**COURSE: CERTIFICATE IN ORTHOPAEDICS AND TRAUMA MEDICINE.**

**UNIT: TRAUMATOLOGY 2.**

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**Introduction:**

Traumatology 2 majorly deals with specific fractures and their management.

**Special features of fractures in children:**

**learning objectives**

* Classify growth plate injuries in children
* Explain why greenstick injuries commonly occur in children
* Discuss the rate of healing of fractures in children
* State the possible effects of injuries on growth, in children

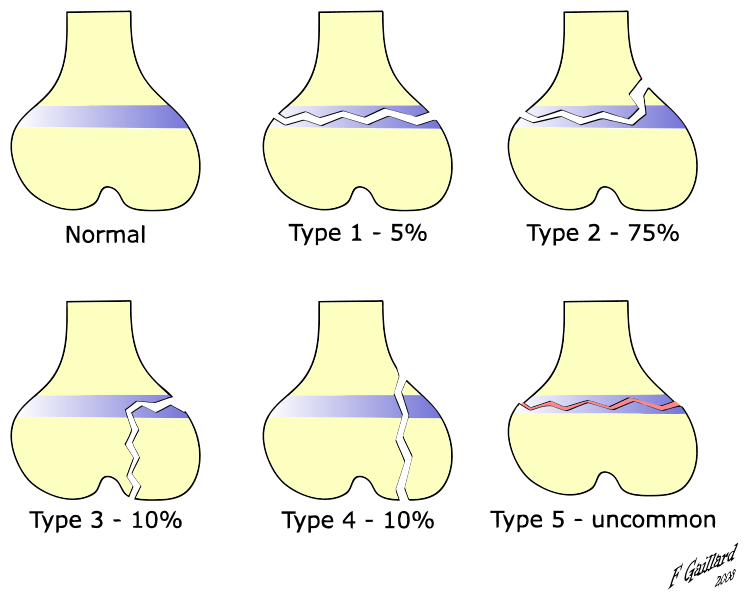
**Injuries involving growth plate**:

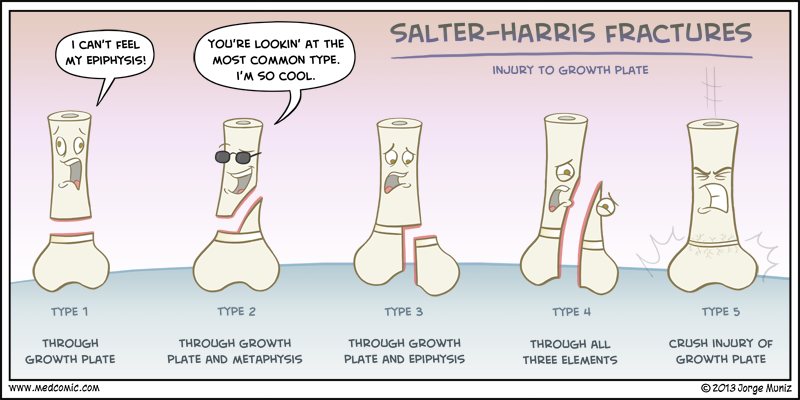
* Also known as epiphysial injuries
* Each end of the long bones has a cartilaginous growth plate.
* Most growth occurs away from the elbow and towards the knee.
* The growth plate is a potentially weak point in the bone and is commonly injured in children.
* Epiphysial injuries can be classified radiologically into **five types** as described by Salter and Harris.
* Designated as **Salter-Harris classification**.

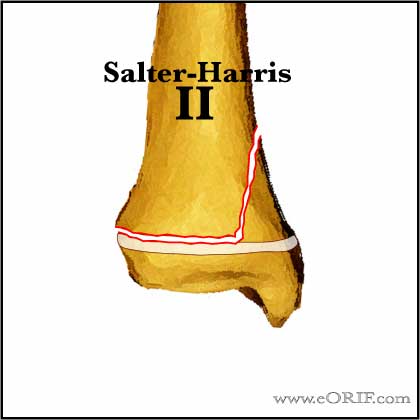
**Salter-Harris classification:**

* **Type I injury**: complete separation of epiphysis at the growth plate without damage to the metaphysis or epiphysis. (Fracture involving the physis not extending to the metaphysis or epiphysis)
* **Type II injury**: the most common type, with a characteristic triangular fragment of the metaphysis attached to the displaced epiphysis. (Fracture involving the physis extending to the metaphysis)
* **Type III injury**: involves the articular surface with separation of an epiphysial fragment. (Fracture involving the physis extending to the epiphysis)
* **Type IV injury**: fracture of the articular surface with extension across the growth plate into the metaphysis. (Fracture involving the physis extending to both metaphysis and epiphysis)

**Type V injury**: compression fracture involving part or all of the growth plate.







**Bone resilience:**

* Bones in children are more resilient and springier, withstanding greater deflection without fracture.
* This explains the predominance of incomplete fractures of the **greenstick** type in children.

**Periosteum**

* The periosteum in children’s bones is attached only loosely to the diaphysis and is therefore easily stripped from the bone over a considerable part of its length by blood collecting beneath it.
* This leads to abundance of callus following injury, even with little displacement of the fragments.

**Sites of fracture:**

* Certain fractures that are common in adults are uncommon in children:
  + Fractures of:
    - Scaphoid bone
    - Neck of femur
    - Trochanteric region of femur
* Some fractures are quite common in childhood:
  + Supracondylar fractures of humerus
  + Fractures of the capitulum of the humerus

**Healing:**

* Healing of childhood fractures is usually rapid, the younger the child the more rapid the healing.
* In infancy a fracture may be soundly united in 2 or 3 weeks
* In later childhood the average time required for union gradually increases.
* Remodeling is very active and complete in early childhood; so much so that all evidence of a past fracture may be obliterated within a matter of months.

**Effects on growth:**

* After a fracture of a long bone in a child, growth is often accelerated for a time, perhaps from hyperemia of the neighboring epiphysial cartilage.
* Growth may be seriously disturbed if the growth plate is damaged.
* If the whole area of the growth plate is fused, all growth ceases at that site.
* The degree of consequent shortening will depend on the age at which premature fusion occurred; the younger the patient at the time of fusion, the greater the eventual shortening.
* If premature fusion occurs in only a part of the epiphysial plate, further growth will be prevented at that point but will continue in the undamaged part of the plate, leading to angulation deformity.
* Angulation will also occur if there is premature arrest in one bone of a pair, as in the forearm or leg.

**FRACTURES OF THE SHOULDER GIRDLE AND THE UPPER LIMB.**

**It comprises the following:**

* Clavicle
* Scapula
* Shoulder Joint
* Humerus
* Elbow Joint
* Forearm Bones-radius/ulna
* Wrist Joint
* Carpals (Scaphoid Bone)
* Metacarpals(5) and phalanges(14)

Mechanism of injury for upper limb fractures:

* Mostly **Indirect**
* Commonly described as “a fall on outstretched hand “
* **Type** of injury depends on **position** of the upper limb at the time of impact: Flexed, Extended, adducted, abducted, pronated or supinated

**Fracture of the clavicle**

* Clavicle Shaft Fractures are common pediatric fractures that most commonly occur due to a fall on an outstretched arm or direct trauma to lateral aspect of shoulder.
* Diagnosis can be made with plain radiographs.
* Treatment is generally nonoperative management with a sling. Surgical management is indicated for open fractures or those associated with impending soft tissue compromise.
* Commonest site is the middle one third (mid-shaft) of the clavicle, at about the junction of the middle and lateral thirds of the clavicle.
* Some fractures also occur at the outer end of the clavicle.

**Mechanism of injury**

* Mainly due to indirect injury
  + A fall on the shoulder with a direct blow to the tip of the shoulder
  + A fall onto the outstretched hand
* Direct injury often leads to comminuted fracture.

**Displacement:**

* In the common mid-shaft fracture, the lateral fragment is displaced downwards (pulled down by the weight of the arm) and medially in relation to the medial fragment.

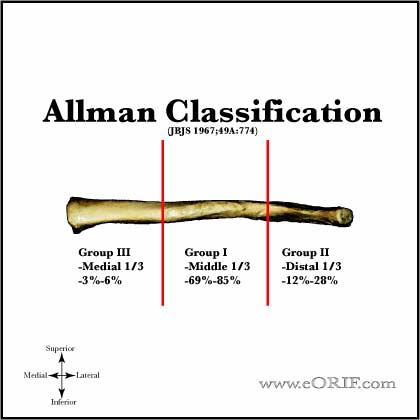
**Clinical features:**

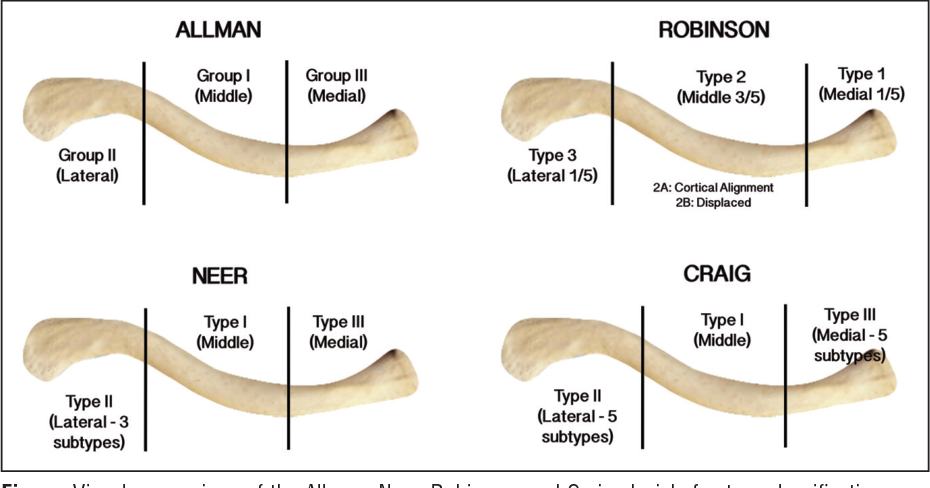
* The arm is clasped to the chest to prevent movement
* There is an obvious **subcutaneous lump** at the site of the clavicle
* Occasionally, a **sharp fragment threatens the skin**
* **Pain** and occasionally **ecchymosis**.



**X-ray findings:**

* The fracture is usually in the middle third of the bone
* The outer fragment lies below the inner fragment, and is usually medially displaced.







**Treatment:**

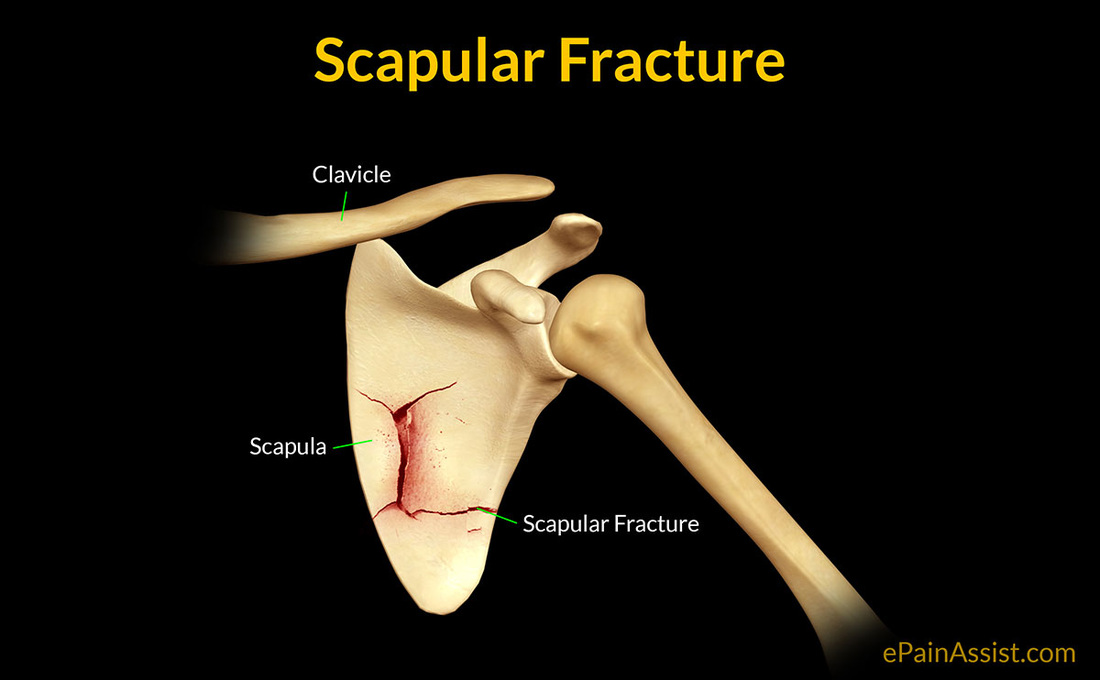
* Conservative treatment
* Support the arm in an arm sling for 2 weeks. This provides good pain relief.
* As soon as the initial sharp pain subsides, active shoulder exercises should be begun to restore full mobility.
* Operative fixation is indicated if there is severe displacement, neurovascular injury or nonunion.
* Operative reduction and internal fixation is done with an intramedullary pin or a contoured plate with screws.
* Fractures of the clavicle unite readily.
* The only common residual disability is a palpable or visible irregularity of bone at the site of the fracture.
* In children normal contour is quickly restored by remodeling.
* In adults some thickening may remain.

**Complications:**

* **Early**: very rarely: -
  + Pneumothorax
  + Damage to subclavian vessels
  + Injury to brachial plexus
* **Late:**
  + Non-union
  + Malunion – common. Leaves a lump at the site
  + Stiffness of the shoulder

**Fractures of the scapula.**

* The scapula may be fractured in the:
  1. Body
  2. Neck
  3. Acromion process
  4. Coracoid process
* The fractures are not very common
* The mechanism of injury is by direct violence.



**Fracture of the body of the scapula:**

* May be comminuted, but there is no important displacement because the fragments are held in position by muscles that attach both on the costal and outer surfaces.

**Fracture of the neck of the scapula:**

* the fracture extends from the scapular notch to the axillary border of the scapula, so that the part bearing the articular surface is detached in one piece from the body of the bone.
* the glenoid fragment may be displaced downwards.

**Fracture of the acromion process:**

* the fracture occurs at a variable distance from the tip of the acromion.
* the fracture may be a crack without displacement, or the acromion may be comminuted and displaced downwards.

**Fracture of the coracoid process:**

* the fracture may be a crack without displacement, or there may be a complete fracture with separation and downward displacement of the coracoid process.

**clinical features**

* Severe pain
* The arm is held immobile
* There may be extravasation of blood into the tissues, with widespread ecchymosis around the scapular region.

**treatment**

* Attention should be given to restoration of shoulder function.
* Support the arm in a sling to relieve pain and provide comfort. The sling can be worn for up to 6 weeks
* As soon as pain begins to subside, active shoulder exercises are begun, and continued until full range of movement is regained.
* For badly comminuted or severely displaced fracture of the acromion, operation to excise the acromion is advised.



**DISLOCATION OF THE SHOULDER JOINT.**

**Among the large joints, the shoulder is the one that most commonly dislocates. Factors contributing include:**

* **Shallowness of the glenoid socket.**
* **Extra ordinary range of movements.**
* **Ligaments laxity**
* **Glenoid dysplasia**
* **Vulnerability of the joint during stressful activities of the upper limb.**

**ANTERIOR DISLOCATION:**

**Mechanism of injury:**

* An anterior shoulder dislocation is usually caused by a blow to the abducted, externally rotated, and extended arm (e.g., player blocking a basketball shot). Alternatively, a blow to the posterior humerus or a fall on an outstretched arm may cause an anterior dislocation.
* **A fall on the hand. The head of the humerus is driven forward, tearing the capsule and producing avulsion of the glenoid labrum. (The Bankart lesion). Occasionary the posterior lateral part of the head is crushed. Nearly always the arm drops, bringing the head to its Sub coracoid position.**

**Clinical features.**

1. **Severe pain**
2. **Patient supports the arm with the opposite hand.**
3. **Flattened lateral outline of the shoulder.**
4. **Bulge felt below the clavicle.**

**NOTE.**

**The arm must always be examined for nerve and vessel injury before reduction is attempted.**

**INVESTIGATIONS.**

**>History**

**>Clinical examination**

**>X-ray Anterior posterior and Lateral views confirms the diagnosis.**

**TREATMENT.**

**Reduction is always done under General Anesthesia>GA.**

**TECHNIQUES:**

1. **Stimson’s technique>The patient left prone with the arm hanging over the side of the bed. After 15-20 minutes the shoulder may reduce.**
2. **Hippocratic method>Gentle traction applied to the arm with the shoulder in slight abduction, while an assistant applies firm counter traction to the body (a towel slung around the patient’s chest under the axilla is helpful). COMMONLY USED.**
3. **Kocher’s method >Elbow bent 90 degrees and held close to the body, no traction should be applied. The arm is slowly rotated 75 degrees laterally, the point of the elbow is lifted forwards and finally the arm is rotated medially. This technique carries the risk of nerve, vessel and bone injury and is not recommended.**
4. **The patient sitting on a reduction chair and with gentle traction of the arm over the back of the padded chair the dislocation is reduced.**

* **Do a check X-ray to confirm reduction and exclude any fracture?**
* **Arm sling applied for 1 to 3 weeks.**
* **Analgesics.**

**COMPLICATIONS:**

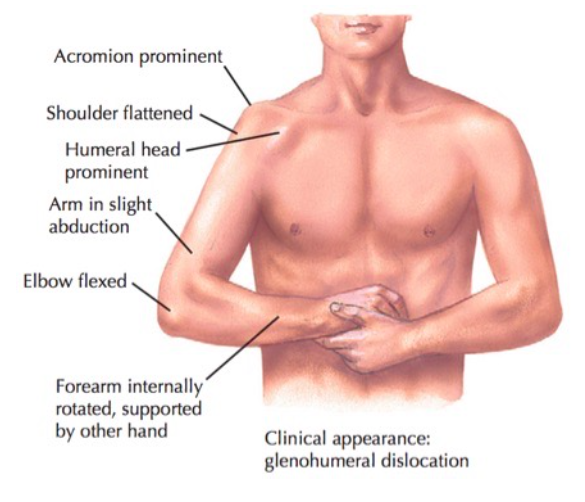
**Early.**

* **Rotator curve tear**
* **Nerve injury>Axillary----supplies the deltoid muscle. Others, Radial, Musculocutaneous, Median or Ulna nerves.**
* **Vascular artery> Axillary artery.**
* **Fracture dislocation>Fracture proximal humerus can occur. In this case open reduction is required to avoid later subacromial impingement.**

