Chapter 1
Introduction

Increasing life expectancy and higher patient expectations have led to a large increase in the number of patients presenting to doctors with musculoskeletal complaints. The World Health Organisation state that musculoskeletal and rheumatic diseases are major causes of morbidity throughout the world, having a substantial influence on health and quality of life, and inflicting an enormous burden of cost on health systems.

Examples of this worldwide burden include:

1. 40% of people over the age of 70 years suffer from osteoarthritis of the knee.
2. 80% of patients with osteoarthritis have some degree of limitation of movement, and 25% cannot perform their major daily activities of life.
3. Rheumatoid arthritis, within a decade of its onset, leads to work disability defined as a total cessation of employment for between 51% and 59% of patients.
4. Low back pain has reached epidemic proportions, being reported by about 80% of people at some time in their lives.

To enable us to correctly treat this increasing volume of patients, knowledge of common orthopaedic and rheumatologic complaints is vital for all student doctors.

In this book, we have attempted to cover the major musculoskeletal diseases, describing clinical presentation, investigation and treatments. It is aimed at not only providing adequate knowledge for the final undergraduate exams but also for junior doctors at work. Extensive yet simple illustrations should aid the student in gaining an understanding of these problems. Enhanced versions of this blinkbook include videos of examination techniques and sample, interactive exam questions.

Chapter 2
Trauma basics

Fracture description and classification

A fracture is defined as a break in the continuity of a bone with an associated soft tissue injury. Fractures are caused by the application of a force, which exceeds the strength of the bone. A direct force or blow applied to a bone will often result in a transverse fracture at the site of application. A twisting or torsional force applied often results in a spiral or oblique fracture at some

distance from the site of application. A force of high energy often results in multiple fracture fragments and is referred to as a *comminuted (or multifragmentary) fracture*.

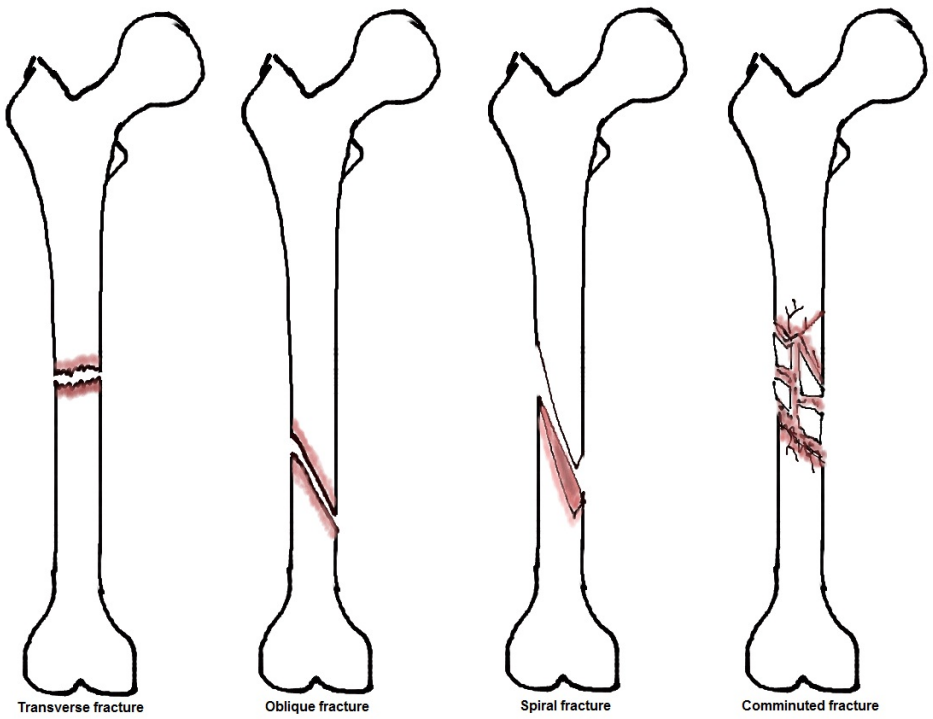
Bones may become weaker if they are infiltrated by tumours (primary or secondary) or in metabolic disorders, such as osteoporosis, that lead to decreased bone mineral density. If a fracture occurs through this region of diseased bone, it often requires much lower force, and is referred to as a *pathological fracture.*

Some fractures occur due to repeated excessive stress application to a bone. This for example occurs in the second metatarsal shaft when an active patient has changed their training regimen and is referred to as a *stress fracture*. A sudden forceful contraction of a muscle may pull off the tendon's bony attachment rather than rupturing the tendon. This is referred to as an *avulsion fracture*. Avulsion fractures may also be a result of traction upon a ligament or joint capsule attachment.

A fracture without disruption of the overlying skin is a *closed fracture*. When the skin and soft tissues overlying a fracture are broken, this is referred to as an *open fracture*. The skin may be broken from within by the sharp bone fragments (*within to out*) or by direct trauma to the skin (*without to in*).

