually, the lateral tibial plateau is impacted and depressed, which creates a concavity, causing a valgus deformity and a major instability of the knee. The accepted treatment consists in elevation, reduction and fixation of the fractured articular surface. The defect of the subchondral cavity left after elevating the depressed articular surface is filled for

support using cement, bone substitutes or grafts [87,88]. Screws and plates are applied to fix the reduction in place. Some surgeons will use minimally invasive hybrid techniques with screws, providing support of the reduced articular surface reinforced by underlying bone grafts or substitutes, while a small bore external fixateur will provide for overall stability (Fig. 17 A, B) [89]. In some instances, the damage to the articular surface is sufficiently major as to be non-reconstructible. In these cases, an arthroplasty is used so that mobility and stability may be rapidly restored (Fig. 18 A, B) [90,91]. Rehabilitation will consist in exercises aimed at regaining range of motion and muscle strengthening. Protected weight bearing will be necessary for the first three months or until clinical and radiological healing has occurred.

Periprosthetic fractures

Periprosthetic fractures are on the rise, parallel to the increasing incidence of articular prostheses implantation [92]. These fractures are serious injuries responsible for a high of mortality rate [93]. Around the knee, these fractures most often involve the proximal femur, but some may be located in the tibia and more rarely in the patella whether resurfaced or non-resurfaced. Various patterns are encountered such as the floating knee, with fracture sites above and under the total knee prosthesis [94] or the interprosthetic fracture involving the femoral shaft between a total hip and a total knee prosthesis [95]. Technical problems such as notching of the distal femur have been mentioned, but falls from standing height and osteoporosis are the major purveyors of these injuries [96]. Periprosthetic fractures can occur around all prostheses including, upper extremity arthroplasties such as the shoulder and elbow but are seen most commonly around the hip and the knee. Clinical diagnosis is straightforward, and imaging involves plain X-ray examination. Some situations may require further imaging with CT, MRI or angiography, in rare cases. Classifications exist to determine

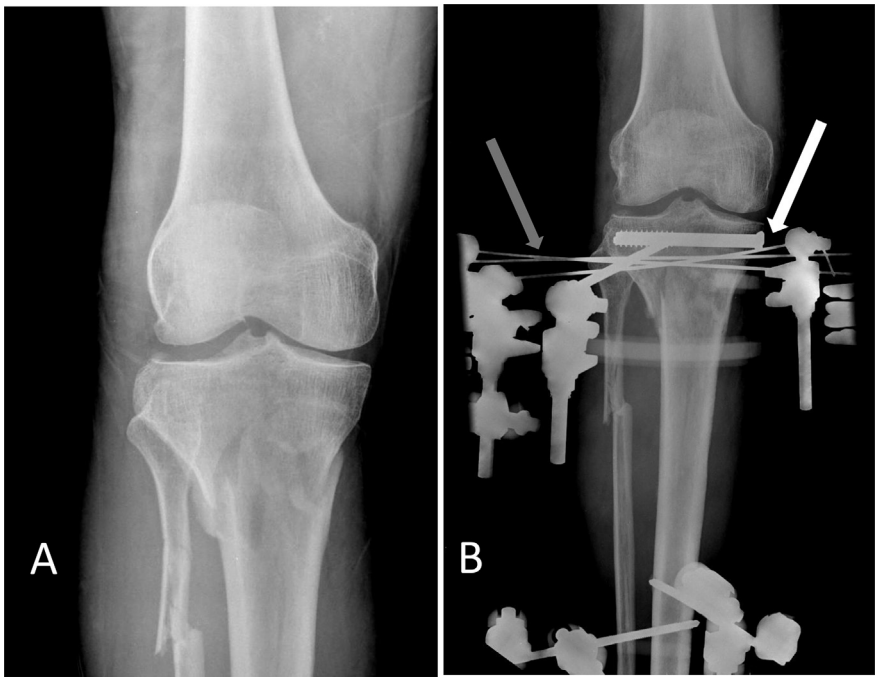

Fig. 17. Fracture of the proximal tibia (A). Fixation with a minimally invasive hybrid system: Percutaneously inserted screws to hold and fix the articular segment (White arrow) and a small bore external fixateur to provide metaphyseal stability. (Gray arrow) (B).

