Chapter 4

Specific fracture management

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Types of fracture

Direct trauma
This will usually result in a **comminuted** fracture. This is commonly **compound**, or open, if the bone is **subcutaneous**, as in the **tibia** or **ulna**.

Bones commonly affected are the **tibia** and the **calcaneus**. 'Bumper' fractures of the lower third of the tibia in pedestrians or motor-cyclists are particularly common.

Indirect trauma
This will usually result in a **transverse** fracture, if caused by an **abduction** injury, or an **oblique** or **spiral** fracture when caused by a **twisting force**.

Complicated fractures
A complicated fracture is one where there is a major injury to a structure other than the bone itself.

- **Compound or open fractures** — Communication from the **skin** or **viscera** can lead to bone **infection**.
- **Head, chest and abdominal injuries** — Damage to the brain or viscera may also progress to numerous complications, which are described in Chapter 2 (pages 92–129).
- **Injury to the spinal cord and peripheral nerves** — Neurological complications are common. They may lead to **paraplegia** or **quadriplegia**, with **paralysis** of the **bladder**.
- **Vascular complications** — Bleeding may be considerable from damage to a **major vessel**. **Popliteal** or **brachial** vessel damage may lead to **ischaemia** or **gangrene** of the **foot** or **hand**. Severe fractures of the **pelvis** may lead to **considerable blood loss** from the smaller **retroperitoneal blood vessels**, in addition to the **iliac arteries** and **veins**.
- **Systemic complications** — Considerable blood loss due to major fractures may cause severe **hypovolaemic shock** and adult respiratory distress syndrome (ARDS). **Fat embolus** and **crush syndrome** may also be a complication of severe fractures.

Complications of fractures and dislocations are discussed under the **individual injuries**.

Healing of fractures

Haematoma
A haematoma will always form following a fracture. This may be **extensive** in **vascular bones**, such as fractures of the shaft
Types of fracture

Direct trauma

Bumper → Comminuted — often compound

Fall on calcaneus → Crush fracture

Indirect trauma

Transverse force → Oblique: twisting force
of the femur and in major fractures of the pelvis. The haematoma is not normally visible on X-ray.

**Granulation tissue**
Granulation tissue forms by organisation of the haematoma with ingrowth of osteoblasts and osteoclasts. Granulation tissue again is not usually seen on X-ray, except as a soft tissue shadow.

**Callus formation**
Callus formation is due to calcification within the granulation tissue with laying down of cartilage across the bone ends. This will show as a shadow on X-ray.

**Bony consolidation**
Bony consolidation with the formation of woven bone occurs due to ossification in the cartilage. This can be seen on X-ray.

**Remodelling**
Remodelling of the fracture site occurs due to the stresses on the fracture site by muscle pull and weight-bearing. This is due to activity of the osteoblasts which lay down bone and osteoclasts which remove unstressed new bone. The woven bone is then replaced with definitive bone.

**Bone union in children**
Bone union in children takes approximately half the time of that seen in adults. In babies and young children union is much more rapid.

**Bone union and type of fracture**
Union usually occurs earlier in oblique fractures than in transverse fractures. It is also more rapid in fractures with a good blood supply, such as the metacarpals, metatarsals and phalanges, than in the shaft of major long bone fractures, due to less vascular supply to the fractured bone ends.

**Delayed union**
Excessive movement, or alternatively too rigid internal fixation can delay fracture union. Infection or pathological bone due to secondary neoplastic malignant deposits in bone, or diseased bone in Paget's disease will also delay union or lead to established non-union.
Types of fracture
Pathological fractures

Minimal force  Secondary deposit  Fragilitas ossium  Senile osteoporosis

Children
Poor history

X-ray both sides if in doubt  Greenstick fracture  Slipped epiphysis ± fracture
Immobilisation times

Upper limb
The union or immobilisation times are illustrated. These are very approximate and there are many exceptions. Some fractures, such as the shafts of metacarpals, require almost no immobilisation. Other fractures, such as the waist of the scaphoid or the shaft of the radius and ulna, require rigid splinting or internal fixation.

• Internal fixation – This is now the usual treatment of most displaced fractures of the shaft of the radius and ulna and of the olecranon. Limited mobilisation of the limb is usually permitted after a few days.

Many pathological fractures of long bones, due to secondary deposits, are now also treated by early internal fixation followed by radiotherapy, with or without chemotherapy or hormones.

Spine and pelvis
Isolated minor fractures of the pelvis, sacrum and coccyx without complications require little or no immobilisation. Major fractures and dislocations of the cervical, thoracic and lumbar spine, often with instability, need protection for 2-3 months.

The same applies to severe central dislocation of the hip, and unstable fractures and disruptions of the pelvis, which may require internal fixation.

Lower limb
Fractures requiring minimal immobilisation include isolated fractures around the hip which do not affect stability, such as isolated fractures of the greater and lesser trochanters, and fractures of the fibula, metatarsals and toes.

Major fractures of the hip, shaft and lower end of the femur, and major fractures of the tibia, neck of the talus and the calcaneus involving the subtalar joint, take 3 months to heal. Except for the calcaneus they often need internal fixation to obtain early mobility. Internal fixation is especially indicated in elderly patients with major fractures of the hip, avoiding the many complications associated with prolonged bed rest.
# Immobilisation

## Injuries of the upper limbs

### Approximate times

<table>
<thead>
<tr>
<th>3 weeks</th>
<th>3–6 weeks</th>
<th>8–12 weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clavicle</td>
<td>Acromio-clavicular joint dislocation</td>
<td>Shaft humerus</td>
</tr>
<tr>
<td>Shoulder dislocation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minor elbow fractures</td>
<td>Dislocated elbow</td>
<td>Shaft radius and ulnar fractures</td>
</tr>
<tr>
<td>Head of radius fractures</td>
<td>Supracondylar fracture</td>
<td></td>
</tr>
<tr>
<td>Triquetral</td>
<td>Fracture olecranon</td>
<td></td>
</tr>
<tr>
<td>Scaphoid tuberosity</td>
<td>Colles and Smith's fractures</td>
<td>Scaphoid (body)</td>
</tr>
<tr>
<td></td>
<td>Dislocated lunate</td>
<td></td>
</tr>
</tbody>
</table>
Immobilisation or non-weight-bearing

Injuries to spine and pelvis

Approximate times

3 weeks

- Spinous process
- Stable fracture spine
- Fracture transverse process
- Fracture of sacrum and coccyx

2-3 months

- Fractures and major dislocation cervical spine
- Unstable fractures and dislocations thoracic and lumbar spine
- Unstable fractures and dislocations of pelvis

Isolated fractures of pelvis

Central dislocation of hip

Bladder, vascular and neurological complications first priority in treatment
Immobilisation

Injuries of the lower limbs

Approximate times

3 weeks or less

- Isolated fractures trochanters
- Tear menisci
- Fibula without ankle damage
- Minor ankle fractures and sprains
- Metatarsals and toes

6 weeks

- Ligaments of knee
- Rupture extensors knee

2-3 months

- Cervical and trochanteric fractures
- Shaft femur
- Femoral condyles
- Plateau tibia
- Shaft tibia
- Major fractures ankle
- Neck of talus
- Calcaneus

* Internal fixation or repair will allow earlier mobilisation
* Physiotherapy is important
Pathological fractures

Pathological fractures occur in bones that have been weakened for any reason.

Causes

- **Senile osteoporosis** — This is the most common cause.
- **Secondary tumour deposits** — These also commonly cause pathological fractures, particularly from carcinoma of the breast, lung, thyroid, kidney, prostate, cervix, bowel, and from multiple myeloma. The treatment of pathological fractures resulting from secondary deposits usually involves internal fixation plus radiotherapy. Hormones or chemotherapy may also be necessary.
- **Other causes** — These vary from congenital bone cysts and fibrous dysplasia, through to Paget’s disease. They also include osteopenic bone in paralysis, such as in poliomyelitis and paraplegia.

History

The history of a previous primary tumour, particularly of the breast, lungs, kidneys and prostate, associated with one or more fractures or potential fractures occurring with minimal trauma, would make one strongly suspect a secondary deposit.

In elderly patients, senile osteoporosis may lead to fractures of the spine, hip and wrist following fairly minor injuries.

Examination

Examination of the patient with a suspected pathological fracture must include a complete physical examination, including a rectal examination. Bones which may be particularly susceptible to secondary deposits are the spine, ribs, pelvis, humeri and femora and, unless fractured, may cause little or no pain or tenderness. Secondary deposits below the knee or elbow are much less common.

Investigations

Blood investigations

A full haematological and biochemical pre-operative assessment is essential, as anaemia is common and an uncorrected pre-operative hypercalcaemia a potentially lethal post-operative complication.
Pathological fractures

Diagnosis and pre-operative assessment

Chest X-ray and CT scan

Bone scan

Secondary deposits

Sometimes positive when X-rays clear

Skeletal survey

X-ray tender bones or if scan positive

Preoperative X-rays (minimum)

- Chest – PA/lateral
- Lumbar spine – lateral
- Cervical spine – lateral
- Both humeri – AP
- Pelvis – AP
- Both femora – AP
Imaging techniques
The appearance on X-ray of an ill-defined, osteolytic destructive lesion, which is often multiple and usually proximal to the knee and elbow, is strongly suggestive of a secondary deposit. Carcinoma of the prostate, however, is usually osteoblastic. Occasionally other secondaries such as from carcinoma of the breast, may also give osteoblastic secondaries.