**Late.**

* **Shoulder stiffness. Common in patients over 40 years of age.**
* **Unreduced dislocation>May be undiagnosed----In unconscious or old patients. (6weeks injury attempt closed reduction). More than 6weeks on the young operative reduction is done.**
* **Recurrent dislocation>Arthroscopic operation is done.**

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**POSTERIOR DISLOCATION OF THE SHOULDER.**

**It is rare accounts for less than 2% of all the dislocations.**

**Mechanism of injury.**

**Very severe indirect force>Fit or Convulsion or Electric shock.**

**A fall on the flexed, adducted arm or on the outstretched hand.**

**Direct blow to the front of the joint.**

**Clinical features.**

**1.Arm is held in internal rotation.**

**2.Front of the shoulder looks flat with a prominent coracoid.**

**3.Pain.**

**4.May be missed. (Frequently).**

**INVESTIGATIONS**

**X-ray Ap and Lateral views.**

**CT SCAN.**

**TREATMENT.**

**Patient under general anaesthesia(GA). The arm is pulled with the shoulder in adduction, rotate arm gently laterally while the humeral head is pushed forwards.**

**Arm sling 3-6 weeks**

**Physiotherapy**

**Analgesics**

**COMPLICATIONS.**

**1.Un-reduced dislocation.**

**Open reduction indicated.**

**2.Recurrent dislocation or subluxation.**

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**INFERIOR DISLOCATION OF THE SHOULDER [LUXATIO ERECTA].**

**Rare but it demands early recognition because the consequences are potentially very serious. The humeral head is levered out of its socket and pokes into the axilla. The arm remains fixed in abduction.**

**Mechanism of injury.**

**A severe hyper abducted force causes the injury. Soft tissue injury may be severe and includes avulsion of the capsule and surrounding tendons, rupture of muscles fracture of the glenoid. Proximal humerus and damage to the brachial plexus and axillary artery can occur.**

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**CLINICAL FEATURES.**

* **Pain.**
* **Arm locked in almost full abduction (confirms the diagnosis).**
* **Humeral head may be felt in or below the axilla.**
* **Always examine for neurovascular damage.**

**INVESTIGATIONS.**

**Ap/X-ray shows the dislocation.**

**TREATMENT.**

**Patient under GA.**

**Pull upwards in the line of the abducted arm, counter traction downwards over the top of the shoulder.**

**Open reduction.**

**Arm sling for 3 weeks.**

**Analgesics**

**Examine again after reduction for evidence of neurovascular injury.**

**SHOULDER DISLOCATION IN CHILDREN.**

**Traumatic dislocation of the shoulder is exceedingly rare in children. The shoulder slips out unexpectedly during everyday activities’ X-ray may confirm the diagnosis.**

**Most of these children have generalized joint laxity and some have glenoid dysplasia or muscle patterning disorders.**

**TREATMENT.**

**a. Physiotherapy.**

**b. Reconstructive surgery.**

**Reduction maneuver:**



**FRACTURE HUMERUS:**

* Can occur in the proximal humerus, shaft of humerus and distal humerus.

**Classification:**

* #s of humerus may be classified into six groups:
  1. Fractures of the neck of humerus
  2. Fracture of the greater and lesser tuberosity
  3. Fracture of the shaft
  4. Supracondylar fracture
  5. Fracture of the condyles

6.Fracture of the epicondyles.

Fracture neck humerus

* Occurs most often in elderly women, in whom it is a common injury.
* In most of such patients there is some degree of rarefaction from osteoporosis, so that the bones are relatively weak.
* Results in **fragility** fracture.
* Follows a fall onto the limb.

**Features:**

* Displacement is variable
* May be no displacement
* There may be moderate or severe **tilting of the head fragment** so that the shaft appears either abducted or adducted in relation to it.
* In well over half the cases the fragments are firmly **impacted** together so that the bone moves as one piece.

**Clinically:**

* + **The fracture may easily be overlooked if it is impacted.**
    - **May be able to use the limb to some extent without severe pain.**
  + **The possibility of a fracture should always be suspected from the nature of the injury, especially if the patient is an elderly woman.**
  + **Extensive bruising in the upper and middle parts of the upper arm also lend support to the diagnosis.**

**Radiographs:**

* + **Show the fracture**
  + **Do not indicate with certainty whether the fracture is impacted or not**
  + **This can best be ascertained by clinical examination.**
  + **Severe pain on slight movement of the arm implies the fracture is not impacted.**
  + **Passive movement of the limb through a reasonable range without severe pain implies the fracture is impacted.**

**Treatment:**

* Impacted fractures: -
  + Immobilization is unnecessary
  + Support in an arm sling for 4-6 weeks
  + Active and assisted shoulder movements are begun as soon as pain subsides.
* Displaced fractures: -
  + Are best managed by **open reduction** and **internal fixation** by use of metal plates and screws.

**Complications:**

* Joint stiffness
  + Shoulder is prone to stiffness in elderly persons.
* Arterial injury
  + Brachial artery
* Nerve injury
  + Axillary nerve.
  + Treatment is expectant.
* Dislocation of the shoulder
  + Rarely the fracture is associated with dislocation of the shoulder.
  + The dislocation should be reduced first.

**IMPACTED AND DISPLACED # NECK HUMERUS:**



**PLATING AND RUSH NAILS:**

**Fracture of the greater tuberosity of humerus:**

**MECHANISMS:**

* Usually caused by a fall onto the shoulder
* Occurs in adults of any age, but mainly the elderly.
* Usually, no marked displacement
* The tuberosity may be comminuted
* At times avulsion of a fragment occurs by the action of attached muscles.

**Treatment:**

* **Undisplaced fracture:** 
  + Requires no rigid splintage.
  + u-slab application + Pouch armsling
  + Shoulder exercises to restore movement and function is all that is needed.
* Avulsed widely separated fragment:
  + Is held by a **screw** through **open reduction** and **internal fixation**.
  + Shoulder exercises should be practiced thereafter.

**Complications:**

* Painful arc syndrome (supraspinatus syndrome)
  + Thickening or irregularity of the greater tuberosity may interfere with the **abduction** at the glenohumeral joint, because the thickened area may **impinge** against the **acromion** process or **coraco-acromial ligament**, causing **pain**.
  + Occurs mainly during the middle phase of abduction.

**FRACTURE SHAFT HUMERUS:**

* Commonest site is in the middle third

**Mechanism of injury:**

* Indirect twisting force
  + Indirect injury results in Spiral fractures
* A fall on the elbow with the arm abducted may cause an oblique or transverse fracture
* Direct blows result in transverse, short oblique or comminuted fracture

**Clinical features**

* Painful arm
* Extensive bruising
* Swelling
* Loss of function
* May present with radial nerve injury

**Radiological findings**

* Will show:
  + Site of fracture
  + Fracture pattern
  + Any displacement
* May show features of pathological fracture.

Proximal half of the humerus is a common site for pathological fracture from carcinomatous metastases.

**Treatment:**

* Fractures of the humerus heal readily
* They do not require perfect reduction or immobilization
* The weight of the arm with an external cast is usually enough to pull the fragments into alignment.
* A **U-slab plaster** is applied to maintain alignment for **6-8 weeks**.
* Further support is provided by an **arm sling**.
* **Active shoulder exercises** are encouraged, **pendulum** exercises within a week, but **active abduction** only when the fracture is sticky – after 6 weeks.
* Once the # is sticky, a well molded cast brace may be used.

**Alternative methods of treatment:**

* When the fragments are very **unstable**, in case of **gross displacement**, or in case of **pathological fracture** from a metastatic tumor, **open reduction** and **internal fixation** is done.
  + Plate and screws
  + Intramedullary nail (with locking screws)
* In the case of contaminated open fracture, or an infected fracture, external fixation is done.



**Complications:**

**Early:**

* Nerve injury – **radial nerve** because of its close contact with the bone as it winds round its posterior aspect in the radial groove.
* Vascular injury – **brachial** artery

**Late:**

* Non-union
* Delayed union
* Joint stiffness – shoulder

**Radial nerve injury**

* Results in **Wrist drop –** due to paralysis of the extensor muscles of the wrist, fingers and thumb.
* Brachioradialis and supinator muscles may also be paralyzed.
* **Sensory loss** in a small area at the anatomical snuff box
* Associated with fracturehumerus in up to 12% of fractures [10-15%]
* 2/3 (8%) of Radial injury are Neuropraxia
* 1/3 (4%) are nerve lacerations or transection

**Management of radial nerve injury:**

* When present in open fractures - immediate **exploration** and ± **repair**
* In closed fractures it is assumed that the nerve is in continuity and **spontaneous recovery** is awaited (conservative treatment)
  + Initial management is doing **Nerve Conduction Studies** (NCS ) and **Electromyography** (EMG ) and awaiting for spontaneous recovery.
* Recovery usually starts after few days but may take up to 9 months for full recovery
* If there is no sign of spontaneous recovery by 12 weeks, then exploration of the nerve should be carried out.

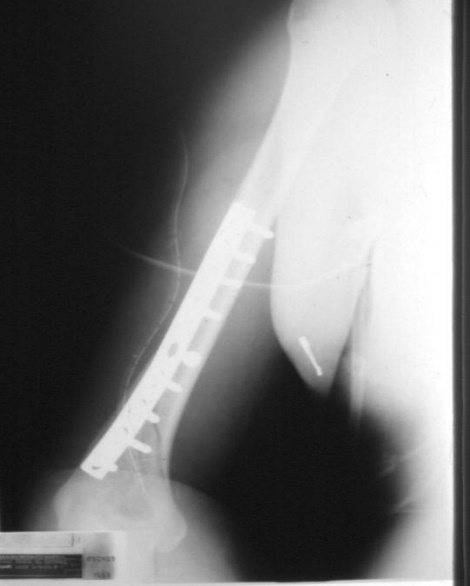
**u-slab/coaptation splint functional brace**



**Indications for ORIF:**

* **Very unstable fragments**
* **Bilateral** humeral fractures
* Severe multiple injuries
* Segmental fractures
* Pathological fracture
* Radial nerve palsy after manipulation
* **Unconscious** patient
* Bed-ridden patient
* **Delayed**-Union, **Non**-Union and **Mal**-Union

**PLATING with screws K**-WIRE FIXATION



**FRACTURE CONDYLES:**

Are relatively uncommon, but often troublesome.

They occur mainly in children.

MODE OF INJURY:

* A fall on the point of the elbow drives the olecranon process upwards, splitting the condyles apart.
* The associated soft tissue injury is usually severe.
* The lateral condyle is fractured much more commonly than the medial.

**CLINICAL FEATURES:**

* Severe pain in the elbow region
* Swelling of the elbow
* Deformity - the elbow is wider than normal
* The tip of the olecranon is higher than normal
* There is tenderness over the lateral condyle

**X-RAY FINDINGS:**

* The usual lateral condylar fracture extends obliquely upwards and laterally from the capitular surface.
* In young children the greater part of the detached fragment may be cartilaginous, so that the fragment appears much smaller as seen radiographically than in fact.
* Fracture could be T-shaped, Y-shaped or even comminuted.

The fractures involve the joint surface.

**TREATMENT:**

**Undisplaced fracture:**

* Splinting of the arm in a **back-slab** with the elbow flexed at 90 degrees, with the forearm in **neutral** position and **wrist extended**.
* The splint is removed after 3-4weeks and exercises are encouraged.

**Displaced fracture:**

* Requires **accurate reduction** and **internal fixation**.
* For a moderately displaced fragment, it may be possible to manipulate it into position by extending the elbow and pressing upon the condyle, then fixing the fragment with **percutaneous pins**.
* If this fails, **open reduction and internal fixation** with **pins** is done, same as for all separated fractures.
* Immobilize the arm in **a cast for 3-4 weeks**, then remove cast and pins.

**COMPLICATIONS:**

**Non-union:**

* Condylar fractures are prone to non-union, and may lead to **deformity** of the elbow and to **osteoarthritis**.
* Treatment is to **refresh** the fracture surfaces then **accurate reduction** and **fixation** with a **screw**.

**Deformity:**

* May be caused by persistent upward displacement of the fractured condyle, or by retardation of epiphyseal growth on the affected side from damage to the growing epiphyseal cartilage.
* If the lateral condyle is affected the deformity will be that of cubitus valgus, whereas involvement of the medial condyle causes cubitus varus.

**Frictional neuritis of the ulnar nerve:**

* In cases of cubitus valgus there is a risk of ulnar paralysis from frictional neuritis where the nerve is angled behind the medial epicondyle.
* Treatment: the nerve should be transposed from its post-epicondylar groove to a new bed in front of the elbow.

**Osteoarthritis:**

* Is liable to occur when a condylar fracture leaves permanent deformity or irregularity of the articular surface.

**Stiffness of the elbow joint:**

* Comminuted intercondylar fractures usually result in some degree of stiffness.

**FRACTURE EPICONDYLES:**

The medial epicondyle is fractured more commonly than the lateral.

**MECHANISMS OF INJURY:**

* Occurs more often in children than in adults
* It is often an **avulsion** injury, the epicondyle being pulled off by the attached flexor muscles (or medial ligament) during a fall on the out-stretched hand with the wrist and elbow extended, and the elbow wrenched into valgus.
* If the elbow subluxate, the small fragment may be dragged into the joint.
* The fracture may also be caused by direct violence

**CLINICAL FEATURES:**

* Pain, swelling and bruising on the medial side of the elbow following an injury.
* Sensation in the fingers should be tested to exclude ulnar nerve damage.

**X-RAY FINDINGS:**

**AP view:**

* The medial epicondylar epiphysis may be tilted or shifted downwards.
* If the joint is dislocated the fragment lies distal to the lower humerus.

**Lateral view:**

* May show the epicondyle looking like a loose body in the joint.

**TREATMENT:**

* Minor displacement may be disregarded.
* The elbow should be **immobilized in plaster for 3 weeks** to relieve pain. A/E BACKSLAB
* Thereafter joint exercises to restore movement.
* If the epicondyle is trapped in the joint, it must be freed.
* This can be done by:
  + **Manipulation** with the elbow in valgus and the wrist hyperextended to pull on the flexor muscles
  + **Opening the joint** and **retrieving** the fragment, fixing it back in position by sutures.

**COMPLICATIONS:**

**Early:**

* Ulnar nerve damage is common due to immediate direct injury in displaced fractures.
* Inclusion of the epicondylar fragment in the joint.

**Late:**

* Ulnar nerve palsy from frictional neuritis due to roughened bony groove.
* Stiffness of the elbow
* Osteoarthritis
* Malunion

**Pediatric Supracondylar Humerus Fractures:**

**OBJECTIVES:**

By the end of this presentation, learners will be better able to:

• Recognize the signs and symptoms of more severe pediatric supracondylar humerus fractures (SCHF)

• Assess the degree of displacement of pediatric SCHF on radiographs

• Determine the type of fracture according to the modified Gartland classification

• Prescribe appropriate treatment for SCHF based on fracture characteristics

• Recognize SCHF that may require more complex care and manage them appropriately

**They are among the commonest fractures in children. The distal fragment may be displaced either posteriorly or anteriorly.**

**Mechanism of injury.**

* **Usually a fall on the outstretched hand.**
* **95% of all cases causes posterior angulation or displacement [Hyperextension injury].**
* **The humerus breaks just above the condyles. The distal fragment is pushed backwards and (because the forearm is usually in pronation) twisted inwards. The jagged end of the proximal fragment’s pokes into the soft tissues anteriorly, sometimes injuring the brachial artery or median nerve**
* **Anterior displacement is rare; it is thought to be due to direct violence (e.g. a fall on the point of the elbow) with the joint in flexion.**

**PEDIATRIC SCHF**

• Most common surgical pediatric fracture

• Frequently require surgical treatment to avoid complications due to:

• Limited contribution of growth of distal humerus = limited remodeling potential • Displaced SCHF are unstable and require reduction and stabilization to heal in appropriate alignment

**PHYSICAL EXAM:**

• Pain

• Refusal/inability to move the elbow

• Deformity proportional to displacement

• Swelling & bruising

• Skin integrity

• Tenting/compromise

• Open fractures

**Brachialis sign:**

• Antecubital ecchymosis

• Skin puckering

• Subcutaneous bone fragment (soft-tissue interposition)

(Indicator of: )

• Significant injury and swelling

• Potential failure of closed reduction



**Neurovascular exam:**

Relatively high rate of neurovascular injuries due to intimate relationship of nerves and artery to displaced fracture fragments

• Neurologic exam can be challenging in injured child but important to document pre-manipulation exam

• Pulseless hand may still be perfused because of excellent collateral circulation in pediatric elbow

**Classification.**

**GARTLANDS CLASSSIFICATION:**

**Type I-------An undisplaced fracture.**

**Type II------An angulated fracture with posterior cortex still in continuity.**

**IIA----A less severe injury with the distal fragment merely angulated.**

**IIB-----A severe injury, the fragment is both angulated and mal-rotated.**

**Type III-------A completely displaced fracture. (Although the posterior periosteum is usually preserved, which will assist surgical reduction).**

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**NOTE.**

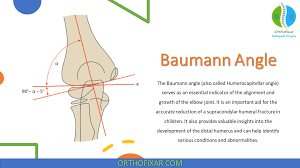
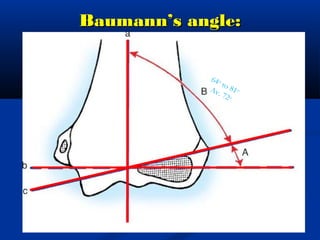
**Feel the pulse and check the capillary return. Wrist and hand should be examined for evidence of nerve injury.**

**IMAGING”:**

**Recommended views are:**

* **Ap & lateral views**

**Measurement of Baumann’s angle is useful in assessing the degree of medial angulation before and after reduction.**

****

**TREATMENT.**

If there is even a suspicion of a fracture the elbow is gently splinted in 30 degrees of flexion to prevent movement and possible neurovascular injury the x-ray examination.

Type I: Undisplaced #

Elbow is immobilized at 90 degrees and a neutral rotation in a light weight splint or cast and arm is supported by a sling. Check x-ray 5-7 days later to check if there is any displacement. Retain the splint for 3 weeks and supervised movement is allowed.

Type IIA: Posteriorly Angulated Fracture-Mild.

