Chapter 4

Specific fracture management

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.**

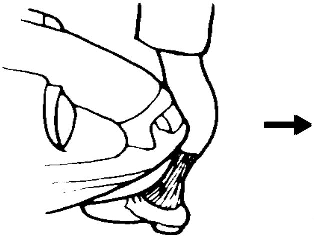
Healing of fractures

Haematoma

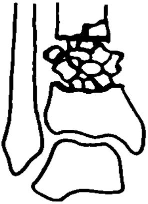
A haematoma will always form following a fracture. This may be **extensive** in **vascular bones**, such as fractures of the shaft

Types of fracture

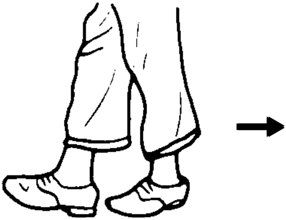
Direct trauma



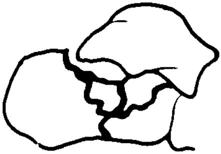
Bumper



Comminuted — often compound

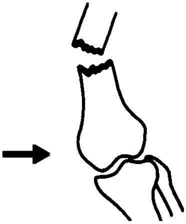


Fall on calcaneus



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

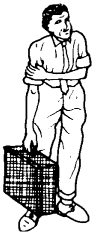
Union usually occurs **earlier** in **oblique fractures** than in transverse fractures. It is also more rapid in fractures with a **good blood supply**, such as the metacarpals, metatarsals and phalanges, than in the shaft of major long bone fractures, due to less vascular supply to the fractured bone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

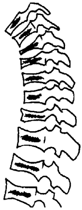
Pathological fractures



Minimal force

Secondary deposit

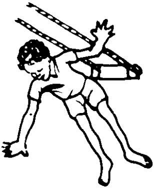
Fragilitas ossium



Senile osteoporosis

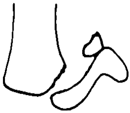
Children

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

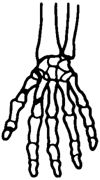
Injuries of the upper limbs

Approximate times

3 weeks

- Clavicle
- Shoulder dislocation

- Minor elbow fractures
- Head of radius fractures

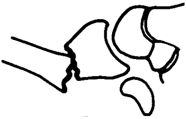


- Triquetral
- Scaphoid tuberosity

3-6 weeks

Acromio-clavicular joint dislocation

- Dislocated elbow
- Supracondylar fracture
- Fracture olecranon



- Colles and Smith's fractures
- Dislocated lunate

8-12 weeks

Shaft humerus

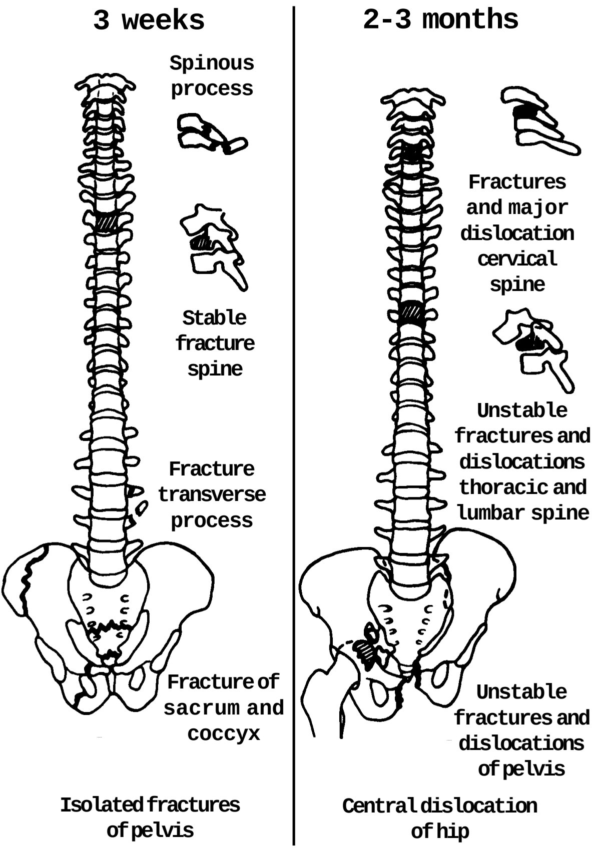
Shaft radius and ulnar fractures

Scaphoid (body)

