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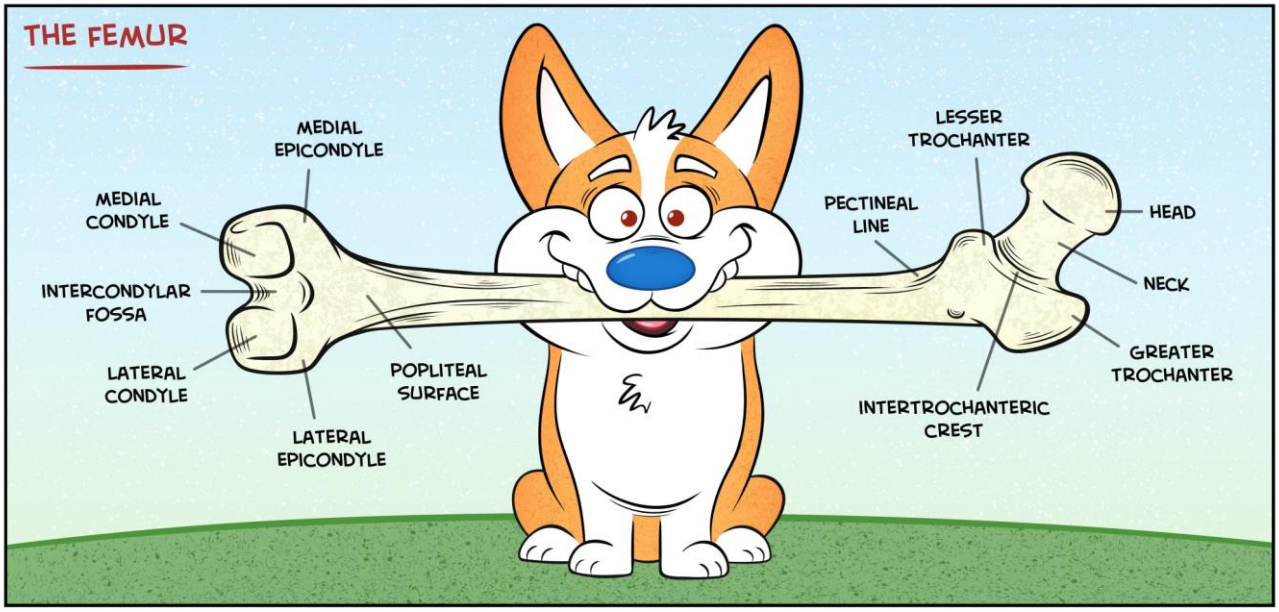


BONE DISEASE / DISORDERS

Disease	Features	Treatment
Paget's	• Focal bone resorption followed by excessive and chaotic bone deposition • Affects (in order): spine, skull, pelvis and femur • Serum alkaline phosphatase raised (other parameters normal) • Abnormal thickened, sclerotic bone on x-rays • Risk of cardiac failure with >15% bony involvement • Small risk of sarcomatous change	Bisphosphonates
Osteoporosis	• Excessive bone resorption resulting in demineralised bone • Commoner in old age • Increased risk of pathological fracture, otherwise asymptomatic • Alkaline phosphatase normal, calcium normal	Bisphosphonates, calcium and vitamin D
Secondary bone tumours	• Bone destruction and tumour infiltration • Mirel scoring used to predict risk of fracture • Appearances depend on primary (e.g.sclerotic - prostate, lytic - breast) • Elevated serum calcium and alkaline phosphatase may be seen	Radiotherapy, prophylactic fixation and analgesia

Metabolic Disorders

Condistion	Comment
Osteoporosis	• Decrease in bone mass (quantitative problem). Most common in elderly patients • 2 types: Type 1: most common, affects cancellous bone (femoral neck, vertebral body, etc);Type 2: age related, 70y.o. Both cancellous and cortical bone mass are defi cient. • DEXA scan is standard for evaluation. Hormone replacement or bisphosphonates may be used.
Scurvy	• Vitamin C defi ciency leads to defective collagen, resulting in a constellation of symptoms.
Osteopetrosis	• "Marble bone disease". Osteoclast dysfunction results in too much bone density.
Paget's disease	• Simultaneous osteoblast & osteoclast activity results in dense, but brittle bones.

Osteomalacia

Basics

- Normal bony tissue but decreased mineral content
- Rickets if when growing
- Osteomalacia if after epiphysis fusion

Types

- Vitamin D deficiency e.g. malabsorption, lack of sunlight, diet
- Renal failure
- Drug induced e.g. anticonvulsants
- Vitamin D resistant; inherited
- Liver disease, e.g. cirrhosis

Features

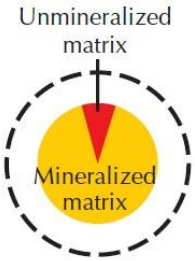
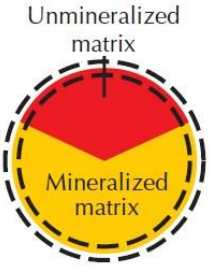
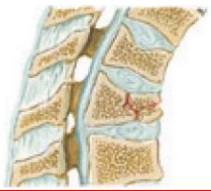
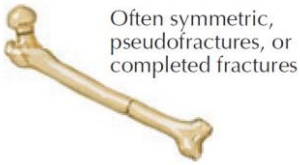
- Rickets: knock-knee, bow leg, features of hypocalcaemia
- Osteomalacia: bone pain, fractures, muscle tenderness, proximal myopathy

Investigation

- Low calcium, phosphate, 25(OH) vitamin D
- Raised alkaline phosphatase
- X-ray: children - cupped, ragged metaphyseal surfaces; adults - translucent bands (Looser's zones or pseudofractures)

Treatment

- Calcium with vitamin D tablets

	Osteoporosis	Osteomalacia
Definition	Bone mass decreased, mineralization normal  	Bone mass variable, mineralization decreased 
Age at onsent	Generally elderly, postmenopause 	Any age 
Etiology	Endocrine abnormality, age, idiopathic, inactivity, disuse, alcoholism, calcium deficiency	Vitamin D deficiency, abnormality of vitamin D pathway, hypophosphatemic syndromes, renal tubular acidosis, hypophosphatasia
Symptomalogy	Pain referable to fracture site 	Generalized bone pain 
Signs	Tenderness at fracture site	Tenderness at fracture site and generalized tenderness
Radiographic Features	Axial predominance 	Appendicular predominance 
Labaratory findings *Serum Ca++* *Serum Pi* *Alk phosphatase* *Urinary Ca++* *Bone biopsy*	 • Normal • Normal Ca++ x Pi >30 • Normal • High or normal • Tetracycline labels normal	 • Low or normal (high in hypophosphatasia) • Low or normal Ca++ x Pi >30 if albumin normal (high in renal osteodystrophy) • Elevated, except in hypophosphatasia • Normal or low (high in hypophosphatasia) • Tetracycline labels abnormal

Paget's Disease

Paget's disease is a disease of increased but uncontrolled bone turnover and is characterised by architecturally abnormal bones. It is thought to be primarily a disorder of osteoclasts, with excessive osteoclastic resorption followed by increased osteoblastic activity causing areas of sclerosis and deformity. Paget's disease is common (UK prevalence 5%) but symptomatic in only 1 in 20 patients

Predisposing factors

- Increasing age
- Male sex
- Northern latitude
- Family history

Clinical features

- Bone pain (e.g. Pelvis, lumbar spine, femur)
- Classical, untreated features: bowing of tibia, bossing of skull
- Raised alkaline phosphatase (ALP). Calcium* and phosphate are typically normal
- Skull x-ray: thickened vault, osteoporosis circumscripta

**usually normal in this condition but hypercalcaemia may occur with prolonged immobilization*

Indications for treatment include bone pain, skull or long bone deformity, fracture, periarticular Paget's

- Bisphosphonate (either oral risedronate or IV zoledronate)
- Calcitonin is less commonly used now

Complications

- **Deafness** (cranial nerve entrapment)
- Bone sarcoma (1% if affected for > 10 years)
- Fractures
- Skull thickening
- High-output cardiac failure

Avascular necrosis

- Cellular death of bone components due to interruption of the blood supply, causing bone destruction
- Main joints affected are hip, scaphoid, lunate and the talus.
- It is not the same as non-union. The fracture has usually united.
- Radiological evidence is slow to appear.
- Vascular ingrowth into the affected bone may occur. However, many joints will develop secondary osteoarthritis.

Presentation
Usually pain. Often despite apparent fracture union.

Investigation
MRI scanning will show changes earlier than plain films.

Treatment
- In fractures at high risk sites anticipation is key. Early prompt and accurate reduction is essential.
- Non weight bearing may help to facilitate vascular regeneration.
- Joint replacement may be necessary, or even the preferred option (e.g. Hip in the elderly).

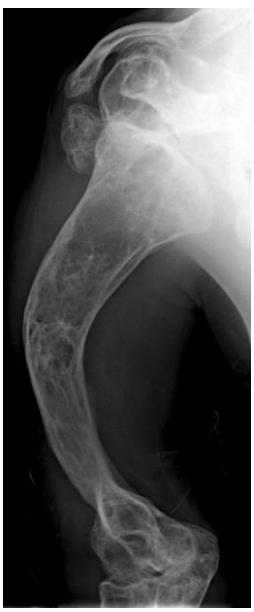
Causes *"PLASTIC RAGS"*
Pancreatitis
Lupus
Alcohol
Steroids
Trauma
Idiopathic, Infection
Caisson disease, Collagen vascular disease
Radiation, rheumatoid arthritis
Amyloid
Gaucher disease
Sickle cell disease

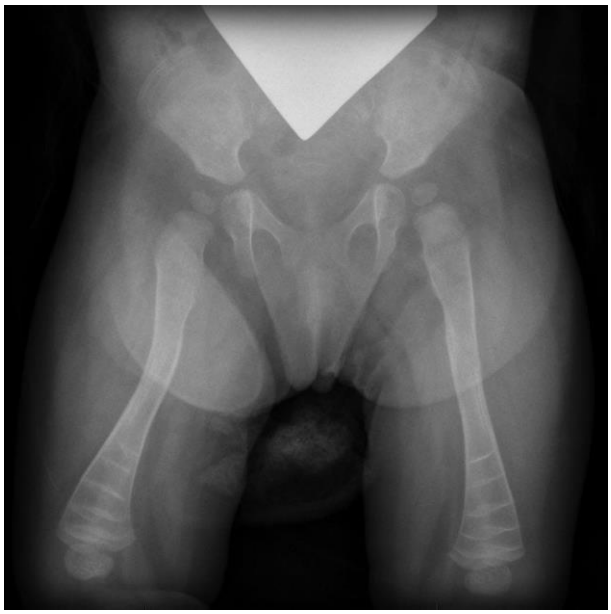
Osteogenesis Imperfecta

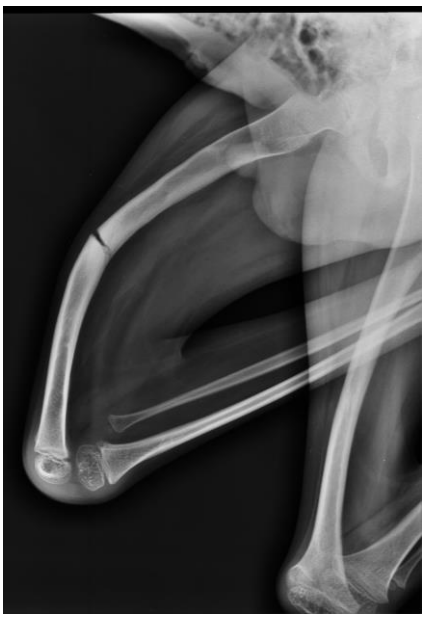
Inherited condition causing increased fragility of bone. It principally affects those tissues containing the main fibrilla collagen type I - eg, bone and teeth. It also affects sclerae, joints, tendons, heart valves and skin.

Type I *Mildest form*	Type II *Lethal form*	Type III *Severely progressive*	Type IV *Moderately severe form*
This accounts for 60% of all cases. This causes reduction in the amount of bone and defective bone formation. Due to abnormal or decreased pro-alpha 1 or pro-alpha 2 collagen polypeptides. There is osteoporotic bone with an excess of osteoblasts and osteocytes. It also causes thin sclerae, slender weak tendons, thin heart valves and dilated aortic root.	Cases arising due to new dominant mutations result in multiple fractures (frequently occurring in utero) and short limbs due to faulty conversion of normal mineralised cartilage to defective bone matrix. The result is completely disorganised and structurally incompetent bone structure.	This is a deforming subtype. This has variable amounts of woven immature bone, disorganised trabeculae and multiple islands of cartilage in the epiphyses and metaphyses. The child may be born with fractures. It is characterised by deformity of bones increasing with age and by extreme short stature due to repeated childhood fractures. There is commonly impaired dentition, 'dentinogenesis imperfecta' (DI), with blue-yellow, small mis-shapen teeth, secondary to the type 1 collagen defect.	This is differentiated from type 1 by having white sclerae and, from type III, by autosomal dominant inheritance.
• Fractures can occur at any time from the perinatal period onwards. • There is a 7 x greater incidence of overall fracture rate than normal, with reduced vertebral bone mineral content in adults. • In childhood, fractures may be numerous but rarely lead to deformity. • **Blue sclerae** is an important sign caused by scleral thinness allowing the pigmented coat of the choroid to become visible.	• Frequently causes death at birth or shortly after, because of the inability to breathe. • Numerous broken bones that develop before birth while the baby is still in the womb. • Severe bone deformities. • Very small stature. • Underdeveloped lungs.	• The child may be born with fractures and the skull is well ossified. • There is progressive deformity of the skull, long bones, spine, chest and pelvis during early years. • The face appears triangular with a large vault, prominent eyes and a small jaw. • Sclera is blue in infancy but normal colour in childhood. • Patients rarely walk, even after multiple surgical procedures and they have very short stature.	• This may be apparent at birth with fractures or bowing of leg bones or recurrent fractures on walking. • The sclera is normal colour in childhood with reduced stature and variable disability. • Patients may have the complication of hyperplastic callus appearing as swollen, painful vascular swelling over the long bones.

Other types have recently been described (types V, VI, VII). The same genetic mutations are not present as in types I-IV.







Pseudogout

Pseudogout is a form of microcrystal synovitis caused by the deposition of calcium pyrophosphate dihydrate in the synovium

Risk factors

- Hyperparathyroidism
- Hypothyroidism
- Haemochromatosis
- Acromegaly
- Low magnesium, low phosphate
- Wilson's disease

Features

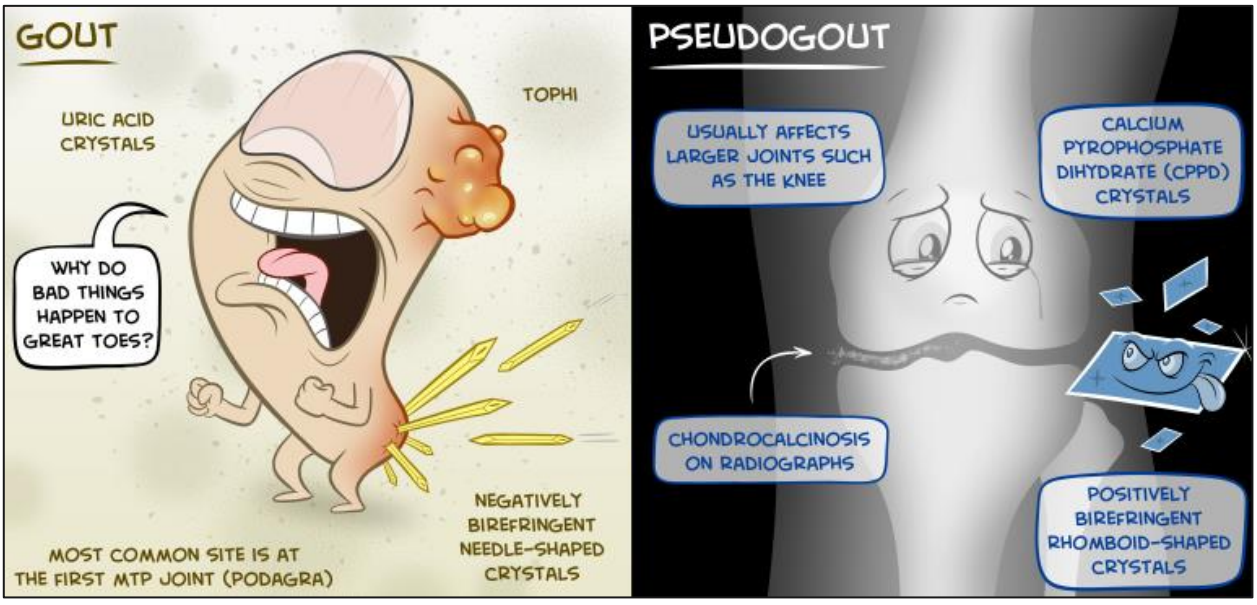
- Knee, wrist and shoulders most commonly affected
- Joint aspiration: weakly-positively birefringent rhomboid shaped crystals
- X-ray: chondrocalcinosis

Management

- Aspiration of joint fluid, to exclude septic arthritis
- NSAIDs or intra-articular, intra-muscular or oral steroids as for gout

Gout vs Pseudogout

Characteristic	Gout	Pseudogout
Crystal composition	Monosodium urate	Calcium pyrophosphate
Crystal shape	Needle-shaped	Rhomboid-shaped
Birefringent	Negative	Positive
Most common site	1st MTPJ	Knee
Radiography	"Rat-bite" erosions	White lines of chondrocalcinosis
1st line treatment	NSAIDs	



Shoulder Disorders

Fractures

See Ortho References

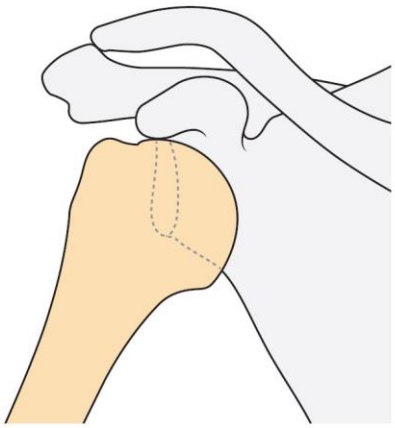
Painful Shoulder Summary

Supraspinatous tear = Rotator cuff muscle tear	• Pain or inability to initiate abduction
Painful arc syndrome = Chronic supraspinatious tendonitis = Impingement syndrome	• Pain on abduction 60 – 120 (middle 1/3 of arc) • Extremes of movements are painless
Frozen shoulder = Adhesive capsulitis	• Restricted movements in all directions • Middle-aged, DM , Female • X-ray normal
Osteoarthritis	• Pain in last degrees of shoulder abduction due to presence of osteophytes
Shoulder dislocation	• History of trauma or fall , loss of shoulder contour

Dislocations

Types

Dislocations around the shoulder joint include glenohumeral dislocation, acromioclavicular joint disruption and sternoclavicular dislocation. Only glenohumeral dislocation will be covered here.



Glenohumeral dislocation

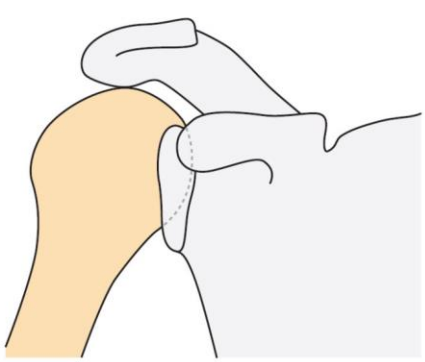
Diagnosis, classification and management are covered here.

Background

Shoulder dislocation is commonly seen in A&E. It has a high recurrence rate that is as high as 80% in teenagers. Initial management requires emergent reduction to prevent lasting chondral damage.

Early assessment and management

Usually a traumatic cause (multi-directional instability in frequent dislocations requires discussion with orthopaedics and is not covered here). Careful history, examination and documentation of neurovascular status of the limb, in particular the axillary nerve (regimental badge sensation). This should be re-assessed post manipulation. Early radiographs to confirm direction of dislocation.

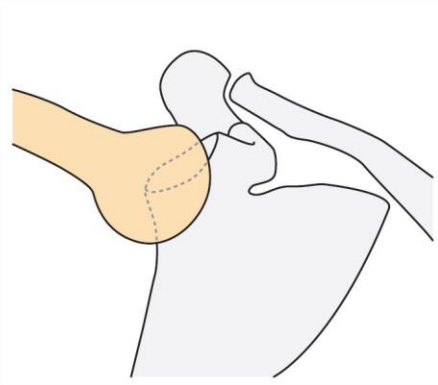


Initial management consists of emergent closed reduction under under entanox and analgesia, but often requires conscious sedation. Arm should then be immobilised in a polysling, and XR to confirm relocation.

Imaging - True anteroposterior (AP), axillary lateral and/or scapula Y view. Reduced humeral head should lie between acromion and coracoid on lateral/scapula view.

Associated injuries with shoulder dislocation

- Bankart lesion - avulsion of the anterior glenoid labrum with an anterior shoulder dislocation (reverse Bankart if poster labrum in posterior dislocation).
- Hill Sachs defect - chondral impaction on posteriosuperior humeral head from contact with gleonoid rim. Can be large enough to lock shoulder, requiring open reduction. (Reverse Hill Sachs in posterior dislocation).
- Rotator cuff tear - increases with age.
- Greater or lesser tuberosity fracture - increases with age.
- Humeral neck fracture - shoulder fracture dislocation. More common in high energy trauma and elderly. Should be discussed with orthopaedics prior to any attempted reduction.