Reduce # under local anaesthesia(LA).

Stepwise manoeuvre:

1.Traction for 2-3days in the length of the arm with counter traction above the elbow.

2.Correction of sideways tilt or shift and rotation (in comparison with the other arm).

3.Gradual flexion of the elbow to 120 degrees and pronation of the forearm, while maintaining traction and exerting finger pressure behind the distal fragment to correct posterior tilt. Then fill the pulse and check capillary, immediately relax the amount of elbow flexion until it improves.

Do a check x-ray to confirm appropriate reduction?

Unstable fracture will require open reduction.

TYPES Band III: ANGULATED AND MALROTATED or POSTERIORLY DISPLACED.

Severe swelling

Often unstable

Difficult to reduce

High risks of neurovascular injury

Circulatory compromise due to swelling.

EMERGENCY OPRATION IN THEATRE.

**Indications for operation:**

1.Fracture which cannot be reduced closed.

2.An open fracture(COMPOUND).

3.Fracture associated with vascular damage.

CONTINOUS TRACTION.

Traction through a screw in the olecranon, with the arm held overhead can be used.

TREATMENT OF ANTERIORLY DISPLACED FRACTURE.

This is a rare injury (less than 5% of supracondylar fractures).

>Stable------reduction and a posterior slab is bandaged for 3 weeks.

>Unstable------percutaneous pins are used.

**COMPLICATIONS.**

Early

1.Vascular injury---brachial artery

2.Nerve injury----Radial nerve, median nerve and ulna nerve.

3.Compartment syndrome.

**Late.**

1.Malunion

2.Elbow joint stiffness

3.Myositis ossificans—Rare but it can occur. Formation of bone tissue inside muscle after an injury.

**DISLOCATION OF THE ELBOW JOINT.**

Dislocation of the ulna-humeral joint is fairly common in adults than in children. The injuries are usually classified according to the direction of displacement. However, 90% of cases the radio-ulnar complex is displaced posteriorly or posterior laterally often together with fractures of the restraining bony process.

**MECHANISM OF INJURY AND PATHOLOGY:**

* A fall on the outstretched hand with the elbow in extension.
* Provided there is no associated fracture reduction will usually be stable and recurrent dislocation is unlikely.
* Combination of ligamentous disruption and fracture of the radial head, coranoid process or olecranon process (or worse still several fractures) will render the joint more unstable and liable to re-dislocation.
* Once posterior dislocation has taken place lateral shift may also occur. Soft tissue disruption is often considerable and surrounding nerves and vessels may be damaged.
* High energy injuries do not follow any rules. The so-called side- swipe injury which occur in cases when a car drivers elbow protruding through the window is struck by another vehicle. The result is forward dislocation with fractures of any or all the bones around the elbow, soft tissue damage (including neuro- vascular injury) is usually severe.

**CLINICAL FEATURES:**

1.Pain

2.Patient supports his forearm with the elbow in slight flexion.

3.Obvious deformity

4.Swelling

5.The bony landmarks (olecranon and epicondyles) may be palpable and abnormally placed.

**NOTE.**

Examine for signs of vascular and nerve damage.

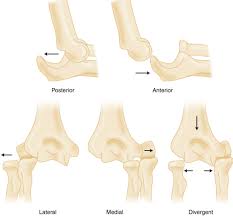
**Imaging:**

X-ray Ap/lateral views to confirm the diagnosis.

**TREATMENT:**

Uncomplicated Dislocation:

* GA
* Reduce-pull the forearm with elbow slightly flexed
* Test for full elbow joint full range movement.
* Check for distal nerves and circulation.
* Arm is held in a collar and cuff with elbow flexed above 90 degrees.
* After one week the patient gently exercises his elbow.
* At 3 weeks the collar and cuff is discarded
* Elbow movements are allowed to return spontaneously and are never forced.

****



* The dislocation should be reduced under anaesthesia as soon as possible
* Reduction is usually easy
* Pull steadily upon the forearm with the elbow semi-flexed, correct any sideways displacement, then apply direct pressure behind the olecranon to push it into the trochlear groove.
* Reduction should be confirmed by radiographic examination and clinical tests.
* Thereafter the elbow should be rested in a backslab cast in 90 degrees of flexion for 2-3 weeks, and thereafter mobilizing exercises.

**DISLOCATION WITH ASSOCIATED FRACTURES.**

Coronoid process.

Coronoid fractures have been classified by Regan and Morrey as:

Type I

Avulsion of the tip. A benign enough injury, but it can represent a substantial soft tissue injury of the elbow.

Type II

A single or comminuted fracture of the coronoid with 50% or less involved. This is usually not repaired surgically as the elbow remains stable.

Type III

A single or comminuted fracture involving more than 50%. If the elbow is unstable after reduction, then fixation is usually needed.

**Medial Epicondyle:**

Reduce and the arm and wrist are splinted with elbow at 90 degrees after 3 weeks’ movements are began under supervision.

**Head of Radius:**

The combination of ligament disruption and a type II or III radial head fracture is unstable injury>Fixation or prosthetic replacement of radial head.

Olecranon:

Open reduction with internal fixation is the best treatment.

**SIDE-SWIPE INJURIES:**

Repair of vascular injury, skeletal stabilization and soft tissue coverage.

Persistent instability:

A hinged external fixator can be applied in order to maintain mobility while the tissue heal.

**Complications:**

**Early.**

**1**.Vascular injury

2.Nerve injury.

**Late.**

**1.**Stiffness

2.Heterotopic ossification (myositis ossificans)

3.Unreduced dislocation

4.Recurrent dislocation

5.Osteoarthritis.

**FRACTURES AROUND THE ELBOW IN CHILDREN:**

Most of these injuries are supracondylar fractures. Boys are injured more than girls and more than half of the patients are under the age of 10 years old.

A fall directly on the point of the elbow or more often onto the outstretched hand with the elbow forced into valgus or Varus. Pain and swelling are often marked and examination is difficult. X-ray interpretation also has problems: The bone ends are largely cartilaginous and therefore radiographically incompletely visualized. A good knowledge of the normal anatomy is essential. If fracture displacements are to be recognized.

**POINTS OF ANATOMY:**

* The elbow is a complex hinge-wide ranges of flexion, extension and rotation, yet also enough stability to support the necessary pushing, pulling and carrying activities of the daily life.
* Liable to be compromised by any break in the articulating structures.
* The surrounding soft tissue structures also are important, especially the capsular and collateral ligaments and to a lesser extent the muscles. Ligament disruption is also therefore a destabilizing factor.
* Always compare the injured limb with the normal one.
* Epiphyses and ossific centers should not be mistaken for fracture fragments on the x-rays.
* The average ages at which the ossific centers appear are easily remembered by the

**MNEMONIC:(**different authors give different yrs of ossification{1-11

* C-capitulum(1yr)
* R-radial head (3yrs)
* I-internal (medial epicondyle)5yrs
* T-trochlea(7yrs)
* O-olecranon(9yrs)
* E-external (lateral epicondyle) 11yrs

Obviously epiphyseal displacements will not be detected on X-ray before these ages.

**FRACTURE HEAD & NECK RADIUS:**

Radial head fractures are common in adults but are hardly ever seen in children (probably because the proximal radius is mainly (cartilaginous) whereas radial neck fractures occur in children more frequently.

**Mechanism of injury:**

**1.**Can occur during elbow dislocation.

2.A fall on the outstretched hand with elbow extended and forearm pronated, causes impaction of the radial head against the capitulum**.**

**Clinical features:**

**1.**Pain on pronation and supination.

2.Tenderness on pressure over the radial head.

3.Swelling.

**Classification:**

**By Mason.**

1. Type I-An undisplaced vertical split in the radial head.
2. Type II-A displaced single fragment of the head.
3. Type III-The head broken into several fragments(comminuted).
4. Type IV-Fractures with elbow dislocation.

****

**Imaging:**

X-ray PA/Lateral views.

Ct-scan in complicated fractures requiring operative management

**Treatment.**

Type I.

* Relief pain
* Aspiration of haematoma under local anaesthesia(LA)
* Arm is held in a collar and cuff for 3 weeks

Prognosis is good.

Type II

Reduction and use of one or two small headless screws.

Type III

Reconstruction with small headless screws or replaced with a metal spacer.

Assess always for an associated soft tissue injury.

I)Rupture of the medial collateral ligament.

II)Rupture of the interosseous membrane (ESSEX LOPRESTI LESION).

III)Combined fractures of the radial head and coronoid process plus dislocation of the elbow>the terrible triad.

**Complications:**

**1.**Joint stiffness

2.Myositis ossificans

3.Recurrent instability of the elbow.

**FRACTURE OF THE RADIAL NECK.**

In adults a displaced fracture of the radial neck may need open reduction. A mini-plate can be applied, making sure not to damage the articular surface. An alternative is to use oblique headless screws.

There are 3 main types:

1. A chisel like split of neck.
2. A marginal fracture.
3. A comminuted fracture.

****

**FRACTURES OF THE OLECRANON:**

**MECHANISMS OF INJURY:**

* The olecranon is fractured by a fall onto the point of the elbow, especially in adults.
* Olecranon fractures typically involve the articular surface of the elbow.
* The triceps muscle inserts onto the olecranon, blending with the periosteum.
* A displaced fracture interrupts the extensor mechanism resulting in loss of active elbow extension.
* The pull from the triceps is the key deforming force, pulling the separated fragment superiorly.
* Greater displacement suggests tearing of the fibrous sheath over the olecranon.

**CLASSIFICATION:**

* The fracture may take three forms:
  1. A **crack** without displacement
  2. A **clean break with separation** of the two fragments
  3. A **comminuted** fracture

**Two broad types of injury are seen;**

**1.** a comminuted fracture which is due to a direct blow or a fall on the elbow.

2. a transverse break due to traction when the patient falls onto the hand while the triceps muscle is contracted.

The two types above can further be classified as>a) displaced and b) undisplaced fracture

****

**Clinical features:**

**1.**Pain

2.Bruise over the elbow.

3.Palpable gap at the fracture site.

4.Patient unable to extend the elbow against resistance.

**Investigation.**

**x-ray**

**AP**

**Lateral view shows the details of the fracture.**

**TREATMENT.**

**1.Rest the arm in a sling for a week.**

**2.Active movements when the pain subsides.**

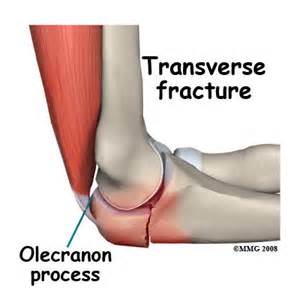
**3.Check x-ray after 2 weeks to ascertain healing.**

**4.Closed immobilization by a cast in about 60 degrees of flexion for 2-3 weeks then exercises are begun.**

**5.Operative treatment for displaced fractures.**

**6.Early mobilization is important to avoid joint stiffness.**

* Depends upon the type of fracture as above:
* **Crack fracture:**
  + The only treatment necessary is to protect the elbow by a light plaster splint for 2 or 3 weeks.
  + The plaster should be applied with the elbow held at 90 degrees. There is no fear of distracting the fragments as they are held together by the surrounding aponeurosis.
* **Clean break with separation:**
  + It is hard to gain and hold perfect reduction by closed methods because the action of the triceps will angulate and distract the fragments.
  + Open reduction and internal fixation is the preferred choice of treatment.
  + The fragments are exposed and fitted together accurately under direct vision, ensuring that the articular surface of the trochlear notch is perfectly smooth.
* **Clean fracture with separation…**
  + Rigid fixation is attained by a **long coarse-threaded cancellous screw** passed down the bone from the upper surface of the olecranon.
  + Fixation can also be done by **short stiff parallel K-wires** driven vertically across the fracture, combined with **a tensed figure-of-eight loop of wire** (tension band wiring)
  + It may be advisable to protect the elbow in plaster for two weeks before mobilizing exercises are begun.
* **Comminuted fracture:**
  + Perfect placement and fixation of the multiple fragments is not usually possible.
  + The usual treatment is therefore to **excise the olecranon fragments** by dissecting them out from the aponeurosis, then securing the triceps to the stump of the ulna by strong sutures passed through drill holes in the bone.
  + The elbow is then protected in a plaster for 3 weeks, followed by mobilization by active exercises

**Transverse fracture fixation with screw and tension and wiring**

**COMPLICATIONS.**

**1.**Stiffness

2.Non-union

3.Damage to ulna nerve.

4. Osteoarthritis as a late complication.

**FRACTURES OF FOREARM BONES (ULNA & RADIUS):**

**This covers the following:**

1. Monteggia fracture-dislocation
2. Galeazzi fracture-dislocation
3. Fractures shafts of radius and ulna
4. Colle’s fracture Smith’s fracture

**MONTEGGIA FRACTURE -DISLOCATION:**

* It is fracture of proximal third of the ulna associated with dislocation of the radial head
* It is named after **Giovanni Battista Monteggia**

**MECHANISMS OF INJURY**

1. Forced pronation of the forearm
2. Direct blow on the back of upper forearm, as a person warding off an assault

* The radial head may dislocate anteriorly, laterally or posteriorly

**Clinical features:**

* Pain on the forearm
* Swelling
* Inability to supinate and pronate the foream
* Deformity

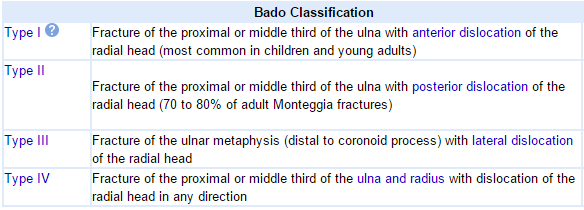
**Investigations**

**X-RAYS( A/P and lateral views)**

* Reveal the fracture of ulna and the dislocation of radial head

**Classsification by Bado:**



**TREATMENT:**

1. Closed reduction by manipulation under G/A, then immobilize with an above elbow POP with the elbow joint at 90° for 6 weeks in adults and 4 weeks in children

* Closed reduction succeeds in children but it’s liable to fail in adults

2. Open reduction with internal fixation using plate and screws is the method of choice in

Adults.

**OPERATIVE MANAGEMENT:**

* **ORIF of ulna shaft fracture**
  + indications
    - acute fractures which are open or unstable (long oblique)
    - comminuted fractures
    - most Monteggia fractures in adults are treated surgically
* **ORIF of ulna shaft fracture, open reduction of radial head**
  + indications
    - failure to reduce radial head with ORIF of ulnar shaft only
      * ensure ulnar reduction is correct
    - complex injury pattern
* **IM Nailing of ulna**
  + indications
    - transverse or short oblique fracture

**COMPLICATIONS:**

1. Delayed union
2. Non union
3. Stiffness of the elbow joint
4. Osteoarthritis of radio-humeral joint
5. PIN neuropathy
   1. up to 10% in acute injuries

**treatment**

* + - observation for 2-3 months
      1. spontaneously resolves in most cases
      2. if no improvement obtain nerve conduction studies

1. Malunion with radial head dislocation
   1. usually caused by failure to obtain anatomic alignment of ulna

**treatment**

* ulnar osteotomy and open reduction of the radial head

**GALEAZZI FRACTURE – DISLOCATION:**

* It is fracture of shaft of radius(junction between mid and lower third) with dislocation of inferior radio-ulna joint
* It is named after **Ricardo Galeazzi**

**MECHANISM OF INJURY**

1. Fall on outstretched hand with the elbow flexed
2. Direct blow

* The head of ulna may be shifted medially, anteriorly or posteriorly

**CLINICAL FEATURES:**

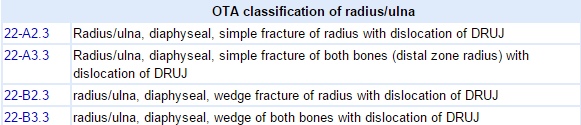
* Pain on the forearm
* Swelling
* Inability to pronate and supinate the forearm due to pain at the inferior radio-ulna joint
* Deformity
* Tenderness

**INVESTIGATION**

**X-RAY(A/P and lateral views)**

* Reveals the fracture of radius and dislocation of inferior radio-ulna joint





**TRATMENT:**

1. Closed reduction by manipulation under G/A, then immobilize with an above elbow POP with the elbow joint at 90° with the forearm supinated for 6 weeks in adults and 4 weeks in children

* Closed reduction succeeds in children but is liable to fail in adults

2.Open reduction with internal fixation using

plate and screws- It is the method of choice in

adults

**OPERATIVE MANAGEMENT:**

* **ORIF of radius with reduction and stabilization of DRUJ**
  + indications
    - all cases, as anatomic reduction of DRUJ is required
    - acute operative treatment far superior to late reconstruction

**COMPLICATIONS:**

1. Delayed union
2. Nonunion- occurs due to inadequate reduction
3. Stiffness of wrist and elbow joints
4. Osteoarthritis of inferior radio-ulna joint
5. Compartment syndrome: high energy crush injury, open fractures, vascular injuries or coagulopathies
6. Neurovascular injury
7. Refracture: removing plate too early (minimum 18 months), large plates (4.5mm), comminuted fractures, persistent radiographic lucency
8. Malunion
9. DRUJ subluxation

**COLLE”S FRACTURE:**

* It was described by **Professor Abraham Colle’s** in 1842
* It is fracture of the lower end of radius, about 2cm above the wrist joint associated with the following features:
* Impaction of fracture fragments
* Dorsal displacement of distal fragment
* Radial(lateral) displacement of distal fragment
* Backward angulation of distal fragment
* Supination of the forearm
* ± Avulsion fracture of Styloid process of the ulna

**INCIDENCE**

* It is rare below the age of 40 years
* It’s common in elderly particularly in postmenopausal women, attributed to osteoporosis

**MECHANISM OF INJURY**

* The fracture is most commonly caused by a fall onto a hard surface and breaking the fall with the outstretched hand in pronation.
* Colles’ fracture usually occurs about one inch proximal to the radio-carpal joint with **posterior** and **lateral displacement** of the distal fragment resulting in the characteristic **"dinner fork"** or "bayonet" like deformity.
* Colles' fracture is a common fracture in people with **osteoporosis**, second only to vertebral fractures.