Fractures are further described by:

X-ray appearance:
Transverse - fracture line runs roughly perpendicular to long axis of the bone (if aligned, may be stable)
Oblique - fracture line runs at an angle from the long axis of the bone (potentially unstable)
Spiral - fracture line is spiral in shape (potentially unstable)
Comminuted/multifragmentary - more than 2 fragments; greater force applied will result in more fracture fragments (unstable)
Impacted - bone fragments are driven into each other (potentially stable)



Position in the bone:
Thirds - bone is divided into proximal, middle and distal third (common descriptive terms)
Anatomical - bone is divided into epiphyseal, metaphyseal and diaphyseal sections (less common)

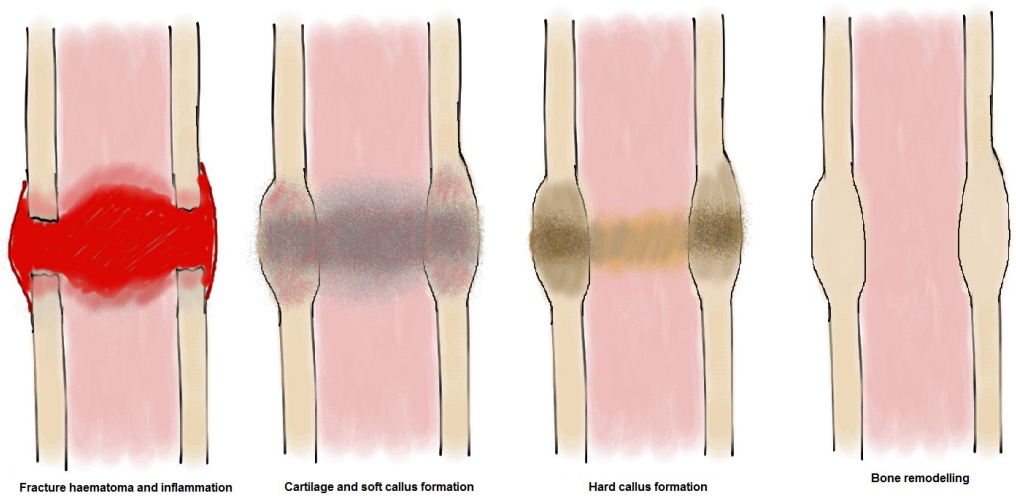
Displacement:
NB: the position of the distal fragment is always described in relation to the proximal fragment.
Translation - bone fragments have shifted relative to each other ie. lateral, medial, anterior or posterior
Tilt - describes angular deviation of the distal fracture fragment ie. dorsal, volar (palmar in the hand and plantar in the foot), valgus or varus
Rotation - bone fragments that are rotated with respect to each other. Can be difficult to recognise with plain radiographs

Fracture healing

Bone healing is a proliferative physiological response. Acceptable healing requires reduction of the fracture, adequate stabilisation in this position and time for healing. A common saying is "Reduce, Fix, Wait, Rehabilitate".

Fracture healing occurs in phases, the length of which varies with severity of injury. Periosteum (the connective tissue membrane covering bone) is vital for healing, supplying precursor cells and nutrient supply. Stripping of the periosteum in a severe comminuted fracture or during surgery may lead to the fracture not healing (*non-union).*

The process of healing occurs in 4 stages:
1. Haemorrhage and haematoma formation - bleeding into the fracture site leads to haematoma formation. Infiltration of phagocytes removes dead or damaged cells. Fibroblasts survive in the damaged area to form vascular granulation tissue.
2. Soft callus formation - periosteal cells at the fracture gap and fibroblasts in the granulation tissue develop into chondroblasts and produce hyaline cartilage. Further from the fracture site, periosteal cells develop into osteoblasts and form woven bone. The cartilage and woven bone grow until they bridge the fracture gap. This is referred to as *fracture callus*. This restores some stability but minimal strength to the bone.
3. Hard callus formation - the callus is substituted by lamellar bone. During this period, initially the woven bone, and then the hyaline cartilage, are replaced by osteoblasts to form new lamellar bone in the form of trabecular bone. This process restores most of the bone's original strength.
4. Remodelling - trabecular bone is digested by osteoclasts followed by osteoblasts laying down compact bone. This occurs in response to the forces applied across the bone (Wolff's Law). This process may take up to 5 years and allows the bone to be restored to a configuration closely resembling its original shape and strength.



Inadequate blood supply, stability or soft tissue (and periosteal) coverage and the presence of infection, dead tissue, tumour or systemic conditions such as diabetes can lead to fracture *delayed union* and eventually to *non-union.*

Principles of fracture management

Fracture management is aimed at protecting the healing process whilst maintaining adequate alignment and allowing for rehabilitation. If the fracture is undisplaced or the patient is unfit for anaesthetic, the position may be accepted and a cast applied.

Management:
Reduction - may be achieved by local anaesthetic block, sedation and analgesia or general anaesthetic. Traction, or closed, and open reduction procedures may be used.
Stabilisation - application of plaster cast, percutaneous wires, plate and screws, external fixator or intra-medullary nails may be required. This decision is made according to fracture pattern, complexity, involvement of a joint and relative stability.
Immobilisation - a period of immobilisation in a cast may be required even after fixation with implants.
Rehabilitation - range of motion along with muscle strengthening exercises must begin as early as is practical but must not compromise fracture healing.

Specific examples are covered in the next chapter.

Major trauma

'Major trauma' is a term used to describe multiple injuries involving different tissues and organ systems that are, or may be, life threatening. Trauma patients require specialist care from a multidisciplinary group of professionals in a major trauma centre. These hospitals must provide 24-hours a day a fully staffed emergency department, a consultant-led resuscitative trauma team, dedicated trauma theatres and operating lists, the presence of all major surgical specialties on a single site (orthopaedic trauma, general and vascular surgery, neurosurgery, plastic surgery, cardiothoracic surgery, head and neck surgery and urology), interventional radiology and anaesthesia with appropriate intensive care facilities.

Advanced Trauma Life Support (ATLS)

An algorithm for management of major trauma patients, developed in the 1970s in the USA. Now adopted worldwide, the system allows a trauma team to manage a multiply injured patient in a standardised manner, allowing early identification and treatment of injuries, prioritised to the most life-threatening injuries first. The mnemonic ABCDE acts as an aide-memoir for the *primary survey* during which the simultaneous processes of identification of injuries and resuscitation occur. This is followed by the *secondary survey* to discover other, less severe injuries.