The minimum X-rays necessary when an operation is planned for a secondary deposit, are:

- **PA and lateral view of the chest** – This may also show secondary deposits, both in the lungs and in the ribs.
- **AP of pelvis.**
- **AP of both femora and humeri** – These bones are often involved in secondary deposits. They may also have a potential pathological fracture which could be stabilised at the time of initial operation.
- **Lateral view of the cervical spine** – A secondary deposit may be asymptomatic. There is a risk of fracture or dislocation during anaesthetic intubation, which may cause a paraplegia or quadriplegia.
- **Lateral view of lumbar and thoracic spine** – The lateral view of the chest may adequately show the thoracic spine.
- **Lateral skull view** – If multiple myeloma is suspected.
- **Other views** – AP and lateral views of any bones which are tender and which may require internal fixation.
- **Nuclear bone scan** – A bone scan may be a useful additional investigation and may show secondary deposits when the X-ray is negative. Conversely, in multiple myeloma and secondary deposits from the thyroid and kidney, the bone scan is sometimes ‘cold’ due to a large haematoma at the site of the lesion, while the X-ray may demonstrate the lesion.
- **Thallium scan** – Occasionally a thallium scan is indicated. This is more specific than technetium 99 for rapidly dividing cells in malignant tumours.
- **CT scan** – In most cases of secondary deposits, these are not necessary. A CT scan may be useful, however, in diagnosing secondaries in the chest and showing the extent of tumour spread up the medullary cavity of a bone.
- **MRI scan** – This is a more accurate, but a much more expensive investigation for routine investigations and for most secondary tumours. It may be invaluable, however, in assessing the extent of primary tumour spread. It is not necessary for most secondary deposits.
Pathological fractures

Most due to secondary deposits or osteoporosis

Cervical spine

Also X-ray thoracic and lumbar spine if indicated

Pre-anaesthetic assessment must always include X-ray of cervical spine

Trephine biopsy

3 mm trephine core or needle biopsy

Biopsy spine only if other diagnostic tests in doubt
Trephine biopsy
A trephine biopsy is sometimes necessary where the diagnosis is uncertain. A simple needle biopsy may sometimes be sufficient for soft tissue. A trephine will produce a bony core of about 10 – 30 mm in length and 2 – 3 mm in diameter, suitable for a histological diagnosis. Only occasionally will an open biopsy be necessary. The biopsy specimen may, however, take several days to decalcify and a definitive diagnosis can seldom be made by frozen section alone.

Pathological fractures – upper limb

Treatment

* Forearm and hand — Pathological fractures due to secondary deposits below the elbow are uncommon. They should be internally fixed if possible, or treated with a skelecast, followed by radiotherapy. Chemotherapy or hormones should also be given if indicated.

* Humerus — Fractures, or potential fractures of the shaft of the humerus, should be treated by internal fixation by the simplest method possible, such as by a Rush nail.

  Fractures of the lower end of the humerus are best treated with a simple skelecast, a plaster back slab or plastic support, followed by radiotherapy.

  Fractures of the head and neck of the humerus, due to secondary deposits, can be treated by a simple triangular sling plus radiotherapy. A prosthetic shoulder and upper humeral replacement may sometimes be indicated, and possibly chemotherapy or hormones.

Pathological fractures of the spine and pelvis

Treatment

* Cervical spine — Fractures of the cervical spine should be treated either with a neck collar or, if unstable, by a halo jacket support, a skelecast or other type of neck splint. Sometimes internal stabilisation by wire fixation is required. Radiotherapy should always be given, plus chemotherapy or hormones, if indicated.

* Cervical collar — In stable cervical spines with secondary deposits and no neurological signs, a simple cervical collar, as illustrated, is usually sufficient during the day, while a soft cervical collar is worn at night. Radiotherapy, with or without hormones and chemotherapy, must always be given in
Pathological fractures

Upper limb treatment

Shoulder and humerus

Huckstep locking ceramic and titanium shoulder and humeral replacement

Humerus

Upper end and shaft
- Sling or collar and cuff if necessary
- Rush nail

Lower end
- Skelecast

Radius and ulna

Skelecast
- Rush nail or plate

- Radiotherapy post-operatively in all cases
- Bone cement, chemotherapy and hormones if indicated
addition. In more severe cases a SOMI (suboccipital mental immobilising collar) will prevent rotation as well as flexion.
• Minerva support – A skelecast or plaster support may be necessary for unstable fractures or potential fractures.
• Halo-vest – A halo-vest support, as illustrated, incorporates a halo attached to the outer table of the skull and is supported in turn on to a lightweight vest. This will give additional support for unstable fractures and will also allow radiotherapy. It will provide additional stability following operative stabilisation.
• Thoracic and lumbar spine – Most fractures without neurological signs require either a Taylor brace for the thoracic spine, or a lumbo-sacral corset for the lumbar spine. Fractures with neurological signs require emergency decompression and stabilisation.
• Pelvis and acetabulum – These are usually treated conservatively with skin traction, non-weight-bearing and radiotherapy, plus hormones and chemotherapy if indicated.

Combined fractures of the neck of the femur and the acetabulum may require a cemented total hip replacement, if the patient is fit and has a life expectancy of at least 3–6 months. It is also essential that any hypercalcaemia is corrected pre-operatively, as this is a possible lethal complication following operations for secondary carcinomatosis.

Pathological fractures of the lower limb

Treatment
• Upper femur – Fractures of the neck or trochanteric region of the femur require a blade plate strengthened with methyl methacrylate cement. Destruction of the head of the femur will usually either require a cemented hemiarthroplasty, or total hip replacement if the patient is young with a reasonable life span.
• Shaft of femur – Fractures, or potential fractures of the shaft of the femur, should be treated by internal nailing with a locked nail, if possible. They may also require extra stabilisation with methyl methacrylate cement.
• Prophylactic internal fixation – Potential pathological fractures should be internally stabilised.
• Pathological fractures of the tibia – These are uncommon and usually will require internal fixation by nails or plates, plus methyl methacrylate cement.

It is essential that radiotherapy is given post-operatively in all cases and, if indicated, chemotherapy and/or hormones.
Pathological fractures

Treatment
Cervical spine

Cervical collar

Skelecast Minerva

Halo-vest

All require radiotherapy ± chemotherapy and hormones in addition
Pathological fractures

Treatment

Thoracic and lumbar spine

Taylor brace — thoracic spine urgent
Lumbo-sacral corset — lumbar spine
decompression and stabilization for paraplegia

Pelvis and upper 1/3 both femora

Pelvis and acetabulum

Examination and pre-operative blood assessment including serum calcium

• Russell traction
• Crutches as soon as possible

• Always give radiotherapy ± chemotherapy/hormones
Pathological fractures

Treatment

Upper femur

Blade plate + methyl methacrylate cement

Huckstep titanium and ceramic locking hip

Shaft femur

- Intramedullary nail inserted 'closed'
- Image intensifier

Huckstep locking nail, screws and cement

Tibia

Plate and cement

Post-operative radiotherapy ± chemotherapy and hormones

Locked nail

Bone cement
Trauma in pregnancy

Overall treatment

Treatment will require modification, especially as fetal survival is dependent on maternal survival. An obstetrician should be informed. The intravascular volume is increased, and gastric emptying is delayed in pregnancy. There may also be a respiratory alkalosis, and an increase in tidal volume.

Other changes include the risk of eclampsia.

Management of mother

This includes the ABCDE of trauma, with the exception that only the leg compartments of MAST suit should be inflated for severe lower limb trauma. X-rays of the abdomen and pelvis should be minimal and ultrasound used where possible. Peritoneal lavage, if indicated, should be performed by the supra-umbilical route. The risk of increased retroperitoneal haemorrhage in pelvic fractures due to the dilated pelvic veins should be borne in mind.

Various other physiological changes occur in pregnancy. These include an increase of pulse rate of up to 90 per minute, and decrease in blood pressure of about 10 mmHg.

Fetus

The fetus is well protected by the thick uterine wall in the first trimester of pregnancy, and by the amniotic fluid in the second trimester. In the third trimester the uterus is thin walled and placental disruption may occur, particularly with shearing forces.

Clinical assessment

Assessment will include the date of the last menstrual period, and assessment of the uterus for contractions, tenderness and height. The fetal heart should be auscultated and fetal movements felt for. Finally a catheter should be passed and the urine assessed, and a vaginal examination carried out for bleeding or amniotic fluid. The normal fetal heart rate is 120-160 beats per minute and bradycardia is a sign of fetal distress. There can be delay in the onset of fetal distress, so observations should be repeated, if necessary, over several days following the initial trauma.
Investigations

Ultrasound is a useful diagnostic test in later pregnancy to assess the volume of amniotic fluid, the presence of intra-amniotic haemorrhage, and also to assess the position of the placenta. Doppler ultrasonography can be used to assess the fetal heart rate from about the third month of pregnancy. Later in pregnancy cardiotocography will compare fetal heart rate with uterine contractions. The Kleihauer test can be used to assess feto-maternal haemorrhage and anaemia in the fetus. If this occurs in a Rhesus negative mother prophylactic anti-D is indicated to protect the fetus against Rhesus sensitisation.

Signs of placental separation

Fetal distress may be the only sign of this complication. Other signs are maternal hypovolaemic shock, abdominal tenderness, increasing height of the fundus, increased irritability of the uterus, vaginal bleeding and amniotic fluid loss. In major separation there is a risk also of disseminated intravascular coagulation.

Penetrating trauma

This is another cause of fetal death although the mother is likely to survive.

Burns in pregnancy

In burns affecting over 50%–60% of the body after the 5th month of pregnancy the fetus should be delivered immediately. This is due to the otherwise poor prognosis for both mother and foetus.

Indications for an emergency Caesarian

In severe injuries there is a need for an immediate Caesarian section for a viable fetus in the event of maternal death from whatever cause.
Pediatric trauma

Emergency treatment

The emergency treatment of the child with multiple or severe injuries may be difficult for the inexperienced. The emergency resuscitation of the injured child is summarised on pages 57–59.

In adults with multiple severe injuries adequate emergency treatment in the first, or ‘golden’ hour may make the difference in survival.

With children this is only half an hour, the so called ‘platinum’ half hour.

Drug dosages and fluid replacement in children should be based on the weight of the child. In the severely injured child this is best achieved by measuring the length of the child and assessing approximate weight and drug dosages from pediatric charts, which should be available in all accident centres.