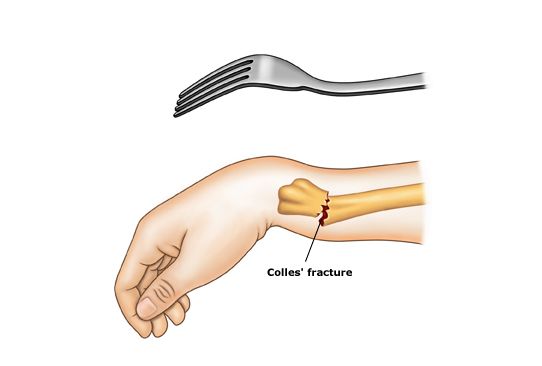
**CHARACTERISTIC FEATURES:**

* The classic Colles’ fracture has the following characteristics:
  + Transverse fracture of the distal radius
  + 2.5 cm (1 inch) proximal to the radio-carpal joint
  + Dorsal displacement/ tilt
  + Dorsal angulation
  + Radial tilt
  + Radial shortening
  + Loss of ulnar inclination
  + Radial angulation of the wrist
  + Dorsal displacement of the distal fragment
  + Comminution at the fracture site
  + Associated fracture of the ulnar styloid process in more than 60% of cases.

**CLINICAL PRESENTATION:**

* History of fall on an outstretched hand
* Pain, numbness, tenderness, bruising, deformity of wrist.
* "Dinner Fork" Deformity
* Swelling of the wrist
* Increased angulation of the distal radius
* Inability to grasp objects
* Inability to move the wrist joint

**DEFORMITY (DINNER FORK IN COLLES #)**



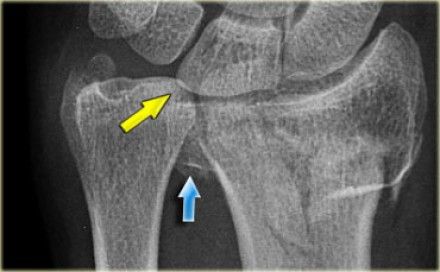


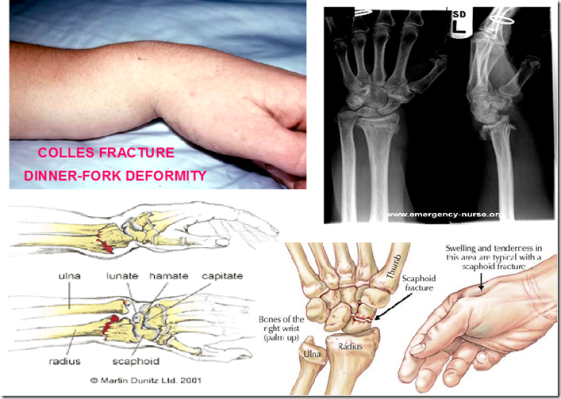
**INVESTIGATIONS:**

**X-RAYS(A/P and lateral views)**

* Reveals the fracture, type and extent of displacement

COLLES FRACTURE





**TREATMENT:**

* Management depends on the severity of the fracture.
* An undisplaced fracture is treated with a below elbow cast alone.
* The cast is applied with the distal fragment in **palmar flexion** and **ulnar deviation**.
* The cast is retained for **six** **weeks**.
* A fracture with mild angulation and displacement requires reduction by closed manipulation, followed by immobilization with a below elbow cast for six weeks.

1. **Closed reduction by manipulation under G/A**

**Technique**

* The hand is grasped and traction is applied in the length of the bone
* The distal fragment is then pushed into place by pressing on the dorsum while manipulating the wrist into flexion, ulnar deviation and pronation
* Request an check X-ray to confirm reduction

Apply a below elbow POP for 6 WEEKS



**COMPLICATIONS:**

* Patients frequently heal well with no complications.
* Possible complications include:
  + Malunion with dinner-fork deformity
  + Persistent translation of the carpus
  + Shortening of radius
  + Stiffness of the wrist
  + Carpal tunnel syndrome (due to median nerve compression)
  + Suddeck's atrophy (reflex sympathetic dystrophy)
  + Ulnar and radial compression neuropathy

**1.Compression of median nerve-** presents with numbness of the fingers.{1,2,3 &small portion of 4.

* If symptoms are marked (**Neuroplaxia**/mildest form of traumatic peripheral nerve injury); open reduction to free the nerve is indicated

2. **Reflex sympathetic dystrophy/ Sudeck’s post traumatic osteodystrophy**

* It is a poorly understood condition, thought to occur as result of disturbance of centrally mediated autonomic regulation with consequent increased stimulation of sympathetic and motor efferent fibres
* Presents with painful, swollen and stiff fingers

**Treatment**

* Physiotherapy
* Intravenous blockade with **guanethidine sulphate** for refractory symptoms

**Weakness of the wrist joint**

**Delayed rupture of extensor policis longus tendon-**

Caused either by the fracture or POP.

Usual time between the time the fracture

occurred and the rupture is 4-8 weeks

* Presents with inability to actively extend the thumb
* Treatment is by tendon transfer of extensor indicis

**Subluxation of distal radio-ulna joint**

* Presents with impaired wrist movements especially adduction (ulna deviation) and rotation

**Treatment**

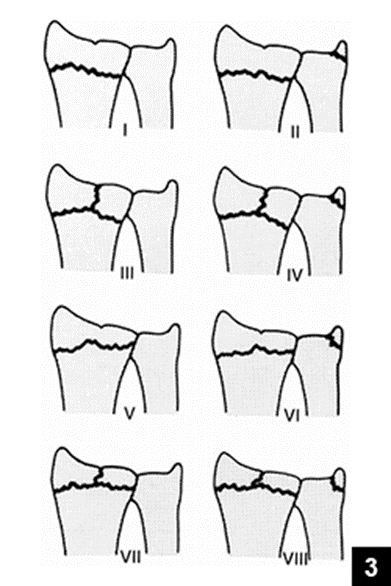
* Minor cases- observation and follow up
* Troublesome cases- **Darroch’s operation** i.e., excision of the lower end of the ulna

CLASSIFICATION:

**Frykman Classification**

Colles’s fracture can be classified into eight different types based on the extra- or intra-articular nature of fractures.

* **Type I**: transverse metaphyseal fracture. (Includes both Colles and Smith fractures as angulation is not a feature)
* **Type II**: type I + ulnar styloid fracture
* **Type III**: fracture involves the radiocarpal joint
  + includes both Barton and reverse Barton fractures
  + **Type IV:** type III + ulnar styloid fracture
  + **Type V**: transverse fracture involves distal radioulnar joint
  + **Type VI**: type V + ulnar styloid fracture
  + **Type VII**: comminuted fracture with the involvement of both the radiocarpal and radioulnar joints
  + **Type VIII**: type VII + ulnar styloid fracture

X

**SMITHS FRACTURE:**

Fracture of the distal radius with anterior displacement. Also called reverse Colles’ fracture.

It is caused by a fall on the back of the hand with the wrist flexed.

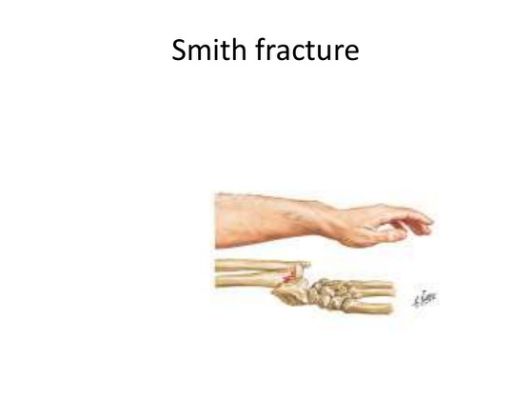
* It is a fracture of distal radius with features opposite those of Colle’s fracture i.e., the distal fragment is displaced forward and rotated forward
* It a rare fracture

**MECHANISMS OF INJURY**

1. Backward fall of an outstretched hand
2. Fall on the dorsum of the hand in a flexed wrist joint

**Clinical features:**

* Pain on the wrist joint
* Swelling around the wrist joint
* Inability to move the wrist joint
* Instead, there is a ‘garden spade’ deformity.



**INVESTIGATION:**

**X-RAYS(A/P and lateral views)**

* Reveals the fracture and the degree of displacement
* There is a fracture through the distal radial metaphysis.
* A lateral view shows the distal fragment displaced and tilted anteriorly – the opposite of Colles’ fracture.
* The entire metaphysis can be fractured or there can be an oblique fracture exiting at the dorsal or volar rim of the radius.



**TREATMENT:**

* The fracture is reduced by **traction**, **supination** and **extension** of the wrist, and the forearm is immobilized in a cast for 6 weeks.
* Check X-rays should be taken after 7-10 days to ensure the fracture has not re-displaced.
* Unstable fractures should be fixed with percutaneous wires or a plate.

1. Closed reduction by manipulation under G/A

* Technique is the reverse of that of Colle’s fracture
* Then immobilize with a below elbow POP with the forearm in supination for 6 weeks

2) Open reduction with internal fixation using

a **Buttress plate**

**Indications:**

1. Severely displaced fractures
2. Pressure to radial artery

**Complications:**

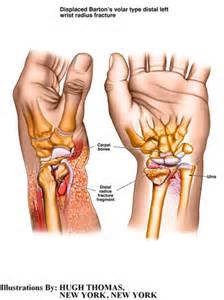
1. Pressure to radial artery
2. Malunion
3. Stiffness of the wrist and fingers
4. Weakness of the wrist joint

**BARTONS FRACTURE:**

Intra-articular fracture of the distal radius.

* A **Barton's fracture** is an intra-articular fracture of the distal radius with subluxation or dislocation of the radiocarpal joint.
* There exist two types of Barton's fracture - **dorsal** and **palmar**, the latter being more common.
* Barton's fracture is caused by a fall on an **extended** and **pronated** wrist increasing carpal compression force on the dorsal rim.
* Intra-articular component distinguishes this fracture from a Smith's or a Colles' fracture.
* Treatment of this fracture is usually done by open reduction and internal fixation with a plate and screws.
* Occasionally the fracture can be treated conservatively, but it easily gets re-displaced.

****

**DIFFERENTIAL DIAGNOSIS:**

* Colles’s fracture
* Smith’s fracture
* Die-punch fracture-is a fracture of articular surface of the radius with depression of lunate facet.
* The chauffer’s #-avulsion fracture of radial styloid process

**Complications:**

* Carpal tunnel syndrome
* Radial nerve compression
* Complex regional pain
* Post traumatic arthritis
* Malunion

**WRIST & HAND FRACTURES.**

**classification**

* Injuries of the carpus
  + Fracture of the scaphoid bone
  + Fracture of other carpal bones
  + Dislocation of the carpal bones
* Injuries of the metacarpal bones and phalanges
  + Fracture of the base of the first metacarpal
  + Other fractures of the metacarpal bones
  + Fractures of the phalanges
  + Dislocations of the metacarpo-phalangeal and interphalangeal joints

Strain of the interphalangeal joints

**Fractures of scaphoid bone:**

**Scaphoid fractures account for about 75% of all carpal injuries.**

* Fracture of the scaphoid bone is common in young adults.
* The scaphoid lies obliquely across the two rows of carpal bones, and is also in the line of loading between the thumb and forearm.

**Mechanisms of injury:**

* Violent hyperextension of the wrist will crack the waist of the scaphoid across its narrowest point.
* The fracture nearly always occurs transversely through the middle, or waist, of the scaphoid.
* The usual cause is a fall onto the outstretched hand.

**Pathology:**

* Most scaphoid fractures are stable. Usually there is no displacement of the fragments, which lie in close apposition.
* If displacement occurs and is allowed to persist, it causes a ‘step’ between the fracture fragments and favors the development of degenerative arthritis.

Problems associated with fracture scaphoid:

* There are very few reliable clinical signs
* The fracture can go on to non-union if it is not immobilized
* It is not easily seen on initial radiographs, even if several views are taken
* Because the blood supply to the proximal pole of the bone enters by the distal pole in most people, the proximal fragment can become devitalized and undergo avascular necrosis.



**Clinical features:**

* There is no deformity, crepitus or bruising around a fractured scaphoid.
* The appearance may be deceptively normal
* Features include:
  + Swelling (fullness) in the anatomical snuff box
  + Tenderness in the anatomical snuff box
  + Weakness of pinch
  + Pain on hyperextension of the wrist /thumb
  + Pain on proximal pressure along the axis of the thumb

**x-ray findings:**

* Antero-posterior, lateral and oblique views are all essential.
* A fresh fracture may be seen only in the oblique view
* Usually, the fracture line is transverse and through the narrowest part (waist)of the bone
* Sometimes only the tubercle of the scaphoid is fractured.
* When the clinical features suggest fracture of the scaphoid bone but the initial radiographs give no confirmation of it, radiographic examination should be repeated after an interval of two weeks.
* A fracture may sometimes become obvious after an interval even though it was not apparent in the initial films.

In the interval it is advisable to support the injured wrist in a plaster.

**Treatment:**

* The fracture is immobilized in a cast for 8-12 weeks [2-3 months].
* Since there is usually no displacement, reduction is not required.
* The plaster used for scaphoid fracture is slightly more extensive than that used for a fracture of the lower end of the radius.
* It should extend down the thumb to the level of the interphalangeal joint and it must be moulded firmly round the first metacarpal bone.
* The palm is left free beyond the proximal skin crease to allow a full range of movement at the metacarpophalangeal joints of fingers, and the thumb should be free to move at the interphalangeal joint.
* The cast must hold the thumb roughly opposite the ring finger and not in wide abduction because this interferes with function and could displace the fragments.
* If the fracture is not united by 12 weeks, internal fixation (by a special compression screw [Herbert]) and grafting should be done.

**Scaphoid cast**:



**Complications:**

* Avascular necrosis
* Delayed union
* Non-union
* Osteoarthritis of the wrist

**Delayed union:**

* Is common
* May still be un-united 4-6 months after injury

**Treatment:**

* + If union has not occurred within 4 months despite continuous rest in plaster, the plaster should be removed, and mobilizing exercises started.
  + If the wrist remains uncomfortable and much restricted in function, operation should be done.
  + Fixation with a special compression screw with cancellous bone graft.

**Non-union:**

* Could be due to: -
* Imperfect immobilization
* Action of synovial fluid hindering the formation of an initial fibrinous bridge between the fragments
* Impairment of blood supply to one of the fragments
* Avascular necrosis of the proximal fragment

**Treatment:**

* + Internal fixation by a compression screw and cancellous bone graft.

**Avascular necrosis of the proximal fragment:**

* The blood supply to the proximal fragment is interrupted by fracture through the waist of the scaphoid because the main nutrient vessels enter the bone through the distal half of the bone.
* If the remaining blood supply is inadequate, the proximal fragment may die.
* Avascular necrosis may be diagnosed from the radiographic appearance, because the avascular bone does not share in the general disuse osteoporosis of the carpal bones, and it therefore **stands in sharp contrast** to the other bones by virtue of its relatively **greater density**. This appearance manifests about 1-3 months after injury.

**Treatment:**

Once arthritic changes develop no treatment can restore the wrist to normal.

**Osteoarthritis:**

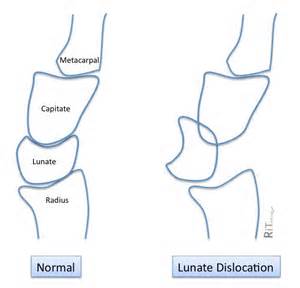
* + Occurs due to non-union or avascular necrosis

Treatment:

* + Often unsatisfactory
    - Protective wrist support
    - Arthrodesis of the wrist

**DISLOCATION OF LUNATE BONE:**

* The lunate is liable to dislocation through **a fall onto the hand**.
* The lunate bone is somewhat wedge-shaped with its base anteriorly, and with the hand extended in a fall, the bone may be **squeezed out from between the capitate bone and the radius**.
* The displacement in a **lateral radiograph** is characteristic: the lunate bone **lies at the front of the wrist** and is rotated through 90 degrees or more on a horizontal axis so that **its concave lower articular surface faces forwards**.
* For it to dislocate to that position, its **posterior ligamentous attachments** must be **torn**, so that it hinges on the anterior ligaments.



**Treatment:**

* Attempt **closed manipulative reduction** of the dislocation under anaesthesia.
* **Strong traction** is first applied to the **hand** to open up the space for the lunate bone.
* **Direct pressure** is then applied over the displaced bone and it may **pop back into position**.
* The position should then be stabilized with percutaneous **Kirschner wires**, then immobilized by cast to avoid redisplacement.
* The cast and wires are retained for 4 weeks before active mobilizing exercises are begun.

**Treatment…**

* If manipulation is unsuccessful, the bone should be replaced (repositioned/ reduced) at **operation**, and the carpus stabilized with Kirschner wires
* In old neglected cases, it may be necessary to **excise** the bone rather than attempt to replace it.

**Complication of lunate dislocation:**

**Avascular necrosis:**

* The blood supply of the displaced lunate is precarious because many of the soft **tissue attachments are torn**.
* There is therefore, risk of **avascular necrosis**.
* Signs of avascular necrosis may appear within 1-4 months.

X-rays [or MRI scanning] should be taken at 2-monthly intervals to observe the condition of the lunate bone after reduction of the dislocation

**Osteoarthritis:**

* Will occur inevitably if the lunate bone is avascular and it is not excised.
* Treatment should be conservative at first – leather or plastic wrist support
* If the disability becomes severe, the only satisfactory treatment is by **arthrodesis** of the wrist.

**Injury to the median nerve:**

* The **median nerve** can be **injured** from **direct pressure of the displaced bone**. It is liable to be trapped between the displaced lunate bone and the flexor retinaculum.
* If nerve injury occurs, the nerve must be **decompressed** as soon as possible by reduction of the lunate dislocation.
* At the same time the **flexor retinaculum** should be **divided** to decompress the carpal tunnel.

**FRACTURE METACARPAL:**

**Base 1 metacarpal #**

* A fracture of the base of the first metacarpal bone is usually sustained from **forced abduction of the thumb**, or **longitudinal violence** applied by a blow, as in **boxing**.
* Clinically there is local **tenderness** **distal to the anatomical snuff box**, unlike a scaphoid fracture, and this may be accompanied by deformity.

PATHOLOGY:

* There are 2 distinct types of this injury:
  1. A **transverse** or short oblique fracture across the base of the metacarpal, but not entering the joint
  2. An **oblique** fracture entering the carpo-metacarpal joint at about the middle of the articular surface (**Bennett’s fracture-subluxation**).
* The second type is the more serious, because unless a smooth surface can be restored, **osteoarthritis** will develop later.
* When the fracture is oblique there is a tendency for the large distal fragment to be displaced backwards and upwards upon the small proximal fragment due to the pull of the abductor pollicis longus tendon.