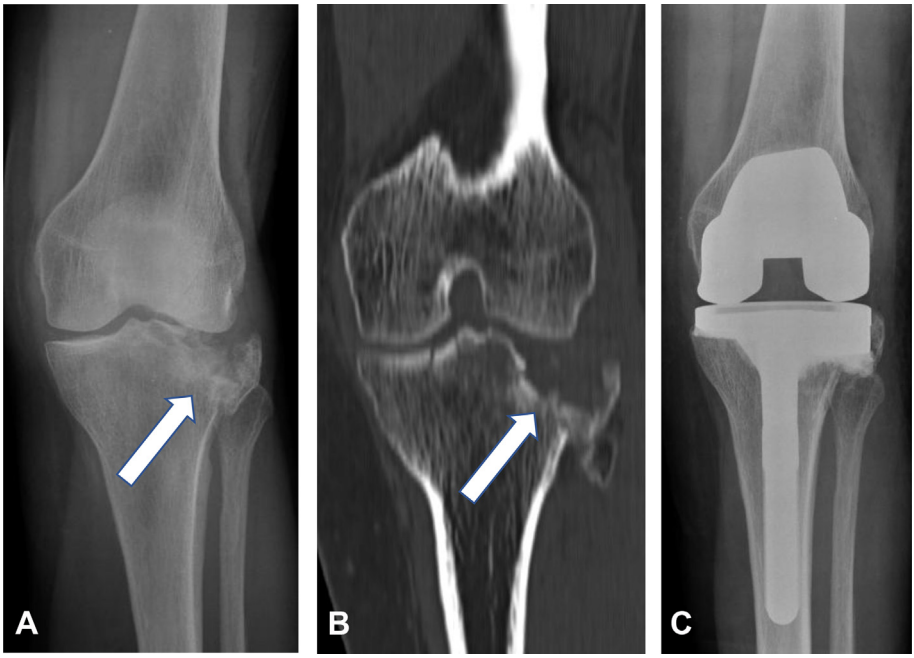

Fig. 18. Fracture of the lateral plateau of the proximal tibia (A). Computed tomography shows destruction of lateral plateau in an osteopenic patient (B). Treatment consisted of inserting a total knee prosthesis with a lateral wedge to fill the defect (C).

the location of the fracture in relation to the prosthesis and include the condition of the implant whether well fixed or loose. All these variables are weighed in on the choices of fixation or replacement techniques. Treatment is surgery with osteosynthesis if the implant is well fixed and also exchange arthroplasty if the components are loose or if the fracture pattern or prosthesis type does not allow for a reliable reconstruction. Before deciding on a surgical procedure, it is imperative for the surgeon to clearly identify the implant in question so that the adequate osteosynthesis material will be on hand if reconstruction is contemplated or the matching components available if the prosthesis is to be partly replaced. A stemmed femoral implant may be used, while the well-fixed tibial implant is retained, for example. At times, it may be necessary to change the entire implant. The intervention must be performed by a team with the expertise, and all the necessary tools and hardware should be on hand if the operation is to be a success. A refracture rate of up to 30% has been cited by some authors (Fig. 19 A, B) [97]. Recovery depends mostly on the pre-fracture status of the patient: Frail elderly patients with comorbidities have, as might be expected, a poorer prognosis [98].

Fractures of the tibia shaft

Fractures of the tibia shaft tend to occur in younger age groups and are associated with sports activities or road traffic accidents. In the older age group, over 65 years of age, women tend to be more affected and present often with open fractures, perhaps because of alterations in the elastic properties of the skin according to COURT-BROWN et al. [99]. One study has reported fatigue fractures of the tibia occurring in elderly patients [100]. In this older age group, tibial fractures are associated with increased mortality and disability [101]. Diagnosis involves clinical examination and plain X-ray examination. Conservative treatment is contemplated in patients with stable fracture patterns or if medically unfit for surgery [102]. Immobilisation using casts or orthoses is not always well tolerated by the frail patient with a thin and fragile skin cover. Treatment is surgical with locked

Fig. 19. Periprosthetic fracture of the distal femur (A). Prosthesis maintained in place and fracture fixation with a locking plate (B).

intra-medullary nailing for mid-diaphyseal fractures and plating with locking plates for periarticular fractures either proximal or distal [103,104]. Complex or open fractures will require extensive treatment including nailing, plating, external fixators and plastic surgery for tissue loss coverage. Compartment syndromes are a risk after high-energy injuries but are relatively infrequent in the elderly age group [105]. Healing occurs in 8–12 weeks, and during that time, protected weight bearing with foot rollover is recommended (Fig. 20 A, B).