Airway

The anatomy of the child is also different. Children have a relatively large head and small oropharynx, with the glottis at the level of C3 or C4 instead of C6, as in the adult. The trachea is also shorter and this may cause problems in intubation. A conscious child also has a well developed gag reflex. As a result an oral airway may cause vomiting and should be avoided if possible.

Diagnosis

Children are not small adults, and their fractures and dislocations may be difficult to treat and also to diagnose. This is because much of the epiphysis in young children may be made of cartilage which is radiolucent. Damage to the epiphysis may not be fully appreciated, especially in a crush injury (Grade V Salter–Harris), and the X-ray may appear to be virtually normal. If in doubt the opposite joint should be X-rayed in the same position or an ultrasound or arthrogram used to make a diagnosis.

Types of fractures

Specific fractures usually seen only in children include fractures in fragilitas ossium (a history usually of multiple previous fractures, and X-ray with clinical evidence of these), fractures through bone cysts, and fractures due to child abuse. Child abuse may account for many of the fractures under the
Fractures in children

Infection may mimic fracture

Battered babies
- Systematic examination includes chest and abdomen
- Admit to hospital and photograph

Emergency treatment

Airway

Oxygen and face mask

Intubation

If intubation impossible—
- Needle cricothyroidotomy
- Open cricothyroidotomy
- Occasional tracheotomy
  (see emergency procedures for details—pages 76 and 496)
age of 1 in some countries, and must always be considered in all fractures in babies, particularly of the long bones.

Investigations

Imaging techniques
A CT scan by itself or combined with an arthrogram may also be necessary to define cartilage which is not visible on a plain X-ray.

Other investigations which may be indicated are a nuclear bone scan or magnetic resonance imaging. The latter has the advantage of not exposing the child to unnecessary irradiation, but is an expensive investigation which may be frightening to small children and require general anaesthesia. The need for anaesthesia should always be a consideration, when prescribing any investigation for children.

Another useful investigation in children is ultrasound imaging for soft tissue swellings, and for cartilage injuries particularly of the elbow, provided it is performed by a skilled operator. It can also be very useful for injuries of the abdomen. Ultrasound is safe, painless and inexpensive, but is not as diagnostic for bone injuries as X-rays.

Haematology and biochemistry
Routine blood, urine and other investigations will help to differentiate infection from a fracture. The white blood count may sometimes not be raised in infections in children, and therefore may be of limited diagnostic help.

Children also have relatively little subcutaneous tissue. This may result in shivering, which in turn leads to biochemical disturbances such as metabolic acidosis.

Epiphyseal and physeal injuries
In children the growth plate is the weakest part of the bone. Injuries which would cause ligamentous rupture or a fracture in an adult will often result in a growth plate fracture separation in the child.

Diagnosis
Diagnosis of an injury to the growth plate is essential. Follow up of a child with growth plate damage for at least 1-2 years after the injury is important.

Investigations
The routine X-ray which will show a definite fracture in an adult, may show very little, or just a flake of bone, in a child.
Common fractures in children

Greenstick fractures

- Femur
- Tibia
- Radius and ulna
- Clavicle
- Humerus

Epiphyseal injuries

- Femur
- Tibia
- Radius

Supracondylar fracture humerus
This is particularly so in **elbow injuries** in children. An apparent small epicondylar fracture may actually be a fracture of the entire lateral condyle. An **epiphyseal separation** may also have **spontaneously reduced** itself and then would only be apparent on a **stress X-ray**.

If in doubt, take **X-rays** of the **opposite joint** in exactly the **same position**, for comparison. In young children an **arthrogram** may also be necessary to show the outline of the radiotranslucent cartilage. An **ultrasound** or **magnetic resonance imaging (MRI)** can also help in the diagnosis.

**Classification and treatment**

- **Epiphyseal injuries** — These may be subdivided into **shearing**, **avulsion**, **splitting** and **crush** types. Such injuries may cause considerable **disturbance** of **growth**.

**Salter-Harris classification**

**Epiphyseal injuries**
The Salter–Harris classification describes damage to the epiphyseal plate with or without a fracture.

- **Type I** — **No fracture**. There is **separation** of the **epiphysis** at the level of the growth plate.
- **Type II** — This involves **separation** of part of the **epiphysis** from the metaphysis through the epiphyseal plate, **plus** a **metaphyseal fracture**.
- **Types I and II** Salter–Harris epiphyseal fractures, if adequately reduced by closed reduction, usually have a **good prognosis**, even if less than perfectly reduced. **Salter Type II** injuries, however, may lead to **growth disturbance** in 5% of children.

- **Type III** — The fracture line extends from the **joint space** to the **growth plate**. It then extends laterally to the edge of the plate separating the fractured epiphysis from the metaphysis. It must be **reduced perfectly** and may require **open operation** and **wire** fixation. The **prognosis** is usually **poor**.
- **Type IV** — These fractures extend from the **joint space** through the growth plate and **across the metaphysis**. These commonly occur in the lateral condyle of the humerus and almost always require **open reduction** and smooth **wire fixation**. The **prognosis** is **poor**. In the elbow this may result in a valgus deformity with a tardy or **late ulnar nerve palsy** due to stretching of the ulnar nerve. The **valgus deformity increases** due to the cessation of growth of the damaged lateral part of the epiphysis, and the continued medial growth.
Epiphyseal damage

Salter-Harris classification

Type I
- Complete separation
- No fracture
- Easy reduction
- Good prognosis

Type II
- Commonest type
- Older children
- Easy reduction
- Good prognosis in most cases

Type III
- Reduction and Kirschner wire fixation
- Prognosis usually poor — same as type IV

Type IV
- Intra-articular open reduction and fixation
- Prognosis poor unless perfect reduction

Type V
- Crushing injuries
- Diagnosis difficult
- Prognosis poor
• **Type V** — This is a severe **crush** injury of the **growth plate** itself. **Displacement** is **unusual** and **injury** may be **unnoticed**. There is almost always a **poor prognosis** with cessation of growth of the epiphyseal growth plate.

It is essential to be **very gentle** with reduction of children’s injuries and **not damage** the **epiphysis** with sharp instruments at the time of operation.

It is also important to **warn relatives** about the risks in these injuries and to **follow the child up** with X-rays for at least **2 years** from the time of injury.

**Complications**

Damage to the epiphyseal plate, especially in **Salter-Harris** Type III, IV or V injuries (see illustration), may lead to **premature fusion** of **part** of the **epiphysis**. This in turn may lead to continued growth of the remaining germinal layer with a resulting **varus** or **valgus** deformity. If the **whole epiphysis** is damaged in this growing period the **leg** or **arm** will be **short**. Conversely, after a **fracture of the shaft of a long bone**, growth stimulation may actually occur with up to **2 cm** of **overgrowth**. This is mainly due to the **hyperaemia following injury**.

**Growth arrest**

• **Treatment** — If this is **less than 50%** of the epiphysis, the **fused area** of the epiphyseal plate should be **excised** and **replaced** with a **fat graft**. If **more than 50%** of the plate is involved the fused epiphysis is usually left without operation, and any later deformity corrected by an **osteotomy** when the child is **skeletally mature**.

**Shortening**

Shortening of a limb can be treated by **lengthening** with Ilizarov wire external fixateurs. The alternative is to carry out an **epiphyseal arrest** on the opposite leg at an appropriate age to equalise the leg lengths by the time growth has ceased. This is done either by temporary **epiphyseal stapling**, or by permanent **epiphyseodesis**, which entails excision of the epiphyseal plate.

**Operative treatment**

In children, operative **internal stabilisation** should be **avoided** if possible, as this may interfere with growth at the epiphyses.

• **Smooth wire fixation** — Even when this extends across epiphyseal plates, it seldom causes major problems provided the wires are **removed** within **4–6 weeks**. They are particularly
Fracture-separation of the distal radial epiphysis

Type I — no fracture

• Manipulation and plaster

Type II

Lateral X-ray

AP X-ray

• Manipulation and plaster

Types III, IV and V

• Often require operative reduction and Kirschner wires

Type III

Type IV

Type V
indicated in unstable fractures such as a supracondylar fracture of the humerus.

- Older child – In the older child, screws, plates and even an intramedullary nail may be sometimes used, provided they do not damage the epiphyseal cartilage.

**Compound fractures**

In compound fractures, as with the adult, external fixateurs, after adequate debridement, may be indicated. As with adults, however, all compound fractures, even with minimal skin damage, should be opened, explored, and left open. In most cases delayed primary closure is the treatment of choice.

**Healing**

Fractures in children heal much more quickly than in adults.

- Femoral shaft fractures – These will usually be united in 1 week in an infant, 1 month in a 1 year old, and 2 months in a 10 year old, compared to 3 months in an adult.

**Remodelling**

Remodelling of the growth plate may also occur, with up to 20°–30° of correction possible. An angulation of the bone, which may not be acceptable in an adult, will often be acceptable in the child, especially in an infant, when 45°–60° of correction can occur in bones such as the upper humerus. This will only occur if the deformity is in plane of movement of the nearest joint.

**Upper limb**

**Lower radius**

Fracture—separation of the distal epiphysis

This is the pediatric equivalent of a Colles’ fracture.

- Diagnosis – The distal radial fragment is both dorsally displaced and rotated. There is also radial displacement and impaction of the fragment. There may be an associated metaphyseal fracture of the radius.

- Treatment – The methods of reduction and the prognosis have already been discussed under the Salter–Harris classification of epiphyseal injuries.

In summary:

**Type I** – Separation of the epiphysis with no fracture requires a closed reduction and has a good prognosis.

**Type II** – This involves separation of the epiphysis, plus a metaphyseal fracture, as illustrated. Again closed reduction with a good prognosis except in 5% of cases.
Supracondylar fractures of the humerus

Treatment

Manipulation and reduction

Immobilisation: padded back slab

Kirschner wire fixation if necessary

Difficult fractures may require countertraction

Lateral view  AP view  Condylar fractures
Types III and IV — These were described earlier in this chapter and are illustrated on page 237. They must be **accurately reduced** and may require **wire fixation**. The prognosis is usually **poor** in both Type III and Type IV injuries.