Primary survey

A - Airway with C-spine control - treatment of any threat to the airway with manoeuvres such as chin lift and jaw thrust, use of adjuncts (oro- and naso-pharyngeal airways) or securing it with a cuffed endotracheal tube or tracheostomy. Throughout the resuscitation process, the cervical (C-) spine

must be immobilised in a hard collar and sand bags or with inline immobilisation and log rolling when transferring. This must be continued until the spine is cleared clinically and radiologically.

B - Breathing - thorough examination including palpation, percussion, auscultation and on to chest X-ray to identify and treat life-threatening conditions such as airways obstruction (treated with removal of obstruction, bronchoscopy or tracheostomy), tension pneumothorax and massive haemothorax (both treated with a chest drain), flail chest with pulmonary contusion (treated with analgesia, physiotherapy and selective ventilation) and cardiac tamponade (treated with cardiocentesis or thoracotomy).

C - Circulation and haemorrhage control - haemorrhage is a major cause of preventable death in trauma. Two large-bore intravenous lines are established and crystalloid solution given followed, if necessary, by blood products. External bleeding is controlled by direct pressure. Occult bleeding may be into the chest, abdomen, pelvis or long bone fractures. Severe abdominal or thoracic haemorrhage may require emergency laparotomy or thoracotomy to control bleeding. Pelvic fracture causing bleeding may initially be controlled with a pelvic binder but may require laparotomy with pelvic packing or interventional radiology and embolisation.

D - Disability - assessment of neurological function using the *Glasgow Coma Score* (GCS) and examination of pupil light reflexes. Alteration of conscious level indicates a need to re-evaluate oxygenation, ventilation and perfusion status. Alcohol, drugs and hypoglycaemia may influence consciousness level. If these causes are ruled out, traumatic brain injury must be considered and searched for.

E - Exposure/Environment - the patient must be fully exposed and examined thoroughly for major injuries. Then warming blankets must be applied.

Secondary survey

This entails a complete history and head to toe examination performed at a time when the patient has been stabilised. Every part of the body must be examined and appropriate X-rays obtained to rule out other injuries. Any deterioration in the patient's vital signs means the primary survey should re-start at the Airway stage to identify a cause.

Complications of fractures

Acute

Compartment syndrome - increased pressure within a myofascial compartment of fixed volume, caused by bleeding and oedema, exacerbated by diminished venous outflow. The raised intra-compartmental pressure can

lead to arterial occlusion within a few hours, leading to muscle and nerve necrosis. Signs are pain out of proportion of the injury and there is pain upon passive stretch of muscle within the compartment. Initially split any constricting bandages or cast. If there is no resolution, an emergency fasciotomy is required.

Arterial injury - often due to joint dislocation, high energy injury or penetrating trauma. This is identified by absent distal pulses manually or on Doppler examination and requires stabilisation of skeletal injury (often with external fixator), followed by revascularisation by vascular surgeons. Fasciotomies may be performed to prevent compartment syndrome secondary to revascularisation after prolonged ischaemia.

Nerve injury - often due to grossly displaced fractures, dislocations or penetrating trauma. Many will recover and can be observed. Those involved in open fractures, associated with vascular injury or injured during surgery require exploration.

Intermediate

Infection - deep bone and soft tissue infection is due to contamination of an open fracture or during surgical fixation. It may be difficult to resolve, may require multiple debridements (excision of dead tissue), long-term antibiotics and reconstruction using external frames. When causing severe disability or sepsis, the limb part may require amputation.

Non-union - failure of fracture to unite due to problems with the bone (local tumour, infection, unstable fracture, severe comminuted fracture), surrounding soft tissues (infection, periosteal stripping, poor vascular supply, skin/muscle loss), and underlying patient issues (diabetes, smoking, malnourishment). Non-union may require multiple procedures to overcome the cause, including revision fixation with bone grafting, vascularised skin/muscle flaps and excision of infected bone and bone growth stimulation with an external frame.

Mal-union – fractures may unite in an abnormal position, leading to pain, reduced function and diminished motion in local joints. Malunited fractures may require surgery to cut and realign the bones.

Late

Osteoarthritis (see chapter 4) - injury to a joint may lead to early development of arthritic pain and reduced function of the joint (secondary/post-traumatic arthritis). Established osteoarthritis may eventually require joint replacement surgery (arthroplasty).