Types of shoulder dislocations

Direction	Features	Cause	Examination	Reduction techniques
Anterior	Most Common >90%	Usually traumatic - anterior force on arm when shoulder is abducted, eternally rotated	Loss of shoulder contour - sulcus sign. Humeral head can be felt anteriorly.	Hippocratic. Milch. Stimson. Kocher not advised due to complication of fracture
Posterior	50% missed in A&E	50% traumatic, but classically post seizure or electrocution	Shoulder locked in internal rotation. XR may show lightbulb appearance.	Gentle lateral traction to adducted arm.
Inferior	Rare	Associated with pectorals and rotator cuff tears, and glenoid fracture	As for primary injury	Management of primary injury
Superior	Rare	Associated with acrominon/clavicle fracture	As for primary injury	Management of primary injury

Rotator Cuff Disease

Rotator cuff disease is a spectrum of conditions that ranges from subacromial impingement to rotator cuff tears and eventually to rotator cuff arthropathy (arthritis).

Anatomy

The rotator cuff is a group of four muscles that are important in shoulder movements, and maintenance of glenohumeral stability.

Muscle	Scapular attachment	Humeral attachment	Action	Innervation
Supraspinatus	Supraspinatus fossa	Superior facet of greater tuberosity	Initiation of abduction of humerus	Suprascapular nerve
Infraspinatus	Infraspinatus fossa	Posterior facet of greater tuberosity	External rotation of humerus	Suprascapular nerve
Teres Minor	Lateral border	Inferior facet of greater tuberosity	External rotation of humerus	Axillary Nerve
Subscapularis	Subscapular fossa	Lesser tuberosity	Internal rotation of humerus	Upper and lower subscapular nerve

- The inferior rotator cuff muscles (infraspinatus, teres minor, and subscapularis) balance the superior pull of the deltoid. Injury/tear results in upward migration of the humeral head on the glenoid (can be seen on AP radiograph).
- Likewise, the anterior muscles (subscapularis) are balanced with the posterior muscles (infraspinatus, teres minor).

Subacromial Impingement

- The most common cause of shoulder pain, which results from impingement of the superior cuff on the undersurface of the acromion, and an inflammatory bursitis.
- Associated with certain types of acromial morphology (Bigliani classification).
- Presents as insidious pain which is exacerbated by overhead activities.

Rotator Cuff Tear

- Often presents as an acute event on the background of chronic subacromial impingement in the older patient, but can present as an avulsion injury in younger patients.
- Majority of tears are to the superior cuff (supraspinatus, infraspinatus, teres minor), though a tear to subscapularis is associated with subcoracoid impingement.
- Tears present as pain and weakness when using the muscles in question.

Rotator Cuff Arthropathy

- Defined as shoulder arthritis in the setting of rotator cuff dysfunction. Results from superior migration due to the loss of rotator cuff function and integrity. Unopposed deltoid pulls the humeral head superiorly.
- Associated with massive chronic cuff tears.

Imaging

- Plain radiographs
  - AP of the shoulder may show superior migration of the humerus with a cuff tear, and features of arthritis with arthropathy. Other causes of pain may also be identified (e.g. calcific tendonitis/fracture)
  - Outlet view is useful for defining the acromial morphology
- USS
  - Allows dynamic imaging of the cuff, and is inexpensive. However, it is very user dependent.
- MRI
  - Best imaging modality for cuff pathology.
  - Also allows imaging of the rest of the shoulder. When intra-articular pathology is suspected, can be combined with an arthrogram for improved sensitivity and specificity.

Treatment

Subacromial impingement

- Physiotherapy, oral anti-inflammatory medication
- Subacromial steroid injection can settle inflammation
- Arthroscopic subacromial decompression by shaving away the undersurface of the acromion, more space is created for the rotator cuff. Cuff integrity is assessed also at time of surgery, and can be repaired if necessary.

Rotator cuff tear

- When considering repair of a cuff tear, the age and activity of the patient, the nature of the tear (degenerative vs. acute traumatic), and the size and retraction of the tear should be considered when making a surgical plan.
- Mild tears or tears in the elderly can be managed conservatively, as outlined above.
- Moderate tears can be repaired arthroscopically. Massive or retracted tears will often require an open repair (occasionally with a tendon transfer). Subacromial decompression is performed at the same time to reduce impingement, symptoms and recurrence.

Calcific tendonitis

Calcific tendonitis involves calcific deposits within tendons anywhere in the body, but most commonly in the rotator cuff (specifically the supraspinatus tendon). When present in the shoulder, it is associated with subacromial impingement and pain.

Pathology

- More common in women aged 30-60 years.
- Association with diabetes and hypothyroidism

There are three stages of calcification

- Formative phase characterized by calcific deposits
- Resting phase deposit is stable, but presents with impingement problems
- Resorptive phase phagocytic resorption. Most painful stage.

Presentation

- Similar in presentation to subacromial impingement, with pain especially with over head activities. Atraumatic in nature.

Imaging

- Plain radiographs show calcification of the rotator cuff, usually within 1.5cm of its insertion on the humerus. Supraspinatus outlet views can show level of impingment. Further imaging is rarely needed.

Treatment

- Non-operative NSAIDS, steroid injection (controversial, but practiced) and physiotherapy. Approximately 75% will resolve by 6 months with conservative management.
- Ultrasound guided or surgical needle barbotage can break down deposits and resolve symptoms. Occasionally surgical excision is required.

Adhesive capsulitis (Frozen Shoulder)

- Pain and loss of movement of shoulder joint, which involves fibroplastic proliferation of capsular tissue, causing soft tissue scarring and contracture. Patients present with a painful and decreased arc of motion.
- Associated with prolonged immobilization, previous surgery, thyroid disorders (AI) and diabetes
- Classically three stages which can take up to two years to resolve:
    - *Stage 1*: the **freezing** and painful stage
    - *Stage 2*: the **frozen** and stiff stage
    - *Stage 3*: the **thawing** stage, where shoulder movement slowly improves

Imaging

- Plain radiographs (normal) to exclude other causes of a painful shoulder
- MRI arthrogram may show capsular contracture, and again may be used to exclude cuff pathology. However, often not performed as diagnosis is largely clinical.

Treatment

- Non-operative NSAIDS, steroid injection and physiotherapy. Patience is required as condition can take up to 2 years to improve.
- Operative MUA or arthroscopic adhesiolysis (release of adhesions) can expedite recovery, followed by intensive physiotherapy.

Glenohumeral Arthritis

Background

- May be osteoarthritis (primary or secondary to cuff tear or trauma), rheumatoid arthritis, or as part of a spondyloarthropathy. Majority of those with RA will develop symptoms.
- More common in the elderly
- Presents like any other arthritis - pain at night and with movement

Imaging

- AP and axillary radiographs will show features of arthritis.
- CT/MRI is often useful to classify the shape of the glenoid and extent of bone loss when considering arthroplasty. MRI also essential to assess integrity of rotator cuff if considering shoulder replacement.

Treatment

Like all orthopaedics, start with simple measures:

- NSAIDS, management of RA, physiotherapy, steroid injection.
- Hemiarthroplasty can sometimes be considered if glenoid is in excellent condition or if patient has large comorbidity.
- Arthroscopic debridement is useful if patient has isolated ACJ arthritis, but is rarely used for glenohumeral arthritis.
- Total shoulder replacement is shown to produce superior outcome when compared to hemiarthroplasty in terms of pain relief, function and implant survival.
- Total shoulder replacement can be anatomical (ball on humerus, with cup on glenoid), or reverse geometry (ball on glenoid, with cup on humerus). Anatomical TSR requires an intact rotator cuff, so often reverse is preferable when the cuff if questionable in integrity.

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Open Fractures

See BOAST 4

See NICE (NG37)

Classification

Gustilo and Anderson

I	Skin opening of ≤ 1 cm, quite clean; most likely from inside to outside; minimum muscle contusion; simple transverse or short oblique fractures
II	Laceration > 1 - 10 cm, with extensive soft tissue damage, flaps, or avulsion; minimum to moderate crushing component; simple transverse or short oblique fractures with minimum comminution
III	Usually > 10 cm. Extensive soft tissue damage, including muscles, skin, and neurovascular structures; often a high-velocity injury with severe crushing component • IIIA Extensive soft tissue laceration, adequate bone coverage; segmental fractures, gunshot injuries • IIIB Extensive soft tissue injury, with periosteal stripping and bone exposure; usually associated with massive contamination; requires soft tissue coverage • IIIC Vascular injury requiring repair

Management (See BOAST & NICE)

- Pain relief
- Antibiotics – started immediately, usually given by ambulance staff in the UK
- Initial splinting by ambulance staff pre-hospital, further immobilisation in splint or plaster on arrival to hospital after appropriate imaging and correction of any obvious deformities under sedation if appropriate in ED.
- Tetanus prophylaxis
- CT Trauma series for poly trauma patients and high energy trauma
- Prior to formal debridement the wound should be handled only to remove gross contamination and to allow photography, then dressed with a saline-soaked gauze and covered with an occlusive film. 'Mini-washouts' outside the operating theatre environment are not indicated.
- Debridement in theatre should be performed using fasciotomy lines for wound extension where possible
    - Immediately for highly contaminated wounds (agricultural, aquatic, sewage) or when there is an associated vascular compromise (compartment syndrome or arterial disruption producing ischaemia).
    - within 12 hours of injury for other solitary high energy open fractures
    - within 24 hours of injury for all other low energy open fractures.
- Definitive internal stabilisation should only be carried out when it can be immediately followed with definitive soft tissue cover

Hip Fractures / Femoral Neck Fractures

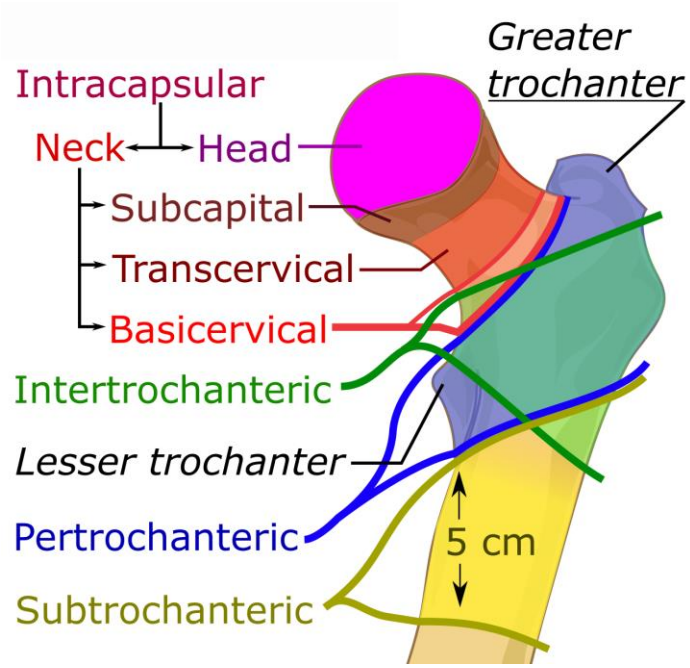
See Hip Anatomy Lower Limb

See also NICE guidelines & BOAST!

A hip fracture means a fracture of the proximal femur (proximal to 5 cm below the lesser trochanter). Hip fractures are the *most common reason for admission to an orthopaedic trauma ward in the UK*

Intracapsular fractures

- Involve the femoral neck between the edge of the femoral head and insertion of the capsule of the hip joint.
- Around half of all hip fractures are intracapsular.
- Intracapsular fractures may disrupt the blood supply to the femoral head, leading to avascular necrosis.



Extracapsular trochanteric fractures

- Distal to the insertion of the capsule, involving or between the trochanters.
- They include intertrochanteric or pertrochanteric and reverse oblique fractures and isolated trochanteric avulsion fractures.
- Isolated trochanteric avulsion fractures can result from sudden violent force avulsing the insertion of gluteus medius from the greater trochanter, or iliopsoas from the lesser trochanter.

Presentation

- Pain is typically in the outer upper thigh or in the groin.
- Inability to bear weight.
- There may be no history of injury, especially in an elderly patient with confusion or dementia.
- Pain may be particularly aggravated by flexion and rotation of the leg.
- The affected leg may be shortened, abducted and externally rotated.
- Where there is a preceding stress injury or bone pathology (eg, metastasis) there may be a preceding history of aching in the groin or thigh.

Mechanism of injury

- Low energy (fall from standing height) in elderly—associated with osteoporosis
- High energy in young patients—associated with vertical fracture orientation and femoral shaft fractures

Imaging

- Plain films (AP and lateral)
- MRI scan should be performed if a hip fracture is suspected but AP pelvic and lateral hip X-rays don't show a fracture. If MRI is not available within 24 hours or is contra-indicated (eg, due to a pacemaker) then computerised tomography (CT) should be requested.

Further Reading

https://www.nice.org.uk/guidance/cg124/chapter/Recommendations

https://www.boa.ac.uk/uploads/assets/6750e0bf-4aa3-4680-b1612265704512db/patients%20sustaining%20a%20fragility%20hip%20fracture.pdf

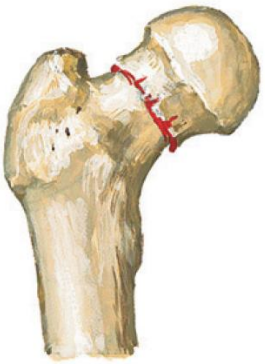
Classifications

Intra-capsular

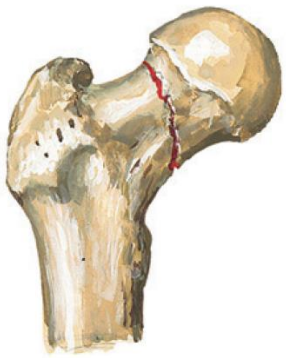
- Garden's classification

Low energy in elderly

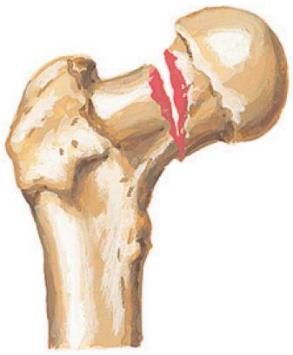
- I – incomplete or valgus impaction
- II – complete, nondisplaced
- III – complete, partially displaced
- IV – complete, totally displaced



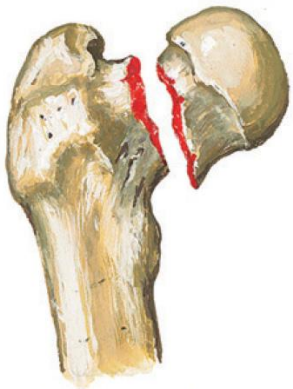
Type I. Impacted fracture



Type II. Nondisplaced fracture



Type III. Partially displaced

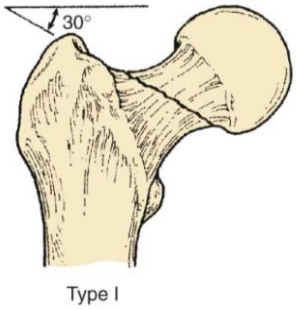


Type IV. Displaced fracture. vertical fracture line generally suggests poorer prognosis

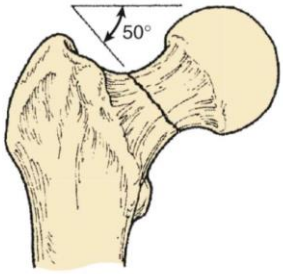
- Pauwels

High energy in the young (based on orientation of fracture line)

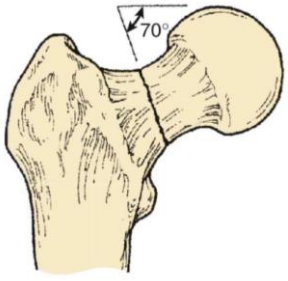
- (I - III) With progression from type I to type III, there are increasing shear forces placed across the fracture site.



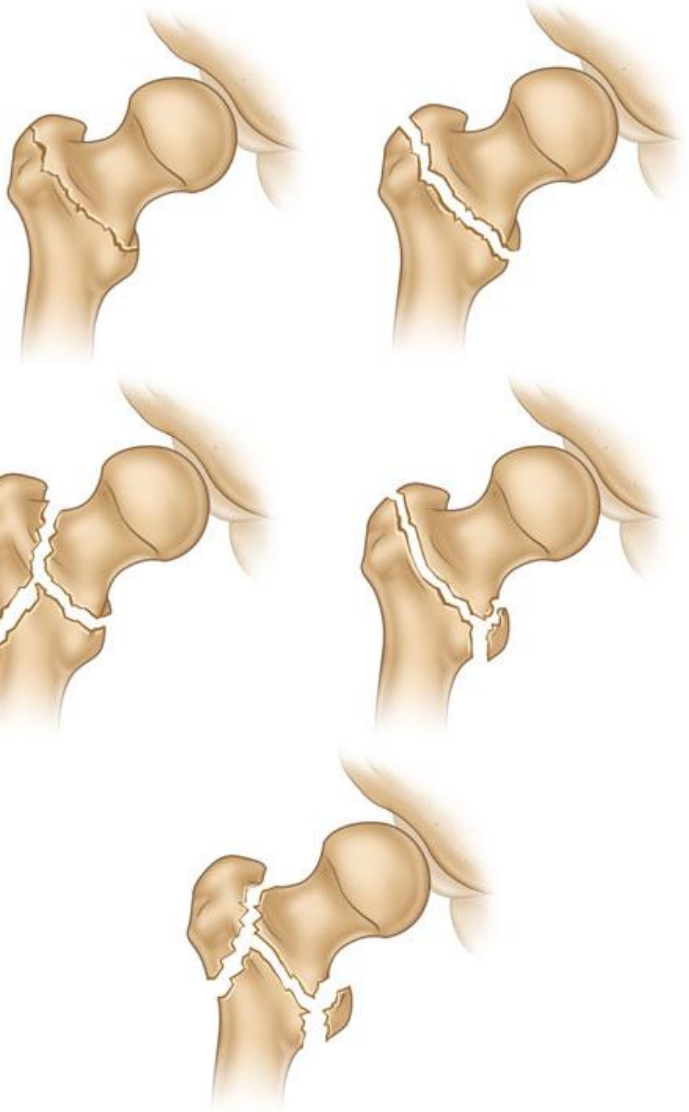
Type I



Type II



Type III



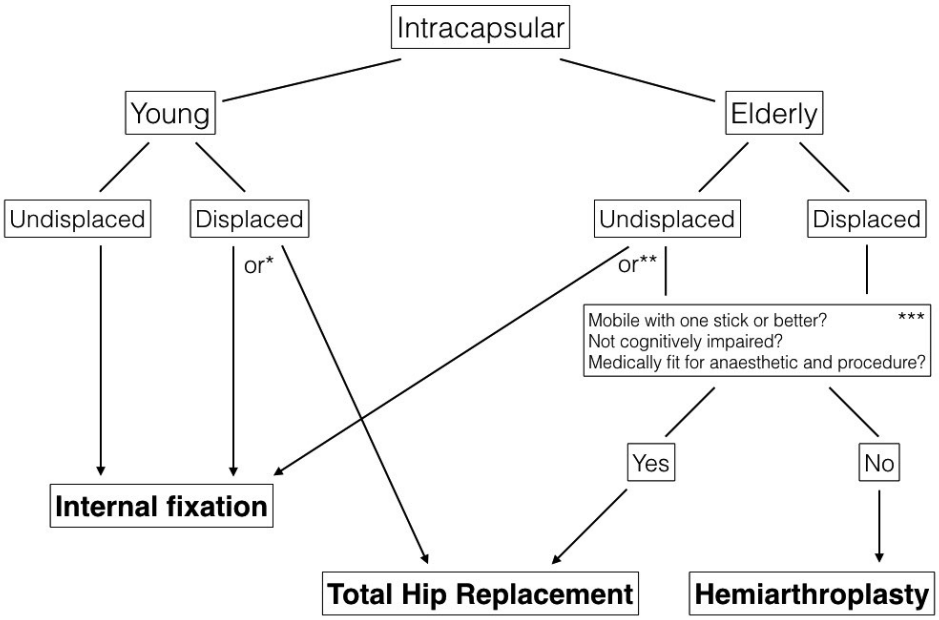
Extra-capsular

- Evans-Jensen (based on the number of fragments)
  - IA – nondisplaced
  - IB – 2 part, displaced
  - IIA – 3 part, GT fragment
  - IIB – 3 part, LT fragment
  - III – 4 part

Management *(Aim for surgery within 1 day of admission)*

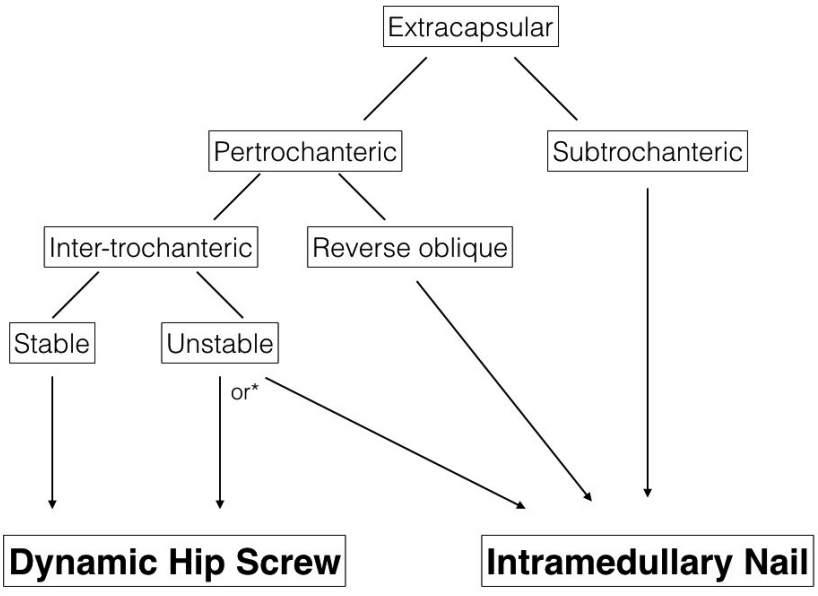
Intracapsular fractures

- Aim to preserve bone in Young patients (Internal fixation) or consider THR in displaced fractures with high risk of AVN
- In older patients, The National Institute for Health and Care Excellence (NICE) recommends:
    - Replacement arthroplasty (hemiarthroplasty or total hip replacement) for patients with a displaced intracapsular fracture.
    - Total hip replacements for patients with a displaced intracapsular fracture who:
        - Are able to walk independently out of doors with no more than the use of a stick; and
        - Are not cognitively impaired; and
        - Are medically fit for anaesthesia and the operation.