Fractures of the ankle

Fractures of the ankle occur in the elderly and frail patient with osteoporosis [106]. Because of the presence of osteoporosis and associated co-morbidities such as neuropathy and vascular insufficiency, the index of suspicion must be high in the elderly patient with ankle pain. A twisting mechanism with the ankle in external rotation and eversion will produce a fracture of the malleoli, while a twisting

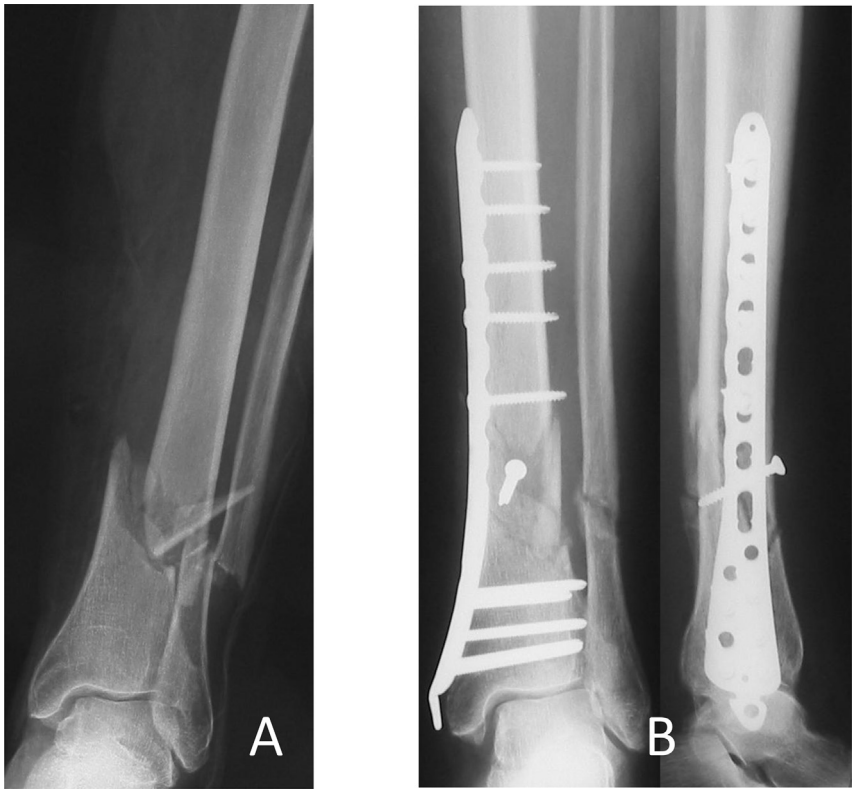

Fig. 20. Fracture of the distal tibia (A). Open reduction and internal fixation with a contoured locking plate (B).

motion in internal rotation and inversion will more likely produce a rupture of the antero-lateral ligament complex. Axial forces such as a fall from a height, even seemingly benign such as a sidewalk, will produce a pilon fracture, which is a crushing injury of the articular surface of the distal tibia. Clinical diagnosis includes immediate functional impotency, loss or deformation of the bony contours, pain on palpation of the bony protuberances of the malleoli and local swelling. The pedal and tibial pulses should be checked. Diagnosis involves X-ray examination. Once a diagnosis is reached, the ankle should be rapidly reduced if the overlying skin is tented to avoid ischemic injury and the ankle immobilised in a splint. After reduction, the pulses are re-checked, and X-ray of the ankle is taken again to ensure it is in an acceptable position. For pilon fractures, a CT scan is advocated to better delineate the fracture pattern. A decision must be made on whether or not surgical intervention is necessary. In the elderly, low-demand patients or if accurate reduction is obtained and maintained, ankle fractures may be treated conservatively in well-padded splints at first and then switched to a below knee walking cast. Some amount of loss of initial reduction might occur, but generally, the results are sufficient to allow nonpainful ambulation after 6–8 weeks. If the fracture is displaced, or if the soft tissue envelope is in jeopardy, open reduction and internal fixation will give provide good results (Fig. 21 A, B, C, D) [107]. A stable construct using plates and screws augmented by the use of cement and intramedullary k-wire for added support will allow early weight-bearing (Fig. 22 A, B) [108,109]. Some surgeons advocate the use of an external fixator left in place until healing has occurred [110].