Type V — This causes a severe crush of the growth plate. The prognosis is **poor**.

### Forearm fractures

These are very **common** fractures in **children** and account for **55%** of all children’s fractures. Fractures of the **distal** one third of the radius account for **75%** of **forearm fractures**.

**Treatment**

- **Simple fractures** — Many of these fractures are **greenstick** fractures and, as a result, the bone may have to be **‘refractured’** to reduce the fracture satisfactorily.
- **Young children** — Nearly all diaphyseal fractures in young children can be treated **without an operation**, and with an **above elbow plaster** in either 45° of **pronation** or **supination**, after reduction if necessary.
- **Over the age of 8 years** — In this age group, **open reduction and plating** or **nailing** may be necessary with **displaced** and **angulated fractures** if adequate **closed reduction** has **failed**.
- **Compound fractures** — In compound or open fractures the wound should be **explored** and always left open with **delayed primary closure**. **External fixateurs** may have to be used to stabilise these fractures.

**Malunion and non-union**

The following is an approximate working rule in children provided a good reduction cannot be easily obtained by manipulation.

- **Under 8 years** — In children some molding can occur and, under the age of 8, **20° of angulation and 20° of malrotation** can sometimes be accepted.
- **Over the age of 8 years** — In this age group **only 10° of angulation** may correct as the child grows.
- **Forearm fractures** — **Apposition of bone ends** should be **50% or more** in all forearm fractures. If **less** than this is present, **manipulation** or **operation** will be required. Otherwise malunion is likely, and occasionally non-union may occur.

**Elbow injuries**

Elbow injuries in children are common and can cause **vascular** and **neurological** complications.
Fractures of the lateral humeral condyle

- **Diagnosis** — Fractures of the lateral condyle may be difficult to diagnose on X-ray in young children due to the large amount of cartilage which is radiolucent. As a result an ultrasound, an arthrogram, a CT scan, or MRI may be necessary.

- **Treatment** — Cases with slight displacement of the epiphysis (less than 2 mm) can usually be treated by a cast alone. Those with a moderate or severe degree of displacement, however, will require open reduction and internal fixation, usually with Kirschner wires, to obtain a perfect result.

- **Complications** — These include non-union or premature fusion with gradually increasing late ulnar nerve palsy. Avascular necrosis is also possible.

Fractures of the medial epicondyle

- **Treatment** — Undisplaced or only slightly displaced fractures can usually be treated with a cast alone. Moderate displacement will require open reduction and wire fixation.

- **Complications** — Severe displacement may lead to entrapment of the medial epicondyle which will always require open reduction and internal fixation with smooth Kirschner wires. Damage to the ulnar nerve must always be looked for pre-operatively and at the time of operation. The ulnar nerve can also be damaged by incorrectly placed Kirschner wires.

Supracondylar fractures

These fractures are most often seen in children aged 6 to 9 years. Approximately 85% of fractures are displaced postero-medially and about 10% postero-laterally. In 5-10% of fractures the displacement is anterior due to a flexion force.

It is essential to diagnose and treat this fracture well, due to the high complication rate, including vascular, neurological and bony complications.

This is a surgical emergency — always admit the patient to hospital and treat the fracture as a matter of urgency if manipulation is required.

Examination

The elbow is swollen, painful and deformed. Always examine for both vascular and nerve impairment of the hand immediately.

- **Diagnosis of vascular insufficiency** — The earliest and most important diagnostic sign is pain on passive extension of the fingers.
The other criteria of vascular occlusion are pallor, pulselessness and paraesthesia. Paralysis is a late sign and its presence may signify irreversible damage. A normal pulse may sometimes be present with a compartment syndrome, and it is essential to be aware of this potentially serious complication.

Treatment

- **Vascular insufficiency** — Careful examination for insufficiency includes the use of a pulse oximeter and assessment of flexor compartment pressure. A digital subtraction angiogram may sometimes be indicated. Do not delay in reducing the fracture under image intensifier in theatre. The reduction is held with 2 Kirschner wires. In most cases (13 out of 17 in one series), the pulse will return and exploration of the artery will not be necessary.

  Following successful reduction, it should be possible for the fingers to be fully extended passively, and the hand should have normal sensation and normal vascularity. There may, therefore, be a place for not exploring the brachial artery, but if there is any doubt as to the patency of the brachial artery it should be explored.

- **Undisplaced fracture** — This usually only requires an elastic bandage over wool until the swelling has subsided, plus a collar and cuff sling for 3 weeks.

- **Displaced fracture** — In the case of a displaced supracondylar fracture the latest treatment is anatomical reduction, followed by internal fixation with two smooth Kirschner wires through the lateral condyle.

- **Unstable fracture** — In a very unstable fracture, one or two wires carefully inserted under image intensifier control in the medial epicondyle may be indicated through a small incision, after the lateral condylar wires have been inserted. The arm is then immobilised in 60°-90° of flexion with a padded backslab.

- **Difficulty in reduction** — In cases where reduction is difficult due to severe swelling, skin traction on the forearm with the hand suspended from an overhead beam, together with counter-traction downwards on the upper arm with a sling for about 3 days, see page 241, may be necessary.

  The contraindications to pinning a fracture are inability to obtain an adequate closed reduction, extensive comminution and massive swelling. In these cases the arm should be suspended, as illustrated, from a beam with the elbow in 90° of flexion as discussed below.
• **Open fractures** – In the case of open fractures, an adequate **debridement** should be carried out **before** the Kirschner wires are inserted.

### Post-reduction care
The limb should be **elevated** and careful **observation** made for symptoms and signs of **vascular impairment**. This includes:

- **Terminal finger perfusion** – This is the most important observation and will include the use of a **pulse oximeter** on a finger.
- **Distal radial pulse** – This should be examined **every hour** for 48 hours following reduction, but is **less diagnostic** than adequate finger perfusion and the ability to extend the fingers.
- **Fingers** – These should be examined for **warmth**, **sensation** and **inability to extend the fingers**, associated with severe forearm **tenderness**.
- **Manipulation** – A supracondylar fracture should never be manipulated **more** than 3 **times**, however poor the position. **Immobilise** for about 3 **weeks** in total.
- **Immobilisation in extension** – Occasionally immobilisation in extension is required.

### Early complications
- **Vascular complications** – **Forearm ischaemia** – This requires **urgent treatment**. The plaster should be removed immediately, the **elbow extended**, and the **fracture reduced** with Kirschner wires. Do not waste time on sympathetic blocks or vasodilators. Operate immediately if the **circulation does not return** with **closed reduction** and Kirschner wires.
- **Operative exposure** – Extend elbow, incise the lower third of the upper arm and most of the forearm overlying the brachial artery. Split the fascia and lacertus fibrosus.
- **Brachial artery** – Identify the artery medial to the biceps tendon. **Open the artery if in spasm**, or if there is any doubt, and look for an **intimal tear**. Consider inserting a reversed vein graft. **Intimal damage** is common in these cases and may not be apparent on external exposure of the artery.
- **Wound closure** – Never suture fascia, and close part of the skin only if this can be done easily. Leave the **wound open** and perform a secondary closure.
- **Compartment syndrome** – This is due to **swelling** due to **ischaemia**, and to a lesser extent to **bleeding** into the flexor compartment of the forearm. This may occur with or without major damage to the brachial artery. A **fasciotomy** of the entire flexor compartment should be carried out. **Delayed primary closure** of the wound is a necessity.
Late complications
- Vascular impairment – Volkmann’s ischaemic contracture or gangrene of the arm.
- Neurological complications – The nerves which are commonly damaged in a supracondylar fracture are the radial and the median nerves. The anterior interosseous and ulnar nerves may also be damaged. The continuity and function of the flexor pollicis longus, and the flexor digitorum longus to the index finger must always be tested. A cubitus valgus deformity may also produce a late ulnar nerve palsy.
- Bony complications – Bony complications of a supracondylar fracture of the humerus include a cubitus varus or cubitus valgus deformity. This is usually due to an incomplete reduction, or to epiphyseal damage, and will result in poor appearance and function.

Humeral shaft fractures

Causes
Birth trauma, child abuse and benign bone cysts must always be considered in the diagnosis.

Common sites
- Metaphysis – This occurs commonly in the metaphyseal region from 4 -12 years.
- Diaphysis – The diaphysis is most often affected under the age of 3 and over the age of 12.

Treatment
- Conservative treatment – Most cases can be treated merely in a collar and cuff sling or hanging cast.
- Operative treatment – The only indication for exploration in closed fractures in children is in cases where radial nerve paralysis is increasing, or where there is obvious muscle interposition between the bone ends which cannot be corrected by manipulation alone. Open fractures will require exploration and adequate debridement and delayed primary closure, if necessary.
- Angulation of up to 45° – In the newborn this can sometimes be accepted.
- Overgrowth – This may be due to increased vascularity.

Complications
Radial nerve injury is less common than in adults. The prognosis is excellent and most cases recover completely in closed injuries without operation.
Proximal humeral fractures
80% of the growth of the humerus occurs in its proximal segment. It has three ossification centres but only one growth plate, and so the diagnosis of a fracture is more difficult in children.

Fracture displacement
• Children under 5 years – Considerable remodelling is possible up to the age of 5 years. In these young children 40° of angulation, and total displacement of the fractures can sometimes be accepted provided there is some bony apposition.
• Children 5 – 12 years – Between the ages of 5 and 12 years up to 40° of angulation can often be accepted.
• Children over 12 years – Over the age of 12 up to 40° of angulation with more 50% apposition of the bone fragments can sometimes be accepted, provided there is at least 2 years of growth remaining.