Extracapsular fractures

- They are usually treated by internal fixation
- NICE recommends
    - Extramedullary implants such as a sliding hip screw in preference to an intramedullary nail in patients with trochanteric fractures above and including the lesser trochanter.
    - Use an intramedullary nail to treat patients with a subtrochanteric fracture.



Knee Injuries

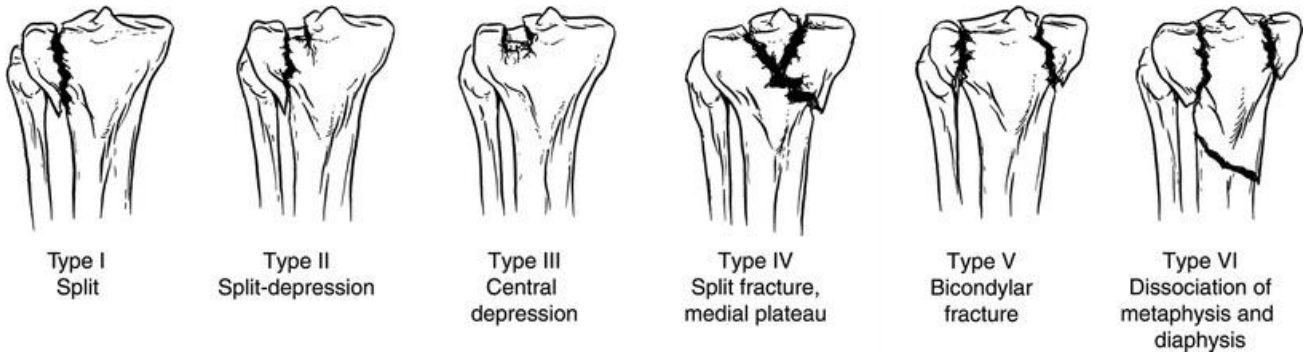
Types of injury

Ruptured anterior cruciate ligament (ACL)	• Sport injury • Mechanism: high **twisting force** applied to a bent knee • Typically presents with: **loud crack/pop**, **pain and rapid joint swelling** (haemoarthrosis) • **Poor healing** • Ix: Anterior drawer test / Lachman test • Management: intense physiotherapy or surgery
Ruptured posterior cruciate ligament (PCL)	• Mechanism: hyperextension injuries • Tibia lies back on the femur • Ix: Posterior drawer test • Paradoxical anterior draw test
Rupture of medial collateral ligament	• Mechanism: leg forced into valgus via force outside the leg • Knee unstable when put into valgus position
Menisceal tear	• Rotational sporting injuries • Delayed knee swelling • Joint locking (Patient may develop skills to "unlock" the knee • Recurrent episodes of pain and effusions are common, often following minor trauma • Ix: McMurray's test
Chondromalacia patellae	• Teenage girls, following an injury to knee e.g. Dislocation patella • Typical history of pain on going downstairs or at rest • Tenderness, quadriceps wasting
Dislocation of the patella	• Most commonly occurs as a traumatic primary event, either through direct trauma or through severe contraction of quadriceps with knee stretched in valgus and external rotation • Genu valgum, tibial torsion and high riding patella are risk factors • Skyline x-ray views of patella are required, although displaced patella may be clinically obvious • An osteochondral fracture is present in 5% • The condition has a 20% recurrence rate

Fractured patella	• 2 types:
	  • Direct blow to patella causing undisplaced fragments
	  • Avulsion fracture

Tibial plateau fracture	• Occur in the elderly (or following significant trauma in young) • Mechanism: knee forced into valgus or varus, but the knee fractures before the ligaments rupture • Varus injury affects medial plateau and if valgus injury, lateral plateau depressed fracture occurs • Classified using the Schatzker system (see below)

Schatzker Classification system for tibial plateau fractures



Knee Collateral Ligament

Anatomy

The tibial collateral ligament is a broad, flat band. Its upper end has an extensive attachment to the medial epicondyle of the femur with some fibres projecting onto the adductor magnus tendon. The ligament passes downwards and forwards to the medial side of the tibia. The deepest fibres are fused with the medial meniscus.
The fibular collateral ligament is round and cord like and stands clear of the thin, lateral part of the fibrous capsule. It is enclosed within the fascia lata. It passes from the lateral epicondyle of the femur to the head of the fibula in front of its highest point and splits the tendon of biceps femoris. On the lateral side of the joint the fibres are short and weak and bridge the interval between the femoral and tibial condyles. The popliteus tendon intervenes between the lateral meniscus and the capsule.

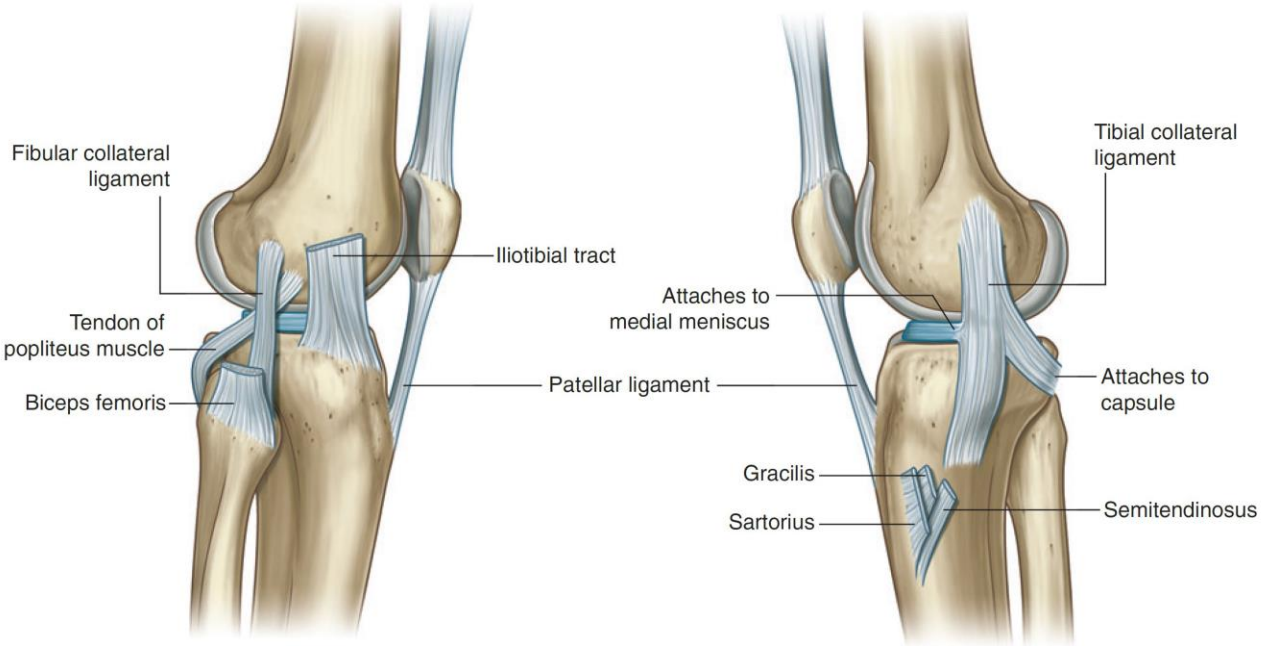
The tibial and fibular collateral ligaments prevent disruption of the joint at the sides. They are most tightly stretched in extension, and then their direction- the fibular ligament downwards and backwards, the tibial downwards and forwards- prevents rotation of the tibia laterally or the femur medially. Rotation may be demonstrated in the flexed knee.

Injury

The collateral ligaments are commonly injured, the medial is most often affected. It requires a significant force such as sporting tackle or motor vehicle to strike the side of the leg. Associated injuries to both the tibial plateau or menisci are not uncommon.

Grading and treatment

Grade of injury	Features	Treatment
1	Minor tearing of ligament fibres Negative instability tests	Conservative (analgesia and physiotherapy)
2	Ligament laxity (seen with knee in 30° flexion) Knee stable when joint extended	Usually splinting or casting for 4-6 weeks
3	Ligament completely torn Joint instability	Surgical ligament reconstruction



Ankle Injuries

An ankle fracture relates to a fracture around the tibiotalar joint. It generally refers to a fracture involving the lateral, and/or medial and/or posterior malleolus. Pilon and Tillaux fractures are also considered to be ankle fractures, but are not covered here.
Ankle fractures are common. They effect men and women in equal numbers, but men have a higher rate as young adults (sports and contact injuries), and women a higher rate post-menopausal (fragility type fracture).

Osseous anatomy

The ankle (or mortise) joint consists of the distal tibia (tibial plafond and posterior malleolus), the distal fibula (lateral malleolus), and the talus. The main movement at the ankle joint is plantar and dorsiflexion.

Ligamentous anatomy *(See lower limb Anatomy file)*

Medial side: Deltoid ligament. This is divided into superficial and deep portions. It is the primary restraint to valgus tilting of the talus.

Lateral side: Lateral ligament complex consisting from anterior to posterior of the anterior talofibular ligament (ATFL), calcaneofibular ligament (CFL), and the posterior talofibular ligament (PTFL). Together they resist valgus stress to the ankle, and are a restraint to anterior translation of the talus within the mortise joint.

Syndesmosis: The syndesmosis is a ligament complex between the distal tibia and fibula, holding the two bones together. It is fundamental to the integrity of the ankle joint, and its disruption leads to instability. It consists of (from anterior to posterior) the anterior-inferior tibiofibular ligament (AITFL), the transverse tibiofibular ligament (TTFL), the interosseous membrane, and the posterior-inferior tibiofibular ligament (PITFL).

Presentation and initial management

Patients will present following a traumatic event with a painful, swollen ankle, and reluctance/inability to weight bear.
The Ottawa rules can be applied to differentiate between an ankle fracture and sprain, but can be unreliable.
In high energy injuries, management should follow ATLS principles to identify more significant injuries first.
Neurovascular status of the foot should be documented, and open injuries should be excluded. If an open injury is identified, it should be managed in line with BOAST 4 principles[1]. If an obvious deformity exists, it should be reduced as soon as possible with appropriate analgesia or conscious sedation. Radiographs of clearly deformed or dislocated joints are not necessary, and removing the pressure on the surrounding soft tissues from the underlying bony deformity is the priority. If the fracture pattern is not clinically obvious then plain radiographs are appropriate and will guide the subsequent manipulation during plaster-of-paris below knee backslab application.

Imaging

AP, lateral and mortise views (20^{o} internal rotation) are essential to evaluate fracture displacement and syndesmotic injury. Decreased tibiofibular overlap, medial joint clear space and lateral talar shift all indicate a syndesmotic injury. (In subtle cases of shift, imaging the uninjured ankle can be helpful as a proportion of the population have little or no tibiotalar overlap [2].)

Where there is suspicion of syndesmosis involvement in the absence of radiographic evidence, stress radiographs can be diagnostic.
Complex fracture patterns (and increasingly posterior malleolar fractures) are best defined using CT.

Classification: The most commonly used classifications are **Lauge-Hansen** and **Danis-Weber**.

Lauge-Hansen

Comprises two parts: first part is the foot position, and the second part is the force applied. Useful for understanding the forces involved and therefore predict the ligamentous or bony injury. Results in four injury patterns:

- Supination - Adduction (SA) - 10-20%
- Supination - External rotation (SER) - 40-75%
- Pronation - Abduction (PA) - 5-20%
- Pronation - External rotation (PER) - 5-20%

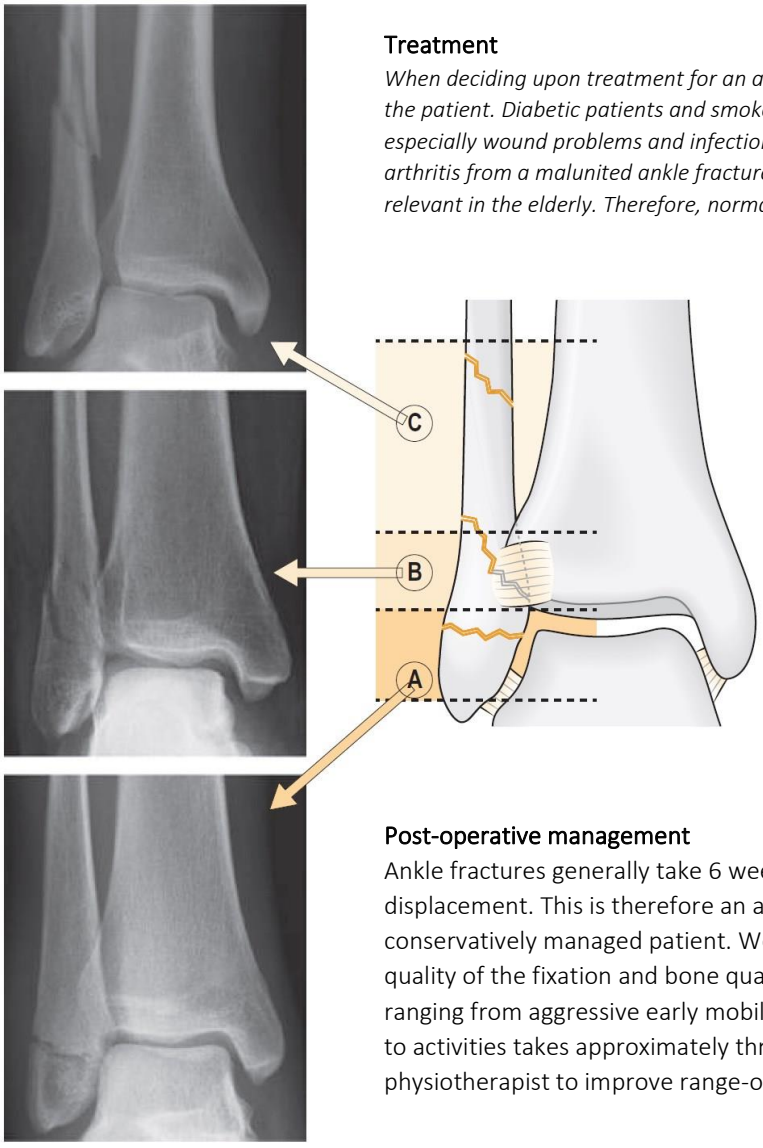
Not often used in clinical practice but good for understanding the principles of ankle fracture.

Danis-Weber

Commonly used. Based on the level of the fibula fracture in relation to the syndesmosis. The more proximal, the greater the risk of syndesmotic injury and therefore fracture instability.

	Weber A	Weber B	Weber C
Level	fracture **below** the level of the syndesmosis	fracture **at the level** of the syndesmosis / level of the tibial plafond	fracture **above** the level of the syndesmosis*
Stability	Stable	Could be stable or unstable	Usually unstable
Mx	• Unimalleolar Weber A Weber fractures by definition are stable and therefore can be mobilised fully weight bearing in an ankle boot.	• B fractures vary greatly. They can be part of a trimalleolar injury and therefore extremely unstable, requiring fixation • A uni-malleolar Weber B fracture can be a stable injury, and therefore mobilised immediately in an ankle boot • Defining the stability can be challenging, and often involves stress radiographs, or a trial of mobilisation and repeat radiographs. Defining stability is the subject of much ongoing research. However, treating undisplaced ankle fractures in a below knee plaster, non-weight bearing for six weeks is still widely practised, and a safe approach.	• Fractures tend to include syndesmotic disruption and are usually bimalleolar (either bony or ligamentous). • They are therefore unstable and usually require operative fixation. • In addition to the fracture fixation, the syndesmosis usually requires reconstruction/augmentation with screws to restore the joint integrity and function.

** This includes Maisonneuve fractures (proximal fibula fracture), which can be associated with ankle instability. Beware the high fibula fracture - it may be an ankle fracture*



Treatment

When deciding upon treatment for an ankle fracture, one must consider both the fracture and the patient. Diabetic patients and smokers are at greater risk of post-operative complication, especially wound problems and infection. Likewise, the long term outcome of post-traumatic arthritis from a malunited ankle fracture is extremely important for a young patient, but not as relevant in the elderly. Therefore, normal surgical decision processes apply as with all fractures.

When operative fixation is appropriate, it is usually via open reduction and internal fixation using plates and screws. It must be carried out when soft tissue swelling has settled in order to minimise the risk of wound problems. This can often take a week to settle.

The use of fibula nails is expanding, but is not yet mainstream. Ankle fractures can also be treated with external fixation, or with a hind foot nail in patients who need fixation but where soft tissue or bone quality is poor.

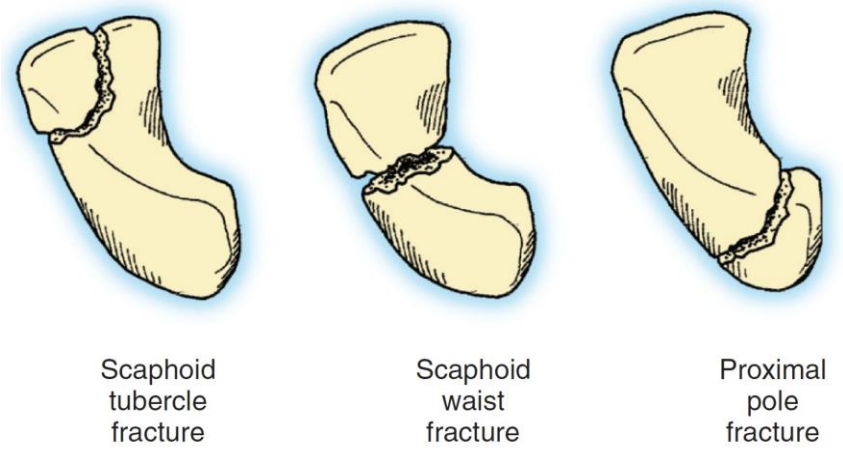
Post-operative management

Ankle fractures generally take 6 weeks to unite enough to prevent secondary displacement. This is therefore an appropriate time period to keep a cast on in a conservatively managed patient. Weight bearing post-operatively depends on the quality of the fixation and bone quality, and preference varies between surgeons, ranging from aggressive early mobilisation to a period of non-weight bearing. Return to activities takes approximately three months, and often requires assistance of a physiotherapist to improve range-of-movement and muscle strengthening.