In the case of pilon fractures, the articular surface of the distal tibia has been destroyed, and complex surgery is necessary to restore the articular surface. After surgery, the patient will need to respect a period of 8–12 weeks of protected weight-bearing, walking with foot rollover [111].

Fig. 21. Highly displaced fracture dislocation of the ankle threatening the integrity of the soft tissue envelope. Notice on view (A) that the tibia is seen in lateral and the talus in anteroposterior and on the (B) view the talus is lateral and the tibia in anteroposterior. Anteroposterior view (C) and lateral view (D) of open reduction and internal fixation with a contoured plate on the fibula and a combination of screw and k-wire on the medial malleolus.

Complications such as non-unions or post-traumatic osteoarthritis [112–114] may occur, but the most serious involve the cutaneous envelope. Skin breakdown over the malleoli will happen if meticulous surgical technique is not used or if the patient is prone to cutaneous fragility, and even when the best technique is used, no patient is immune from this dreadful complication, and they must

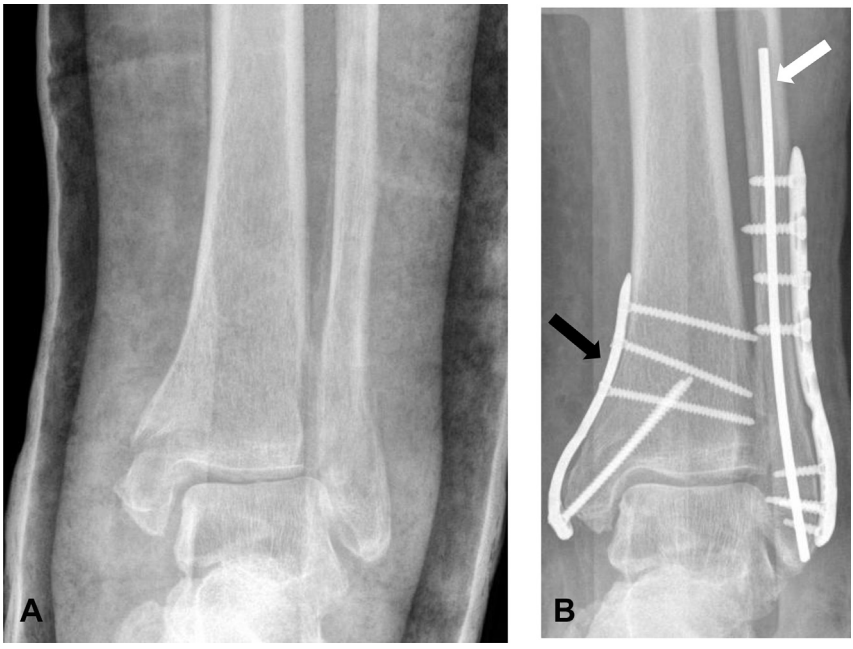

Fig. 22. Displaced ankle fracture in an osteopenic bone in a preoperative padded splint (A). Stronger fixation of the lateral malleolus obtained by an additional intramedullary k-wire plus the plate (white arrow), and for enhanced stability, a plate is used on the medial malleolus (black arrow) (B).

be informed of the situation, which may necessitate lengthy and complex surgical interventions to ensure coverage. Some patients (0.3% according to BULLEN et al.) will develop complex regional traumatic pain syndrome (CRTS) and will necessitate enhanced physiotherapy and appropriate drug therapy, including Vitamin C [115].