Treatment
• Conservative treatment – The patient can often be treated merely by a collar and cuff sling. In the case of severe displacement, a shoulder spica or an abduction brace may be required for up to 6 weeks.
• Operative treatment – Only occasionally is open reduction and K wire fixation required. This is in patients where displacement cannot be controlled by conservative measures. Open fractures, again, will require adequate debridement and delayed primary closure, if necessary.

Lower limb

Hip and upper femur

Causes
In some countries in children under the age of 1 year, 70% of femoral shaft fractures have been reported as being due to child abuse. Overall, 30% of fractures in children of all ages are also said to be due to child abuse. This diagnosis should be especially suspected if there is a history of previous child abuse, if there is delay in attending hospital, or if there is evidence of other acute fractures or of multiple past fractures. This cause must be particularly considered if fractures of long bones are transverse, diaphyseal, or short oblique.
• Pathological fractures – About 12.5% of fractures in children are pathological and include osteogenesis imperfecta,
rickets and fractures through bone cysts. **Pathological fractures** must always be excluded in all cases where a fracture has occurred with **minimal trauma**.

**Diagnosis**
The upper end of the femur has **3 ossification centres**.
- **Diagnosis** — In children, due to these ossification centres, the X-ray appearance may be deceptive. If in doubt an X-ray of the **opposite hip**, an arthrogram, or ultrasound, may be indicated.
- **Neck of the femur** — These are the most common fractures and usually occur **without commination**.
- **Displacement** — This is usually **minimised** by the thick joint capsule in children.

**Investigations**
If a plain X-ray does **not** show a **concentric reduction**, further investigations are essential. A CT scan or arthrogram are important and may show an **osteochondral fracture** of the **head** of the **femur**.

**Treatment**
The treatment should be to:
- **Aspirate**, or evacuate the joint of **haematoma** as soon as possible, to **minimise** the risk of **avascular changes** occurring in the femoral head, due to capsular compression.
- **Reduce** and accurately internally fix the fracture with **fine wires** and a **hip spica**. If **compression screws** are used they should **not cross a physis**.

**Complications**
Hip injuries in children have a **high complication rate**. If not treated adequately these may lead to a **deformed hip**, a **short leg** and secondary **osteoarthritis**.
- **Traumatic dislocated hip** — This is very **unusual** in a child and the femoral head may **rarely buttonhole** through the capsule. It may be **difficult to reduce** by closed manipulation.
- **Ligamentum teres** — This may pull off an **osteochondral fracture** from the **head** of the **femur**. This in turn will prevent reduction of a dislocated hip.
- **Sciatic nerve** — This is very close to the back of the acetabulum and may be stretched or **contused**.
- **Intracapsular haematoma** — This may cut off the **blood supply** of the femoral head due to obliteration of capsular vessels.
- **Associated fractures** of the femoral head, pelvis, femur and patella may be present, and should be looked for.
Fractures in children

Neck femur

- Internally fix with 3 wires
- No screws across physis in young children

Femoral shaft fractures

Child under 15 kg weight

Knees should be splinted with back slabs in about 10° flexion

90/90 hip spica

Plaster or plastic hip spica allows young child to be treated at home

Child over 15 kg

Adjustable Thomas splint

Up to 5 kg traction 0.5 kg/year
Femoral shaft fractures

Treatment under 6 years

• Gallows traction – In children under the age of 3 years, gallows traction for 3–4 weeks with both knees flexed about 10° in simple padded plaster of Paris back splints.

• Hip spica – In the child under the age of 6 years, with less than 2.5 cm of shortening, a hip spica in the sitting position (90° flexion of hip and 90° flexion of knee) is often the best method of management, once the fracture is stable.

• Special cases – Compound fractures may require either skin or skeletal traction. The fractured leg should be in slight valgus as the femur tends to displace into varus.

Treatment 6–12 years

Skin or skeletal traction in a Thomas splint for 3 weeks, followed by a spica, is indicated. Shortening should not be over corrected as 0.5–1.5 cm of shortening will allow for future bone overgrowth which commonly occurs following femoral shaft fractures in children, and may be up to 2 cm due to increased vascularity.

Treatment over 12 years

Over the age of 12, and in patients with head injuries, either Enders nails or locked intramedullary nails may be indicated if closed reduction and traction in a Thomas splint is unsuccessful.

Complications

• Avascular necrosis – The rate is very high in children and occurs in the head of the femur in about 40% of cases. It has been reported present in 80% of cases with a displaced epiphysis, 35% with displaced fractures of the cervical region of the femur, and 25% in those with displaced fractures of the base of the neck of the femur.

Tibial fractures

Treatment

Tibial shaft fractures in children should usually be treated conservatively by a padded above-knee plaster with the knee flexed to about 10°.
Fractures in children

Complications

Overgrowth

Overgrowth of 1–2 cm common

Avoid overdistracting fractures

Malunion

Correct angulation

Shortening

Epiphysiodesis opposite side

Growth disturbances

Avascular necrosis

Epiphyseal damage causes varus, valgus or shortening

Late osteoarthritis

Specific fracture management 251
Complications

The most common complication of proximal metaphyseal fractures of the tibia in children is a valgus deformity. This deformity often corrects spontaneously. Operative correction, if necessary via a tibial osteotomy, should be delayed until growth has ceased.

Occult fractures in children

Occult or hidden fractures are common in children. This is because there is a large amount of cartilage in immature bones, particularly about the epipyses, which have not yet ossified, and are therefore radiolucent.

Diagnosis

- **Epiphyseal fractures** — These may masquerade as dislocations.
- **Condylar fractures** — These may appear to be epicondylar fractures.
- **Difficult fractures** — Those which are particularly difficult to diagnose, especially in young children, are fractures of the hip, knee and distal humerus.
- **Elbow** — If an X-ray appears to be normal with a swollen elbow, suspect a fracture. X-ray the opposite elbow in the same position as the injured side. If there is still doubt an ultrasound should be carried out. Consider performing an arthrogram in all children under 3 years and most under 6 years. An apparent dislocation may be a Type I or Type II epiphyseal fracture and an arthrogram or MRI may be the only method of demonstrating this.
- **Humerus** — Condylar fracture — This is easy to miss under the age of 3 years and may appear merely as a flake or as an epicondylar fracture. Open reduction and K wire fixation is often required.
- **Head injuries** — Due to the resilience of the skull, severe brain damage may occur without evidence of fracture.
- **Spine** — Spinal cord damage may occur without radiological evidence of fracture.
- **Chest and abdomen** — The resilience of the ribs may result in severe lung, heart and upper abdominal trauma, without evidence of rib fracture.
- **Hip** — Hip fractures may be difficult to diagnose and lead to avascular changes to the femoral head.
• Femoral shaft and tibia – Crush injuries and minor displacements of the epiphyseal growth plate may be difficult to diagnose and may result in epiphyseal growth arrest or deformity, particularly in the lower femur and upper and lower tibia. In addition, greenstick fractures may be missed and cause overgrowth of the affected limb.

Specific complications of fractures in children

The complications in children include those seen in adults, such as vascular and neurological complications, non-union and malunion, plus those specific to children. These specific injuries are due to the pliability of children’s bones and the presence of epiphyseal plates with growth potential, which may be affected when damaged. Only those complications specific to children will be discussed.

• Bone overgrowth – This is common following a fracture, particularly in young children. Overgrowth of 1–2 cm is common. It is therefore important not to overdistact fractures, and sometimes even to leave a fracture of the lower limb 1 cm short, to allow for this later overgrowth.

• Malunion – Although a small degree of angulation in bones such as the humeral shaft will correct itself in young children (as discussed earlier), more than 10° of angulation of some bones, such as the radius and ulna, will require correction to prevent a residual disability. In assessing the likelihood of remodelling, this is much more likely to occur if the deformity is in the planes of motion of the nearest joint, and if there is at least 2 years of residual growth remaining.

• Lower limb shortening – This may require stapling or epiphysiodesis of the opposite leg at an appropriate time, to equalise leg lengths.

• Growth disturbance – Apart from shortening, epiphyseal damage may cause a varus or valgus deformity. This may necessitate early insertion of a fat graft across a prematurely fusing epiphysis after excision of the bony bridge. Later osteotomy to correct the deformity may be necessary once skeletal maturity has been reached.

• Avascular necrosis and osteoarthritis – The head of the femur is particularly liable to progress to avascular necrosis following a fracture of the neck of the femur in children. It may require a vascular bone graft to diminish the likelihood of osteoarthritis.
Fractures in the elderly

Causes

Metabolic
The elderly patient is more likely to slip and fall, and also, having fallen, to sustain a fracture.

• Osteoporosis — This is a relatively common finding in the elderly and is an important factor in fracture aetiology.

• Vertebrae — These may sustain crush fractures following little or no trauma. This is partly due to prolapse of the intervertebral disc into the soft osteoporotic body of the vertebrae. Multiple vertebrae, particularly in the thoracic region, commonly show stable crush fractures and cause the smooth thoracic kyphosis seen in the elderly.

• Hip — This also is osteoporotic in the elderly, and most likely to fracture following a fall.

Pathological fractures

• Secondary tumour — Deposits in bone from carcinoma elsewhere, particularly from the breast and lung in females, and prostate and lung in males, may lead to fractures following little or no trauma.

• Paget’s disease — Pathological fractures may also occur in Paget’s disease.

Medication

Medication for conditions such as Parkinson’s disease may also cause osteoporosis. Long term use of oral glucocorticosteroids for conditions such as asthma, chronic airway limitations and various connective tissue disorders, such as rheumatoid arthritis, will often result in bony demineralisation, thus making the patients more prone to pathological fractures.

Common fracture sites

The following are the most common fractures in the elderly. The detailed treatment of all these fractures is discussed in the relevant section of this book.