**BENNETTE #**



TREATMENT:

* Manipulative reduction under anaesthesia.
* Often difficult to maintain the reduction in the oblique Bennett fracture.
* A **well-moulded cast** should be applied (including the forearm and wrist), holding the thumb metacarpal well extended at the carpo-metacarpal joint.
* **Check radiographs** are taken twice during the first week to determine whether a good position has been maintained.
* **Reduction** should be **accurate** for fractures involving the joint.
* Therefore, **operation** is advised in the majority of intra-articular fractures.

Open reduction and internal fixation of the fragments with a small **screw**

* An alternative method is to use **percutaneous Kirschner wire** after the fracture is first reduced by traction combined with thumb pressure against the displaced base of the metacarpal.
* The K-wire is driven obliquely through the base of the metacarpal into the trapezium.
* After fixation by either method **a well-fitting cast** should be retained for 4-6 weeks.

**COMPLICATION:**

* Osteoarthritis:
  + Likely to follow intra-articular fractures that have left the joint surface irregular.

**OTHER METACARPAL FRACTURES:**

* Are fairly common at all ages
* The most common causes are a fall onto the hand or a blow on the knuckles as in boxing.

**CLASSSIFICATION:**

* May be classified according to site:
  + **Fracture through the base of the metacarpal** – transverse and undisplaced
  + **Fracture through the shaft** – transverse or oblique.
    - A transverse fracture may be undisplaced, or may be displaced with overlap of fragments
    - An oblique fracture tends to allow telescoping with consequent shortening and recession of the knuckle.
  + **Fracture through the neck of the metacarpal** – may be undisplaced.



**TREATMENT:**

* Depends upon the degree of displacement.

**Undisplaced fractures:**

* Includes fractures with acceptable displacement
* The position is stable
* Sound union and perfect recovery of function may be expected without treatment.
* Provide temporary support to relieve pain and apprehension.
  + Apply a light dorsal plaster slab for 3 weeks.
  + Finger movements and active use should be encouraged from the beginning.

**Displaced fractures:**

* Reduction of the displacement and maintenance of the reduction are required.
* May require manual reduction and external splintage or operation, depending on the nature of the individual fracture.
* Loss of end-to-end apposition of transverse #s may result in overlap and necessitate open reduction with intramedullary wire or miniature plate fixation.
* Long oblique fractures may require transfixion wire of small fragment screws.

**FRACTURES OF THE PHALANGES:**

* May be of various patterns:
  1. Long spiral fracture of shaft
  2. Oblique fracture of base
  3. Transverse fracture of shaft
  4. Comminuted fracture of distal phalanx
  5. Mallet finger from avulsion fracture of base of distal phalanx

**TREATMENT:**

* Immobilization should be kept to a minimum
* Nearly all phalangeal fractures proceed to bony union whether they are splinted or not.
* The main purposes of splintage are:
  + To prevent redisplacement of fractures that have been reduced
  + To relieve pain

Splintage is maintained for 2-3 weeks

**Undisplaced fractures of the shaft**

* The fragments are held together with periosteal sheath.
* There is no fear of displacement.
* Treatment is directed towards relief of pain
* Bind the phalanges of the injured finger lightly to the corresponding segments of an adjacent normal finger with adhesive strapping.
* The sound finger thus acts as support to the injured one – ‘**buddy splintage**’.

**Displaced fractures and fractures involving joint surfaces**

* Reduce the displacement by manipulation, and hold the position by a **malleable splint**.
* Immobilize for not more than 3 weeks.
* Start active exercises
* If displacement cannot be controlled by splintage, operation may be required.
* The fragments may be held in position by **Kirschner wires** inserted **percutaneously** after manipulation, or after **open reduction.**

**Comminuted fracture of distal phalanx**

* The pulp or nail bed may be torn, and the nail may often separate.
* The fracture should be **ignored** and attention directed solely to the **soft tissue injury**.

**MALLET FINGER: (BASEBALL FINGER #)**

* Is caused by **sudden passive flexion** of the **distal interphalangeal join**t, as in a ball striking the tip of the finger, **rupturing** the **extensor tendon** at the point of its insertion into the base of the distal phalanx.
* Sometimes a fragment of bone is avulsed from the phalanx.
* The distal interphalangeal joint **rests in moderate flexion** and **cannot be actively extended**.
* There is tenderness over the site of avulsion.



**TREATMENT:**

* Tendon avulsion, with or without a small bone fragment, is treated by **uninterrupted splintage** in the **fully straight position for 6 weeks**.
* Immobilization is confined to the **distal interphalangeal joints**, the proximal joint being left free.
* Larger avulsed fragment that is displaced may be reduced at operation and held in position by a K-wire passed through the distal phalanx and the reduced fragment, and across the joint to hold it fully extended.

**MALLET FINGER SPLINT:**



**DISLOCATION OF METACARPO-PHALANGEAL & INTERPHALANGEAL JOINTS:**

**MECHANISMS OF INJURY:**

* Most dislocation of finger and thumb joints are caused by **forced hyperextension**.
* The **distal segment** is usually **displaced backwards** from the proximal.

**TREATMENT:**

* The dislocation should be **reduced promptly**.
* Reduction is effected easily by **pulling upon the digit** and applying **direct pressure** over the **base of the displaced phalanx**.
* Can often be done without anaesthesia.
* Radiographs should be taken to check the reduction.
* Immobilization is not required, and **active movements** of the joint should be encouraged from an early stage.

**‘Button-hole’ injuries**

* Sometimes in metacarpo-phalangeal dislocations the head of the metacarpal bone is driven forwards through a rent in the front of the capsule at the same time as the phalanx is dislocated backwards.
* In this case manipulative reduction may be impossible and operation is required.
* The capsular slit is enlarged sufficiently to allow it to be hooked back over the metacarpal head.

**FRACTURES OF THE PELVIC RING:**

* Pelvic ring fractures are high energy fractures of the pelvic ring which typically occur due to blunt trauma or mva.
* Diagnosis is made radiographically with pelvic radiographs and further characterized with CT scan.
* Treatment is typically operative fixation depending on degree of pelvis instability, fracture displacement and patient activity demands.

**ETIOLOGY**

* Associated injuries
  + orthopaedics
    - chest injury in up to 63%
    - long bone fractures in 50%
    - spine fractures in 25%
  + non-orthopaedic
    - urogenital
      * sexual dysfunction up to 50%

* + - head and abdominal injury in 40%
* Pediatric pelvic ring fractures
  + children with open triradiate cartilage have different fracture patterns than do children whose triradiate cartilage has closed
    - if triradiate cartilage is open the iliac wing is weaker than the elastic pelvic ligaments, resulting in bone failure before pelvic ring disruption
    - for this reason fractures usually involve the pubic rami and iliac wings and rarely require surgical treatment
* **ANATOMY**
  + Osteology
    - ring structure made up of the sacrum and two innominate bones
    - stability dependent on strong surrounding ligamentous structures
    - displacement can only occur with disruption of the ring in two places
    - neurovascular structures intimately associated with posterior pelvic ligaments
      * high index of suspicion for injury of internal iliac vessels or lumbosacral plexus
  + Ligaments
    - anterior
      * symphyseal ligaments
        + resist external rotation
    - pelvic floor
      * sacrospinous ligaments
        + resist external rotation
      * sacrotuberous ligaments
        + resist shear and flexion
    - posterior sacroiliac complex (posterior tension band)
      * strongest ligaments in the body
      * more important than anterior structures for pelvic ring stability
      * anterior sacroiliac ligaments
        + resist external rotation after failure of pelvic floor and anterior structures
      * interosseous sacroiliac
        + resist anterior-posterior translation of pelvis
      * posterior sacroiliac
        + resist cephalad-caudad displacement of pelvis
      * iliolumbar
        + resist rotation and augment posterior SI ligaments
  + Vascular
    - common iliac system begins near L4 at bifurcation of abdominal aorta
      * external iliac artery courses anteriorly along pelvic brim and emerges as the common femoral artery distal to the inguinal ligament
      * internal iliac artery dives posteriorly near SI joint and divides in the posterior division (giving of superior gluteal artery) and anterior division (becoming obturator artery)
    - corona mortis is a connection between the obturator and external iliac systems
      * mean distance of 6.2cm from the pubic symphysis
    - venous plexus in posterior pelvis accounts for 90% of the hemorrhage associated with pelvic ring injuries
  + Neurologic
    - Lumbosacral trunk crosses anterior sacral ala and SI joint
    - L5 nerve root exits below L5 TP a courses over sacral ala 2cm medial to SI joint

**INCIDENCE:**

* high energy blunt trauma
* High mortality rate: 15-25% for closed fractures, 50% for open fractures
* In paediatrics triradiate cartilage is open the iliac wing is weaker than the elastic pelvic ligaments, resulting in bone failure before pelvic ring disruption

**ASSOCIATED INJURIES:**

* chest injury in up to 63%
* long bone fractures in 50%
* sexual dysfunction up to 50%
* head and abdominal injury in 40%
* spine fractures in 25%
* **PHYSICAL EXAM**
  + Symptoms
    - pain & inability to bear weight
  + Physical exam
    - inspection
      * test stability by placing gentle rotational force on each iliac crest
        + low sensitivity for detecting instability
        + perform only once
      * look for abnormal lower extremity positioning
        + external rotation of one or both extremities
        + limb-length discrepancy
    - skin
      * scrotal, labial or perineal hematoma, swelling or ecchymosis
      * flank hematoma
      * lacerations of perineum
      * degloving injuries (Morel-Lavallee lesion)
    - neurologic exam
      * rule out lumbosacral plexus injuries (L5 and S1 are most common)
      * rectal exam to evaluate sphincter tone and perirectal sensation
      * up to 10-15% of patients will sustain neurologic injury
    - urogenital exam
      * most common finding is gross hematuria
      * more common in males (21% in males, 8% in females)
    - vaginal and rectal examinations
      * mandatory to rule out occult open fracture(HIDDEN)

**RADIOLOGICAL EXAMINATION:**

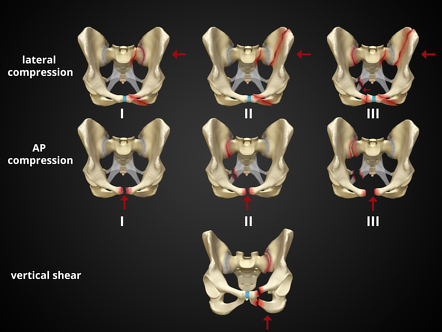
* AP Pelvis
  + part of initial ATLS evaluation
  + look for asymmetry, rotation or displacement of each hemipelvis
  + evidence of anterior ring injury needs further imaging
* inlet view
  + X-ray beam angled ~45 degrees caudad (may be as little as 25 degrees)
    - adequate image when S1 overlaps S2 body
  + ideal for visualizing:
    - anterior or posterior translation of the hemipelvis
    - internal or external rotation of the hemipelvis
    - widening of the SI joint
    - sacral ala impaction
* outlet view
  + X-ray beam angled ~45 degrees cephalad (may be as much as 60 degrees)
    - adequate image when pubic symphysis overlies S2 body
  + ideal for visualizing:
    - vertical translation of the hemipelvis
    - flexion/extension of the hemipelvis
    - disruption of sacral foramina and location of sacral fractures
* routine part of pelvic ring injury evaluation
* better characterization of posterior ring injuries
* helps define comminution and fragment rotation
* visualize position of fracture lines relative to sacral foramina

**TILES CLASSIFICATION:**

|  |  |  |
| --- | --- | --- |
| * + Tile classification | | |
| * + A: Stable |  |  |
|  | * + A1: fracture not involving the ring (avulsion or iliac wing fracture) |  |
|  | * + A2: stable or minimally displaced fracture of the ring |  |
|  | * + A3: transverse sacral fracture (Denis zone III sacral fracture) |  |
| * + B: Rotationally unstable, vertically stable |  |  |
|  | * + B1: open book injury (external rotation) |  |
|  | * + B2: lateral compression injury (internal rotation) |  |
|  | * + B2-1: with anterior ring rotation/displacement through ipsilateral rami |  |
|  | * + B2-2-with anterior ring rotation/displacement through contralateral rami (bucket-handle injury) |  |
|  | * + B3: bilateral |  |
| * + C: Rotationally and vertically unstable |  |  |
|  | * + C1: unilateral |  |
|  | * + C1-1: iliac fracture |  |
|  | * + C1-2: sacroiliac fracture-dislocation |  |
|  | * + C1-3: sacral fracture |  |
|  | * + C2: bilateral with one side type B and one side type C |  |
|  | * + C3: bilateral with both sides type C |  |

**YOUNG BURGESS CLASSIFICATION:**

* **Anterior Posterior Compression** (APC)
* **Lateral Compression** (LC)
* **Vertical Shear** (VS)



PUBIC SYMPHYSIS DIASTASIS

**Young-Burgess Classification**

|  |  |  |
| --- | --- | --- |
| * + Anterior Posterior Compression (APC) | | |
| * + APC I | * + Symphysis widening < 2.5 cm |  |
| * + APC II | * + Symphysis widening > 2.5 cm.   Anterior SI joint diastasis.  Posterior SI ligaments are intact.  Disruption of sacrospinous and sacrotuberous ligaments. |  |
| * + APC III | * + Disruption of anterior and posterior SI ligaments (SI dislocation).   Disruption of sacrospinous and sacrotuberous ligaments.   * + APCIII associated with vascular injury |  |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| * + Lateral Compression (LC) | | | | | |
| * + LC I | | * + Oblique or transverse ramus fracture and ipsilateral anterior sacral ala compression fracture. | |  | |
| * + LC II | | * + Rami fracture and ipsilateral posterior ilium fracture dislocation (crescent fracture). | |  | |
| * + LC III | | * + Ipsilateral lateral compression and contralateral APC (windswept pelvis).   + Common mechanism is rollover vehicle accident or pedestrian vs auto. | |  | |
| * Vertical Shear (VS) | | | | | |
| * Vertical shear | | * Posterior and superior directed force. * Associated with the highest risk of hypovolemic shock (63%); mortality rate up to 25% | |  | |

**INITIAL MANAGEMENT & RESUSITATION**

* Bleeding Source
  + intraabdominal (present in up to 40% of cases)
  + intrathoracic
  + retroperitoneal
  + extremity (thigh compartments)
  + pelvic
    - common sources of hemorrhage
      * venous injury (80%)
        + shearing injury of posterior thin walled venous plexus
        + leads to retroperitoneal hematoma (can hold up to 4L of blood)
      * bleeding cancellous bone
    - uncommon sources of hemorrhage
      * arterial injury (10-20%)
        + superior gluteal most common (posterior ring injury, APC pattern)

* + - * + internal pudendal (anterior ring injury, LC pattern)
        + obturator (LC pattern)
* **Treatment**
  + **resuscitation**
    - PRBC (PACKED RED BLOOD CELLS):FFP(FRESH FROZEN PLASMA):Platelets ideally should be transfused 1:1:1
    - this ratio shown to improve mortality in patients requiring massive transfusion
  + **pelvic binder/sheet**

* + - indications
      * initial management of an unstable ring injury

* + - * + should be centered over the greater trochanters

* + - **contraindications**
      * hypothetical risk of over-rotation of hemipelvis and hollow viscus injury (bladder) in pelvic fractures with internal rotation component (LC)
      * no clinical evidence exists of this complication occurring
    - **pitfalls**
      * binder can mask pelvic ring injuries, creating false negative radiographs and CT images

* + - * stress examination under anesthesia may be indicated in patients who present to the trauma slot in a pelvic binder, hemodynamic instability, and negative pelvis radiographs/CT scan
  + **external fixation**
    - indications
      * pelvic ring injuries with an external rotation component (APC, VS, )
      * unstable ring injury with ongoing blood loss
      * should be placed before emergent laparotomy

* + - contraindications
      * ilium fracture that precludes safe application
      * acetabular fracture

**angiography / embolization**

* + - technique
      * selective embolization of identifiable bleeding sources
      * in patients with uncontrolled bleeding after selective embolization, bilateral temporary internal iliac embolization may be effective
        + repeat angiography if patient continues to be hypotensive after embolization

recurrent hemorrhage from previously embolized artery is common

* + - * complications include gluteal necrosis
* **DEFINITIVE TREATMENT**
  + Overview by Classification

|  |  |  |
| --- | --- | --- |
| * + - Definitive treatment of Anterior Posterior Compression (APC) injuries | | |
| * + - APC I | * + - Non-operative. Protected weight bearing |  |
| * + - APC II | * + - Anterior symphyseal plate or external fixator +/- posterior fixation |  |
| * + - APC III | * + - Anterior symphyseal multi-hole plate or external fixator and posterior stabilization with SI screws or plate/screws |  |

|  |  |  |
| --- | --- | --- |
| * + - Definitive treatment of Lateral Compression (LC) injuries | | |
| * + - LC I | * + - Non-operative.   -Protected weight bearing (complete, comminuted sacral component.  -Weight bearing as tolerated (simple, incomplete sacral fracture) |  |
| * + - LC II | * + - Open reduction and internal fixation of ilium |  |
| * + - LC III | * + - Posterior stabilization with plate or SI screws as needed.   Percutaneous or open based on injury pattern and surgeon preference. |  |

|  |  |  |
| --- | --- | --- |
| * + - Definitive treatment of Vertical Shear (VS) injuries | | |
| * + - Vertical Shear | * + - Posterior stabilization with plate or SI screws as needed.   Percutaneous or open based on injury pattern and surgeon preference. |  |

* + Nonoperative
    - **weight bearing as tolerated**
      * indications
        + mechanically stable pelvic ring injuries including

LC1

anterior impaction fracture of sacrum and oblique ramus fractures with < 1cm of posterior ring displacement

APC1

traumatic widening of symphysis < 2.5 cm with intact posterior pelvic ring

isolated pubic ramus fractures

parturition-induced pelvic diastasis

bedrest and pelvic binder in acute setting with diastasis less than 4cm

* + Operative
    - **ORIF**
      * indications
        + symphysis diastasis > 2.5 cm