Scaphoid Fractures

See carpal bones Anatomy Upper Limb

- Scaphoid fractures are the commonest carpal fractures.
- Surface of scaphoid is covered by articular cartilage with small area available for blood vessels (fracture risks blood supply)
- Forms floor of anatomical snuffbox
- Risk of fracture associated with fall onto outstretched hand (tubercle, waist, or proximal third)
- Ulnar deviation AP needed for visualization of scaphoid
- Immobilization of scaphoid fractures difficult

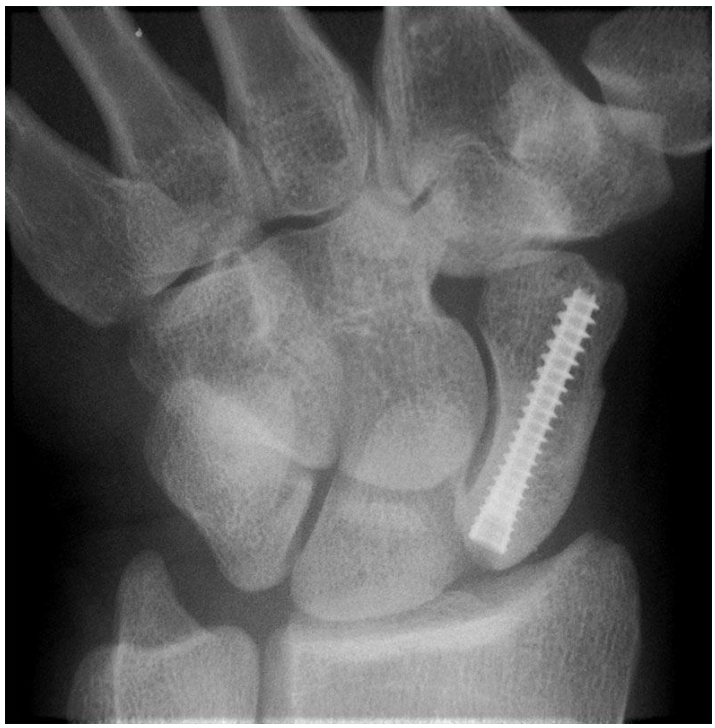


Management

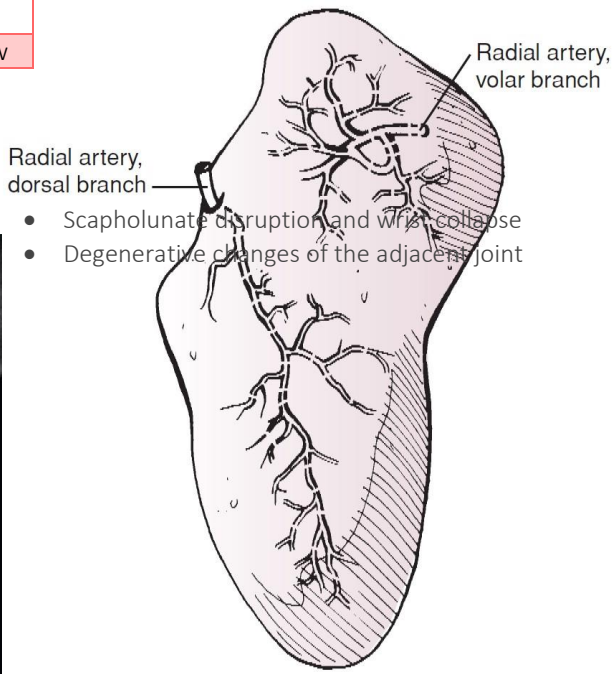
Non-displaced fractures	• Casts or splints • Percutaneous scaphoid fixation
Displaced fracture	Surgical fixation, usually with a screw

Complications

- Nonunion of scaphoid
- Avascular necrosis of the scaphoid
- Scapholunate disruption and wrist collapse
- Degenerative changes of the adjacent joint



Scaphoid fixation via a headless compression screw



The vascular supply of the scaphoid is provided by

Eponymous Fractures

Colles' fracture (dinner fork deformity)

- Fall onto extended outstretched hand
- Classical Colles' fractures have the following 3 features:
    - Transverse fracture of the radius
    - 1 inch proximal to the radio-carpal joint
    - Dorsal displacement and angulation

Smith's fracture (reverse Colles' fracture)

- Volar angulation of distal radius fragment (Garden spade deformity)
- Caused by falling backwards onto the palm of an outstretched hand or falling with wrists flexed

Bennett's fracture

- Intra-articular fracture of the first carpometacarpal joint
- Impact on flexed metacarpal, caused by fist fights
- X-ray: triangular fragment at ulnar base of metacarpal

Monteggia's fracture

- Dislocation of the proximal radioulnar joint in association with an ulna fracture
- Fall on outstretched hand with forced pronation
- Needs prompt diagnosis to avoid disability

Galeazzi fracture

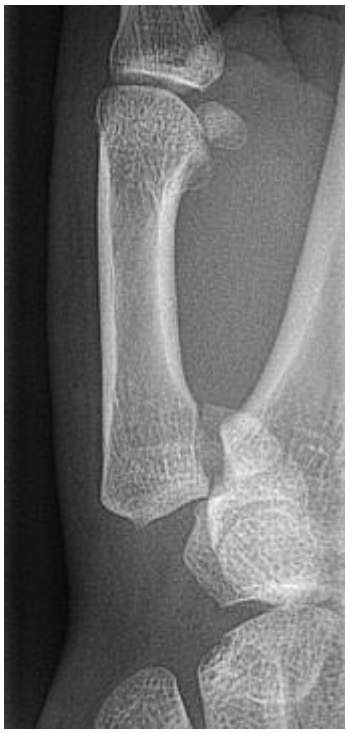
- Radial shaft fracture with associated dislocation of the distal radioulnar joint
- Direct blow

Pott's fracture

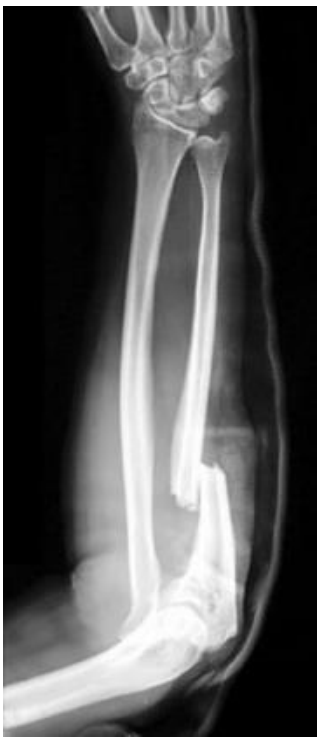
- Bimalleolar ankle fracture
- Forced foot eversion

Barton's fracture

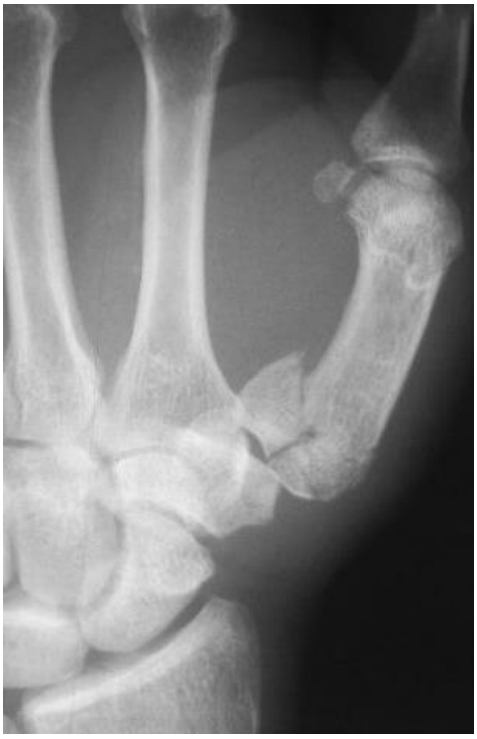
- Distal radius fracture (Colles'/Smith's) with associated radiocarpal dislocation
- Fall onto extended and pronated wrist
- Involvement of the joint is a defining feature



Bennett's fracture



Monteggia's fracture



Rolando fracture

Pathological Fractures

- A pathological fracture occurs in abnormal bone due to insignificant injury

Causes	
Metastatic tumours	• Breast • Lung • Thyroid • Renal • Prostate
Bone disease	• Osteogenesis imperfecta • Osteoporosis • Metabolic bone disease • Paget's disease
Local benign conditions	• Chronic osteomyelitis • Solitary bone cyst
Primary malignant tumours	• Chondrosarcoma • Osteosarcoma • Ewing's tumour

Compartment Syndrome

See Emergency Medicine & Trauma

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BONE TUMOURS

Tumours by location

EPIPHYSEAL
• Chondroblastoma • Giant cell tumor • Clear cell chondrosarcoma (femoral head)
METAPHYSEAL
• Osteosarcoma • Chondrosarcoma • Metastatic disease
DIAPHYSEAL
• A = adamantinoma • E = eosinophilic granuloma • I = infection • = osteoid osteoma/osteoblastoma • U = Ewing sarcoma • Y = myeloma, lymphoma, fibrous dysplasia • Metastatic disease

FLAT BONES
• Chondrosarcoma • Fibrous dysplasia • Hemangioma • Paget disease • Ewing sarcoma
SPINE
• Anterior column • Giant cell tumor • Metastatic disease • Posterior column • Osteoid osteoma/osteoblastoma • Aneurysmal bone cyst
SACRUM
• Midline • Chordoma • Eccentric • Aneurysmal bone cyst/giant cell tumor/metastatic disease

Most Common Musculoskeletal Tumours

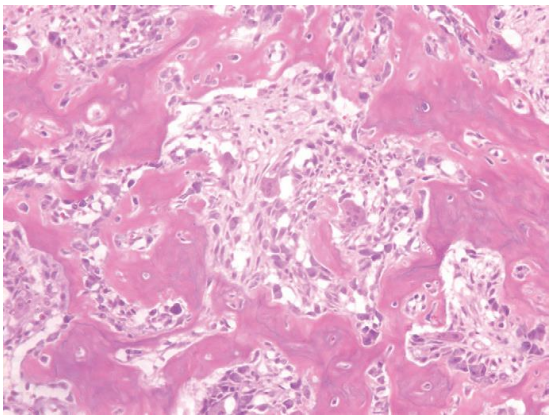
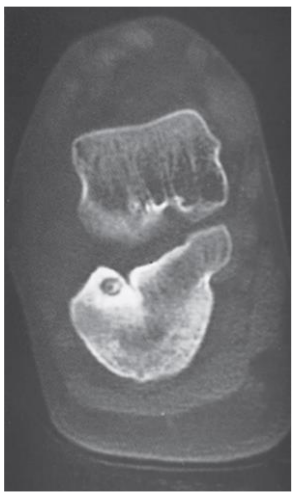
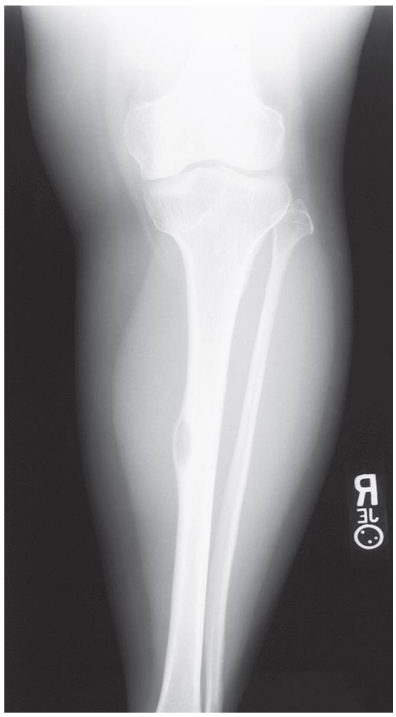
Tumour type	Tumour name
Soft tissue tumor (children)	Hemangioma
Soft tissue tumor (adults)	Lipoma
Malignant soft tissue tumor (children)	Rhabdomyosarcoma
Malignant soft tissue tumor (adults)	Undifferentiated pleomorphic sarcoma (UPS)
Primary benign bone tumor	Osteochondroma
Primary malignant bone tumor	Osteosarcoma
Secondary benign lesion	Aneurysmal bone cyst
Secondary malignancies	Malignant fibrous histiocytoma Osteosarcoma Fibrosarcoma
Phalangeal tumor	Enchondroma
Soft tissue sarcoma of the hand and wrist	Epithelioid sarcoma
Soft tissue sarcoma of the foot and ankle	Synovial sarcoma

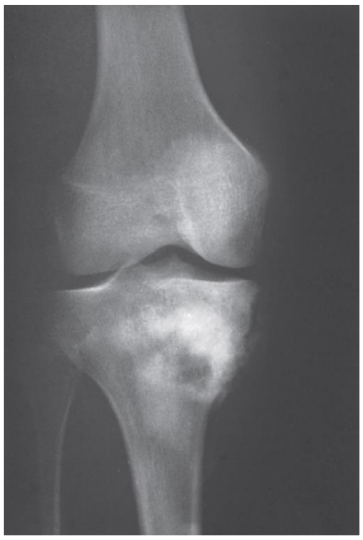
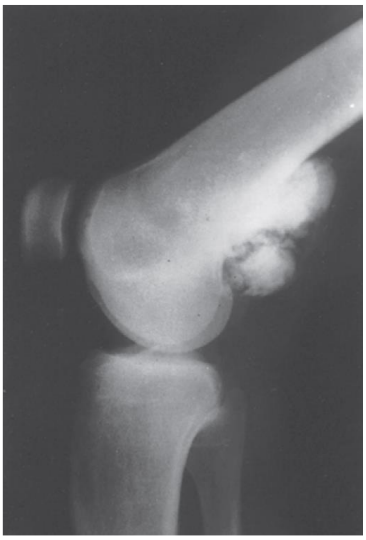
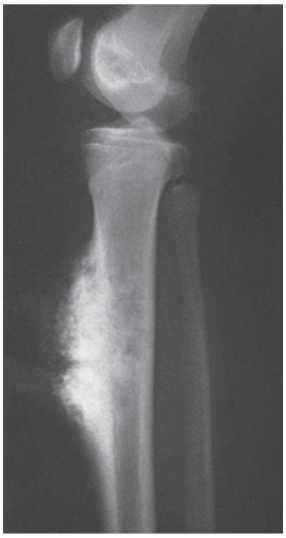
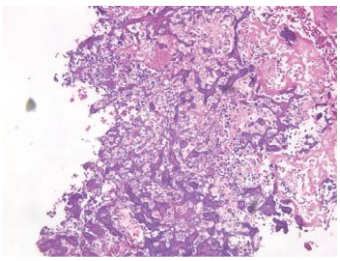
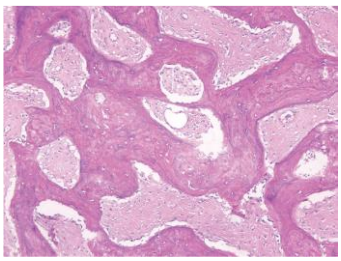
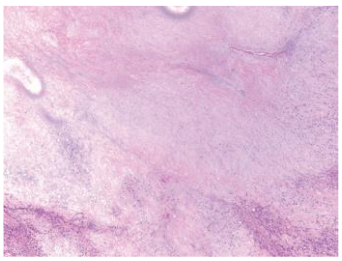
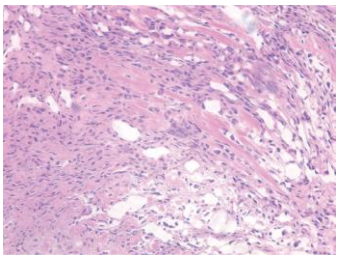
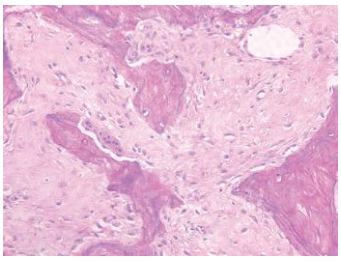
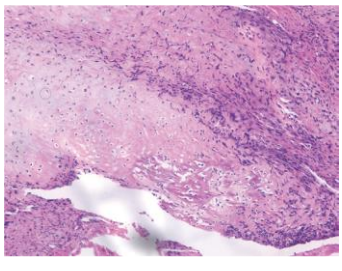
Bone Lesions by Age

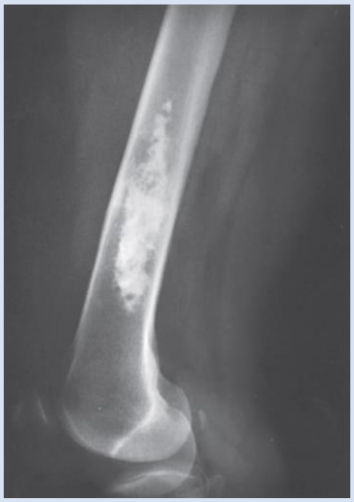
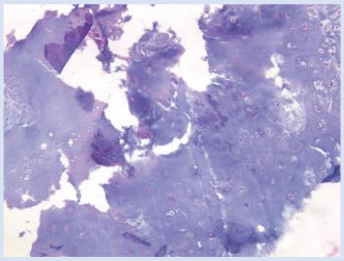
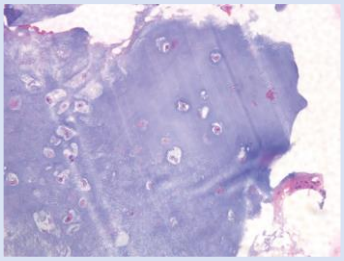
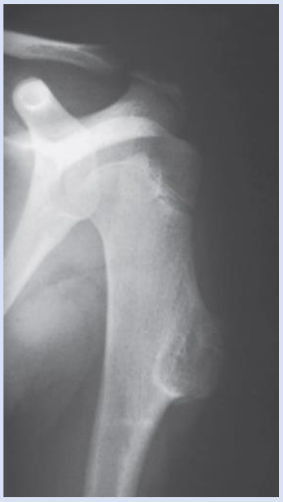
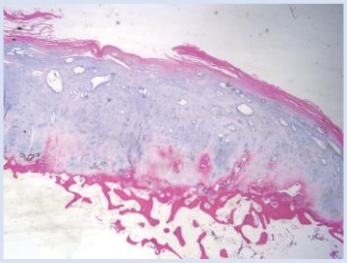
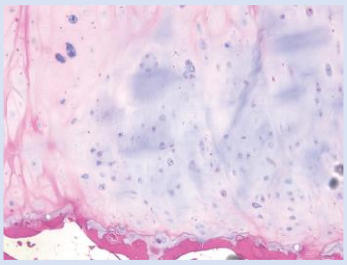
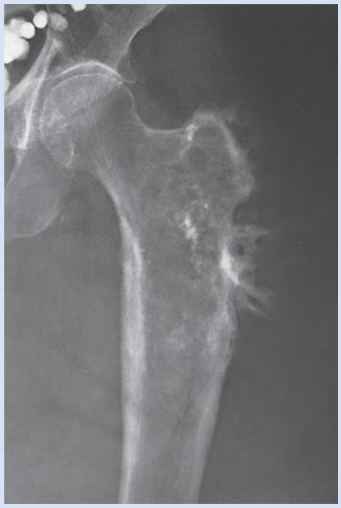
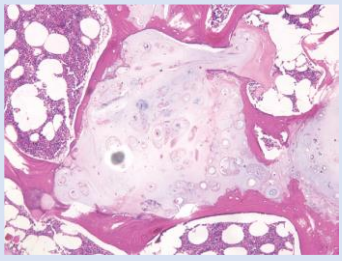
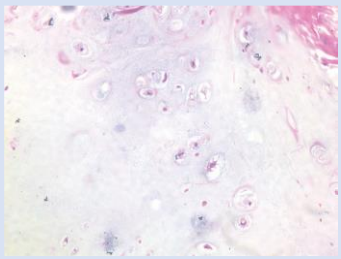
	< 5	< 30	> 30
Malignant	• LCH (Letter-Siwe) • LCH (Hand-Schüller-Christian) • Metastatic rhabdomyosarcoma • Metastatic neuroblastoma	• Ewing sarcoma • Osteosarcoma	• Chondrosarcoma • Metastases • Lymphoma • Myeloma • Chordoma • Adamantinoma
Benign	• Osteomyelitis • Osteofibrous dysplasia	• Osteoid osteoma • Osteoblastoma • Chondroblastoma • Aneurysmal bone cyst • LCH • Osteofibrous dysplasia • Nonossifying fibroma	• Giant cell tumor • Paget disease

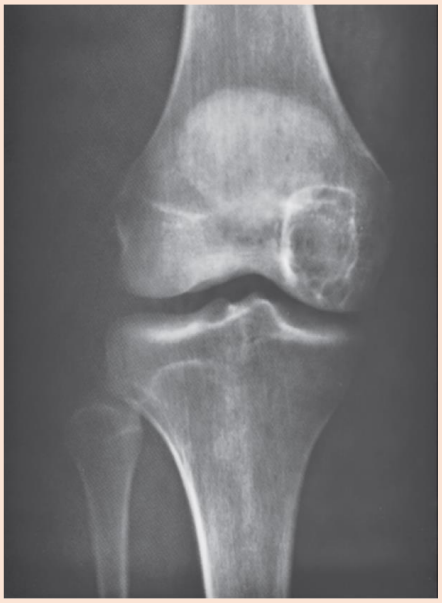
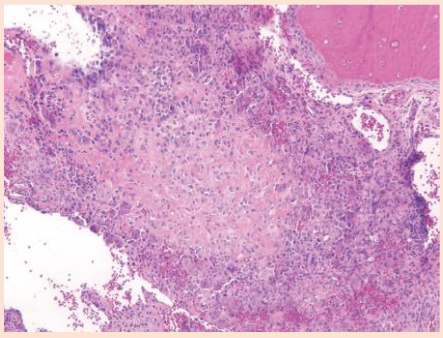
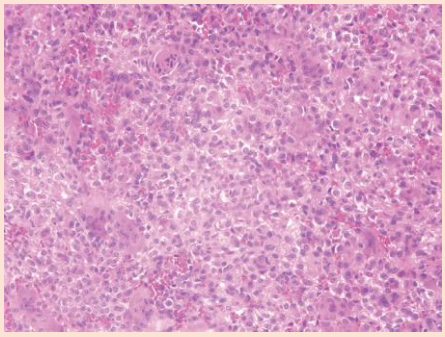
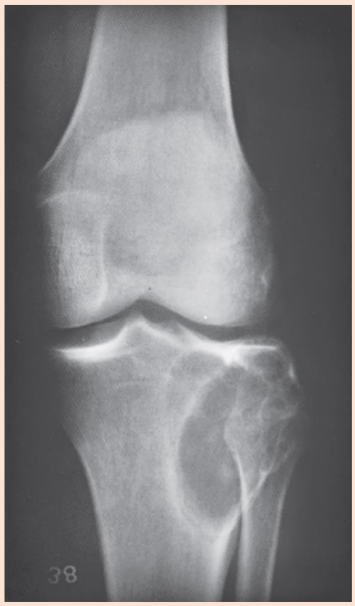
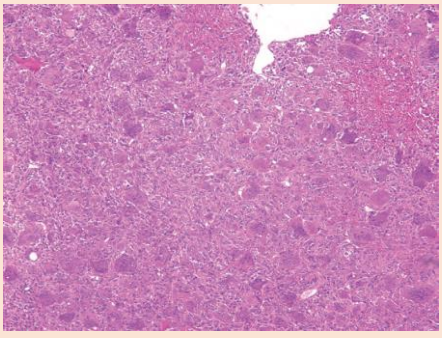
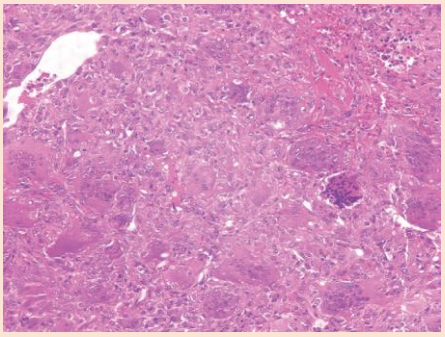
Classification of Primary Tumors of Bone and Bone Matrix