Immobilisation or non-weight-bearing

Injuries to spine and pelvis

Approximate times



Bladder, vascular and neurological complications first priority in treatment

Immobilisation

Injuries of the lower limbs

Approximate times

3 weeks or less

Isolated fractures trochanters

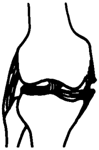
Tear menisci

Fibula without ankle damage

Minor ankle fractures and sprains

Metatarsals and toes

6 weeks



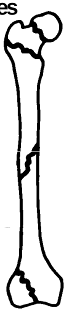
Ligaments of knee

Rupture extensors knee

Major ligamentous injuries ankle

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

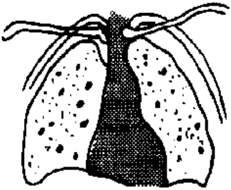
Blood investigations

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

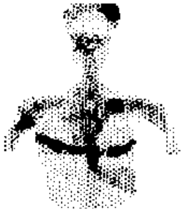
Diagnosis and pre-operative assessment

Chest X-ray and CT scan



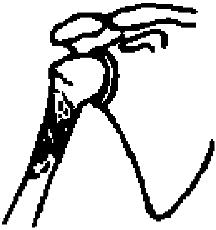
Secondary deposits

Bone scan



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

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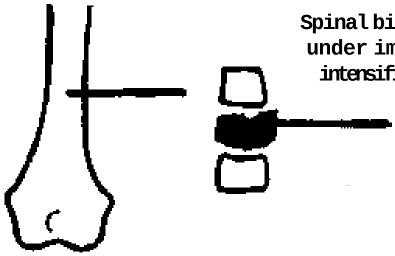
Trephine biopsy



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

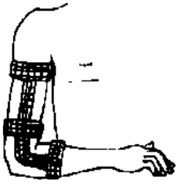
Humerus

Upper end and shaft

Sling or collar and cuff if necessary

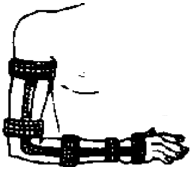
Rush nail

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.**

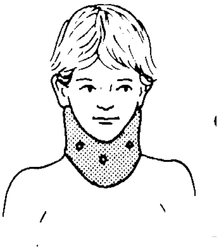
• **Prophylactic internal fixation** – Potential pathological fractures should be internally stabilised.

• **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.

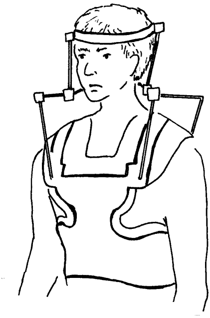
Pathological fractures

Treatment
Cervical spine



Cervical collar

Skelecast Minerva



Halo-vest

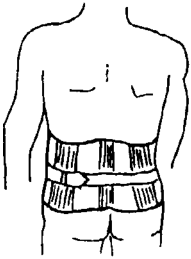
All require radiotherapy ± chemotherapy and hormones in addition

Pathological fractures

Treatment

Thoracic and lumbar spine

Taylor brace – thoracic spine urgent decompression and stabilisation for paraplegia

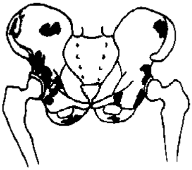


Lumbo-sacral corset – lumbar spine

Pelvis and upper 1/3 both femora

Examination and pre-operative blood assessment including serum calcium

Pelvis and acetabulum



- 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.