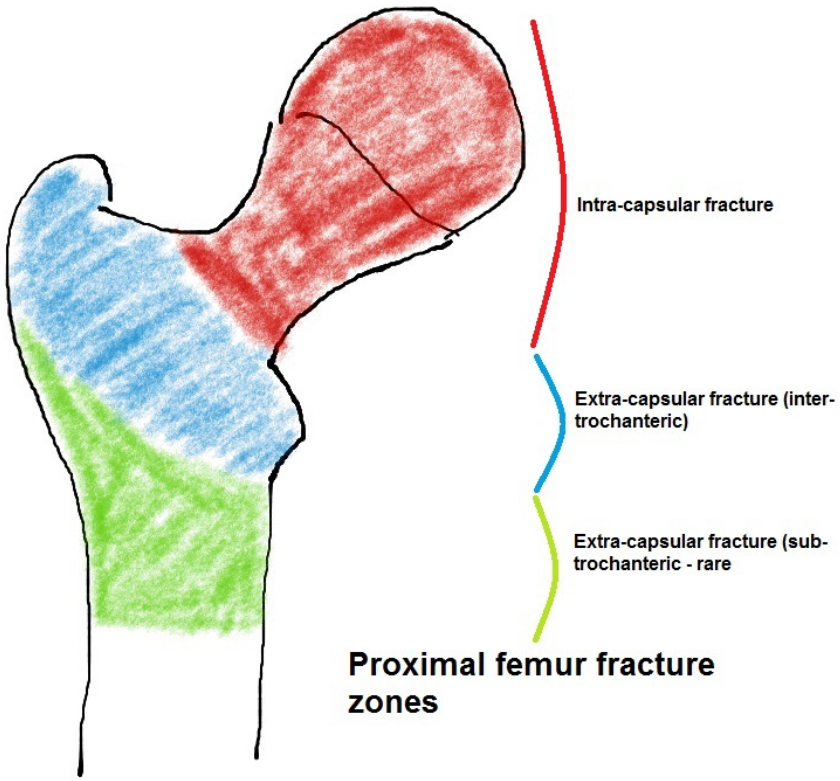
Chapter 3

Common fractures

Hip fractures

Typically a *fragility fracture* (associated with osteoporosis) is seen in post-menopausal women over the age of 70 years. Risk factors include medical morbidity, falls history and previous fractures. The incidence is between 70,000 to 75,000 fractures each year and the annual cost in the UK is about £2 billion. About 10% of patients with a hip fracture die within 1 month and about one-third within 12 months. Most of the deaths are due to associated conditions and not to the fracture itself, reflecting the high prevalence of comorbidity. In young adults, this is a high-energy injury and should be treated as an orthopaedic emergency.

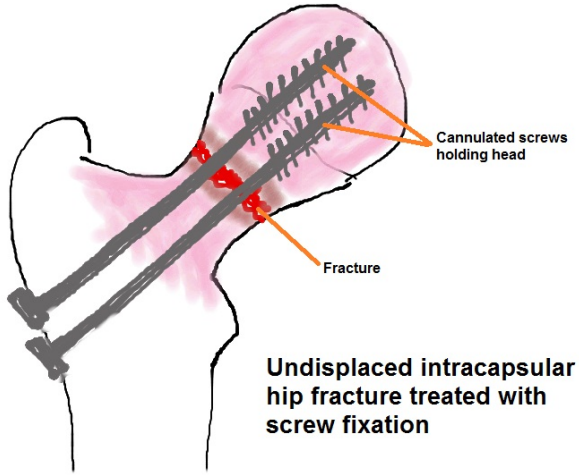
There are two major common types of hip fracture and one rarer configuration, all of which require different treatments. These are defined by the position of the fracture on the neck of the femur:



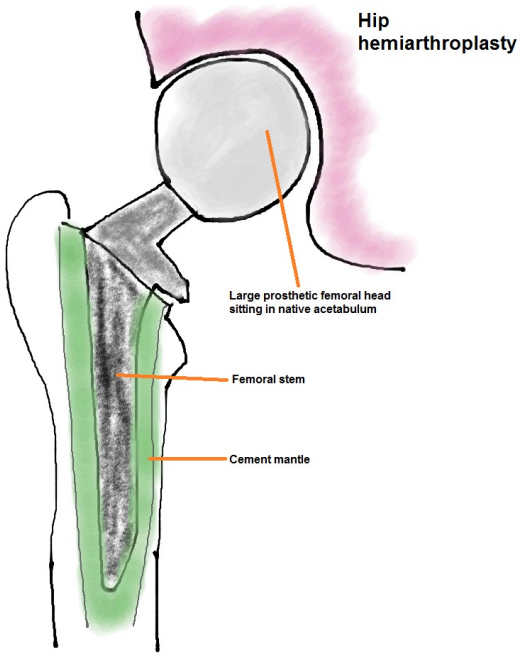
Intracapsular hip fractures
The fracture line is proximal to the insertion of the hip capsule on the femoral neck. A displaced fracture disrupts the retinacular arteries that run up the neck, cutting the blood supply to the weight-bearing femoral head. If the head is subsequently fixed back in place, there is a high risk of it dying and collapsing due to avascular necrosis (AVN). Therefore, if displaced, the head is cut out (excised) and replaced with a half (hemi) or total hip replacement

(arthroplasty). If entirely undisplaced, the head may be retained and fixed with screws (relying on the assumption that the lack of fracture displacement means the arteries are undamaged). The Garden classification of intracapsular fractures is commonly used to describe displacement:

Garden I - partial fracture, undisplaced - fix fracture with screws
Garden II - complete fracture, undisplaced - fix fracture with screws
Garden III - complete fracture, partial displacement - replace head with hemiarthroplasty or hip joint with total hip arthroplasty
Garden IV - complete fracture, totally displaced - replace head with hemiarthroplasty or hip joint with total hip replacement