* + - * + SI joint displacement > 1 cm
        + sacral fracture with displacement > 1 cm
        + displacement or rotation of hemipelvis
        + open fracture
        + chronic pain and diastasis in parturition-induced diastasis or acute setting >4-6cm
      * technique
        + for open fractures aggressive debridement according to open fracture principles
    - **anterior subcutaneous pelvic fixator (INFIX)**
      * indications
        + same indications as anterior external fixation and symphyseal plating
      * complications
        + heterotopic ossification, femoral nerve injury, infection
    - **diverting colostomy**
      * indications
        + consider in open pelvic fractures

especially with extensive perineal injury or rectal involvement

**TECHNIQUES**

* **Pelvic Binding**
  + technique
    - centered over greater trochanters to effect indirect reduction
    - do not place over iliac crest/abdomen
      * ineffective and precludes assessment of abdomen
    - may augment with internal rotation of lower extremities and taping at ankles
    - transition to alternative fixation as soon as possible
      * prolonged pressure from binder or sheet may cause skin necrosis
    - working portals may be cut in sheet to place percutaneous fixation
  + early pelvic binding and CT have been associated with underestimation of pelvic ring instability

* + - fluroscopic exam under anesthesia can be used to assess stability in these circumstances

**Rehabilitation**

* + stable fractures treated nonsurgical
    - patients may mobilize immediately with protected weight bearing after stable fracture pattern in confirmed (may require post-mobilization views to confirm stability)
  + unstable fractures treated surgically
    - patient mobility and weight bearing depend on the location of the posterior pelvic ring fracture
    - mobility includes weight-of-limb weight bearing ipsilateral to the posterior pelvic injury with full weight bearing on contralateral side
    - patients with bilateral posterior pelvic ring injuries limited to bed-to-chair transfers only
    - when radiographic healing has occured weight bearing can be gradually advanced
* **COMPLICATIONS**
  + Urogenital Injuries
    - present in 12-20% of patients with pelvic fractures
      * higher incidence in males (21%)
    - includes
      * posterior urethral tear
        + most common urogenital injury with pelvic ring fracture

* + - * bladder rupture
        + may see extravasation around the pubic symphysis
        + associated with mortality of 22-34%
    - diagnosis
      * made with retrograde urethrocystogram
      * indications for retrograde urethrocystogram include
        + blood at meatus
        + high riding or excessively mobile prostate
        + hematuria
    - treatment
      * **suprapubic catheter placement**
        + suprapubic catheter is a relative contraindication to anterior ring plating
      * **surgical repair**
        + rupture should be repaired at the same time or prior to definitive fixation in order to minimize infection risk
    - complications
      * long-term complications common (up to 35%)
        + urethral stricture - most common
        + impotence
        + anterior pelvic ring infection
        + incontinence
        + parturition sequelae (i.e. caesarean section)
  + Neurologic injury
    - L5 nerve root runs over sacral ala joint
    - may be injured if SI screw is placed to anterior
    - anterior subcutaneous pelvic fixator may give rise to LFCN injury (most common) or femoral nerve injury

* + DVT and PE
    - DVT in ~ 60%, PULMONARY EMBOLISM in ~ 27%, fatal PE in 2%
    - prophylaxis essential
      * mechanical compression
      * pharmacologic prevention (LMWH or Lovenox)
      * vena caval filters (closed head injury)
  + Chronic instability
    - rare complication; can be seen in nonoperative cases
    - presents with subjective instability and mechanical symptoms
    - diagnosed with alternating single-leg-stance pelvic radiographs (flamingo views)

* + Infection

* + - risk factors include:
      * obesity
      * diabetes
      * prolonged operation time
      * prolonged ICU stay
      * larger amount of packed red blood cell transfusions,
      * associated genitourinary and abdominal trauma
      * open fractures
      * preoperative angioembolization is controversial

**FRACTURE ACETABULUM:**

* Acetabulum fractures are pelvis fractures that involve the articular surface of the hip joint and may involve one or two columns, one or two walls, or the roof within the pelvis.
* Diagnosis can be made radiographically with dedicated pelvis radiographs (including Judet views) but frequently require CT pelvis for surgical planning.
* Treatment can be nonoperative for non-displaced fractures but displaced injuries require anatomic open reduction and internal fixation to minimize development of post-traumatic osteoarthritis.

**Incidence**

* + ~ 4 per 100,000 per year
* Demographics
  + fractures occur in a bimodal distribution
    - high energy trauma in younger patients (e.g., motor vehicle accidents)
    - low energy trauma in elderly patients (e.g., fall from standing height)
    - **ETIOLOGY**
  + Pathoanatomy
    - fracture pattern predominately determined by
      * force vector
      * position of femoral head at time of injury
      * bone quality (e.g., age)
  + Associated conditions
    - orthopaedic manifestations
      * lower extremity injury (36%)
      * nerve palsy (13%)
        + most commonly seen in transverse + posterior wall fracture patterns
        + most commonly affects the peroneal division of the sciatic nerve
      * spine injury (4%)
    - systemic injuries
      * head injury (19%)
      * chest injury (18%)
      * abdominal injury (8%)
      * genitourinary injury (6%)

**ANATOMY**

* + Osteology
    - acetabular inclination & anteversion
      * mean lateral inclination of 40 to 48 degrees
      * anteversion of 18 to 21 degrees
    - column theory
      * acetabulum is supported by two columns of bone
      * form an "inverted Y"
      * connected to sacrum through sciatic buttress
        + posterior column

comprised of quadrilateral surface

posterior wall and dome

ischial tuberosity

greater/lesser sciatic notches

* + - * + anterior column

comprised of

anterior ilium (gluteus medius tubercle)

anterior wall and dome

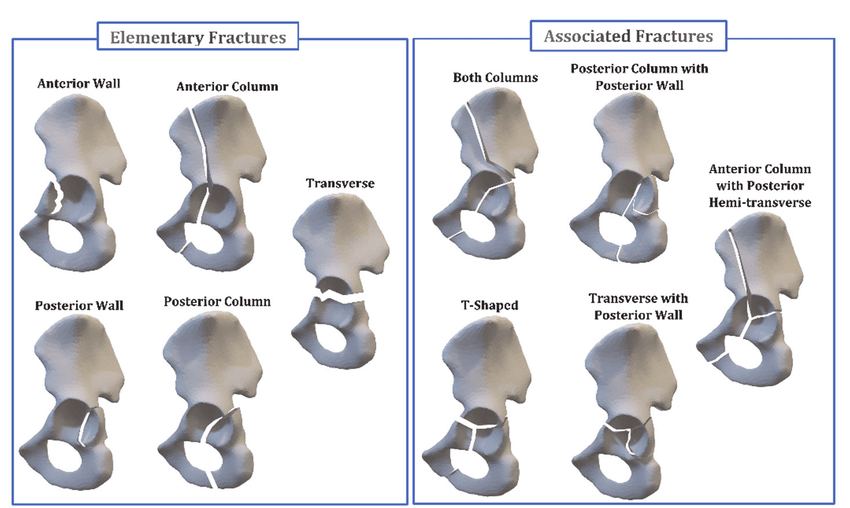
iliopectineal eminence

lateral superior pubic ramus

* + Vascular
    - corona mortis
      * anastomosis of external iliac (epigastric) and internal iliac (obturator) vessels
      * at risk with lateral dissection over superior pubic ramus

**LETOURNEL CLASSIFICATION**

* Judet and Letournel
  + most common referenced classification system
    - classifed as 5 elementary and 5 associated fracture patterns
  + most common fracture patterns
    - younger
      * posterior wall
      * transverse fracture "family"
        + transverse
        + T-type
        + transverse + posterior wall
    - elderly
      * anterior column (e.g., quadrilateral plate fractures)
      * anterior column, posterior hemitransverse
      * assoicated both column fractures

**IMAGING**

* Radiographs
  + Recommended views
    - AP
    - judet

* + - * obturator oblique
        + shows profile of obturator foramen
        + shows anterior column and posterior wall
      * iliac oblique
        + shows profile of involved iliac wing
        + shows posterior column and anterior wall
  + Optional views
    - inlet/outlet if concerned for pelvic ring involvement
    - examination under anesthesia (EUA)

* + - * used to assess posterior wall stability
      * hip positioned in flexion, adduction and axial load
      * obtain obturator oblique view
      * opening of the medial clear space suggests instability of the posterior wall fracture

* + Findings
    - radiographic landmarks of the acetabulum
      * iliopectineal line (anterior column)
      * ilioischial line (posterior column)
      * anterior wall
      * posterior wall
      * weight bearing roof
      * Shenton's line
    - roof arc angle
      * angle between vertical line through femoral head and line through fracture
      * helps to define fracture pattern stability
      * considered stable if the fracture line exits outside the weight bearing dome of the acetabulum
      * defined as < 45° on AP, obturator and iliac oblique views
      * not applicable for associated both column or posterior wall pattern because no intact portion of the acetabulum to measure
    - gull sign
      * represents impaction of superomedial roof
      * seen on iliac oblique view
      * pathognomic for posterior wall fractures
    - spur sign
      * represents most caudal part of intact ilium due to medialization of articular components
      * seen on obturator oblique view
      * pathognomic for ABC fractures
* CT scan
  + indications
    - now considered a gold standard in management
  + findings
    - fracture pattern orientation
    - define fragment size and orientation
    - identify marginal impaction

* + - identify loose bodies (e.g., post-reduction)
    - look for articular gap or step-off
* Duplex doppler ultrasound
  + indications
    - delayed presentation to treating hospital
    - rule out DVT

**TREATMENT**

* Nonoperative
  + **protected weight bearing for 6-8 weeks**
    - indications
      * patient factors
        + high operative risk (e.g., elderly patients, presence of DVT)
        + morbid obesity
        + open contaminated wound
        + late presenting > 3 weeks
      * fracture characteristics
        + minimally displaced fracture (< 2 mm)
        + < 20% posterior wall fractures

treatment based on size of posterior wall is controversial

recommend an exam under anesthesia (EUA) using fluoroscopy best method to test stability

* + - * + femoral head congruency with weight bearing roof (out of traction)

both column fracture pattern with secondary congruence (out of traction)

* + - * + displaced fracture with roof arcs > 45° in AP and Judet views or >10 mm on axial CT cuts
    - technique
      * skeletal traction NOT required if stable fracture pattern, outside the weight-bearing dome
      * activity as tolerated with crutches/walker
      * weight-bearing
        + lowest joint reactive forces seen with toe-touch weight bearing and passive hip abduction

greatest joint contact force seen when rising from a chair on the affected extremity

* + - * DVT prophylaxis
      * close radiographic follow-up

Operative treatment

* + **open reduction and internal fixation**
    - indications
      * patient factors
        + < 3 weeks from date of injury
        + physiologically stable
        + adequate soft-tissue envelope
        + no local infection

pregnancy is not contraindication to surgical fixation

* + - * fracture factors
        + displacement of roof (> 2 mm)
        + unstable fracture pattern (e.g. posterior wall fracture involving > 40-50%)
        + marginal impaction
        + intra-articular loose bodies

* + - * + irreducible fracture-dislocation

**total hip arthroplasty**

* indications
  + usually elderly patients with
    - significant osteopenia and/or significant comminution
    - pre-existing arthritis
  + post-traumatic arthritis in all ages

**COMPLICATIONS**

* Post-traumatic Degenertive Joint Disease
  + most common complication
  + 80% survival noted at 20 years for patients s/p ORIF

* + risk factors for DJD include
    - age >40
    - associated fracture patterns
    - concomitant femoral head injury
* Heterotopic ossification

* Osteonecrosis
* DVT and PE
* Infection
* Bleeding
* Neurovascular injury

**PROGNOSIS**

* + Poor outcomes are associated with:
    - multi-system trauma
    - increasing age
    - poor articular congruency
    - associated femoral head articular injury
    - post-traumatic arthritis

**HIP DISLOCATION +\_ fracture:**

* LEARNING OBJECTIVES:
* Classify dislocations and fracture-dislocations of the hip
* State the precautions you take in order not to miss the diagnosis of hip injury
* Describe the mode of injury of posterior dislocation of the hip
* Describe the clinical features of posterior dislocation/fracture-dislocation of the hip
* Describe the treatment of posterior dislocation of the hip
* State the complications of posterior dislocation/fracture-dislocation of the hip
* Describe the mode of injury of anterior dislocation of the hip
* Describe the clinical features of anterior dislocation of the hip
* Describe the treatment of anterior dislocation of the hip
* State the complications of anterior dislocation of the hip.
* Describe central fracture-dislocation of the hip
* Describe the mode of injury of central fracture dislocation of the hip
* Describe the treatment of central fracture-dislocation of the hip
* Outline the complications of central fracture-dislocation of the hip

INTRODUCTION:

* + Hip dislocations are traumatic hip injuries that result in femoral head dislocation from the acetabular socket.
  + Diagnosis can be made with hip radiographs to determine the direction of dislocation and CT scan studies to assess for associated injuries.
  + Treatment is urgent reduction to minimize risk of avascular necrosis followed by CT scan to assess for associated injuries that may require surgical treatment (loose bodies, femoral head fractures, acetabular fractures).

CLASSIFICATION:

* Hip dislocations are classified based on

(1) the relationship of the femoral head to the acetabulum

(2) whether or not associated fractures are present.

* 3 main types:
  + Posterior dislocation or fracture-dislocation
  + Anterior dislocation
  + Central fracture-dislocation.

Posterior dislocation is the commonest.

* When there are other serious injuries in the same limb, particularly a fracture of the shaft of the femur, it is easy to overlook a dislocation or fracture-dislocation of the hip.
* Do a full clinical survey of the whole body in cases of major injury
* Make sure the X-rays in every case of fractured femoral shaft take in the whole length of the bone and include the hip joint.

**POSTERIOR DISLOCATION:**

* Posterior Dislocations comprise 85% to 90% of traumatic hip dislocations.
* **Mode of injury**
  + The femoral head is forced out of the back of the acetabulum by violence applied along the shaft of femur while the hip is flexed or semi flexed.
  + E.g., motor vehicle accident – car involved in collision- occupant thrown forwards and strikes the front of his flexed knees against a part of the vehicle body framework (e.g., dashboard injury)
  + Motor cycle accident
* About ½ of the cases are fracture-dislocations; the head of femur carries with it a fragment of bone from the rim of the acetabulum.
* If the hip is in the neutral or slightly adducted position at the time of impact, a dislocation without acetabular fracture will likely occur.
* If the hip is in slight abduction, an associated fracture of the posterior–superior rim of the acetabulum usually occurs.
* Unrestrained motor vehicle accident occupants are at a significantly higher risk for sustaining a hip dislocation than passengers wearing a restraining device.



**CLINICAL FEATURES:**

* Pain in the affected hip
* Inability to use the limb
* Medial rotation of the femur and whole lower limb
* Upward displacement of femur leading to shortening of the limb by 2-3 cm.
* Adduction of the femur (thigh)
* Flexion of the hip and knee
* \*examine for signs of sciatic nerve injury



INVESTIGATIONS:

* X-ray of the pelvis A/P view will show the dislocation. Upward, outward and posterior displacement.
* If there is an associated acetabular fracture it will be shown.

The femur is seen medially rotated and adducted



TREATMENT:

* Reduction under general anaesthesia as soon as possible by pulling longitudinally upon the femur while the hip is flexed at right angle and rotated laterally.
* Technique:
  + Patient is placed supine on the floor or on a low table, and an assistant grasps the pelvis firmly through the iliac crests. You then flex the hip and knee to right angle so that the line of the femur points vertically upwards. You then pull the thigh steadily upwards, at the same time gradually rotating the femur laterally.

**ALLIS METHOD OF REDUCTION:**

* This consists of traction applied in line with the deformity.
* The patient is placed supine with the surgeon standing above the patient on the stretcher or table.
* Initially, the surgeon applies in-line traction while the assistant applies countertraction by stabilizing the patient’s pelvis.
* While increasing the traction force, the surgeon should slowly increase the degree of flexion to approximately 70 degrees.
* Gentle rotational motions of the hip as well as slight adduction will often help the femoral head to clear the lip of the acetabulum.
* A lateral force to the proximal thigh may assist in reduction.
* An audible “clunk” is a sign of a successful closed reduction
* After reduction, a light skin traction (Russell’s ) is applied for 3-6 weeks.
* Meanwhile, mobilizing exercises for the hip and knee are begun after a few days and are gradually intensified.
* A small marginal fragment from the acetabulum usually falls back into place following reduction of the dislocation.
* If a large acetabular fragment remains unreduced, open reduction and internal fixation with a screw or small plate is required.

**OPERATIVE TREATMENT:**

Indications for open reduction of a dislocated hip include:

* Dislocation irreducible by closed means
* Nonconcentric reduction
* Fracture of the acetabulum or femoral head requiring excision or open reduction and internal fixation
* Ipsilateral femoral neck fracture

COMPLICATIONS:

* Injury to the sciatic nerve
* Damage to the femoral head
* Avascular necrosis of the femoral head
* Post-traumatic ossification
* Osteoarthritis
* Recurrent dislocation
* Unreduced dislocation

Injury to sciatic nerve:

* Sciatic nerve lies behind the posterior wall of the acetabulum and is vulnerable to injury.
* It is particularly liable to damage when a large acetabular wall fragment is driven backwards with the head of femur.
* The nerve lesion is usually a neurapraxia or an axonotmesis, but it may be virtually a complete division (neurotmesis).

**Treatment:**

* + Relief of pressure by early reduction of dislocation and replacement of displaced bone fragment, if possible, by operation.

Prognosis:

* + Good after minor nerve lesion (neurapraxia)
  + Poor after severe injury of the nerve at this high level. Recovery of good muscle power is poor because of the length to be regenerated and the likelihood that the distal muscles will have suffered irreversible changes before they are reinnervated.

**Thompson and Epstein Classification of Posterior Hip Dislocations**

* Type I: Simple dislocation with or without an insignificant posterior wall fragment
* Type II: Dislocation associated with a single large posterior wall fragment
* Type III: Dislocation with a comminuted posterior wall fragment
* Type IV: Dislocation with fracture of the acetabular floor
* Type V: Dislocation with fracture of the femoral head

**Complications:**

* + Post-traumatic arthritis
    - up to 20% for simple dislocation, markedly increased for complex dislocation
  + Femoral head osteonecrosis
    - 5-40% incidence
    - Increased risk with increased time to reduction
  + Sciatic nerve injury
    - 8-20% incidence
    - associated with longer time to reduction
  + Recurrent dislocations
    - less than 2%

**Anterior dislocation of the Hip:**

* Less common than posterior dislocation
* Caused by forced abduction and lateral rotation of the limb, usually in a violent injury e.g., motor accident or aircraft crash.
* Usually no associated acetabular fracture.
* These injuries result from external rotation and abduction of the hip.
* The degree of hip flexion determines whether a superior or inferior type of anterior hip dislocation results.
  + Inferior (obturator) dislocation is the result of simultaneous abduction, external rotation, and hip flexion.
  + Superior (iliac or pubic) dislocation is the result of simultaneous abduction, external rotation, and hip extension.