Fractures of the foot

Fractures of the foot are relatively uncommon in the elderly. These injuries may cause major and painful loss of mobility to elderly patients. Patients must be warned that the time to healing takes time up to several months. Complex regional pain syndrome is always a possibility to keep at the forefront in case of a protracted evolution [115]. These fractures may occur in any of the tarsal, metatarsal and phalangeal bones, and the treatment needs to be tailored to the situation [116–119]. Before any type of intervention, whether conservative or operative, the neurovascular status must be ascertained. Absent pedal pulses, pre-existing ulcerations or neuropathy may render treatment of these fragile patients difficult. Well-padded splints or casts may be necessary, and in some situations, when the displacement is significant, and the instability is major, internal fixation using pins or plates may be necessary, and in some cases, an external fixateur with small bore pins will be necessary [120]. In elderly patients, after a fracture to the foot, appropriate footwear, flexible and resilient, such as found in modern sportswear must be counselled, avoiding, in many instances, expensive and often unwieldy custom footwear.

Conclusion

To conclude, fractures in frail and elderly patients are common and a major cause of disability. Clinical examination must be precise and well conducted. It is useful to remember that one only finds what one is looking for. After any trauma, no matter how slight, suspicion must be elevated, severe lesions may occur in frail and osteoporotic patients even after seemingly minor traumatic events. Accurate diagnosis must be established by plain X-ray examination, and occasionally, adjunct imaging such as CT or MRI. Treatment modalities must be tailored to the specific fractures or injuries and also to the general condition of the patient. Particular considerations must be taken into account before conservative or surgical intervention: Cutaneous and soft tissue envelope status, osteoporosis, vascular insufficiency, diabetes and the presence of neuropathy all weigh heavily in the treatment decision-making process. Preventive measures must also be taken. After occurrence of a fracture, the treating surgeon or physician must confer with the family and the team of health care providers to put in place all measures aiming to avoid further falls or injuries befalling the frail, elderly, osteoporotic patient in their care.

Summary

Fractures of the extremities, mainly caused by falls, constitute more than two-thirds of injuries befalling frail, osteoporotic and sarcopenic patients. Upper extremity fractures hinder activities of daily living and are debilitating. Treatment is first and foremost conservative, but some fractures need surgical intervention: Open fractures in any location and displaced fractures involving the distal humerus or the forearm are situations needing surgical intervention. Fractures of the wrist tend to be increasingly treated operatively, allowing early motion and use of the hand. Fractures of the lower extremity preclude mobility. Long bone fractures, i.e. tibia and femur, will as a rule necessitate surgical fixation if ambulation is to be recovered, thereby avoiding prolonged immobilisations in casts or braces, poorly tolerated by the elderly. Conservative treatment consisting of short weight-bearing casts or braces may be applied to undisplaced fractures around the foot and ankle. Frail and elderly patients have comorbidities, therefore fracture treatment, whether conservative or surgical, must be tailored individually. It must be kept in mind that fractures, no matter the treatment, take three to four months to consolidate in the best of cases. During this time, joint mobility

and muscle strength must be maintained, aiming at preserving autonomy. Finally, caring for extremities trauma is a team effort, involving family members and health care providers. Prevention is mandatory to avoid further incapacitating fracture episodes. Clearly, more research is needed to minimise the trauma of surgical intervention, to efficaciously treat osteoporosis without unwanted effects and to improve sarcopenia.

Practice points

- Extremity fractures in frail osteoporotic and sarcopenic patients remain a therapeutic challenge.
- Accurate diagnosis needs clinical acumen and adequate imaging.
- Therapeutic options include conservative approach and/or surgical intervention depending on functional demands, associated comorbidities and nature of the injury.
- Maintaining motion and muscle strength is paramount during the healing phase.
- Prevention is essential and involves family members and associated healthcare workers.

Research agenda

- Promising treatments of osteoporosis are already on the market, but side effects must be curtailed.
- Sarcopenia is a whole new field of research that will need future major investments.
- Minimally invasive surgical techniques need further development.
- Rehabilitation techniques applied to the elderly must be elaborated.

Funding statement

The authors have received no funding pertaining to this work.

Conflicts of interest

The authors declare no conflicts of interest.

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