Histologic type	Benign	Malignant
Osteogenic	• Osteoid osteoma • Osteoblastoma	• Osteosarcoma • Parosteal osteosarcoma • Periosteal osteosarcoma
Chondrogenic	• Osteochondroma • Chondroma • Chondroblastoma • Chondromyxoid fibroma	• Primary chondrosarcoma • Secondary chondrosarcoma • Dedifferentiated chondrosarcoma • Mesenchymal chondrosarcoma • Clear cell chondrosarcoma
Unknown origin	• Giant cell tumor • Fibrous histiocytoma	• Ewing tumor • Malignant giant cell tumor • Adamantinoma
Hematopoietic		• Myeloma • Lymphoma
Fibrogenic	• Fibroma • Desmoplastic fibroma	• Malignant fibrous histiocytoma
Notochordal		• Chordoma
Vascular	• Hemangioma	• Hemangioendothelioma • Hemangiopericytoma
Lipogenic	• Lipoma	• Liposarcoma
Neurogenic	• Neurilemoma	• Malignant peripheral nerve sheath tumor (MPNST)

Osteogenic (Bone Forming Tumors)		
Benign Tumors		
	OSTEOID OSTEOMA	OSTEOBLASTOMA
Presentation	• Diurnal pain pattern/night pain • Pain relieved by aspirin/NSAIDs	• Random pain pattern • Pain not relieved by aspirin/NSAIDs
Imaging	• Central radiolucent nidus < 1 cm • Large secondary bone reaction • Characteristic "target" appearance	• Central radiolucent nidus > 2 cm • Minimal secondary bone reaction gives lesion a more aggressive appearance
Location	Diaphyseal (typical)	Diaphyseal or metaphyseal Posterior spine elements
Growth pattern	• Self-limited growth pattern • NO associated aneurysmal bone cyst	Unlimited growth pattern 40% can have associated aneurysmal bone cyst
Gross	• round-to-oval masses of hemorrhagic gritty tan tissue: They are less than 2 cm in the greatest dimension	round-to-oval masses of hemorrhagic gritty tan tissue: Larger than 2 cm.
Micro	• Both neoplasms are composed of interlacing trabeculae of woven bone surrounded by osteoblasts. • The intervening stroma is loose, vascular connective tissue containing variable numbers of giant cells.	
Treatment	• Radiofrequency ablation (RFA) • Surgery if tumor is close to nerve or vessels (e.g., spine)	Intralesional excision
Image	 *Osteoid osteoma of the calcaneus. Radiograph shows a well-circumscribed lytic lesion with dense surrounding bone and a central nidus.*  *High-power photomicrograph (×160) shows mineralizing new bone with a loose fibrovascular stroma.*	 *Plain radiograph with a diaphyseal, cortically based lesion with a nidus larger than 2 cm*

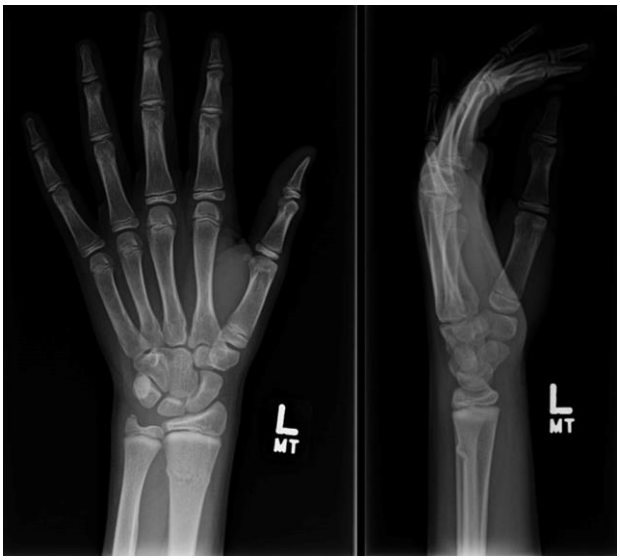
Osteogenic (Bone Forming Tumors)			
Malignant Tumors – Osteosarcomas comparison			
	CONVENTIONAL (INTRAMEDULLARY)	PAROSTEAL	PERIOSTEAL
Age	<30 and > 60	<45	<30
Presentation	Pain	Painless	Pain
Imaging	Mixed lytic/destructive aggressive intramedullary bone producing lesion	Ossified lobulated surface lesion	Sunburst saucerized surface lesion
Location	Metaphyseal	Metaphyseal Characteristic location posterior distal femur	Diaphyseal Characteristic location femur or tibia
Histology	• Poorly arranged osseous trabeculae with malignant rimming osteoblasts • Atypical spindle cells	• Regularly arranged osseous trabeculae • Minimally atypical spindle cells	• Osseous trabeculae • Chondroblastic elements
Biology	65% 5-year survival	95% 5-year survival	80% 5-year survival
Treatment	Chemotherapy Limb salvage surgery	Limb salvage surgery	Chemotherapy Limb salvage surgery
Image			
			
			
	Conventional osteoblastic osteosarcoma of the proximal tibia. A, Radiograph shows a poorly defined osteoblastic lesion in the proximal tibial metaphysis. B, Low-power photomicrograph (×160) shows lacelike mineralizing osteoid surrounding atypical osteoblasts. C, Higherpower photomicrograph (×400) shows pleomorphism and bone formation.	*Parosteal osteosarcoma of the distal femur. A, Radiograph shows an exophytic bony mass in the posterior distal femur. B, Low-power photomicrograph (×160) shows plates of new bone in a fibrous matrix. C, Higher-power photomicrograph (×400) shows a fibrous stroma with atypical cells.*	*Periosteal osteosarcoma of the diaphysis of the tibia. A, Lateral radiograph showing a surface lesion with bone formation. B, Low-power photomicrograph (×160) showing cartilage and bone formation. C, Higher-power photomicrograph showing pleomorphism and direct production of osteoid by the tumor cells.*

Cartilage Tumors			
	ENCHONDROMA	OSTEOCHONDROMA	CHONDROSARCOMA
Age	Any	Any	>50
Symptoms	Incidental	Mechanical	Pain
Imaging	• No change in bone architecture • No endosteal scalloping or erosion	• Sessile or pedunculated lesion is confluent with the intramedullary canal.	• Bone architecture is altered. • Endosteal scalloping and erosion • Bone destruction • Soft tissue mass
Pathology	Bland cartilage with minimal cellular elements	Mature bone stalk with a benign, mature cartilage cap	Differing degrees of cellular atypia and a high rate of mitotic figures
Treatment	Observation	Observation unless mechanical pain is significant	Wide surgical resection
Caveats	Pathology may have high degree of cellularity in the hands and feet and can be confused with chondrosarcoma.	Lesions should mature with the patient; a cartilage cap >2 cm requires observation.	Chemotherapy is added with dedifferentiated and mesenchymal hondrosarcoma.
Syndrome association	Ollier disease Maffucci syndrome	Multiple hereditary exostoses (MHE)	Ollier disease Maffucci syndrome MHE
Image	   *Enchondroma of the distal femur. A, Radiograph shows densely mineralized medullary lesion. B, Low-power (×160) photomicrograph shows mineralized hyaline cartilage. C, Higher-power (×250) photomicrograph shows bland chondrocytes in lacunae.*	   *Osteochondroma of the proximal humerus. A, Radiograph shows sessile osteochondroma of the proximal humerus. B, Photomicrograph (×6) shows the osteochondroma with a cartilaginous cap. C, Higher-power photomicrograph (×25) is a close-up view of the cartilage cap, which is undergoing endochondral ossification.*	   *Central (intramedullary) chondrosarcoma of the proximal femur. A, Radiograph shows an expansile lytic lesion in the proximal femur with stippled calcifications. B, Low-power photomicrograph (×40) shows cartilage with a permeative growth pattern. C, Higher-power photomicrograph (×250) shows cellular cartilage.*

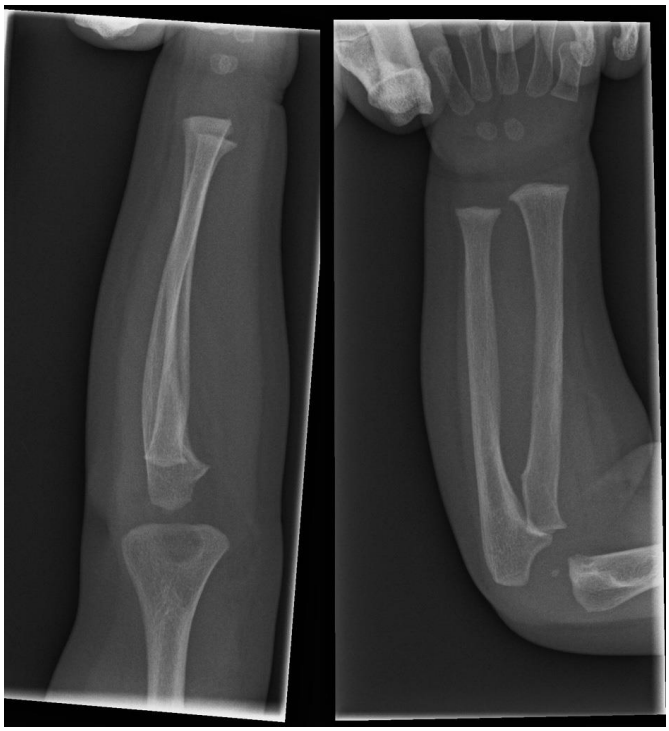
Epiphyseal Lesions—Chondroblastoma versus Giant Cell Tumor		
	CHONDROBLASTOMA	GIANT CELL TUMOR
Age	< 30	> 30
Imaging	Plain x-ray—skeletally immature • Well-circumscribed lytic lesion • Stippled calcifications MRI • edema surrounding lesion greatly out of proportion to the lesion	Plain x-ray—skeletally mature • Poorly circumscribed eccentric, lytic lesion MRI • Lesion may contain fluid-fluid levels (ABC collision)
Histology	• Chondroblasts • "Chicken-wire" calcifications in a lacelike pattern	• Multinucleated giant cells within a background of mononuclear stromal cells • Frequent ABC component
Biology	Lung metastases in <1% of patients	Lung metastases in 5% of patients
Treatment	Intralesional curettage	Intralesional curettage For pathologic fracture, ORIF or resection and reconstruction
Image	   *Chondroblastoma of the distal femur. A, Radiograph shows a wellcircumscribed lytic lesion with a sclerotic rim in the distal femoral epiphysis. B, Low-power photomicrograph (×160) shows cellular stroma in a chondroid matrix. C, Higher-power photomicrograph (×400) shows rounded stromal cells with multinucleated giant cells.*	   *Giant cell tumor of the proximal tibia. A, Radiograph shows a well-circumscribed lytic lesion involving both the epiphysis and the metaphysis. B, Low-power photomicrograph (×160) shows sheets of multinucleated giant cells. C, Higher-power photomicrograph (×300) shows giant cells and mononucleic cells.*

Fracture Patterns

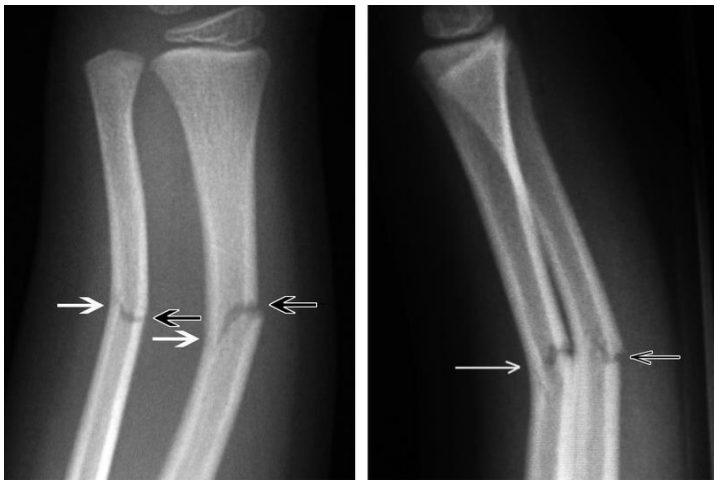
- Buckle fractures or torus fractures
  The bones of pediatric patients are more porous than mature bone, placing them at greater risk for compression fractures
- Plastic deformation or bowing fractures.
  The increased flexibility of pediatric bones makes them more likely to bend rather than break
- Greenstick fractures
  occur when the bone bends and partially breaks but does not extend through the width of the bone, giving it a tented appearance.
- Avulsion type fractures.
  The tendons and ligaments in pediatric patients are proportionally much stronger than the bones, leading to an increased incidence of avulsion



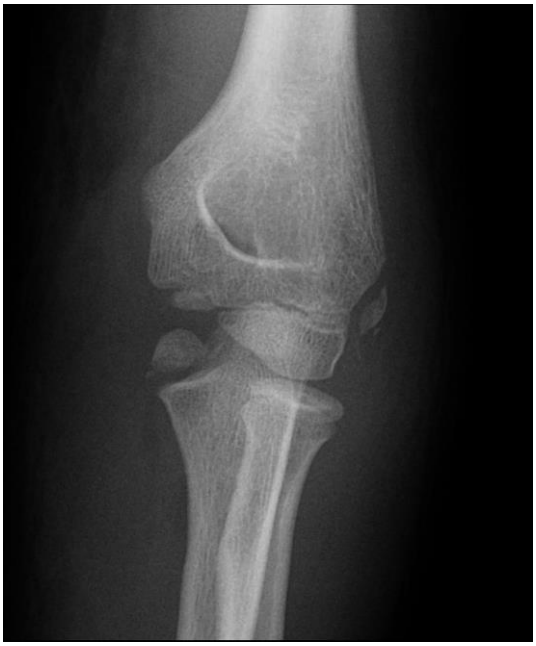
Buckle/Torus fracture



Plastic deformation / bowing



Greenstick fracture



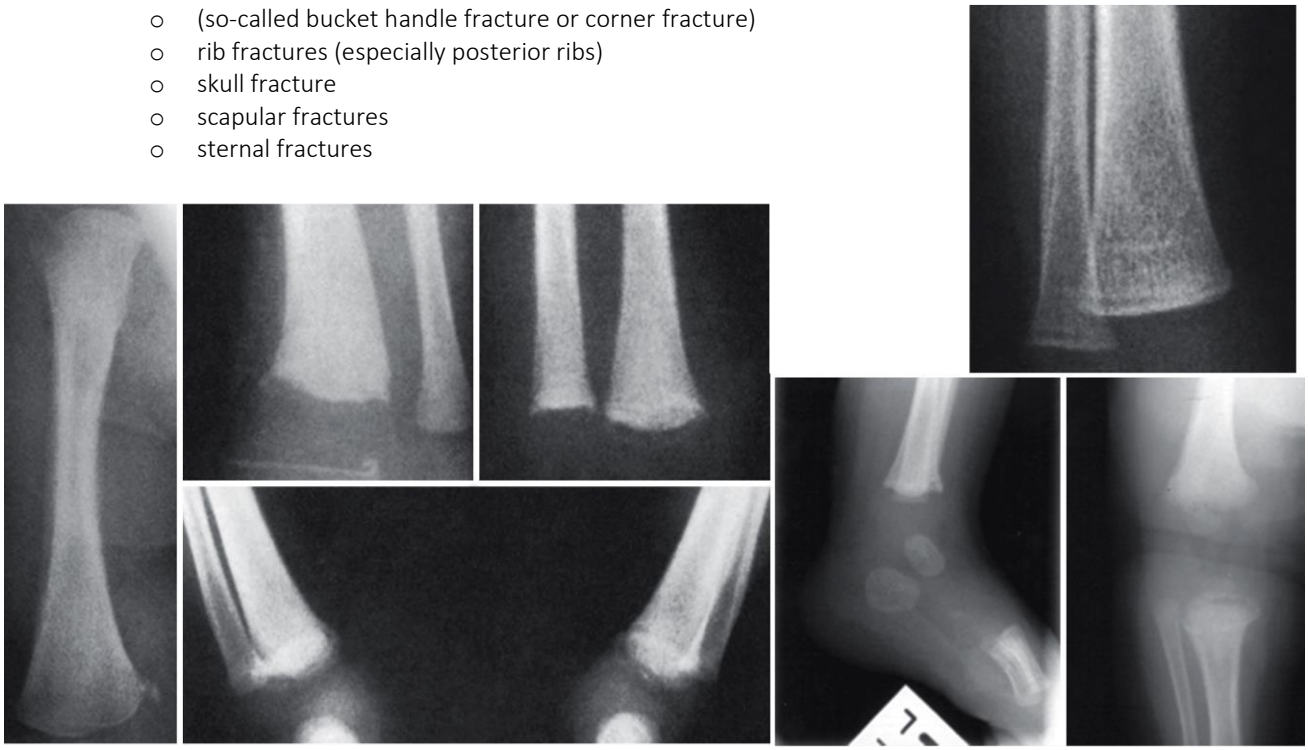
Medial condyle avulsion

Non-Accidental Injury (NAI)

- One must always be alert for the “battered child.”
- It's very important to report suspected child abuse. If child abuse is not diagnosed and reported there is a 30% to 50% chance of repeat abuse and a 5% to 10% chance of death from subsequent abuse.
- Abuse accounts for 50% of fractures in children younger than age 1 year and 30% of fractures in children younger than age 3.
- The most common cause of femur fractures in nonambulatory children is abuse.

When to suspect NAI?

- Injury in non-ambulatory / totally dependent child
- Injury and history given are incompatible
- Delay in seeking medical attention
- Multiple fractures with no family history of osteogenesis imperfecta
- Retinal hemorrhage
- History of household falls resulting in fracture.
- Specific fractures
    - metaphyseal fracture
    - (so-called bucket handle fracture or corner fracture)
    - rib fractures (especially posterior ribs)
    - skull fracture
    - scapular fractures
    - sternal fractures



Supracondylar Humerus Fractures

See BOAST 11

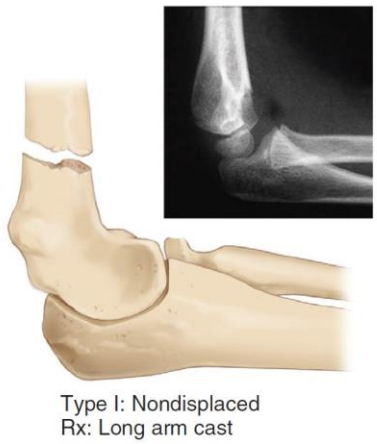
- One of the most common types of fractures
- 95% to 98% extension type; typically occur from a fall on outstretched hand with elbow in extension or hyperextension
- 2% to 5% flexion type; typically occur from a fall onto the flexed elbow
- Peak incidence in children between ages 5 and 8
- 1% associated with vascular injuries

Diagnosis

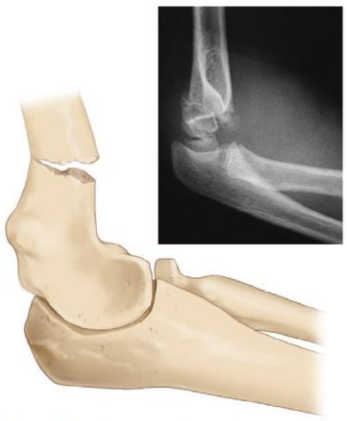
- AP and lateral radiographs essential
- AP view should be examined for Baumann angle; may need to compare with contralateral arm
- Lateral radiograph should be examined to see if the anterior humeral line intersects the middle third of the capitellar ossification center.
- Posterior fat pad displacement is always pathologic and can indicate a nondisplaced fracture.