**Clinical features:**

* Pain in the hip
* Inability to use the limb
* Tenderness in the hip region
* Hip is in extension
* Limb rests in marked lateral rotation
* Abduction of the hip

**Treatment:**

* Reduction under anaesthesia
  + By strong traction upon the limb combined with medial rotation.
  + Apply light skin traction for 3-6 weeks

**Complications:**

* Rarely, injury to the femoral artery, vein, or nerve may occur as a result of an anterior dislocation.
* Avascular necrosis
* Osteoarthritis

**Epstein Classification of Anterior Hip Dislocations:**

* Type I: Superior dislocations, including pubic and subspinous
  + IA: No associated fractures
  + IB: Associated fracture or impaction of the femoral head
  + IC: Associated fracture of the acetabulum
* Type II: Inferior dislocations, including obturator, and perineal
  + IIA: No associated fractures
  + IIB: Associated fracture or impaction of the femoral head
  + IIC: Associated fracture of the acetabulum

**Central Fracture-dislocation**

* The femoral head is driven through the medial wall, or ‘floor’, of the acetabulum towards the pelvic cavity.
* The capsule remains intact, but
* There is inevitably a fracture of the acetabulum, usually with much comminution.

**Causes:**

* Central fracture-dislocation is caused by a heavy lateral blow upon the femur as occurs in a fall from a height on to the side.

A longitudinal force acting upon the femur (e.g. a blow upon a flexed knee) while the hip is abducted

Degree of displacement:

* Depends on the severity of the violence / force
* Minor type:
  + Fracture of the acetabulum with only minimal inwards displacement (a few millimeters)
* Severe type:
  + The innominate bone, including the acetabulum, is shattered and driven inwards together with the femoral head (protrusion acetabula)



**Treatment:**

* Energetic resuscitation if shocked / internal bleeding
* Treatment depends largely upon the degree of comminution and displacement of the acetabular fragments, and upon whether or not it is possible to restore the articular surface to its normal shape.
* Cases in which restoration of the articular surface is possible:
  + If the major part of the weight-bearing area of the acetabulum remains mainly in one piece, attempt to restore it to its anatomical position.
  + Apply heavy weight traction upon the femur through a Steinmann pin passed antero-posteriorly through the greater trochanter. The direction of pull should be downwards and outwards.
  + After reduction, maintain traction (light) for 4-6 weeks
  + If traction fails, the fragment can be reduced at operation and fixed with screws and contoured plates, then maintained on light traction for 4-6 weeks.
* Cases in which severe comminution precludes accurate reduction:
  + Reduce the femoral head to the normal position in the acetabulum by applying combined lateral and downward traction through pins transfixing the trochanter and the lower end of femur.
  + Duration of traction: 6 weeks

Complications:

* Severe haemorrhage from damage to major blood vessel
* Osteoarthritis – treated by arthrodesis or total hip replacement.

**FRACTURE HEAD FEMUR:**

* Femoral head fractures are rare traumatic injuries that are usually associated with hip dislocations.
* Diagnosis can be made by pelvis/hip radiographs but frequently require CT scan for surgical planning.
* Treatment may be nonoperative or operative depending on the location of the fracture and degree of fracture displacement.
* **ETIOLOGY**
  + Pathophysiology
    - mechanism of injury
      * impaction, avulsion or shear forces involved
        + unrestrained passenger MVA (knee against dashboard)
        + falls from height
        + sports injury
        + industrial accidents
    - pathoanatomy
      * the location and size of the fracture fragment and degree of comminution depend on the position of the hip at the time of dislocation
        + 5-15% of posterior hip dislocations are associated with a femoral head fracture because of contact between femoral head and posterior rim of acetabulum
        + anterior hip dislocations are associated with impaction/indentation fractures of the femoral head
  + Associated conditions
    - femoral neck fracture (see Pipkin Classification below)
    - acetabular fracture (see Pipkin Classification below)
    - sciatic nerve neuropraxia
    - femoral head AVN
    - ipsilateral knee ligamentous instability (knee vs dashboard)

**ANATOMY**

* + Blood supply
    - medial femoral circumflex artery (MFCA)
      * main blood supply to the weightbearing portion of the femoral head
      * MFCA originates from the profunda femoris
    - artery to the ligamentum teres
      * lesser blood supply (10-15%)
      * from the obturator artery or MFCA
      * supplies perifoveal area

**CLASSIFICATION**

|  |  |  |
| --- | --- | --- |
| * + Pipkin Classification | | |
| * + Type I | * + Fracture below fovea/ ligamentum (small)   + Does not involve the weight-bearing portion of the femoral head |  |
| * + Type II | * + Fracture above fovea/ ligamentum (larger)   + Involves the weight-bearing portion of the femoral head |  |
| * + Type III | * + Type I or II with an associated femoral neck fracture   + High incidence of AVN |  |
| * + Type IV | * + Type I or II with associated acetabular fx (usually posterior wall fracture) |  |

* **PRESENTATION**
  + History
    - frontal impact MVA with knee striking dashboard
    - fall from height
  + Symptoms
    - localized hip pain
    - unable to bear weight
    - other symptoms associated with impact
  + Physical exam
    - inspection
      * shortened lower limb
        + with large acetabular wall fractures, little to no rotational asymmetry is seen
      * posterior dislocation
        + limb is flexed, adducted, internally rotated
      * anterior dislocation
        + limb is flexed, abducted, externally rotated
      * ipsilateral knee
        + ligamentous stability
    - neurovascular
      * may have signs of sciatic nerve injury

**investigations:**

x-ray ap/lateral /jedet confirms the diagnosis.

* Radiographs
  + recommended views
    - AP pelvis, hip series
      * both pre-reduction and post-reduction
    - judet views
      * associated acetabular fracture
    - inlet and outlet views
      * associated pelvic ring injury

**CT scan**

* indications
  + post reduction to evalute for loose bodies and presence/size of fracture fragments

**TREATMENT**

* Nonoperative
  + **hip reduction**
    - indications
      * acute dislocations
        + reduce hip dislocation within 6 hours
    - outcomes
      * 5-40% incidence of femoral head osteonecrosis
      * increased risk with increased time to reduction
  + **(touch down weight bearing)TDWB x 4-6 weeks, restrict adduction and internal rotation**
    - indications
      * Pipkin I
      * nondisplaced Pipkin II with < 1 mm step off
      * no interposed fragments
      * stable hip joint
    - outcomes
      * + serial radiographs required
      * development of post-traumatic arthritis based on joint incongruity and initial cartilage damage

Operative

* **ORIF**
  + indications
    - Pipkin II with > 1 mm step off
    - if performing removal of loose bodies in the joint
    - associated neck or acetabular fx (Pipkin type III and IV)
    - polytrauma
    - irreducible fracture-dislocation
    - Pipkin IV
      * treatment dictated by characteristics of acetabular fracture
      * small posterior wall fragments can be treated nonsurgically and suprafoveal fractures can then be treated through an anterior approach
* **arthroplasty**
  + indications
    - Pipkin I, II (displaced), III, and IV in older patients
    - fractures that are significantly displaced, osteoporotic or comminuted
  + outcomes
    - best resereved for older patients
    - higher dislocation risk than Total Hip Arthroplasty performed for OA
* **arthroscopy**
  + indications
    - removal of loose bodies
  + outcomes
    - dependent on ability to remove incarcerated fragments and initial cartilage damage

**rehabilitation**

* + mobilization
    - immediate early range of motion
  + weightbearing
    - delay weight bearing for 6-8 weeks
  + stress strengthening of the quadriceps and abductors
* radiographs
  + radiographs after 6 months to evaluate for AVN and osteoarthritis

**COMPLICATIONS**

* + Heterotopic ossification
  + AVN
    - incidence is 0-23%
      * risk is greater with delayed reduction of dislocated hip
  + Sciatic nerve neuropraxia
    - incidence is 10-23%
      * usually peroneal division of sciatic nerve
      * spontaneous recovery of function in 60-70%
  + DJD
    - incidence 8-75%
    - due to joint incongruity or initial cartilage damage
  + Decreased internal rotation
    - may not be clinically problematic or cause disability
  + unreduced dislocation
  + Recurrent instability

**NECK FEMUR FRACTURE:**

* Femoral neck fractures are common injuries to the proximal femur associated with increased risk of avascular necrosis, and high levels of patient morbidity and mortality.
* Diagnosis is generally made radiographically with orthogonal radiographs of the hip.
* Treatment is generally operative with open reduction and internal fixation versus arthroplasty depending on the age of the patient, activity demands and pre-injury mobility.

**EPIDEMIOLOGY**

* Incidence
  + common
    - increasingly common due to aging population
* Demographics
  + women > men
* **ETIOLOGY**
  + Pathophysiology
    - healing potential
      * femoral neck is intracapsular, bathed in synovial fluid
      * lacks periosteal layer
      * callus formation limited, which affects healing
  + Mechanism
    - high energy in young patients
    - low energy falls in older patients
  + Associated injuries
    - femoral shaft fractures
      * 6-9% associated with femoral neck fractures

* + - * treat femoral neck first followed by shaft

**ANATOMY**

* Osteology
  + normal neck shaft-angle 130 +/- 7 degrees
  + normal anteversion 10 +/- 7 degrees
* Blood supply to femoral head
  + major contributor is medial femoral circumflex (lateral epiphyseal artery)
  + some contribution to anterior and inferior head from lateral femoral circumflex
  + some contribution from inferior gluteal artery
  + small and insignificant supply from artery of ligamentum teres
  + displacement of femoral neck fracture will disrupt the blood supply and cause an intracapsular hematoma (effect is controversial)

**CLASSIFICATION**

|  |  |  |
| --- | --- | --- |
| * + - **Garden Classification**     - (based on AP radiographs and does not consider lateral or sagittal plane alignment) | | |
| * + - Type I | * + - Incomplete fx (valgus impacted) |  |
| * + - Type II | * + - Complete fx, nondisplaced |  |
| * + - Type III | * + - Complete fx, partially displaced |  |
| * + - Type IV | * + - Complete fx, fully displaced |  |

|  |  |  |
| --- | --- | --- |
| * + - Simplified Garden Classification | | |
| * + - Nondisplaced | * + - Includes Garden I and II |  |
| * + - Displaced | * + - Includes Garden IIII and IV |  |

|  |  |  |
| --- | --- | --- |
| * + - **Pauwels Classification**     - (based on vertical orientation of fracture line) | | |
| * + - Type I | * + - < 30 deg from horizontal |  |
| * + - Type II | * + - 30 to 50 deg from horizontal |  |
| * + - Type III | * + - > 50 deg from horizontal (most unstable with highest risk of nonunion/AVN) |  |

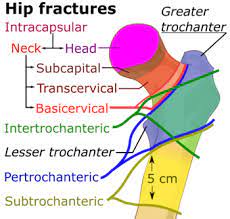
**ANATOMICAL CLASSIFICATION:**

There are three types:

subcapital: femoral head/neck junction.

transcervical: midportion of femoral neck.

basicervical: base of femoral neck.



**TREATMENT**

* + Nonoperative
    - **observation alone**
      * indications

may be considered in some patients who are non-ambulators, have minimal pain, and who are at high risk for surgical intervention

skin traction for 6weeks.

**Operative**

* + - **ORIF**
      * indications
        + displaced fractures in young or physiologically young patients

ORIF indicated for most pts <50 years of age

female sex associated with increased reoperation rate

* + - **cannulated screw fixation**
      * indications
        + nondisplaced transcervical fx
        + Garden I or II in the physiologically elderly
        + displaced transcervical fx in young patient

achieve reduction to limit vascular insult

reduction must be anatomic, so open if necessary

* + - **sliding hip screw**

* + - * indications
        + basicervical fracture
        + vertical fracture pattern in a young patient

sliding hip screw biomechanically superior to cannulated screws (may not be clinically superior)

* + - * consider placement of additional cannulated screw above sliding hip screw to prevent rotation
    - **hemiarthroplasty**

* + - * indications
        + debilitated elderly patients

* + - * + metabolic bone disease
      * cemented hemiarthroplasty
        + decreased fracture rates
        + improved short- and medium-term mobility

* + - **total hip arthoplasty**

* + - * indications
        + older active patients
        + patients with preexisting hip osteoarthritis

more predictable pain relief and better functional outcome than hemiarthroplasty

* + - * + Garden III or IV in patient < 85 years
* **COMPLICATIONS**
  + Osteonecrosis (AVN)
  + Nonunion
  + Failure rates
  + Loss of independence
  + Hip osteoarthritis
  + Malunion
  + dislocation

**FRACTURES OF TROCHANTERIC REGION:**

* These are fractures lying in the region between the greater and lesser trochanter.
* Trochanteric fractures unite readily no matter how they are treated.
* Avascular necrosis and non-union are hardly encountered.
* Common in the elderly- especially in women.
* The cause is nearly always a fall.
* Intertrochanteric Fractures are common extracapsular fractures of the proximal femur at the level of the greater and lesser trochanter that are most commonly seen following ground-level falls in the elderly population.
* Diagnosis is made with orthogonal radiographs of the hip. MRI is most helpful to evaluate occult hip fractures.
* Treatment is generally operative with sliding hip screw versus cephalomedullary nail depending on fracture stability.

Risk factors

* + proximal humerus fractures increase risk of hip fracture for 1 year
  + osteoporosis
  + advancing age
  + increased number of comorbidities
  + increased dependency with ADLs

**CLINICAL FEATURES:**

* History of fall
* Unable to get up without assistance
* Unable to put weight on the limb
* Severe pain in trochanteric region
* Swelling

**O/E:**

* Lateral rotation of the limb
* Shortening of the limb
* Marked tenderness over trochanteric region
* Visible ecchymosis at back of upper thigh (a feature not seen in case of femoral neck # coz extravasated blood is retained within joint capsule)

**Blood supply**

* + rich collateral circulation reduces risk of nonunion
    - trochanteric anastomosis
      * ascending branch of medial circumflex femoral artery (MFCA)
      * ascending branch of lateral circumflex femoral artery (LFCA)
      * deep branch of superior gluteal artery
      * inferior gluteal artery
    - transverse branch of LFCA and MFCA
    - periosteum and surrounding muscles

**RADIOGRAPHIC EXAMINATION:**

* Anteroposterior and lateral radiographs are required.
* In most cases the fracture is obvious
* A fracture without displacement may easily be overlooked
* Careful scrutiny of the radiographs is necessary.

**CLASSIFICATION:**

* **Classified into 4 types:**
  + Type 1: undisplaced, uncomminuted fracture
  + Type 2: displaced; minimal comminution; lesser trochanter fracture; varus deformity.
  + Type 3: displaced fracture; greater trochanter fractured; comminution; varus deformity.
  + Type 4: severely comminuted; subtrochanteric extension of fracture.

**TREATMENT:**

* Trochanteric fractures heal readily.
* Fragments should be held in good position
* Early internal fixation is the treatment of choice in elderly patients.
  + Internal fixation is by a **compression screw-plate** (dynamic hip screw)
  + Post-op. the patient is nursed free in bed with active hip and knee exercises from the start.
  + Walking with partial support of a walking frame or crutches is begun within 1 or 2 days of operation.
* Continuous traction:
  + In young patients, conservative treatment by rest in bed with continuous weight traction can be used with good results.
  + Russell’s traction is very suitable for these cases.
  + Traction is maintained for 10-12 weeks.
* Plaster hip spica:
  + May be used to immobilize the fracture in children after manipulative reduction.

**COMPLICATIONS:**

* **Failure** **of** **the** **fixation** **device** – the fixation screw may cut out from the femoral head if the bone is very soft (osteoporosis), especially in severe comminution.
* **Mal-union** – is a frequent complication of trochanteric fractures. Union with reduced neck-shaft angle (**coxa** **vara**) is common. Marked lateral rotation of the shaft fragment may occur in neglected cases.
* Coxa vara is associated with **shortening**, but this seldom exceeds 2 or 3 cm

**Intertrochanteric femur fracture**



**FRACTURES SHAFT OF FEMUR:**

* Femoral shaft fractures are high energy injuries to the femur that are associated with life-threatening injuries (pulmonary, cerebral) and ipsilateral femoral neck fractures.
* Diagnosis is made radiographically with radiographs of the femur as well as the hip to rule out ipsilateral femoral neck fractures.
* Treatment generally involves intramedullary nailing which is associated with >95% union rates.

**ETIOLOGY:**

* Mechanism
  + traumatic
    - high-energy
      * most common in younger population
      * often a result of high-speed motor vehicle accidents
    - low-energy
      * more common in elderly
      * often a result of a fall from standing
      * gunshot
* **CLASSIFICATION**

|  |  |  |
| --- | --- | --- |
| * + - Winquist and Hansen Classification | | |
| * + - Type 0 | * + - No comminution |  |
| * + - Type I | * + - Insignificant amount of comminution |  |
| * + - Type II | * + - Greater than 50% cortical contact |  |
| * + - Type III | * + - Less than 50% cortical contact |  |
| * + - Type IV | * + - Segmental fracture with no contact between proximal and distal fragment |  |

|  |  |  |
| --- | --- | --- |
| * + - AO/OTA Classification | | |
| * + - 32A - Simple | * + - A1 - Spiral     - A2 - Oblique, angle > 30 degrees     - A3 - Transverse, angle < 30 degrees |  |
| * + - 32B - Wedge | * + - B1 - Spiral wedge     - B2 - Bending wedge     - B3 - Fragmented wedge |  |
| * + - 32C - Complex | * + - C1 - Spiral     - C2 - Segmental     - C3 - Irregula |  |

* Occurs at any age
* Almost equally common in the upper, middle and lower thirds
* Follows severe violence e.g. RTA, fall from a height, trauma by heavy object.
* Upper third is common site for pathological fracture due to carcinomatous metastasis

**PATTERNS:**

* Transverse
* Oblique
* Spiral
* Comminuted
* Greenstick (children)
* Segmental



CLICAL FEATURES:

* Severe pain over the thigh
* Swelling
* Deformity
* Lateral rotation of leg
* Marked tenderness over the thigh
* Shortening of the limb
* Mobility may be demonstrable at mid-thigh

Bone feels thickened due to overlapped fragments

**RADIOGRAPHIC EXAMINATION:**

* Should always take in the hip and knee
* Likelihood of overlooking hip dislocation in fracture of femoral shaft if hip not captured on X-ray.
* X-rays will show the position and type of fracture, and also any displacement.
* Displacement may be marked, in the form of angulation and overlap.