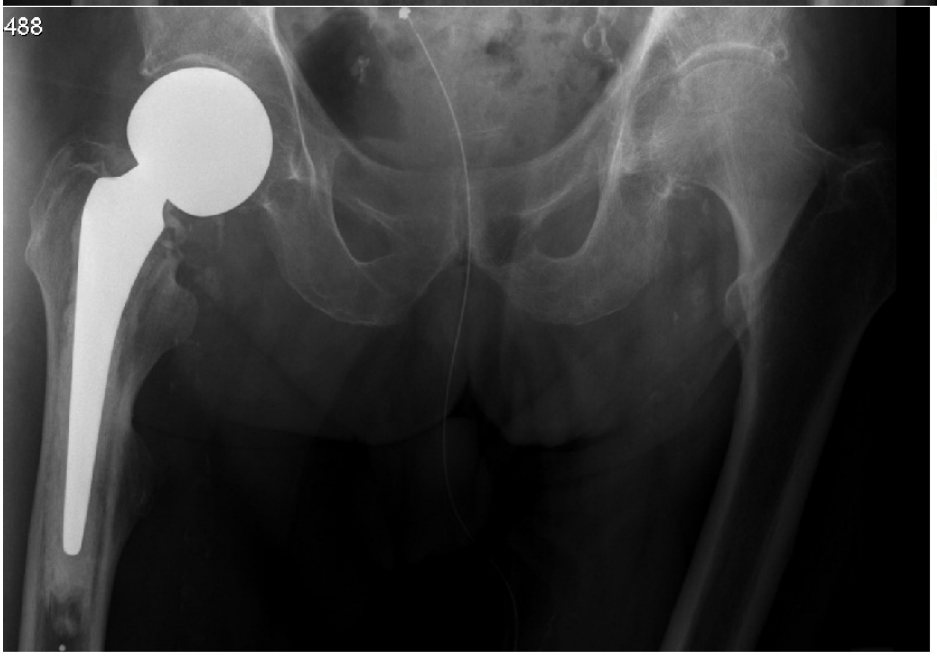


Undisplaced intracapsular hip fracture treated with screw fixation



Although widely accepted, the Garden classification has been shown to have large intra- and inter-observer error and is rarely used. It is easier to just describe these fractures as undisplaced or displaced.

X-ray: displaced intracapsular fracture right hip



X-ray: right hip hemiarthroplasty

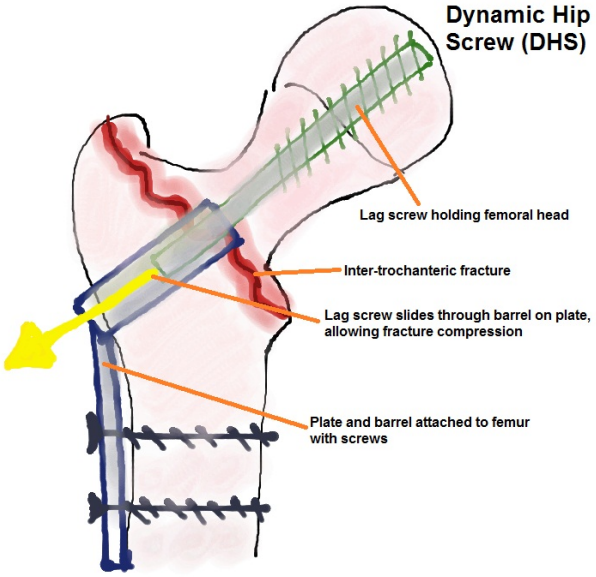
Complications of screw fixation include infection, non-union, loss of position and femoral head AVN (if painful, requires total hip replacement).

Complications of hip (hemi)arthroplasty include infection, dislocation, venous thromboembolism and wear through the acetabulum in hemiarthroplasty (requiring total hip arthroplasty).

Extracapsular hip fractures
The fracture line is distal to the insertion of the capsule and therefore there is no risk of AVN. These fractures are described by the position in the proximal femur (intertrochanteric or sub-trochanteric) and the number of fracture fragments e.g. intertrochanteric 3-part fracture.

Intertrochanteric fractures are usually treated by fixation with a special plate and screw called a dynamic hip screw (DHS). The screw grips into the

femoral head and can slide down through plate barrel (yellow arrow on diagram), allowing the fracture to compress and heal.

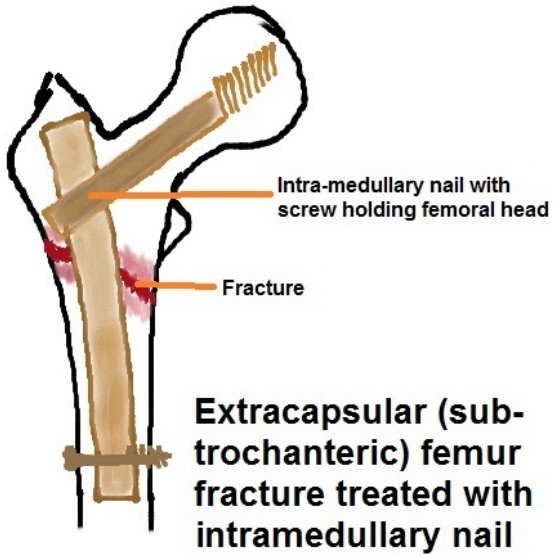


Complex fracture configurations involving more pieces (4-part or if involving the lesser trochanter) will be more unstable and are often treated with a proximal femoral intramedullary nail. An intramedullary nail provides a mechanically stronger construct, although current literature does not show a difference in the outcome between this device and a DHS.

X-ray: extracapsular neck of femur fracture

X-ray: left Dynamic Hip Screw (DHS)

Subtrochanteric fractures are inherently unstable due to the position of the fracture and require fixation with a femoral intramedullary nail.



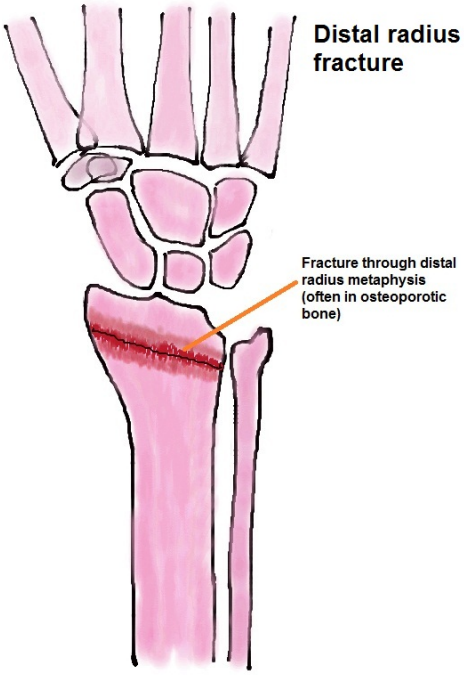
Extracapsular (sub-trochanteric) femur fracture treated with intramedullary nail

Treatment principles

The priority of treatment of all hip fractures revolves around early surgery, which allows immediate mobility, reducing the risk of chest infection, venous thromboembolism and pressure sores. Current National Institute of Clinical Excellence (NICE) guidelines target surgery within 24-36 hours of admission, combined management by orthopaedic surgeons and geriatricians and commencement of bone protection medication (such as bisphosphonates).