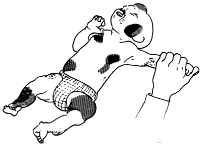
Diagnosis

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

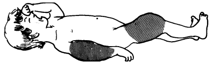
Fractures in children



Battered babies

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

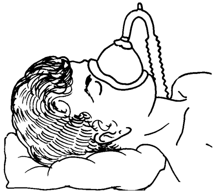
Infection may mimic fracture



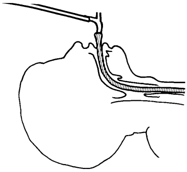
Look for other injuries and causes

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 injurie

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

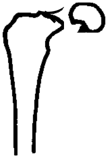

Tibia


Radius and ulna


Humerus


Clavicle

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.

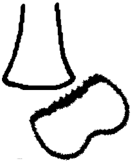
• **Type III** – The fracture line extends from the **joint space** to the **growth plate**. It then extends laterally to the edge of the plate separating the fractured epiphysis from the metaphysis. It must be **reduced perfectly** and may require **open operation** and **wire** fixation. The **prognosis** 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.

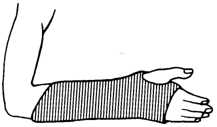
Operative treatment

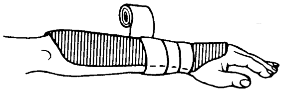
In children, operative **internal stabilisation** should be **avoided** if possible, as this may interfere with growth at the epiphyses.

• **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

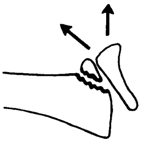
Type I – no fracture



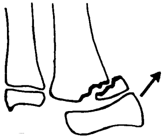


• Manipulation and plaster

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:

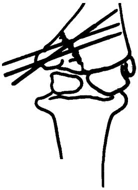
Type I – **Separation** of the **epiphysis** with **no fracture** requires a **closed reduction** and has a **good prognosis**.

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

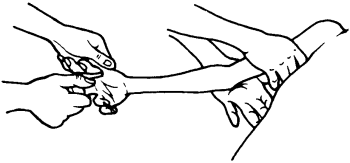
Lateral view

AP view

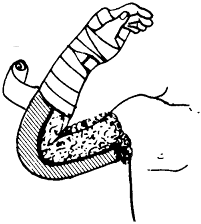


Condylar fractures

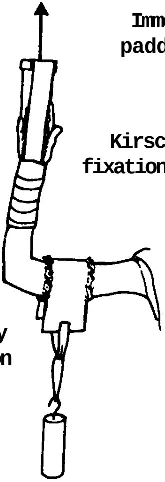
Treatment



Manipulation and reduction



Immobilisation: padded back slab



Kirschner wire fixation if necessary

Difficult fractures may require countertraction

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 impotant 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 comminution**.
- **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.**

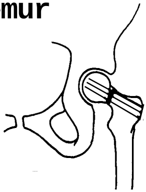
Complications

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.

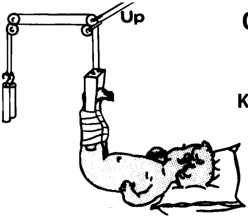
Fractures in children

Neck femur



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

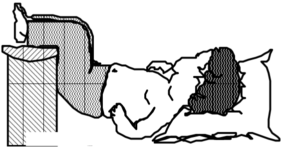
Femoral shaft fractures



Child under 15 kg weight

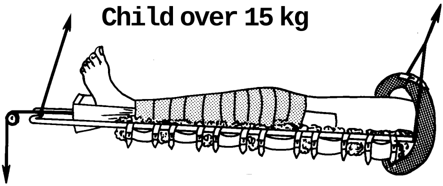
Knees should be splinted with back slabs in about 10° flexion