Gartland classification

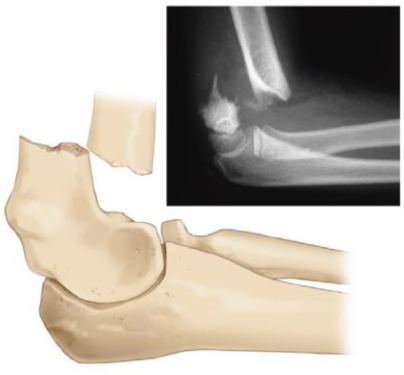
- Type I: Nondisplaced (beware of subtle medial comminution)
- Type II: Displaced, posterior cortex and periosteal hinge intact
- Type III: Completely displaced



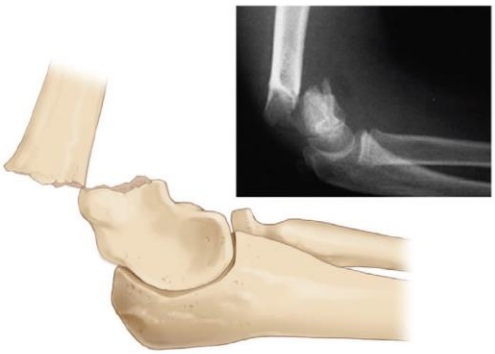
Type I: Nondisplaced
Rx: Long arm cast



Type II: Displaced/angulated, posterior cortex intact
Rx: Long arm cast vs. CRPP



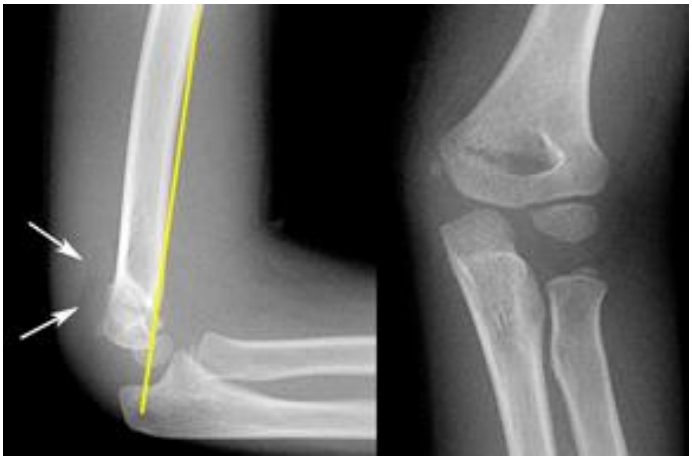
Type III: Completely displaced
Rx: CRPP



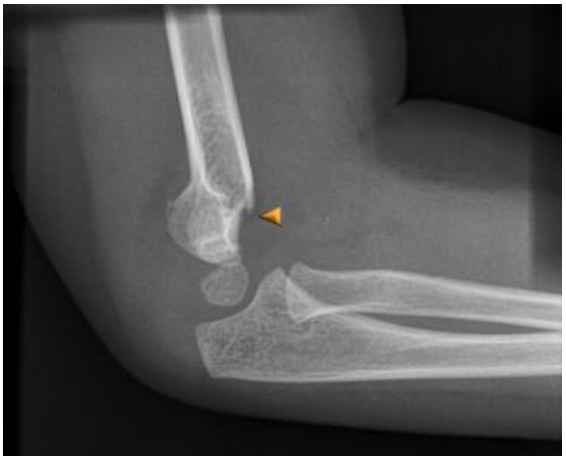
Flexion type
Rx: Based on displacement; similar to extension type

Neurovascular structures at risk

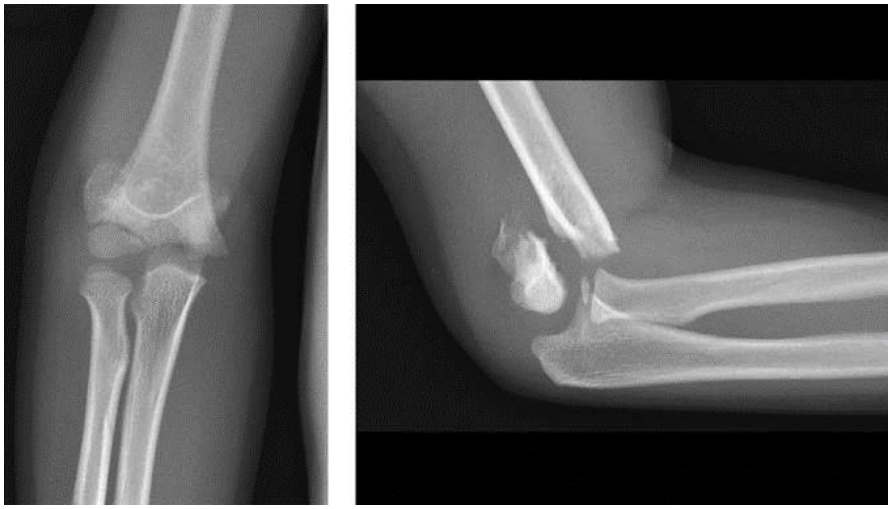
- **Anterior interosseous nerve (AIN)** injury most common for extension-type fractures; usually neurapraxia
- Ulnar nerve injury usually iatrogenic from medial pinning and also the most common nerve injury from flexion type
- Posteromedial angulation associated with radial nerve injury (the second most common neuropraxia after AIN palsy)
- Posterolateral angulation associated with **brachial artery** and median nerve injury
- Immediate surgery indicated in presence of vascular compromise (pale, cool hand)
- Most injuries can be splinted in a non-flexed position and treated the following day with no adverse impact on outcome.



Gartland I



Gartland II



Gartland III

Management

Type I—nondisplaced

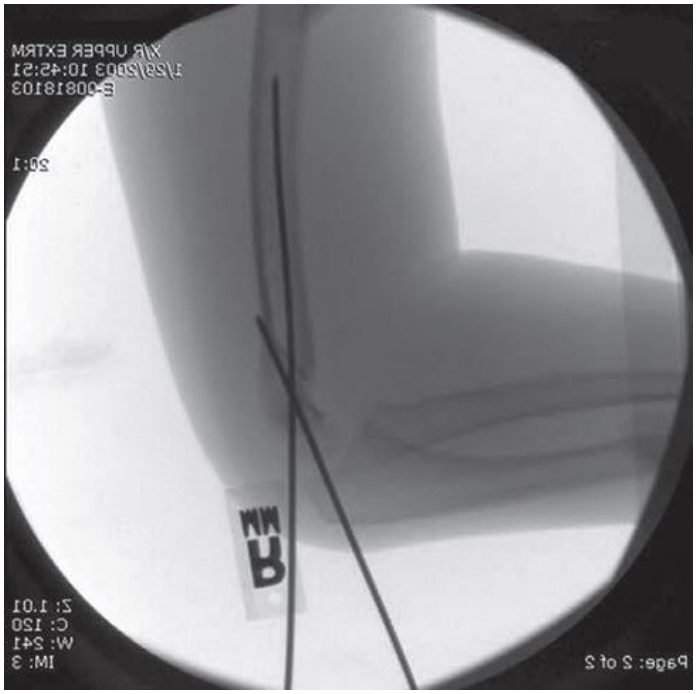
- Treated closed in a long-arm cast for 2 to 3 weeks

Type II—displaced with intact posterior cortex

- Conservative treatment for type II fractures is appropriate if all of the following criteria are met:
    - No significant swelling
    - Anterior humeral line intersects the capitellum
    - No medial distal humeral cortical impaction
    - Otherwise, CRPP is appropriate with postoperative long-arm immobilization at 90 degrees of flexion.

Type III—completely displaced; can be displaced posteromedially or posterolaterally

- CRPP
- ORIF rarely needed
- Rotationally unstable fractures,
- Open fractures
- Fractures associated with neurovascular injuries



Intra-operative imaging for closed reduction and percutaneous pinning (CRPP)

Epiphyseal Fractures

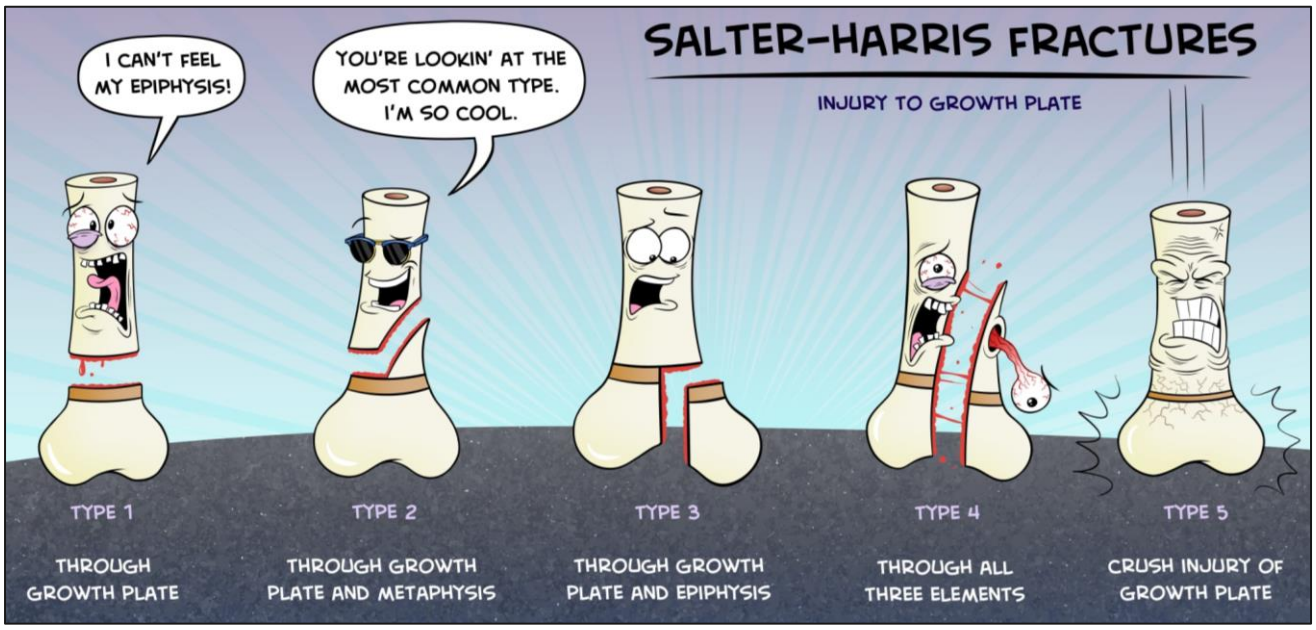
Fractures involving the growth plate in children are classified using the Salter - Harris system.
There are 5 main types.

Salter Harris Classification – *SALTER Mnemonic*

Type	Description
Type 1 – S	**S**lip - Transverse fracture through the growth plate
Type 2 – A	**A**bove - Fracture through the growth plate to the metaphysis (commonest type)
Type 3 – L	**L**ower - Fracture through the growth plate and the epiphysis with metaphysis spared
Type 4 – TE	**T**hough **E**verything - Fracture involving the growth plate, metaphysis and epiphysis
Type 5 - R	**R**ammed (Crushed) - Compression fracture of the growth plate (worst outcome)

Management

Non displaced type 1 injuries can generally be managed conservatively. Unstable or more extensive injuries will usually require surgical reduction and/ or fixation, as proper alignment is crucial.



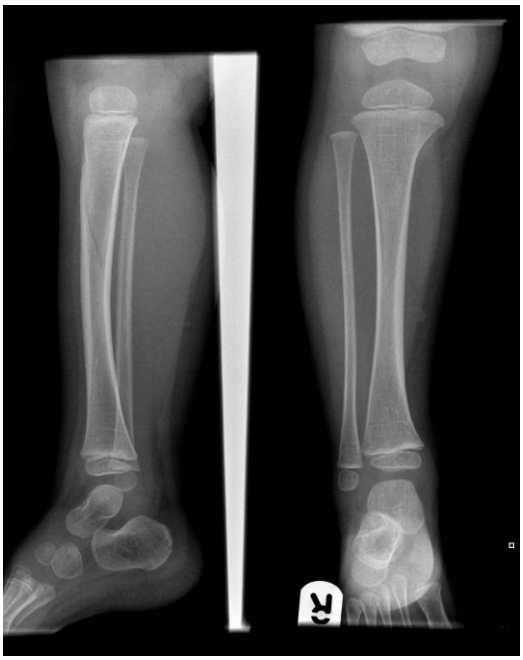
Toddler Fracture

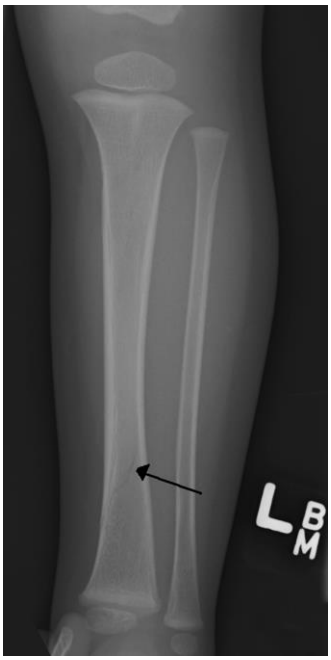
Also called childhood accidental spiral tibial fracture

Minimally or undisplaced spiral fracture, usually of the tibia, typically encountered in toddlers. It is a potentially difficult diagnosis to establish on account of both the symptoms and imaging findings being subtle

It is caused by a twisting injury while tripping, stumbling, or falling. Children usually present limping or refusing to walk.

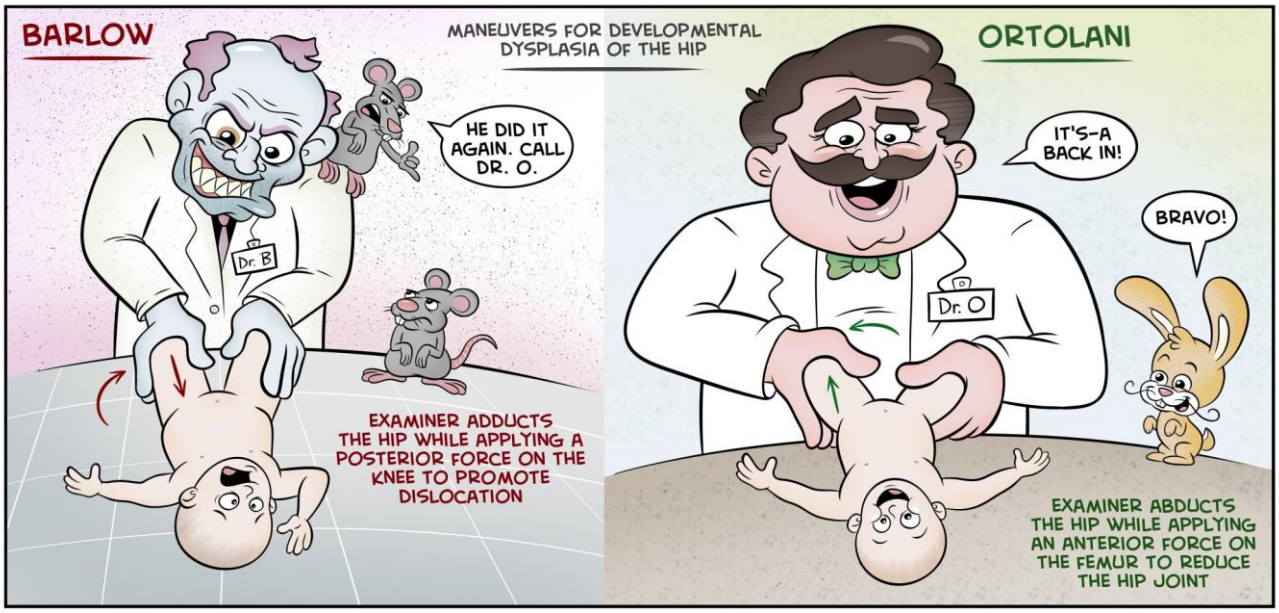
Treatment: Plaster

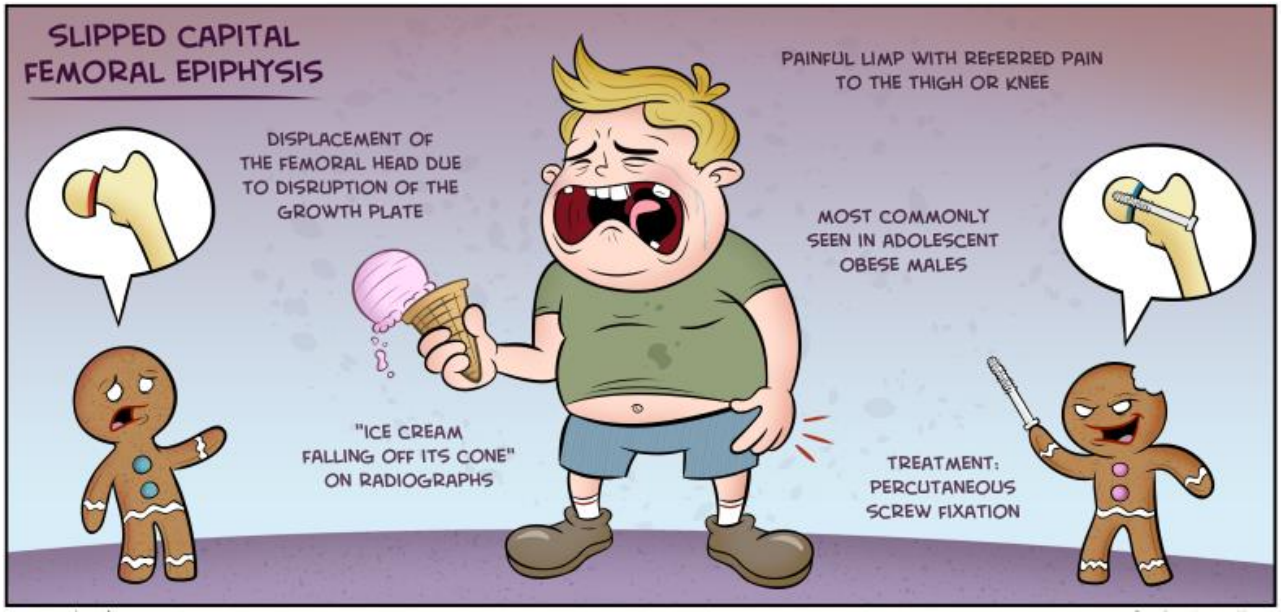




PAEDIATRIC CONDITIONS

Diagnosis	Mode of presentation	Treatment	Radiology
Developmental dysplasia of the hip	Usually diagnosed in infancy by screening tests. May be bilateral, when disease is unilateral there may be leg length inequality. As disease progresses child may limp and then early onset arthritis. More common in extended breech babies.	Splints and harnesses or traction. In later years osteotomy and hip realignment procedures may be needed. In arthritis a joint replacement may be needed. However, this is best deferred if possible as it will almost certainly require revision	Initially no obvious change on plain films and USS gives best resolution until 3 months of age. On plain films Shentons line should form a smooth arc
Perthes Disease	Hip pain (may be referred to the knee) usually occurring between 5 and 12 years of age. Bilateral disease in 20%.	Remove pressure from joint to allow normal development. Physiotherapy. Usually self-limiting if diagnosed and treated promptly.	X-rays will show flattened femoral head. Eventually in untreated cases the femoral head will fragment.
Slipped upper femoral epiphysis	Typically seen in **obese** male adolescents. Pain is often referred to the knee. Limitation to internal rotation is usually seen. Knee pain is usually present 2 months prior to hip slipping. Bilateral in 20%.	Bed rest and non-weight bearing. Aim to avoid avascular necrosis. If severe slippage or risk of it occurring then percutaneous pinning of the hip may be required.	X-rays will show the femoral head displaced and falling inferolaterally (like a melting ice cream cone) The Southwick angle gives indication of disease severity





Perthes Disease

Perthes disease

- Idiopathic avascular necrosis of the femoral epiphysis of the femoral head
- Impaired blood supply to femoral head, causing bone infarction. New vessels develop and ossification occurs. The bone either heals or a subchondral fracture occurs.

Clinical features

- Males 4x's greater than females
- Age between 2-12 years (the younger the age of onset, the better the prognosis)
- Limp
- Hip pain
- Bilateral in 20%

Diagnosis

Plain x-ray, Technetium bone scan or magnetic resonance imaging if normal x-ray and symptoms persist.

Catterall staging

Stage	Features
Stage 1	Clinical and histological features only
Stage 2	Sclerosis with or without cystic changes and preservation of the articular surface
Stage 3	Loss of structural integrity of the femoral head
Stage 4	Loss of acetabular integrity

Management

- To keep the femoral head within the acetabulum: cast, braces
- If less than 6 years: observation
- Older: surgical management with moderate results
- Operate on severe deformities

Indication for treatment (aide memoire): **Half a dozen, half a head**

Those aged greater than 6 years with >50% involvement of the femoral head should almost always be treated.

Prognosis

Most cases will resolve with conservative management. Early diagnosis improves outcomes.

Septic Arthritis - Paediatric

Septic arthritis

- Staph aureus commonest organism
- Urgent washout and antibiotics otherwise high risk of joint destruction

Diagnosis

- Plain x-rays
- Consider aspiration
- Utilise the Kocher criteria (see below)

Kocher criteria:

1. Non weight bearing on affected side
2. ESR > 40 mm/hr
3. Fever
4. WBC count of >12,000 mm^3

When 4/4 criteria are met, there is a 99% chance that the child has septic arthritis

Treatment

Surgical drainage of the affected joint is required, this should be done as soon as possible since permanent damage to the joint may occur. In some cases repeated procedures are necessary. Appropriate intravenous antibiotics should be administered.