Wrist fractures

These are commonly seen, especially in the distal radius, in elderly osteoporotic bone or paediatric wrist joints with open growth plates (physes). Distal radius fractures in mature adults are typically high-energy injuries. The incidence is between 40,000 to 60,000 distal radius fractures in adults per year in the UK.

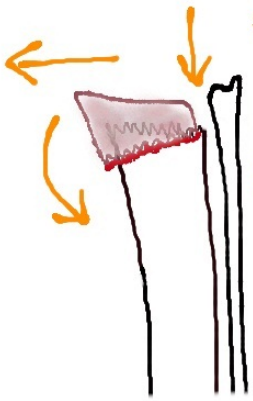


Elderly fractures

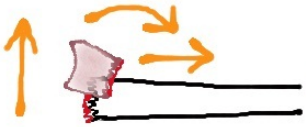
The most common fracture in the elderly population is a Colles' fracture caused by a fall onto a flexed wrist in osteoporotic bone. The incidence increases with age. Other risk factors include female sex and post-menopause. A Colles' fracture has five distinct deformities described in terms of the distal fragment:

1. Dorsal displacement
2. Dorsal tilt
3. Radial displacement
4. Radial tilt
5. Impaction (shortening)

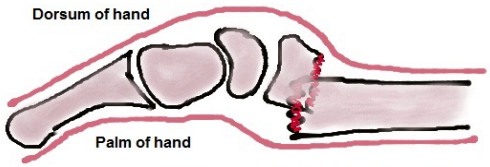
Common deformities seen in Colles fractures



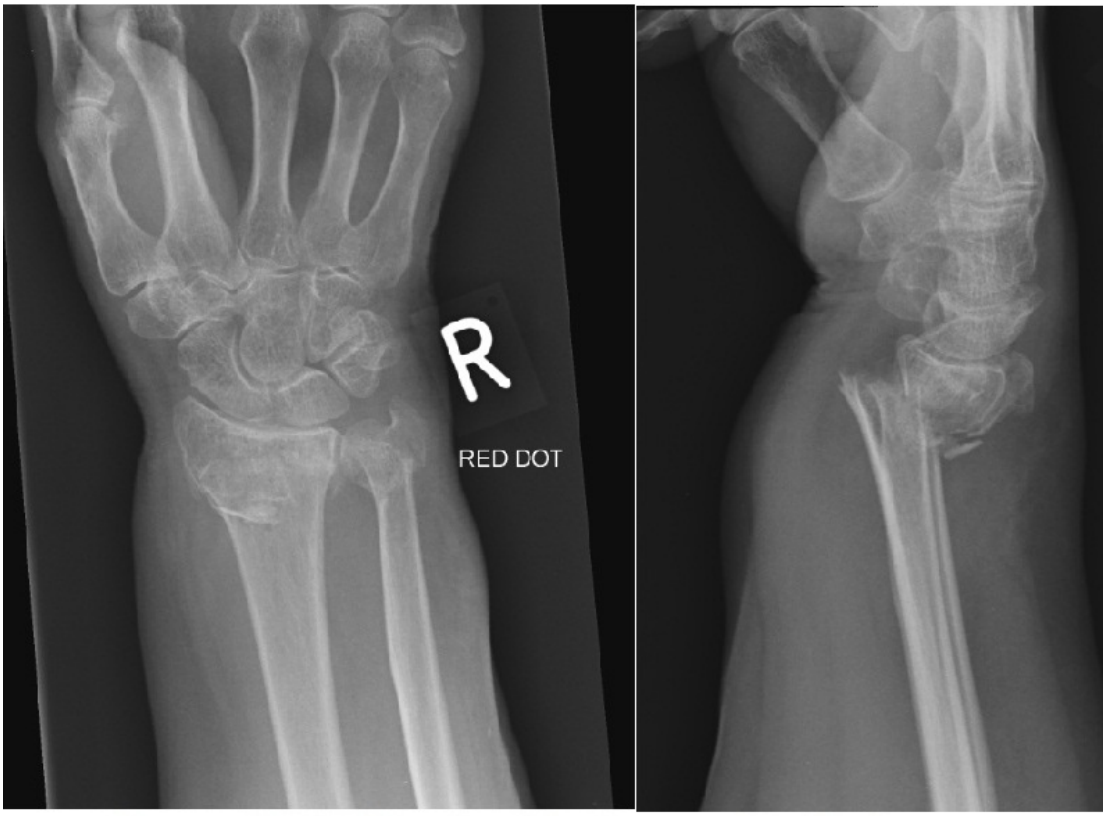
AP view: radial deviation, radial tilt, shortening (impaction)



Lateral view: dorsal deviation, dorsal tilt, shortening (impaction)



"Dinner-fork" deformity seen with Colles fracture of the distal radius



X-ray: Right distal radius fracture (Colles)