Colles’ fracture
This is a very common injury, particularly in elderly females. It is often secondary to a fall on the outstretched hand.
Common fractures in the elderly

Shoulder
Fracture or fracture dislocation

Wrist
Colles' fracture

Femoral neck or trochanter

Fracture in several osteoporotic vertebrae with ballooning or secondary deposits

Fractured pelvis

Intramedullary fixation in patients within 24 hours if possible

Specific fracture management
Fracture of the neck of humerus
The fall on the hand may cause both a fracture of the neck of the humerus and a Colles' fracture.

Fractures of the spine
Fractures of the thoracic and lumbar spine frequently occur without any recognised trauma due to ballooning of intervertebral discs into the osteopenic vertebrae. Several vertebrae are usually involved and may lead to an increasing smooth kyphosis in the thoracic region.
- Differential diagnosis — Secondary deposits from a carcinoma are more likely to cause isolated fractures.

Pelvic fractures
Fractures of the pubic rami and floor of the acetabulum are the most common and are usually minor and stable.
- Treatment — Most of these fractures can be treated conservatively in the elderly with mobilisation of the patient, and full weight-bearing, within a few days of injury.

Hip fractures
Both transcervical and intertrochanteric fractures are common.
- Treatment — Operate, if possible, on the day of injury and internally fix the fracture and mobilise the patient with full weight-bearing within 2 or 3 days following operation. A hemiarthroplasty is used for displaced subcapital fractures and a screw plate for trochanteric fractures.

Fractures of the lateral tibial plateau
Fractures of the lateral plateau of the tibia are particularly common, both as a result of a fall, and also when a pedestrian is struck by a car bumper bar on the lateral aspect of the tibia.

Ankle fractures
Fractures of the ankle are common in the elderly.
- Treatment — Early mobility and weight-bearing, with internal fixation or a walking plastic support, are important in these patients.

Complications
Complications of prolonged bed rest and immobilisation in the elderly may include decubitus ulcers, joint contractures of the lower limbs, urinary retention and infection, deep vein thrombosis and pulmonary embolus, bronchopneumonia and delirium (see page 257).
General principles in elderly patients

- Early mobilisation of all joints and physiotherapy
- Internally fix if necessary and early weight-bearing
- Avoid pressure sores and joint contractures
- Prevent bladder and lung complications
- Deep vein thrombosis prophylaxis
- Mobilise patients and home early
Falls from a height

Falls from a height, mainly from ladders, may involve window cleaners, painters, tilers, builders, and plumbers. Parachutists are also at risk.

- **Spine** — Fractures, particularly of the lumbar spine, are common in falls from a height. These are often missed if a routine X-ray of the lumbar spine is not always taken in all patients with calcaneal fractures, however minor.
- **Calcaneal fractures** — A fracture may be unilateral or bilateral. They may be of any gradation from a minor crush, to complete comminution and severe flattening with involvement of the subtalar joint.
- **Fractures of the talus** — A fracture of the neck of the talus may lead to avascular necrosis of the body of the talus and secondary osteoarthritis at a later stage.
- **Ankle fractures** — Any fracture of the ankle may occur. A plafond or comminuted fracture into the lower tibial articular surface, may be due to a fall from a height.
- **Pelvic fractures** — These vary from a minor fracture of the acetabulum, to compound or comminuted pelvic fractures with damage to neurovascular structures and pelvic organs.
- **Multiple fractures** — Other types of fracture may occur when the force of a fall directly onto the heel is transmitted up to the hip and pelvis and thence to the spine and in particular to the lumbar spine.
- **Coexistent fractures** — Fractures of the calcaneum and lumbar spine are common and often missed, because the patient may complain more of the painful calcaneal fracture. Lateral X-ray views of the lumbar spine are essential in all cases of calcaneal fractures.
- **Central dislocation of the hip** — This causes a fracture of the acetabulum with late osteoarthritis.
- **Pelvic vertical shear fracture** — The sciatic nerve and other pelvic structures, including blood vessels, may be damaged.
- **Crush fracture of other vertebrae** — These may be missed.

**Treatment**

This is discussed in the relevant sections of this book, under the individual fractures.
Fractures due to falls from a height

Fracture calcaneum

Pelvic shear

Central dislocation of hip

Fracture spine

Fracture calcaneum
Falls on the hand

Hand and wrist injuries
- **Bennett's fracture** – This is a *fracture dislocation* of the carpo-metacarpal joint of the thumb.
- **Scaphoid** – This may *fracture alone*, or half of the *scaphoid* may *dislocate* with the *lunate* – the so-called *trans-scaphoid perilunar fracture dislocation*.
- **Distal radius** – Colles’, Barton’s and Smith's fractures are common.

Forearm fractures
- **Radial shaft** – This may *fracture* with or without an associated *fracture* or *dislocation* of the *ulna*.
- **Head of the radius** – Force transmitted through the lower radius *crushes* the head of radius on to the lower end of the humerus.

Humeral and shoulder injuries
- **Lower humerus** – This may cause a *comminuted fracture* which may split the lower humeral epiphysis.
- **Children** – In children a fall on the outstretched hand will often cause a *supracondylar fracture*.
- **Adults** – In adults the the capitellum may be fractured or the lower humerus may be comminuted.
- **Shaft of humerus** – The force transmitted up the humerus can cause an oblique fracture of the shaft.
- **Neck of humerus** – In elderly patients fractures of the neck of the humerus are common and are often impacted and stable. Most do not require reduction.
- **Dislocation of the shoulder** – If the arm is abducted and externally rotated, an anterior *dislocation* of the shoulder may result. This is common in patients with a limited normal range of external rotation.

Clavicular trauma
The force of a fall on the hand may be transmitted through to the clavicle.
- **Clavicle** – A fracture is common at the junction of the lateral two-thirds and medial one-third of the shaft.
- **Sterno-clavicular joint** – This may also *dislocate*.
Falls on the hand

- Neck and shaft of humerus
- Dislocated shoulder
- Clavicle fracture
- Head radius
- \* Supracondylar in children
- \* Intercondylar in adults
- Colles' fracture
- Radius and ulna fracture
- Scaphoid fracture
- Lunate dislocation
Orthopaedic splints

Splints

- **Aluminium splints** – Aluminium and plastic splints are used in both emergency splinting and in the convalescent stages of upper limb injuries. In lower limb trauma they will allow some mobility of the injured joints such as the knee and ankle, whilst still protecting against unwanted movement, such as full extension of the knee in fractures of the tibia or after knee reconstruction.

- **Thomas splint** – This is usually used for fractures of the lower limb, particularly of the femur. It can also be used for the knee and tibia as an emergency splint.

- **Detachable splint** – Detachable splints may be made of various plastics, or of other materials. They are used for injuries of the wrist, elbow, knee, tibia and ankle. They are particularly useful in ligamentous injuries to allow limited mobility with protection.

- **Calipers** – These are removable ‘leg irons’ to support a weak or short leg and may be combined with a toe raising spring or back stop.

Slings

Collar and cuff and triangular slings are used mainly for the upper limb and these have already been described.

Traction

This may include skin traction such as is used in fractures of the femoral neck. Skeletal traction is used where more traction is needed. It is used for some fractures of the shaft of the femur and tibia.

Plastic supports

Plastic supports, particularly the newer lightweight versions are being used increasingly. These are plastics that can be dipped in either hot or cold water and molded to the patient.

- **Indications** – They have a place where there is not much swelling or following a preliminary treatment with plaster where further support is required.

- **Advantages** – These supports can be permanent or detachable with ‘velcro’ straps and are lighter and more comfortable than plaster of Paris.

- **Disadvantages** – The disadvantages of plastic supports are their cost and their difficulty in application. They cannot be molded as well as plaster of Paris.

- **Spinal supports** – There are many neck and spinal supports and some of these are illustrated. They are usually
Orthopaedic splints

Hand and wrist

Aluminium cock-up splint
Lively hand splint for nerve injuries and stiff fingers

Cervical spine

Shoulder Lumbar spine

Abduction splint Lumbar support
adjustable and are used to support the cervical, thoracic and lumbar spine.

- **Cervical supports** — These vary from simple pneumatic or plastic neck supports, which merely give limited support to the neck, to complete halo-thoracic braces to give full support to a fracture of the cervical spine.

- **Thoracic supports** — For the thoracic spine, where adequate support is required, a Taylor brace may be used. This has shoulder straps which support the upper and lower thoracic as well as the lumbar spine.

- **Lumbar supports** — The lumbo-sacral brace gives limited support in stable fractures of the lumbar spine and in back pain and sciatica.

- **Miscellaneous spinal supports** — Supports which brace the whole spine from the cervical to the lumbar region are used in scoliosis surgery and following arthrodesis of the spine. They include halo-pelvic traction which connects pins in the pelvis to pins in the outer table of the skull.

**Hip spicas**

Spicas can support the upper femur alone or one or both legs, together with the back. These are used in patients who have severe injuries in the upper femur or following arthrodesis of the hip. A long below-knee spica extending down to the foot will also support the knee and tibia.

**Lower limb**

Splints for the lower limb mainly support injuries to the knee and ankle. They include a variety of detachable knee braces used mainly for ligamentous injuries of the knee. Elastic supports and plastic and light-weight metal splints will support collateral and cruciate ligament laxity. Similarly, ankle supports and a variety of footwear are available for lateral ligamentous and other ankle injuries. A pneumatic ankle support, which allows dorsiflexion and plantarflexion, is a particularly comfortable and useful support for ligamentous ankle injuries as it prevents inversion and eversion.
Lower limb supports

Protection for unstable knees and fractures

Supports for fractures and paralysis

Expanded polyethylene and other plastics

Above knee caliper and boot

Knee support for ligamentous injuries

Pneumatic ankle support

Specific fracture management 265
Plaster of Paris (POP)

- **Plaster of Paris** — This has the advantage of ease of application. It is used in most acute fractures requiring either emergency splinting or immobilisation after manipulation.
- **Padded backslab** — This is applied to splint acute fractures and is completed when the swelling has subsided.
- **Full plaster** — In the acute stage it should be split along its entire length so that it can be opened if severe swelling occurs.
- **Lower limb** — A completed plaster may be either weight-bearing or non-weight-bearing.