Summary of Painful hip in children

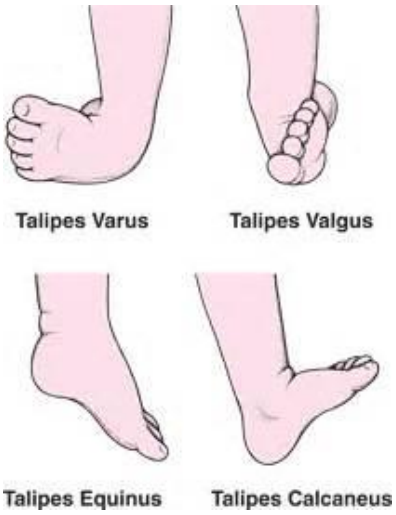
Developmental Dysplasia of the Hip (DDH)	• Diagnosed in infancy by screening tests.
	• May be bilateral. When disease is unilateral there may be **leg length inequality**.
	• Child may limp
	• More common in extended **breech babies & females**
	• *Risk factors*
	  ○ Female Sex
	  ○ Oligohydramnios
	  ○ Multiple pregnancies
	  ○ Breach position
	  ○ First born child with prematurity
	  ○ Certain ethnic groups - native American

Perthes Disease	• Hip pain (may be referred to the knee) usually between **5 and 12 years of age**. • Bilateral disease in 20% • **X-ray normal in early stages**.
Slipped upper femoral epiphysis	• **Obese male adolescents**. • Pain is often referred to the knee. • Limitation to internal rotation is usually seen. Knee pain is usually present 2 months prior to hip slipping. • Bilateral in 20%.
Irritable hip = Transient synovitis	• A common childhood condition that causes symptoms such as hip pain and limping. • Pain in the knee or thigh • Restricted movement in one of the hip joints • A slightly **higher temperature** than normal or **hx of viral infection** • Self-resolving

Talipes Equinovarus

Congenital talipes equinovarus.
Features:

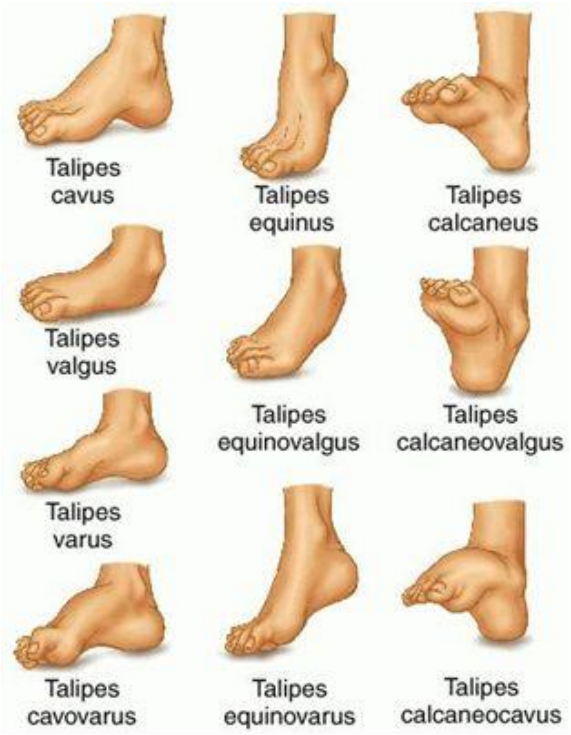
- Equinus of the hindfoot.
- Adduction and varus of the midfoot.
- High arch.



Most cases in developing countries. Incidence in UK is 1 per 1000 live births. It is more common in males and is bilateral in 50% cases. There is a strong familial link. It may also be associated with other developmental disorders such as Down's syndrome.

Key anatomical deformities:

- Adducted and inverted calcaneus
- Wedge shaped distal calcaneal articular surface
- Severe Tibio-talar plantar flexion.
- Medial Talar neck inclination
- Displacement of the navicular bone (medially)
- Wedge shaped head of talus
- Displacement of the cuboid (medially)

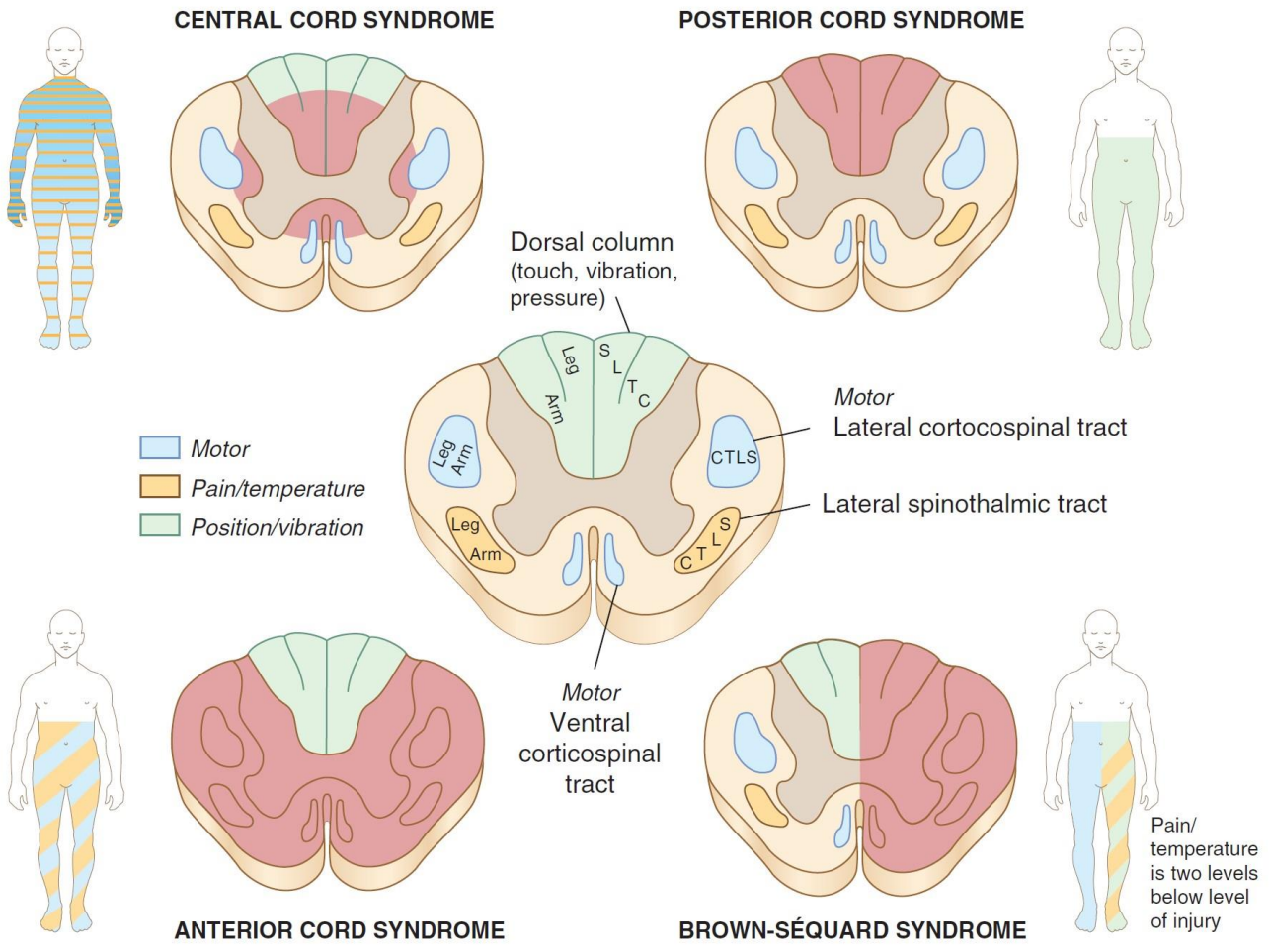


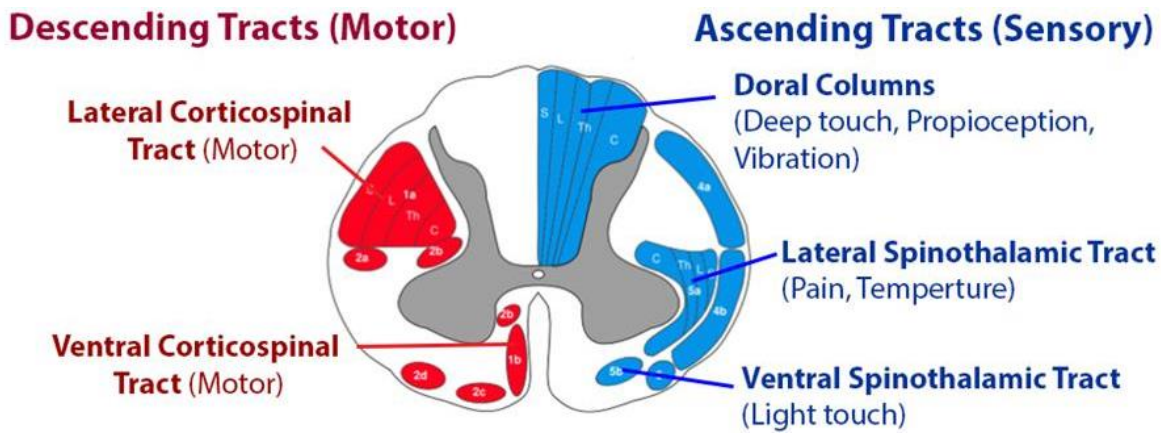
Management
Conservative first, the Ponseti method is best described and gives comparable results to surgery. It consists of serial casting to mold the foot into correct shape. Following casting around 90% will require an Achilles tenotomy. This is then followed by a phase of walking braces to maintain the correction.

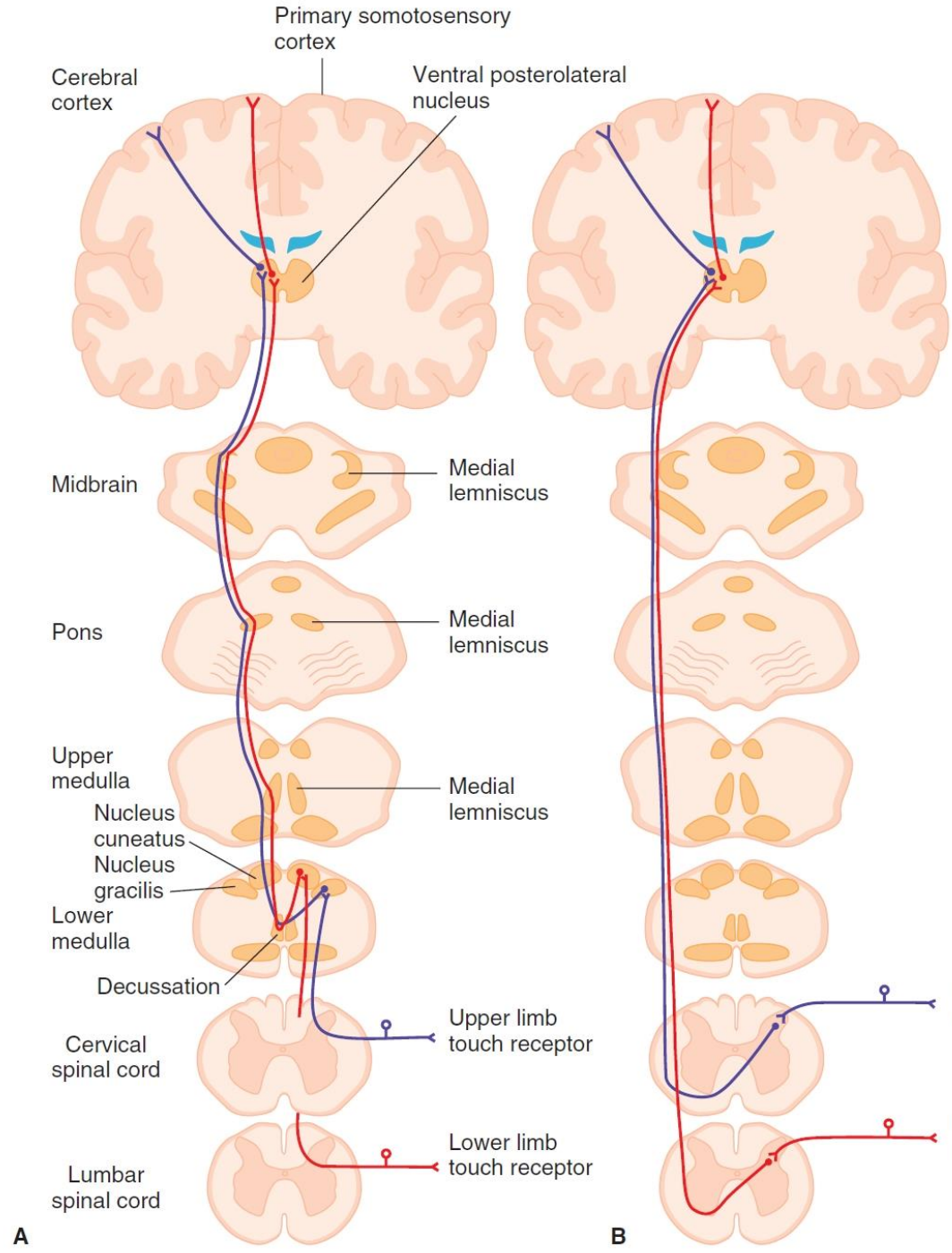
Surgical correction is reserved for those cases that fail to respond to conservative measures. The procedures involve multiple tenotomies and lengthening procedures. In patients who fail to respond surgically an Ilizarov frame reconstruction may be attempted and gives good results.

SPINAL DISORDERS

Dorsal column lesion	• Loss vibration and proprioception • Tabes dorsalis, SACD
Spinothalamic tract lesion	• Loss of pain, sensation and temperature
Osteomyelitis	• Normally progressive • Staph aureus in IVDU, normally cervical region affected • Fungal infections in immunocompromised • Thoracic region affected in TB
Infarction spinal cord	• Dorsal column signs (loss of proprioception and fine discrimination)
Cord compression	• UMN signs • Haematoma • Malignancy • Fracture
Central cord lesion	• *Mechanism:* Usually seen in older patients with cervical spondylosis • Flaccid paralysis of the upper limbs • Preserved motor and sensory fibers to lower limb *(these are located peripherally)*
Anterior cord syndrome	• *Mechanism:* Common after compression fractures • Often damage to anterior spinal artery, so neurological damage is a combination of direct trauma with ischemic damage • Corticospinal – loss of power • Spinothalamic – pain & temperature
Posterior cord syndrome	• *Mechanism:* Hyperextension injuries • Posterior column affected • Proprioception is affected - ataxia
Brown-sequard syndrome	• *Mechanism:* Hemisection of the spinal cord • Ipsilateral paralysis • Ipsilateral loss of proprioception and fine discrimination • Contralateral loss of pain and temperature



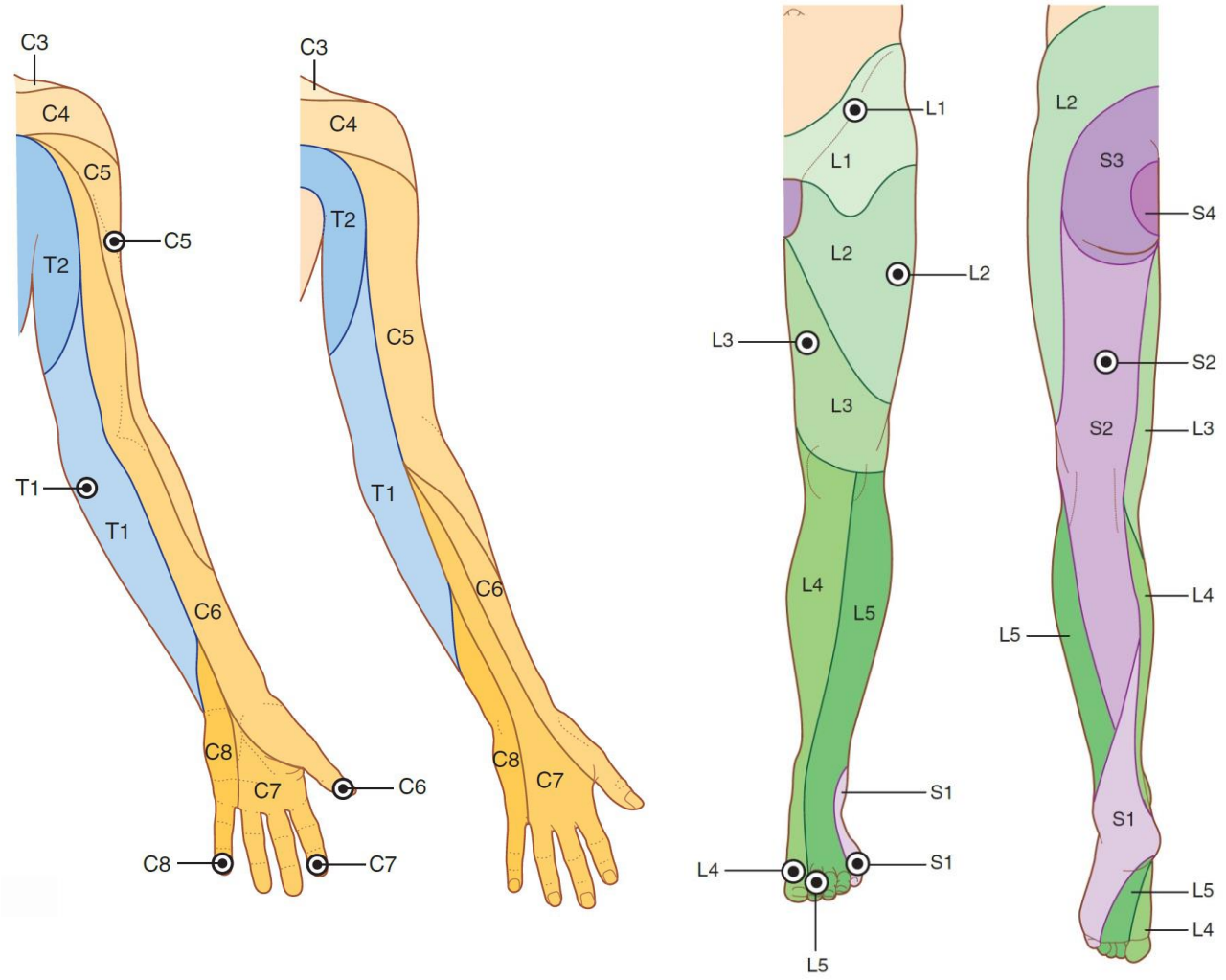




Ascending tracts carrying sensory information from peripheral receptors to the cerebral cortex. A) Dorsal column pathway mediates touch, vibratory sense, and proprioception. Sensory fibers ascend ipsilaterally via the spinal dorsal columns to medullary gracilus and cuneate nuclei; from there the fibers cross the midline and ascend in the medial lemniscus to the contralateral thalamic ventral posterior lateral (VPL) and then to the primary somatosensory cortex. B) Ventrolateral spinothalamic tract mediates pain and temperature. These sensory fibers terminate in the dorsal horn and projections from there cross the midline and ascend in the ventrolateral quadrant of the spinal cord to the VPL and then to the primary somatosensory cortex.

Dermatomes

- **C2 to C4** The C2 dermatome covers the occiput and the top part of the neck. C3 covers the lower part of the neck to the clavicle. C4 covers the area just below the clavicle.
- **C5 to T1** Situated in the arms. C5 covers the lateral arm at and above the elbow. C6 covers the forearm and the radial (thumb) side of the hand. C7 is the middle finger, C8 is the medial aspect of the hand, and T1 covers the medial side of the forearm.
- **T2 to T12** The thoracic covers the axillary and chest region. T3 to T12 covers the chest and back to the hip girdle. The nipples are situated in the middle of T4. T10 is situated at the umbilicus. T12 ends just above the hip girdle.
- **L1 to L5** The cutaneous dermatome representing the hip girdle and groin area is innervated by L1 spinal cord. L2 and 3 cover the front part of the thighs. L4 and L5 cover medial and lateral aspects of the lower leg.
- **S1 to S5** S1 covers the heel and the middle back of the leg. S2 covers the back of the thighs. S3 cover the medial side of the buttocks and S4-5 covers the perineal region. S5 is of course the lowest dermatome and represents the skin immediately at and adjacent to the anus.