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

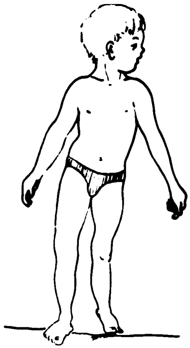
Treatment

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 1-2cm common

Avoid overdistracting fractures

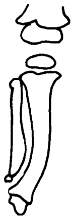
Malunion

Correct angulation

Shortening

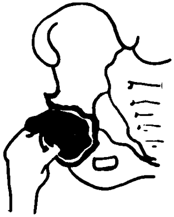
Epiphysiodesis opposite side

Growth disturbances



Epiphyseal damage causes varus, valgus or shortening

Avascular necrosis



Late osteoarthritis

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 **epiphyses**, 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 **overdistract** fractures, and sometimes even to leave a fracture of the lower limb **l 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**.

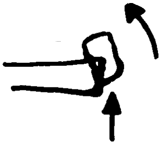
Common fracture sites

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

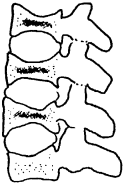
This is a very common injury, particularly in **elderly females**. It is often secondary to a fall on the **outstretched hand.**

Common fractures in the elderly

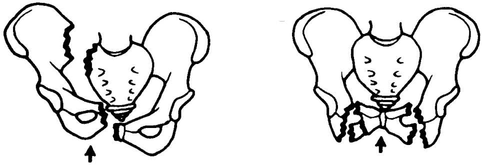


Wrist
Colles' fracture

Shoulder
Fracture or fracture dislocation

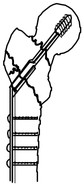


Fracture in several osteoporotic vertebrae with ballooning or secondary deposits



Fractured pelvis

Femoral neck or trochanter



Intramedullary fixation in patients within 24 hours if possible

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.**

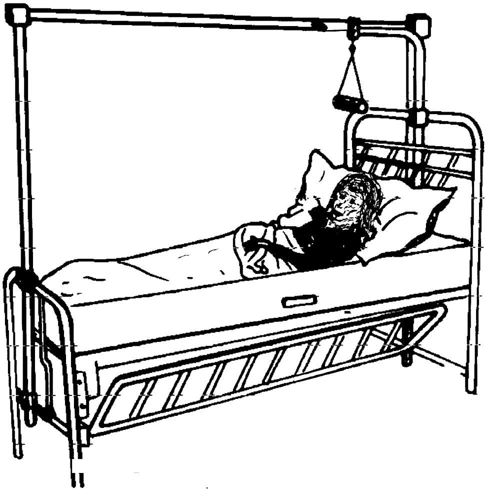
• **Treatment** – **Early mobility** and weight-bearing, with **internal fixation** or a **walking plastic support**, are important in these patients.

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 thombosis prophylaxis
- Mobilise patients and home early



Falls from a height

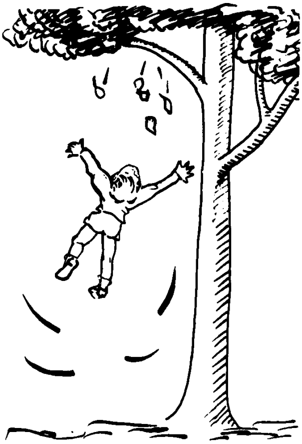
Falls from a height, mainly from **ladders**, may involve window cleaners, painters, tilers, builders, and plumbers. Parachutists are also at risk.

- **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 **subtaloid 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

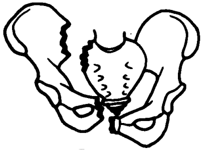
This is discussed in the relevant sections of this book, under the **individual fractures.**

Fractures due to falls from a height



Fracture spine

Central dislocation of hip



Pelvic shear

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

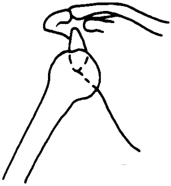
The force of a fall on the hand may be transmitted through to the clavicle.

• **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**.