Types of plaster bandage

Plaster bandages come in the following sizes.
- **Hands and arms** — 5, 7.5, 10 and 15 cm.
- **Legs, hip spicas and plaster jackets** — 10, 15 and 20 cm.

Plaster hardens completely in 24 to 48 hours, but is fairly strong in 1-2 hours and firm in about 5 minutes, depending on the type of plaster. Weight-bearing should be delayed for at least 48 hours to allow the plaster to harden properly.

Preparation of plaster application

It is important that plaster bandages are applied quickly and evenly. Padding with plaster wool and foam is important if pressure sores and other complications are to be avoided, especially in acute fractures where oedema is common.

Immersion of the plaster bandage

- **Cold water** — This is usually used. Warm water can be used if more rapid setting is required.
- **Dip the plaster** — This is done in the water until the bubbles stop appearing.
- **Removing the bandage** — The bandage is lifted out of the water and the surplus water drips back into the bucket (not onto the floor!). Squeeze gently to extract water and not plaster.

Application of plaster bandage

- **Acute fractures** — Those needing manipulation will usually require a well padded plaster or backslab. A thin layer of plaster wool should be used, plus a stockinette under the plaster. Additional padding with wool or foam should be used over pressure areas.
- **Apply the plaster** evenly and make sure that the joints are in the correct position. Use a backslab to strengthen a plaster where possible.
- **Pad pressure areas** carefully with plaster wool or foam plastic. Toes and fingers must be free to move.
Plaster of Paris

Equipment

- Slab slightly longer than necessary
- 6-12 thicknesses plaster slab
- 5, 7.5, 10, 15 and 20 cm plaster bandages
- Plaster wool
- Stockinette
- Oscillating blade
- Do NOT press without padding
- Plaster shears
- Plaster scissors
- Plaster saw
- Plaster benders
- Plaster openers

Specific fracture management
• Split the plaster or cut a window if there is any possibility of a pressure area, or if oedema is to be expected following application of the plaster. It is better to do this 100 times unnecessarily than risk a single pressure sore with its resulting complications.

**Immobilisation**

For many fractures the following sites should be immobilised:

• The fracture site itself.
• The joint above the fracture
• The joint below the fracture.

**Exceptions to excessive immobilisation**

• Certain fractures involving joints (e.g. Colles’ and Pott’s fractures). These only require the joint itself to be splinted.
• Fractures that usually unite without rigid support (e.g. fractured clavicle, metacarpals and metatarsals).
• Where joint stiffness would be more troublesome to the patient than a poorly immobilised fracture site or a plaster would be too heavy or unnecessary (e.g. neck of humerus).
• Aluminium splints — Always use aluminium splints for finger and minor wrist injuries, where possible.
• Slings — These are used for elbow, humerus and shoulder injuries with appropriate splints if required.
• Skelecasts — Use skelecasts, if available, in cases where manipulation is not necessary but immobilisation is important (i.e. scaphoid fractures).

**Disadvantages**

The disadvantage of plaster is that, unless properly padded, pressure areas may occur. Plaster may also get wet and may break or fragment. In addition it takes 2 to 3 days to harden properly, so a patient with a lower limb plaster needs to avoid weight-bearing while the plaster is hardening. Completed plasters tend to be heavy and hot, particularly those above the knee.

**Plastic materials**

There are numerous new waterproof plastic materials available which will harden, after dipping in cold water, in about 5-10 minutes. They come in different colours and are much lighter and stronger than plaster. They are used when manipulation of a fracture is not required. They also allow for almost immediate weight-bearing (see individual fractures for details of splints and plasters).
Plaster of Paris

Technique

Stockinette  Plaster wool

Padding

Acute fractures require adequate wool

Split plaster for potential oedema

Wait until bubbles cease

Squeeze gently

- Application of plaster
- Slab held with elastic bandage
- Complete plaster when oedema settled
The skelecast is a simple concept of lightweight fixation of the limbs and trunk invented by the author in 1966. It is based on the premise that most fractures and dislocations merely require 3 or 4 point fixation and not complete encasement with hot, heavy plasters, except where a fracture requires manipulative reduction.

Advantages
There are many advantages in using the skelecast including:

- **Skin** — The ability to inspect the skin. This is particularly important if there are vascular and neurological complications or infection. The skin can be seen, wounds can be dressed and radiotherapy can be given.
- **Skin and muscle tone** — This is maintained with earlier union of fractures in most cases.
- **Adjustment** — The ability to tighten, loosen or change individual struts means better fixation, in most cases, than with complete encasement in plaster.
- **Lightweight and waterproof** — Skelecasts are lightweight, cool and can be easily adjusted or removed and are usually made of waterproof plastics or other materials. This enables patients to have daily showers, to swim, and often to return to work.
- **Joint mobility** — Hinges can be incorporated in the knee and elbow to allow for even better mobility.
- **Contraindications** — They are not indicated when manipulation of a fracture is necessary. In most weight-bearing supports they are not as strong as a complete plaster wrap.
- **Union of fractures** — Many thousands of skelecasts have been applied since this concept was first developed by the author in 1966. The average time of union of fractures is approximately two-thirds of the equivalent time of complete plaster encasement. This is presumably due to the better tone of muscles, the increased use of the limb and the good skin care in limbs supported by skelecasts. Joints regain their movement much more rapidly following removal of a skelecast, even without a hinge, compared to plaster immobilisation.

Disadvantages
Skelecasts require more skill in the application and are not indicated in most acute fractures requiring manipulation.
Types of material

Thermoplastic skelecast

Thermoplastic bandage in hot water 60–80°C → Apply strips over foam padding

Lightcast skelecast

Lightcast bandage 2.5 cm–15 cm bandages + Light source 3,200–4,000 A 
Hardens 15 seconds–cures 3 minutes

Polyester resin skelecast

• Polyester resin putty + hardener—impregnate fibreglass tape or bandage 
• Cheap and useful for developing countries

Hinged skelecast

Adjustable for tightness

Hinge preventing last 20½ of extension
They are also not as strong as a completed plaster or complete plastic splint for weight-bearing.

Removal and X-rays
The supports can be removed easily by simply cutting through the struts with 'tin snips', and in most cases, X-rays can be taken through the gaps in the skelecast without removing the skelecast, as is often necessary with plaster. Deep X-ray therapy can also be given for pathological fractures.

Acute fractures
• Oedema — In acute fractures oedema is controlled initially by merely putting a little wool and an elastic compression bandage around the limb and the struts until the swelling has settled.
• Contraindications — Skelecasts are not usually indicated where a complete wrap is necessary after a manipulation of fracture. The skelecast can be applied, however, as soon as the fracture is sufficiently stable, to enable the support to be changed without the danger of the fracture slipping.

Material
The skelecast can be made out of a variety of materials, as illustrated. Many of the newer plastics can be used. These include thermoplastics which are softened in hot water at 65-80°C. They are applied to the patient as struts directly over waterproof lining. Some cold water plastics can also be used. They are dipped into cold water and applied directly to the patient in the form of struts. Ordinary hardware shop polyester resin, or a light sensitive polyester resin, can also be used. Newer materials are constantly being developed. The one most suited, and available, should be used.

• Longitudinal struts — These are usually thin aluminium struts covered by one or two layers of the plastic or other material used in the manufacture of the support. The exact type of plastic or metal used is unimportant, provided that good rigid fixation is obtained. The support should also be waterproof and strong, and the points of contact between the struts are properly molded and strengthened if necessary.

Indications

Upper limb
• Specific indications — The scaphoid skelecast is ideal. Other suitable indications for this type of support include above-elbow skelecasts for the radius and ulna following internal fixation of fractures. The Colles’ type of skelecast is also
Skelecasts
Upper limb

Colles' fracture type

Elastic bandage over wool for oedema

Scaphoid fracture

• Cast is waterproof and light
• Patients can bathe and swim

Above elbow

Adjustable by cutting struts and repairing
indicated for fractures of the wrist not requiring manipulation.

- **Other indications** – Injuries of the upper limbs which do not have much swelling, such as the wrist, radius, ulna and elbow, after initial treatment by *internal fixation* or *plaster*, respond well to protection with a skelecast.

**Lower limb**
- **Indications** – In the lower limb the *cylinder skelecast* for knee injuries, and above and below the knee skelecasts for fractures of the *tibia and ankle*. These supports are particularly indicated for protecting the lower limb where only *non-weight-bearing* or *partial weight-bearing* is planned. A *complete plastic wrap* is indicated for patients who require a stronger support.

**Other indications**
- **Children** – In children with congenital dislocation of the hip and other hip lesions, a waterproof skelecast *hip spica* allows immobilisation with lightness and mobility.
- **Compound fractures** – They are particularly useful in compound fractures, or in the case of *wounds*. The struts can be easily positioned so that the skin can be seen and *dressings changed*. In those cases where the *fracture* is being held by *external pins*, fixation can be *strengthened* by the *plastic skelecast struts*.
- **Neurological deficit** – In patients with diminished sensation, such as in *nerve injuries* and *paraplegia*, the ability to see the skin under the struts diminishes the likelihood of pressure sores occurring.
- **Radiotherapy** – In patients with *secondary deposits* with a pathological or potential *pathological fracture* a skelecast will enable radiotherapy to be given.
- **Post-operatively** – In the operating theatre, for patients undergoing operations such as a patellectomy, screwing of an ankle fracture or internal fixation of fractures of the radius and ulna, lower humerus or olecranon, a *plaster backslab* over wool should be applied for about *3 days*. After the suction drain has been removed, and the *post-operative oedema has diminished*, it is a simple matter for a *skelecast* to be applied. The *wound* can be *viewed* and *sutures removed without removing the support*.