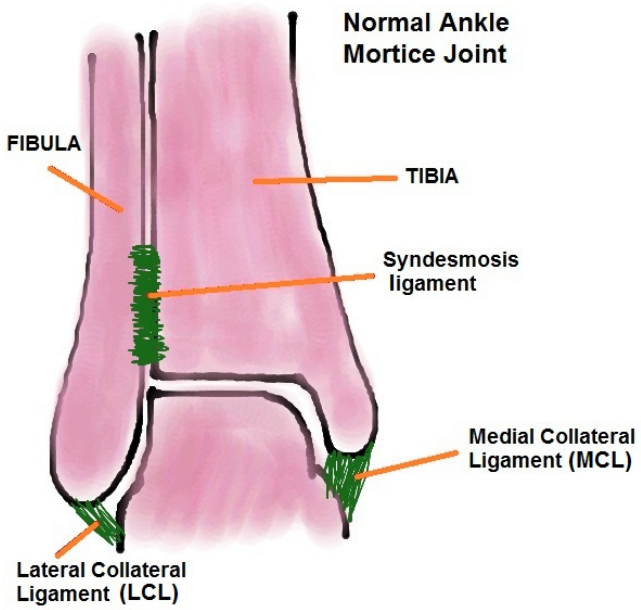
Treatment principles
Initially analgesia is given and assessment made for nerve compromise (typically median nerve) and other injuries. Preceding causes of the fall including cardiac and neurological disease must be considered. Diagnosis is with AP and lateral X-rays. Reduction is attempted by manipulation in the emergency department under haematoma block, Biers block or conscious sedation. Reduction is via in-line traction followed by a manoeuvre to initially increase the deformity (wrist extension) followed by reduction (flexion and ulnar deviation). A back slab is applied in this position and the wrist immobilised for 5-6 weeks with weekly check X-rays for the first 3 weeks to ensure reduction is maintained.

If adequate reduction is not achieved or is lost, re-manipulation may be considered. If the patient is fit and functional, this may include reduction under general anaesthesia plus fixation with percutaneous K-wires or plate and screws.

These elderly patients are at risk of further falls and other osteoporotic fractures, including spine wedge fractures and hip fractures. Thus, they must also be considered by their geriatrician for review in a falls prevention clinic and introduction of bone protection medication.

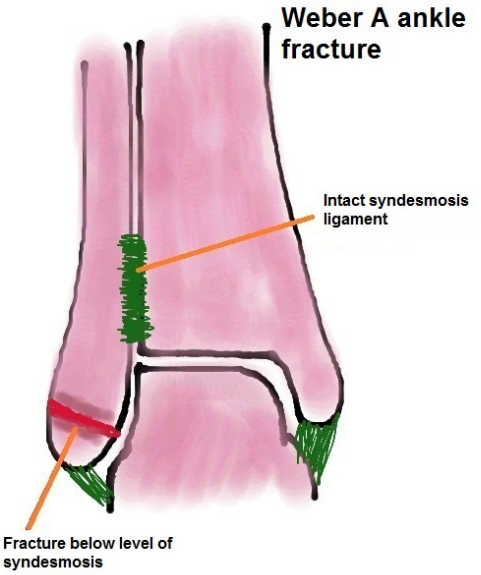
Ankle fractures

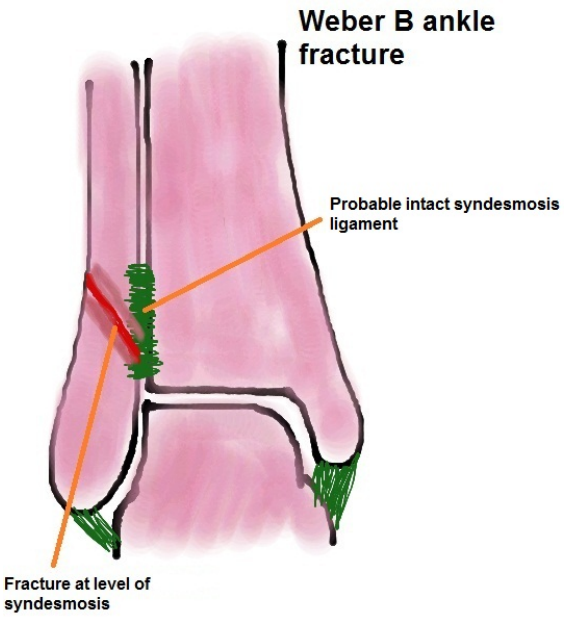
Increasing in incidence since the 1960s, most involve a single malleolus with about 30% being bi- or tri-malleolar. The ankle is a complex hinge joint with stability dependent upon the ligaments between the distal tibia and fibula (the syndesmosis) and the medial and lateral collateral ligaments of the ankle. Disruption of the syndesmosis following an ankle fracture allows the tibia and fibula to drift apart (diastasis). If the medial collateral ligament is also disrupted, the talus position under the tibia may displace laterally (talar shift). These must be detected and treated early to avoid the early onset of ankle arthritis.