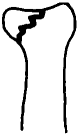
Falls on the hand

Neck and shaft of humerus

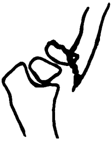


Dislocated shoulder

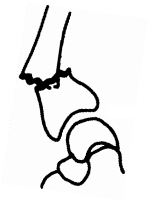
Clavicle fracture



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.

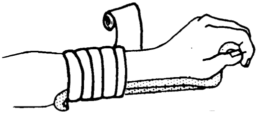
• **Advantages** – These supports can be permanent or detachable with 'velcro' straps and are **lighter** and **more comfortable** than plaster of Paris.

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

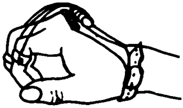
• **Spinal supports** – There are many **neck** and **spinal** supports and some of these are illustrated. They are usually

Orthopaedic splints

Hand and wrist

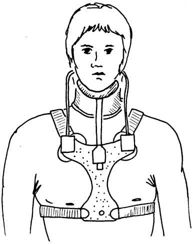


Aluminium cock-up splint



Lively hand splint for nerve injuries and stiff fingers

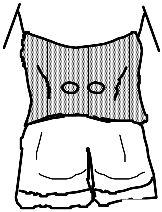
Cervical spine



Shoulder

Abduction splint

Lumbar spine



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

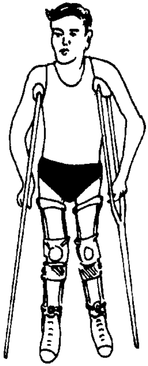
Splints for the lower limb mainly support injuries to the **knee** and **ankle.** They include a variety of detachable **knee braces** used mainly for **ligamentous injuries** of the **knee.** Elastic supports and plastic and light-weight metal splints will support collateral and cruciate ligament laxity. 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

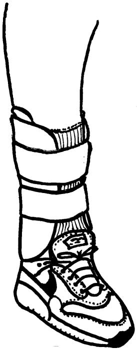
Expanded polyethylene and other plastics

Supports for fractures and paralysis



Above knee caliper and boot

Knee support for ligamentous injuries



Pneumatic ankle support

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 20cm.
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

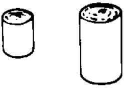
• **Cold water** – This is usually used. **Warm water** can be used if more **rapid setting** is required.
• **Dip the plaster** – This is done in the water until the bubbles stop appearing.
• **Removing the bandage** – The bandage is lifted out of the water and the surplus water drips back into the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

Application of plaster bandage

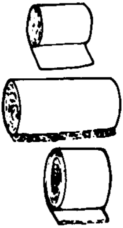
• **Acute fractures** – Those needing manipulation will usually require a **well padded** plaster or backslab. A thin layer of **plaster wool** should be used, plus a **stockinette** under the plaster. Additional **padding** with **wool** or **foam** should be used over pressure areas.
• **Apply the 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



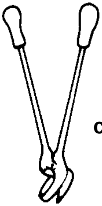
5, 7.5, 10,
15 and 20 cm plaster
bandages



Plaster wool
stockinette

Slab slightly
longer than
necessary

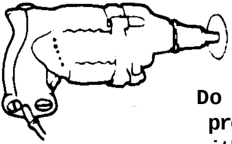
6-12
thicknesses
plaster slab



Use
carefully

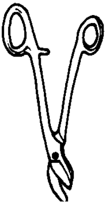
Plaster shears

Oscillating blade

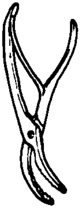


Do NOT
press
without
padding

Plaster saw



Plaster
scissors



Plaster
benders

Plaster
openers

• **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

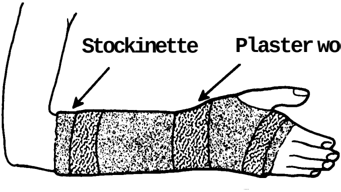
The disadvantage of plaster is that, unless properly padded, **pressure areas** may occur. Plaster may also get **wet** and may **break** or fragment. In addition it takes **2 to 3 days** to **harden** properly, so a patient with a lower limb plaster needs to avoid weight-bearing while the plaster is 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