Myotomes

Upper limb

Elbow flexors/Biceps	C5
Wrist extensors	C6
Elbow extensors/Triceps	C7
Long finger flexors	C8
Small finger abductors	T1

Lower limb

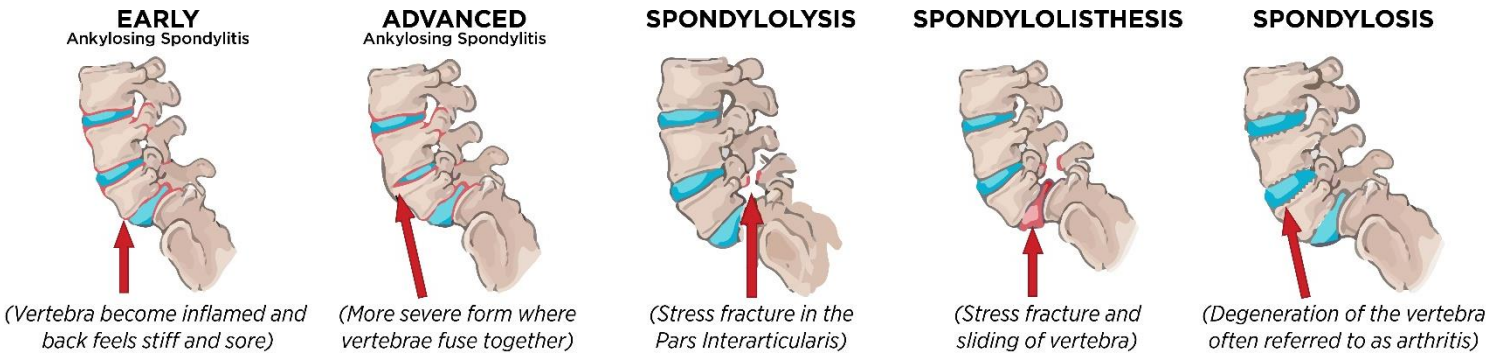
Hip flexors (psoas)	L1 and L2
Knee extensors (quadriceps)	L3
Ankle dorsiflexors (tibialis anterior)	L4 and L5
Toe extensors (hallucis longus)	L 5
Ankle plantar flexors (gastrocnemius)	S1

S2,3,4 keeps the ***3*** P's ***off the floor*** (Penis, Poo, and Pee). ***S2,3,4*** innervates the anal sphincter, urethral sphincter, and causes erection.
1, 2 *Buckle my shoe (Ankle).* ***3, 4*** *Kick the door (Knee).*
5, 6 *Pick up sticks (Biceps & Brachioradialis).* ***7, 8*** *Shut the gate (Triceps).*
C5, 6, 7 *Raise your arms up to heaven (Serratus anterior) Nerve root for Long Thoracic Nerve.*

Diseases Affecting the Vertebral Column

Ankylosing spondylitis	• Chronic inflammatory disorder affecting the axial skeleton • Sacroiliitis is a usually visible in plain films • Up to 20% of those who are HLA B27 positive will develop the condition • Affected articulations develop bony or fibrous changes • Typical spinal features include loss of the lumbar lordosis and progressive kyphosis of the cervico-thoracic spine
Scheuermann's disease	• Epiphysitis of the vertebral joints is the main pathological process • Predominantly affects adolescents • Symptoms include back pain and stiffness • X-ray changes include epiphyseal plate disturbance and anterior wedging • Clinical features include progressive kyphosis (at least 3 vertebrae must be involved) • Minor cases may be managed with physiotherapy and analgesia, more severe cases may require bracing or surgical stabilisation
Scoliosis	• Consists of curvature of the spine in the coronal plane • Divisible into structural and nonstructural, the latter being commonest in adolescent females who develop minor postural changes only. Postural scoliosis will typically disappear on manoeuvres such as bending forwards • Structural scoliosis affects > 1 vertebral body and is divisible into idiopathic, congential and neuromuscular in origin. It is not correctable by alterations in posture • Within structural scoliosis, idiopathic is the most common type • Severe, or progressive structural disease is often managed surgically with bilateral rod stabilisation of the spine
Spina bifida	• Non fusion of the vertebral arches during embryonic development • Three categories; myelomeningocele, spina bifida occulta and meningocele • Myelomeningocele is the most severe type with associated neurological defects that may persist in spite of anatomical closure of the defect • Up to 10% of the population may have spina bifida occulta, in this condition the skin and tissues (but not bones) may develop over the distal cord. The site may be identifiable by a birth mark or hair patch • The incidence of the condition is reduced by use of folic acid supplements during pregnancy
Spondylolysis	• Congenital or acquired deficiency of the pars interarticularis of the neural arch of a particular vertebral body, usually affects L4/ L5 • May be asymptomatic and affects up to 5% of the population • Spondylolysis is the commonest cause of spondylolisthesis in children • Asymptomatic cases do not require treatment
Spondylolisthesis	• This occurs when one vertebra is displaced relative to its immediate inferior vertebral body • May occur as a result of stress fracture or spondylolysis • Traumatic cases may show the classic "Scotty Dog" appearance on plain films with a collar. * • Treatment depends upon the extent of deformity and associated neurological symptoms, minor cases may be actively monitored. Individuals with radicular symptoms or signs will usually require spinal decompression and stabilisation

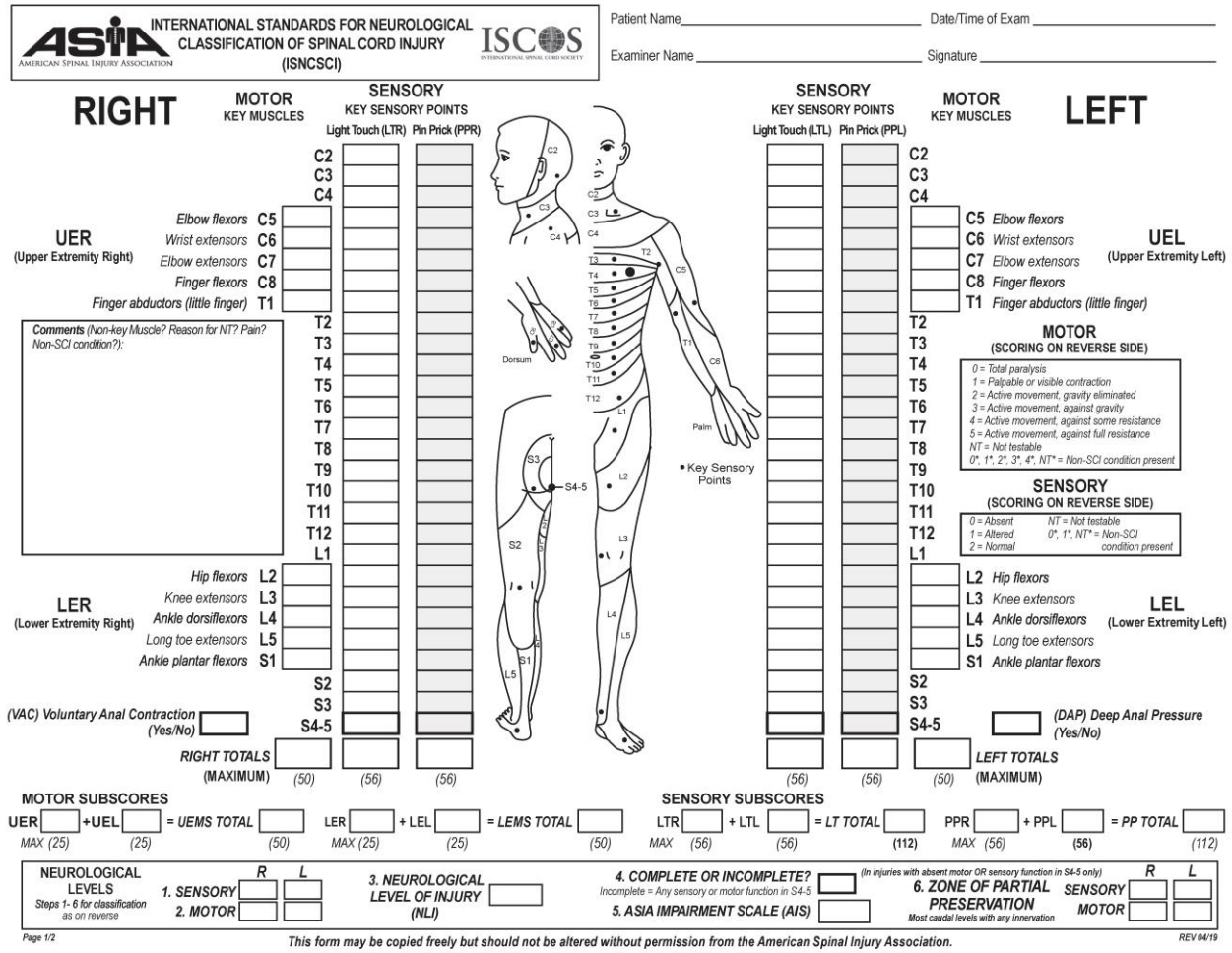
**The Scottie dog sign refers to the normal appearance of the lumbar spine when seen on oblique radiographic projection. If spondylolysis/spondylolisthesis is present, the pars interarticularis, or the neck of the dog, will have a defect or break. It often looks as if the dog has a collar (pars defect) around the neck (or decapitation for those with a bloodier imagination).*

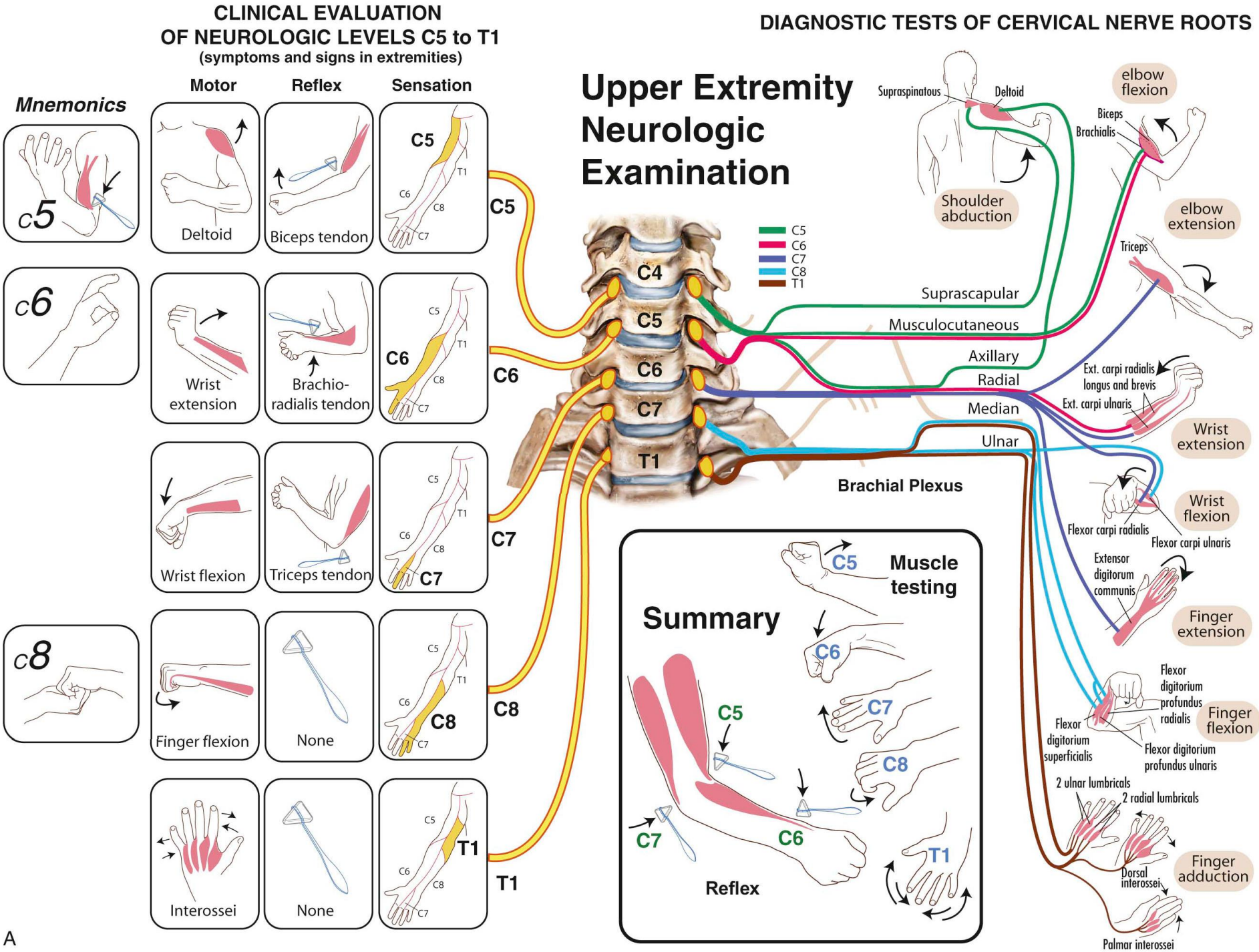


Findings in Nerve Root Compression

Root	Sensory Deficit	Muscle Weakness	Reflex Changes
C4	• Lateral neck • Shoulder	• Scapula	• None
C5	• Upper lateral arm and elbow	• Deltoid • Biceps (variable)	• Biceps
C6	• Lateral forearm • Thumb and index finger	• Biceps • Wrist extensors	• Brachioradialis
C7	• Middle finger	• Triceps • Wrist flexors • Long finger extensors	• Triceps
C8	• Little and ring finger • Ulnar border of palm • Medial forearm	• Finger flexors	• None
T1	• Medial arm	• Dorsal interossei • Abductor digiti minimi	• None

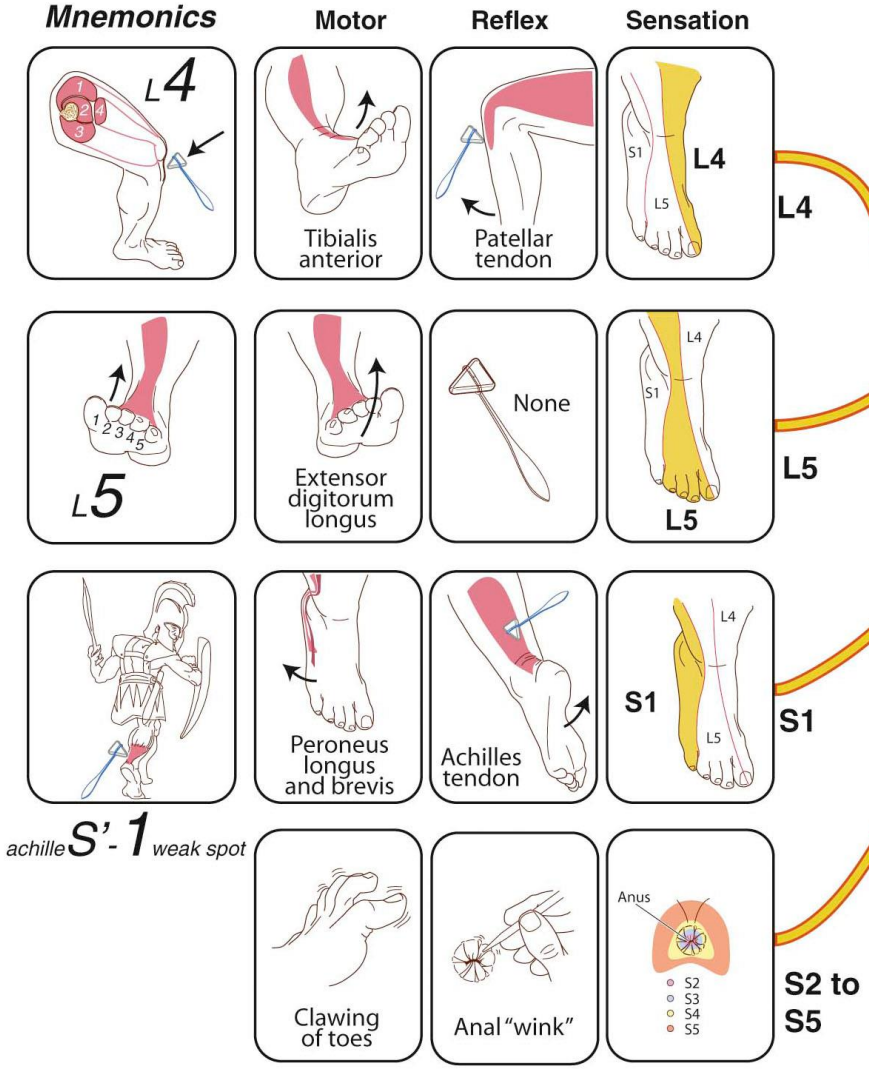
Root	Sensory Deficit	Muscle Weakness	Reflex Changes
L2	• Anteromedial thigh	• Iliopsoas	• None
L3	• Anterior thigh	• Quadriceps	• None
L4	• Anteromedial leg	• Tibialis anterior	• Patella tendon
L5	• Lateral leg • Dorsum foot/big toe	• Extensor hallucis longus • Gluteus medius	• Medial hamstring
S1	• Posterior calf • Plantar foot	• Gastrosoleus complex • Gluteus maximus	• Achilles tendon
S2, 3, 4	• Perianal	• Bowel/Bladder	• Cremasteric

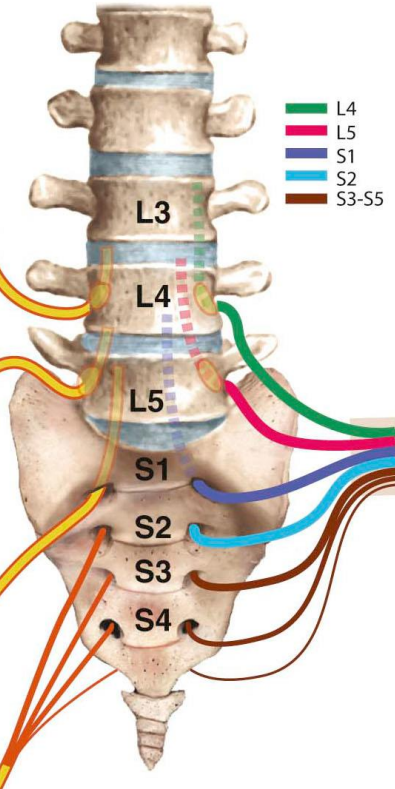



CLINICAL EVALUATION
OF NEUROLOGIC LEVELS C5 to T1
(symptoms and signs in extremities)
Mnemonics
Motor
Reflex
Sensation
c5
Deltoid
Biceps tendon
C5
c6
Wrist extension
Brachio-radialis tendon
C6
Wrist flexion
Triceps tendon
C7
c8
Finger flexion
None
C8
Interossei
None
T1
A
DIAGNOSTIC TESTS OF CERVICAL NERVE ROOTS
Upper Extremity Neurologic Examination
Supraspinatous
Deltoid
Shoulder abduction
elbow flexion
Biceps
Brachialis
elbow extension
Triceps
C4
C5
C6
C7
T1
Suprascapular
Musculocutaneous
Axillary
Radial
Median
Ulnar
Brachial Plexus
Ext. carpi radialis longus and brevis
Ext. carpi ulnaris
Wrist extension
Wrist flexion
Flexor carpi radialis
Flexor carpi ulnaris
Extensor digitorum communis
Finger extension
Flexor digitorum profundus radialis
Finger flexion
Flexor digitorum superficialis
Flexor digitorum profundus ulnaris
2 ulnar lumbricals
2 radial lumbricals
Finger adduction
Dorsal interossei
Palmar interossei
Summary
Muscle testing
Reflex

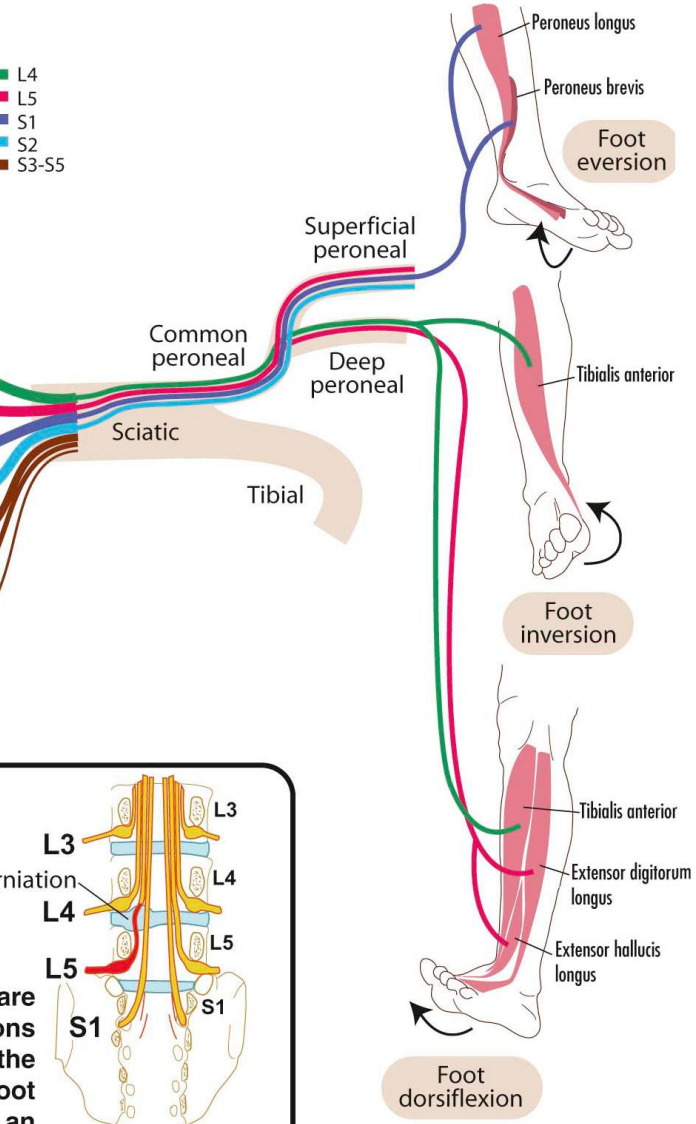
Lower Extremity Neurologic Examination

CLINICAL EVALUATION OF NEUROLOGIC LEVELS L4 to S1
(symptoms and signs in extremities)





DIAGNOSTIC TESTS OF LUMBOSACRAL NERVE ROOT



Most lumbar HNPs are paracentral herniations and thus affect the traversing nerve root (e.g., the L5 root at an L4-L5 herniation).