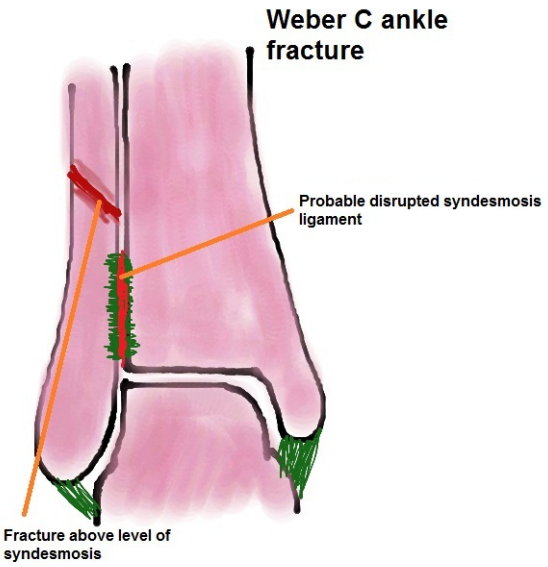


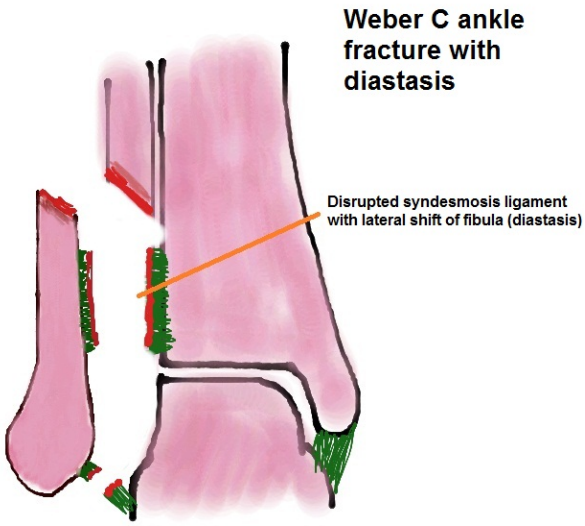
Injury pattern is related to the foot and ankle position at the time of injury. The level of the fracture on the lateral malleolus is indicative of the risk of injury to the syndesmosis (the more proximal, the greater the risk). Commonly described by the Weber classification:

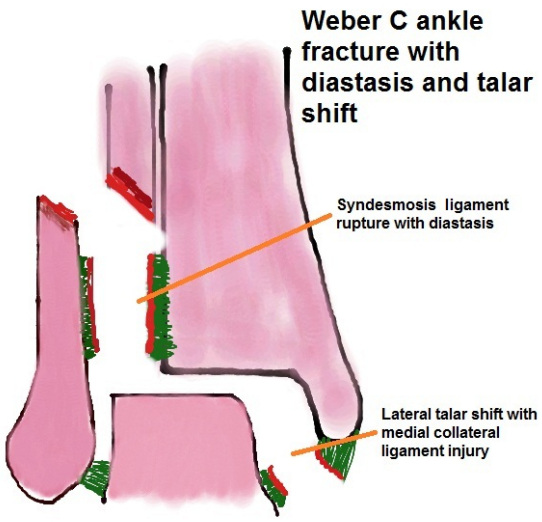
Weber A: fracture below the level of the distal tibial joint surface. No risk of diastasis.
Weber B: fracture at the level of the syndesmosis. 50% have associated disruption of the syndesmosis.
Weber C: fracture above the level of the syndesmosis. Syndesmosis almost always disrupted.


Weber A ankle fracture
Intact syndesmosis ligament
Fracture below level of syndesmosis


Weber B ankle fracture
Probable intact syndesmosis ligament
Fracture at level of syndesmosis


Weber C ankle fracture
Probable disrupted syndesmosis ligament
Fracture above level of syndesmosis


Weber C ankle fracture with diastasis
Disrupted syndesmosis ligament with lateral shift of fibula (diastasis)



Treatment principles

Weber C fractures require open reduction and internal fixation (ORIF) with plate and screws and a large screw holding the fibula reduced on the tibia (known as a diastasis or syndesmosis screw). This screw will often be removed once the ligament has healed after 8-9 weeks. Typically Weber B fractures require fixation of the lateral malleolus with plate and screws but if there is associated diastasis, they will also require a diastasis screw. Weber A fractures and undisplaced Weber B fractures may be managed non-operatively in a non-weight bearing below-knee cast for 6 weeks.

X-ray: Weber C ankle fracture with diastasis and lateral talar shift

Tibial and femoral shaft fractures

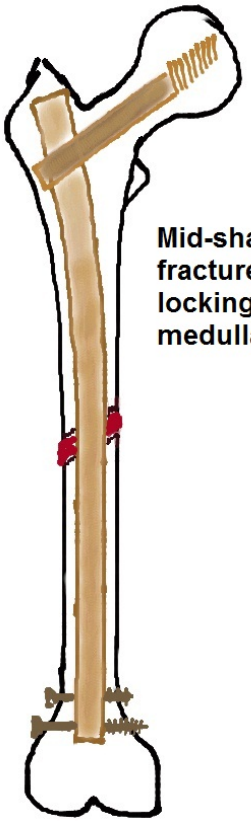
Femoral shaft fractures occur in a bimodal distribution, most frequently in young men after high-energy trauma and elderly women after a low-energy fall. Neurovascular injury is uncommon after these injuries but major blood loss may occur with greater than 1.2L being the average loss and about 40% of patients requiring transfusion. Careful evaluation for other injuries must be carried out.

Tibial fractures are the most common long bone fractures. Men are most commonly affected, with incidence being about 41 per 100,000 per year. Injury may be via direct high-energy blows, penetrating trauma and bending or torsional forces. The tibia has a subcutaneous border and so has a high incidence of open fractures. These require early antibiotics (and tetanus cover), skeletal stabilisation, aggressive wound debridement and early skin coverage or closure.

Compartment syndrome is a risk in long bone fractures, particularly those of the tibia, and must be closely monitored for. Pain out of proportion to the injury is the most reliable sign. Any suspicion of compartment syndrome requires emergency fasciotomy - delay leads to extensive muscle necrosis with the risk of acute renal injury and toxic shock and eventual chronic contractures and limited limb function.

Treatment principles

The aims of treatment are to stabilise the fracture allowing the patient to mobilise (and possibly ambulate) whilst allowing the fracture to heal. The most common treatment is intra-medullary nail fixation. This should be performed within 24 hours and early stabilisation of long bone fractures appears particularly important in the multiply injured patient. External fixators may be used as a temporary or permanent stabilisation technique, particularly in fractures with open wounds or complex articular injuries. External fixators are rarely used as definitive treatment for femoral fractures. Plates are rarely used for tibial and femoral shaft fractures and are often reserved for intra-articular involvement or for treatment of non-unions.



Mid-shaft femur fracture treated with locking intra-medullary nail