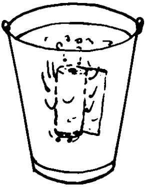
Technique



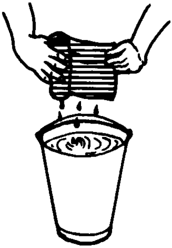
Acute fractures require adequate wool

Padding

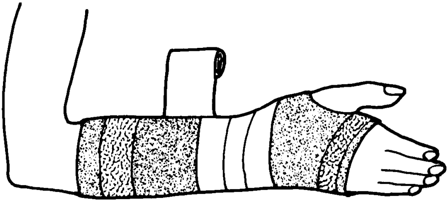
Split plaster for potential oedema



Wait until bubbles cease



Squeeze gently



- Application of plaster
- Slab held with elastic bandage
- Complete plaster when oedema settled

Skelecasts

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 60-80½C → Apply strips over foam padding

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Lightcast skelecast

Lightcast bandage 2.5 cm-15 cm bandages
+
Light source 3,2000-4,000 A

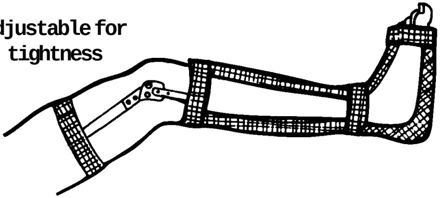
Hardens 15 seconds-cures 3 minutes

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

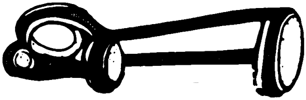
• **Specific indications** –The **scaphoid** skelecast is ideal. Other suitable indications for this type of support include **above-elbow skelecasts** for the radius and ulna following internal fixation of fractures. The **Colles'** type of skelecast is also

Skelecasts
Upper limb

Colles' fracture type

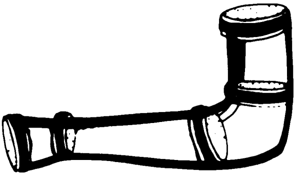
Elastic bandage over wool for oedema

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.

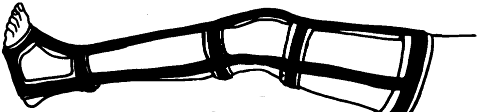
• **Post-operatively** – In the operating theatre, for patients undergoing operations such as a patellectomy, screwing of an ankle fracture or internal fixation of fractures of the radius and ulna, lower humerus or olecranon, a **plaster backslab** over wool should be applied for about **3 days**. After 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

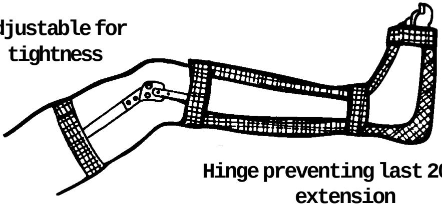
The method of application of a skelecast is **illustrated** on **page 277**, and is relatively simple. It often takes **longer to apply**

Skelecasts

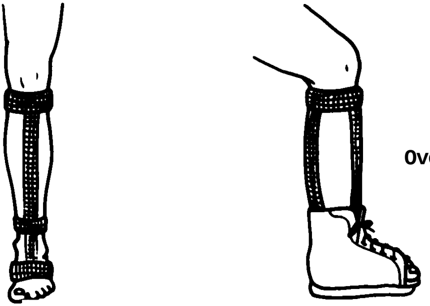
Above-knee skelecast



Hinged skelecast



Partial weight-bearing skelecast



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. lt 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 l 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.