**Method of application**
The method of application of a skelecast is illustrated on page 277, and is relatively simple. It often takes *longer to apply*
Skelecasts

Above-knee skelecast
Adjust strips for dressings

Hinged skelecast
Adjustable for tightness
Hinge preventing last 20½ of extension

Partial weight-bearing skelecast
Overboot
Complete plastic wrap to allow full weight-bearing
than a simple complete wrap of plaster or synthetic material, but its many advantages more than compensate for this. Patients who have experienced a skelecast will not return to plaster fixation.

- **Lining** – Firstly, thin strips of *waterproof lining*, in one layer of thickness, are put around the arm or leg, as illustrated, and *overlapped slightly* and held with strips of tape.

- **Circular struts** – While one circular strut is being applied, the next is dipped for a few seconds in *hot water* at about 70°C by an assistant. Some *cold water plastics* can be similarly dipped. It is important that each circular strut be carefully *molded* and made to *adhere to itself* before the next one is applied. All the circular and longitudinal *struts* should be *cut* to the right length from 5 or 7.5 cm wide plastic, *before* they are *dipped*. It is then a simple matter to dip each one in turn in the water, lay it on a towel, fold it on itself 2 or 3 times and then apply it directly over the lining. *Rubber gloves* are *not necessary* due to the low conductivity of the plastic but can be worn to *protect the hands*. A special *water soluble lubricant* supplied prevents the thermoplastic sticking to the gloves.

- **Longitudinal struts** – After application of the circular strut, 2 or 3 longitudinal struts of *aluminium strips*, about 1-1.5 cm in diameter, *covered* with a layer of *thermoplastic* and cut to the correct length and overlapped by about 1 cm at each end by the plastic, are dipped into the hot water. These can then be applied to the patient. Extra circular strips of thermoplastic, or other plastic or polyester resin, are then applied to hold the longitudinal struts in place. It is important that these are carefully *molded at the joints* with the longitudinal struts, and to the circular struts to make sure they adhere.

- **Removal** – Individual *struts* can be *easily removed* for X-ray or radiotherapy. *Circular struts* can be cut or *opened out* for *oedema* or *closed in*. The area can be repaired later with an *epoxy resin glue* or the original material.

- **Hinges** – A hinge for *elbows* and *knees* can be inserted to allow for flexion of the joint. The *last 20°-30°* of extension can be *prevented* if necessary.

**Conclusion**

A skelecast, if applied properly and carefully and for the correct indications, is superior to complete encasement with plaster-of-Paris or other plastic material where a fracture has *not* needed to be *manipulated*. It has a potential for application of *over 50% of all fractures* and for many other orthopaedic conditions.
Thermoplastic skelecasts

Technique

- Water 65–80½ for thermoplastics
- Dip thermoplastic briefly into water

Towel

- Fold hot plastic into 2 or 3 thicknesses
- Aluminium covered plastic with 1 cm overlap at ends

Waterproof lining

Circular strips of plastic

Longitudinal strips of covered aluminium

Further circular strips
Complications of trauma

Injuries may involve not only bones, joints, nerves, blood vessels and muscles but also the brain, spinal cord, lungs and heart, together with the abdominal and pelvic organs.

Bone and joint complications

Delayed and non-union

- Poor blood supply — This is the most common cause of delayed and non-union. The head of the femur, the proximal half of the scaphoid and the body of the talus are particularly prone to avascular changes due to their mainly peripheral blood supply being interrupted.
- Other causes — These include excessive movement at the fracture site, interposition of soft tissue between bone ends, infection and pathological bone, such as in secondary deposits from carcinoma and due to Paget’s disease.
- Over-distraction — This, together with operative periosteal stripping, may also delay bony union.

Mal-union

- Radius and ulna — This is a particularly important complication as it affects forearm rotation.
- Femur and the tibia — Malalignment may result in osteoarthritis due to asymmetrical weight-bearing on the hip, knee and ankle.

Shortening

- Lower limb — In fractures of the tibia and femur, this may cause a limp and secondary low back pain.
- Apparent shortening — This may also occur due to an adduction deformity of the hip, or fixed flexion of the knee.

Growth disturbances

- Epiphyseal injuries — Growth disturbances are common in children following trauma.
- Shortening or deformity — This may result from premature or asymmetrical fusion of the epiphyses. Fractures of long bones, such as the femur in children, may conversely lead to overgrowth of up to 2 cm in the affected leg.
General complications

Bones

<table>
<thead>
<tr>
<th>Head of femur</th>
<th>Scaphoid</th>
<th>Radius and ulna</th>
</tr>
</thead>
</table>
| Impaired blood supply | • Avascular necrosis  
| Delayed and non-union | • Non union  
|                   | • Mal-union  
|                   | • Cross-union  |

<table>
<thead>
<tr>
<th>Tibia and fibula</th>
<th>Epiphyseal damage</th>
<th>Compound fractures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shortening</td>
<td>Growth disturbances</td>
<td>Osteomyelitis</td>
</tr>
</tbody>
</table>
Osteomyelitis

Compound fractures are particularly likely to lead to osteomyelitis. This is difficult to treat and may lead to non-union and shortening. Fractures may also become infected following operations for internal fixation.

Joint stiffness and pain

- Joint injuries – Stiffness may be a complication.
- Prolonged immobilisation – Particularly in plaster.
- Prolonged traction – Especially of the knee.
- Common sites – The shoulder and metacarpo-phalangeal joints, if immobilised for more than three weeks.

Miscellaneous bone and joint complications

- Instability – This is common in the knee and ankles, due to ligamentous injuries and wasting of muscles.
- Osteoarthritis – This is common in incompletely reduced fractures, particularly in the joints.
- Asymmetrical weight-bearing – This includes a varus or valgus deformity with secondary degenerative arthritis.
- Avascular necrosis – This may follow subcapital fractures of the hip, neck of the talus and neck of the scaphoid, with secondary osteoarthritis.

Neurological complications

Spinal cord

- Thoracic region – The spinal cord is often completely transected in the thoracic region following minor displacement, as it is a tight fit in the spinal canal.
- Cervical and lumbar – Cervical nerve roots and the cauda equina are more likely to be damaged than the cord.
- Thoraco-lumbar – In this region, both the spinal cord and nerve roots may be damaged.

Upper limb

- Brachial plexus injuries – These have a poor prognosis and often follow falls on the shoulder.
- Axillary nerve – This may follow fractures or dislocations of the shoulder.
- Radial nerve – Damage commonly follows fractures of the mid-shaft of the humerus and usually recovers.
- Ulnar nerve – Paralysis is often due to fractures of the medial epicondyle of the humerus.
- Median nerve – This may be injured in wrist fractures and lunate dislocations.
General complications

Joints

Old ligament injury

Incomplete reduction

Instability

Osteoarthritis

Prolonged immobilisation

Stiffness, pain, secondary osteoarthritis

Plaster of Paris pressure areas

Nerve injuries

Spinal cord

Upper limb

Lower limb

• Sciatic

• Common peroneal and posterior tibial nerves

• Cord

• Cauda equina

• Nerve roots

Brachial plexus

axillary, radial, ulnar and median nerves

Specific fracture management 281
Lower limb

- **Sciatic nerve** — This is commonly damaged in *posterior dislocations* of the *hip* and in *pelvic fractures*.
- **Common peroneal nerve** — This is commonly injured in fractures of the *neck of the fibula*, and in *knee dislocations*.

Vascular complications

Upper limb

- **Supracondylar fracture of the humerus** — This may damage the *brachial artery*.
- **Compartment syndrome with ischaemia of the flexor muscles** — This is due to *oedema* or to *bleeding* into the *flexor compartment of the forearm* following a *supracondylar fracture*. It is a *surgical emergency*, and all cases of *displaced supracondylar fractures in a child*, and fractures of the *lower humerus in an adult*, require *admission to hospital*.

  Limitation of extension of the fingers, with pain, is the *earliest clinical indication of ischaemia* of the forearm flexor muscles. *Urgent reduction of supracondylar fractures*, and *decompression of the flexor compartment* if necessary, is *required* (see pages 243–245). *Exploration of the brachial artery* should be considered, plus repair or reconstruction, if necessary. Failure to treat this complication can lead to a *Volkmann's ischaemic contracture*, or even *gangrene* of the hand.

Lower limb

- **Supracondylar fractures of the femur** — These may cause damage to the *popliteal vessels*. The *popliteal artery* has a *poor collateral blood supply* and may lead to *ischaemia* of the *calf muscles* and *gangrene* of the *toes*, similar to the brachial artery causing ischaemia to the upper limb.
- **Dislocation of the knee** — A *Doppler scan* and an *arteriogram* are urgently required in most cases of knee dislocation. *Intimal damage* with *thrombosis* is *common* and may require a *vein graft*.
- **Disruption of the pelvis** — This is particularly liable to lead to *massive retropelvic bleeding*. 
Vascular injuries

Supracondylar fracture humerus
• Supracondylar fracture femur
• Dislocation knee

Tight plaster

Other fractures of limb and trunk can cause compartment syndromes

Other complications

Myositis ossificans — especially in dislocated hips and elbows

• Head and spinal injuries
• Chest injuries: lung, heart, major vessels, diaphragm
• Abdominal and pelvic injuries: including stomach, pancreas, intestine, liver, spleen, kidney and bladder
• Major vessels and other organs
• Other limb injuries

Specific fracture management
Miscellaneous complications

- **Plaster of Paris** – An unpadded or poorly fitting plaster may cause a **vascular** compromise and **pressure sores**.
- **Local complications** – These include traumatic ossification or **myositis ossificans** due to calcification, followed by ossification in a haematoma following a fracture, joint dislocation or periosteal damage. This is particularly common if there is **associated neurological damage**.
- **General complications** – These include **respiratory obstruction** in head, jaw and chest injuries. Other complications are **shock**, **fat embolus**, and the **crush syndrome** following abdominal, pelvic and limb injuries.

  Details of the **complications** associated with head, chest, abdomen, spine and limb injuries and their treatment are discussed in the **individual sections** of this book.