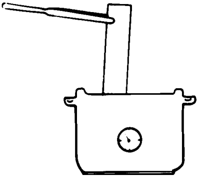
• **Hinges** – A hinge for **elbows** and **knees** can be inserted to allow for flexion of the joint. The **last 20°-30°** of extension can be **prevented** if necessary.

Conclusion

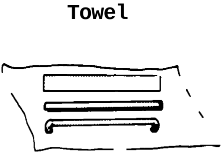
A skelecast, if applied properly and carefully and for the correct indications, is superior to complete encasement with plaster-of-Paris or other plastic material where a fracture has **not** needed to be **manipulated**. It has a potential for application of **over 50% of all fractures** and for many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

Thermoplastic skelecasts

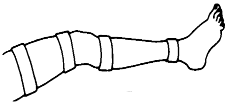
Technique



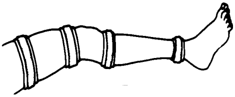
• Water 65-80½ for thermoplastics
• Dip thermoplastic briefly into water



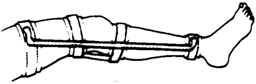
• Fold hot plastic into 2 or 3 thicknesses
• Aluminium covered plastic with 1 cm overlap at ends



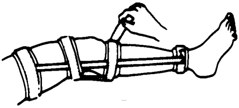
Waterproof lining



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

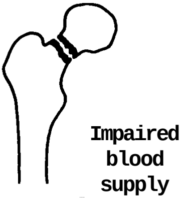
• **Epiphyseal injuries** – Growth disturbances are common in **children** following trauma.

• **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

Head of femur

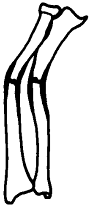


Delayed and non-union

Scaphoid

- Avascular necrosis
- Non union

Radius and ulna

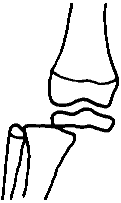


- Mal-union
- Cross-union

Tibia and fibula

Shortening

Epiphyseal damage



Growth disturbances

Compound fractures

Osteomyelitis

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**.

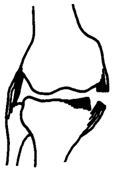
Upper limb

- **Brachial plexus injuries** – These have a **poor prognosis** and often follow falls on the shouder.
- **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

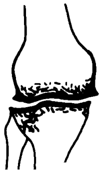
Joints

Old ligament injury



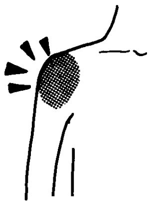
Instability

Incomplete reduction

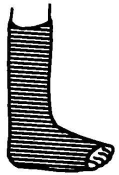


Osteoarthritis

Prolonged immobilisation



Stiffness, pain, secondary osteoarthritis



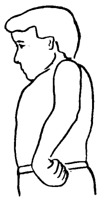
Plaster of Paris pressure areas

Nerve injuries

Spinal cord

- Cord
- Cauda equina
- Nerve roots

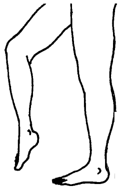
Upper limb



Brachial plexus
axillary, radial,
ulnar and median nerves

Lower limb

- Sciatic
- Common peroneal and posterior tibial nerves



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

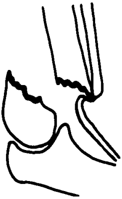
- **Supracondylar fracture of the humerus** – This may damage the **brachial artery**.
- **Compartment syndrome with ischaemia of the flexor muscles** – This is due to **oedema** or to **bleeding** into the **flexor compartment** of the **forearm** following a **supracondylar fracture**. It is a **surgical 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

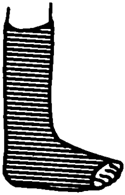
- **Supracondylar fractures of the femur** – These may cause damage to the **popliteal vessels**. The **popliteal artery** has a **poor collateral blood supply** and may lead to **ischaemia** of the **calf muscles** and **gangrene** of the **toes,** similar to the brachial artery causing ischaemia to 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

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**.