TREATMENT:

* Conservative treatment by sustained traction
* Operative treatment:
  + Internal fixation
  + External fixation
* ‘Gallows’ or Bryant’s traction in children below 3 years

**Conservative treatment by sustained traction**

* Reduce the fracture by traction or manipulation
* Support the limb in a Thomas’s splint
* Maintain continuous traction by means of a weight
* Rehabilitation by exercise

**REDUCTION:**

* Traction to lower leg by either skin or skeletal traction
* A Thomas’s splint with Pearson knee flexion attachment is fitted.
* By combination of traction and manipulation an attempt is made to bring the fragments into correct apposition and alignment.
* Canvas strips slung between the bars of the Thomas’s splint are adjusted for tension
* The knee is flexed 15 or 20 degrees to permit control of rotation.
* Weight of 4-6kg (10-15 pounds) is attached to traction cord according to build of patient.
* Repeat check X-rays are advisable in the first 2 weeks and appropriate adjustments to the slings or weight made as required.
* Traction is maintained for 12-16 weeks in adults

**REHABILITATION:**

* Exercises for the lower leg and foot to preserve muscle tone and prevent deformity (equinus)
* Active quadriceps and knee exercises are begun as soon as initial pain of fracture wanes.

**OPERATIVE TREATMENT INTERNAL FIXATION:**

**Intramedullary nail**

* Plain intramedullary nail (e.g. Kunstcher nail)
* Perforated nail with locking screws (interlocking nail e.g. Sign nail) – enhances fixation and controls rotation.
* Postoperatively the patient lies free in bed and exercises the hip, knee and related muscles.
* Walking with partial support of crutches is begun 2 or 3 weeks after operation

**Plate and screws**

* Is used where the medullary cavity is too wide for nail
* Can be used as an alternative method to nailing
* Need at least 4 holes for fixation of the plate above the fracture and 4 holes below the fracture.

**GALLOWS /BRYANTS TRACTIION:**

* For children up to 3 years old
* The child’s lower limbs are suspended from an overhead beam by means of adhesive skin strapping applied directly to the legs.
* The cords are tightened just enough to raise child’s buttock clear of the mattress
* The weight of the pelvis and lower trunk provides reduction and alignment.
* Traction is maintained for 3-4 weeks
* Knees should be semi-flexed by splints to prevent spasm of a major artery.

**COMPLICATIONS:**

* Simultaneous dislocation of the hip
* Injury to major artery (femoral artery)
* Injury to nerve (sciatic nerve, tibial nerve, common peroneal nerve)
* Infection (for open fracture)
* Delayed union (insufficient union after 5 months)
* Non-union (no union. # surfaces rounded and sclerotic)
* Mal-union (angulation, overlap – shortening, lateral bowing)
* Stiffness of the knee (periarticular and intramuscular adhesions)

**SUPRACONDYLAR FRACTURE OF THE FEMUR:**

* + Distal femur fractures are traumatic injuries involving the region extending from the distal metaphyseal-diaphyseal junction to the articular surface of the femoral condyles.
  + Diagnosis is made radiographically with CT studies often required to assess for intra-articular extension.
  + Treatment is generally operative with ORIF, intramedullary nail, or distal femur replacement depending on available bone stock, age of patient, and patient activity demands.



**FEATURES:**

* Occurs just proximal to the point where the medial and lateral cortices of the femur flare out to form the condyles.
* May be T-shaped # line due to vertical extension of the fracture splitting the condyles apart.
* The main fracture is more or less transverse
* The distal fragment is commonly tilted anteriorly upon the shaft, without serious loss of end-to-end apposition.

**CLASSIFICATION**

* + Descriptive
    - supracondylar
    - intercondylar
  + OTA: 33
    - A: extraarticular
    - B: partial articular
      * portion of the articular surface remains in continuity with shaft
      * 33B3 is in the coronal plane (Hoffa fragment)
    - C: complete articular
      * articular fragment separated from the shaft

**TREATMENT**

* + Nonoperative
    - **hinged knee brace**
      * indications (rare)
        + stable, nondisplaced fractures
        + nonambulatory patient
        + patient with significant comorbidities presenting an unacceptably high degree of surgical/anesthetic risk

**Non-operative treatment:**

* Continuous weight traction with limb supported on a Thomas’s splint with a knee flexion attachment.
* In displaced supracondylar fractures, the angle of knee flexion is very essential in reduction and stabilization of the fracture. Forward tilting of the distal fragment can be corrected by increasing the angle of knee flexion.
* Radiographs should be taken to confirm reduction during the first few days after injury. These determine the correct position of the knee.
* Avoid knee movements in the first 2 or 3 weeks in order not to disturb the position of the fragments.
* Do active ankle, foot and toe exercises and static contractions of the quadriceps and gluteal muscles.
* Full length plaster may be applied when the fracture shows signs of commencing union (sticky), often about 4-6 weeks after the injury.
* This allows walking with partial weight bearing.
* The plaster should be maintained for 6-8 weeks.
* Operative reduction and internal fixation:
* Has become the standard method of treatment in most centers.
* It is the method of choice for the elderly to avoid prolonged recumbency.
* Use of a combined nail-plate or a sliding screw and plate (Dynamic condylar screw) is recommended.
* The nail or screw is driven horizontally across the lower fragment and the plate, at right angles to the nail, is screwed to the outer side of the main upper fragment.
* Use of a long intramedullary nail driven down the femur and across the knee joint into the upper half of the tibia.
* When the fracture is united, the nail is removed and knee movement is restored by active exercises.

Operative

* + - **external fixation**
      * indications
        + temporizing measure to restore length, alignment, and stability

unstable, polytrauma

soft tissues not amenable to surgical incisions and internal fixation, or until the patient is stable

contamination requiring multiple debridements

* + - * + definitive treatment

severe open and/or comminuted fractures

patients unstable for surgery

**open reduction internal fixation (ORIF)**

* + - * indications
        + displaced fracture
        + intra-articular fracture
        + periprosthetic fracture with osteoporotic bone
        + nonunion

**retrograde intramedullary nail**

* + - * indications
        + extraarticular fractures
        + simple intraarticular fractures
        + periprosthetic fractures with implants with an "open-box" design

distal femoral replacements do not allow retrograde nail fixation

**arthroplasty and distal femoral replacement**

* + - * indications
        + arthroplasty

preexisting osteoarthritis with amenable fracture pattern

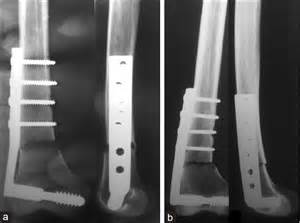
* + - * + distal femoral replacement

low demand patients

un-reconstructable fracture

fracture around prior total knee arthroplasty with loose component

osteoarthritis



**COMPLICATIONS:**

* Mal-union
* Stiffness of the knee
* Injury to popliteal artery
* Injury to a major nerve trunk (tibial nerve, common peroneal nerve).
* Symptomatic hardware
* Infection
* Non union
* Implant failure

**FRACTURES OF FEMORAL CONDYLE:**

* Usually caused by direct violence to the region of the knee.
* Two patterns of fracture are usually encountered:
  + Oblique fracture shearing the condyle
  + T-shaped fracture separating both condyles
* The fracture may be a crack without displacement, or there may be complete separation of a condyle with marked displacement.
* Depends on the degree of displacement.
* Undisplaced fractures:
  + Treated by immobilization in a long leg plaster for about 6-8 weeks, walking being allowed from an early stage.

**Displaced fractures:**

* + Accurate reduction is required
  + Reduction by traction and manipulation should be tried. If successful, continuous weight traction in Thomas’s splint can be done or use full length plaster.
  + If unsuccessful reduction, operative reduction and internal fixation should be done, e.g. by a long screw or bolt. T-shaped # can be treated by a right angled compression screw-plate (dynamic condylar screw)

**COMPLICATIONS:**

* Stiffness of the knee.
  + Caused by intra-articular adhesions and partly by peri-articular and intramuscular adhesions.
  + Treated by active exercises
* Osteoarthritis of the knee
* Injury to artery or nerve
  + Popliteal artery
  + One of the main nerve trunks

**KNEE DISLOCATION:**

* Devastating injury resulting from high or low energy high-energy
  + usually from MVC or fall from height
  + commonly a dashboard injury resulting in axial load to flexed knee
* low-energy
  + often from athletic injury
  + generally, has a rotational component
  + morbid obesity is a risk-factor



* Knee dislocations are high energy traumatic injuries characterized by a high rate of neurovascular injury.
* Diagnosis is made clinically with careful assessment of limb neurovascular status. Radiographs should be obtained to document reduction.
* Treatment is generally emergent reduction and stabilization with assessment of limb perfusion followed by delayed ligamentous reconstruction.

**Associated injuries:**

* vascular injury
  + 5-15% in all dislocations
  + 40-50% in anterior/posterior dislocations
  + due to tethering at the popliteal fossa
    - proximal - fibrous tunnel at the adductor hiatus
    - distal - fibrous tunnel at soleus muscle
* nerve injury
  + usually common peroneal nerve injury (25%)
  + tibial nerve injury is less common
* fractures
  + present in 60%
  + tibia and femur most common
* **CLASSIFICATION**
  + Descriptive

|  |  |  |
| --- | --- | --- |
| * + - Kennedy classification   (based on the direction of displacement of the tibia) | | |
| * + - Anterior (30-50%) | * + - most common   due to hyperextension injury   * + - usually involves tear of PCL     - an arterial injury is generally an intimal tear due to traction     - the highest rate of peroneal nerve injury |  |
| * + - Posterior (30-40%) | * + - 2nd most common     - due to axial load to the flexed knee (dashboard injury)     - the highest rate of vascular injury based on Kennedy classification    has highest incidence of a complete tear of the popliteal artery |  |
| * + - Lateral (13%) | * + - due to a varus or valgus force     - usually involves tears of both ACL and PCL |  |
| * + - Medial (3%) | * + - varus or valgus force     - usually disrupted PLC and PCL |  |
| * + - Rotational (4%) | * + - usually irreducible     - posterolateral is most common rotational dislocation     - buttonholing of femoral condyle through the capsule |  |

* + - Kennedy classification based on the direction of displacement of the tibia

Schenck Classification

* + - based on a pattern of multiligamentous injury of knee dislocation (KD)

|  |  |  |
| --- | --- | --- |
| * + - Schenck Classification   (based on the number of ruptured ligaments) | | |
| * + - KD I | * + - Multiligamentous injury with the involvement of the ACL or PCL |  |
| * + - KD II | * + - Injury to ACL and PCL only (2 ligaments) |  |
| * + - KD III | * + - Injury to ACL, PCL, and PMC or PLC (3 ligaments).   KDIIIM (ACL, PCL, MCL) and KDIIIL (ACL, PCL, PLC, LCL). |  |
| * + - KD IV | * + - Injury to ACL, PCL, PMC, and PLC (4 ligaments)   Has the highest rate of vascular injury (5-15%%) |  |
| * + - KD V | * + - Multiligamentous injury with periarticular fracture |  |

* **PRESENTATION**
  + Symptoms
    - history of trauma and deformity of the knee
    - knee pain & instability
  + Physical exam
    - appearance
      * no obvious deformity
        + 50% spontaneously reduce before arrival to ED
        + may present with subtle signs of trauma (swelling, effusion, abrasions, ecchymosis)
      * obvious deformity
        + reduce immediately, especially if absent pulses
        + "dimple sign" - buttonholing of medial femoral condyle through the medial capsule

indicative of an irreducible posterolateral dislocation

a contraindication to closed reduction due to risks of skin necrosis

* + - vascular exam
      * priority is to rule out vascular injury on exam both before and after reduction
        + serial examinations are mandatory
        + palpate the dorsalis pedis and posterior tibial pulses on injured and contralateral side
      * if pulses are present and normal
        + does not indicate the absence of arterial injury

collateral circulation can mask a complete popliteal artery occlusion

* + - * + measure Ankle-Brachial Index (ABI) on all patients with suspected KD

if ABI >0.9

then monitor with serial examination (100% Negative Predictive Value)

if ABI <0.9

perform an arterial duplex ultrasound or CT angiography

if arterial injury confirmed then consult vascular surgery

* + - * If pulses are absent or diminished
        + confirm that the knee joint is reduced or perform immediate reduction and reassessment
        + immediate surgical exploration if pulses are still absent following reduction

ischemia time >8 hours has amputation rates as high as 86%

* + - * + imaging contraindicated if it will delay surgical revascularization
        + if pulses present after reduction then measure ABI then consider observation vs. angiography
    - neurologic exam
      * assess sensory and motor function of peroneal and tibial nerve as nerve deficits often occur concomitantly with vascular injuries
    - stability
      * diagnosis based on instability on physical exam (radiographs and gross appearance may be normal)
      * may see recurvatum when held in extension
      * assess ACL, PCL, MCL, LCL, and PLC
* **TREATMENT**
  + Nonoperative
    - **emergent closed reduction followed by vascular assessment/consult**
      * indications
        + considered an orthopedic emergency
      * vascular consult indicated if
        + pulses are absent or diminished following reduction
        + if arterial injury confirmed by arterial duplex ultrasound or CT angiography
    - **immobilization as definitive management**
      * indications (rare)
        + successful closed reduction without vacular compromise
        + most cases require some form of surgical stabilization following reduction
      * outcomes
        + worse outcomes are seen with nonoperative management
        + prolonged immobilization will lead to loss of ROM with persistent instability
  + Operative
    - **open reduction**
      * indications
        + irreducible knee
        + posterolateral dislocation
        + open fracture-dislocation
        + obesity (may be difficult to obtain closed)
        + vascular injury
    - **external fixation**
      * indications
        + vascular repair (takes precedence)
        + open fracture-dislocation
        + compartment syndrome
        + obese (if difficult to maintain reduction)
        + polytrauma patient
    - **delayed** **ligamentous reconstruction/repair**
      * indications
        + instability will require some kind of ligamentous repair or fixation
        + patients can be placed in a knee immobilizer until treated operatively

improved outcomes with early treatment (within 3 weeks)

**TECHNIQUE**

* **Closed reduction**
  + approach
    - anterior dislocation - traction and anterior translation of the femur
    - posterior dislocation - traction, extension, and anterior translation of the tibia
    - medial/lateral - traction and medial or lateral translation
    - rotatory - axial limb traction and rotation in the opposite direction of deformity
  + splinting
    - 20 to 30 degrees of flexion

**Complications:**

* Stiffness (arthrofibrosis)
  + is most common complication
  + more common with delayed mobilization
* Laxity and instability
* Peroneal nerve injury
  + most common in posterolateral dislocations
  + poor results with acute, subacute, and delayed (>3 months) nerve exploration
  + neurolysis and tendon transfers are the mainstay of treatment
* Vascular compromise
  + in addition to vessel damage, claudication, skin changes, and muscle atrophy can occur

**TIBIAL PLATEAU FRACTURE:**

**MECHANISM OF INJURY.**

* Tibial Plateau fractures are periarticular injuries of the proximal tibia frequently associated with soft tissue injury.
* Diagnosis is made with knee radiographs but frequently require CT scan for surgical planning.
* Treatment is often ORIF in the acute setting versus delayed fixation after soft tissue swelling subsides.
* **This is sometimes the result of a car striking a pedestrian (bumper fracture) more often it is due to a fall from a height in which the knee is forced into valgus or Varus.**
* **The tibia condyle is crushed or split by the opposing femoral condyle which remains intact.**



**PATHOLOGICAL ANATOMY.**

* Location
  + lateral plateau 70-80%
  + bicondylar 10-30%
  + medial plateau 10-20%

**The fracture pattern and degree of displacement depend on the type of direction of force as well as the quality of the bone at the upper end of tibia.**

Associated conditions

* + meniscal tears
    - lateral meniscal tear

* + - * more common than medial
      * associated with Schatzker II fracture pattern

* + - * associated with >10mm articular depression

* + - * associated with >6mm condylar widening
    - medial meniscal tear
      * most commonly associated with Schatzker IV fractures

* + ACL injuries
    - more common in type IV and VI fractures (25%)

* + compartment syndrome
  + associated soft tissue injuries have little bearing on final outcomes
  + neurovascular injury
    - commonly associated with Schatzker IV fracture-dislocations

* + - common peroneal nerve is most common nerve injury

Hohl and Moore Classification

* + Useful for
    - true fracture-dislocations
    - fracture patterns that do not fit into the Schatzker classification (10% of all tibial plateau fractures)
    - fractures associated with knee instability

|  |  |  |
| --- | --- | --- |
| * + Hohl and Moore Classification of proximal tibia fracture-dislocations | | |
| * + Type I | * + Coronal split fracture |  |
| * + Type II | * + Entire condylar fracture |  |
| * + Type III | * + Rim avulsion fracture of lateral plateau |  |
| * + Type IV | * + Rim compression fracture |  |
| * + Type V | * + Four-part fracture |  |

**CLASSIFICATION**

* Schatzker classification

|  |  |  |  |
| --- | --- | --- | --- |
| * + Schatzker Classification | | | |
| * + Type I | * + Lateral split fracture | * + young patient with strong subchondral bone |  |
| * + Type II | * + Lateral Split-depressed fracture | * + most common |  |
| * + Type III | * + Lateral Pure depression fracture   + Depression of weight bearing part leaving the condylar rim intact | * + uncommon, elderly osteoporotic |  |
| * + Type IV | * + Medial plateau fracture | * + associated fx-dislocation   + high rate of NV and ligamentous injuries |  |
| * + Type V | * + Bicondylar fracture | * + tibial spines remain continuous with shaft |  |
| * + Type VI | * + Metaphyseal-diaphyseal disassociation | * + significant soft-tissue injury |  |

**CLINICAL FEATURES.**

**1.The knee is swollen**

**2.Deformity**

**3.Bruises**

**4.Pain**

* + **DIFFERENTIAL**
    - Distal femur fracture
    - Knee dislocation
    - Patella instability
    - Patella fracture
    - Patella tendon rupture
    - Quadriceps tendon rupture
    - ACL tear
    - Meniscus tear

**IMAGING**

* + Radiographs
    - recommended views
      * AP
      * lateral
      * oblique
        + oblique is helpful to determine amount of depression
    - findings
      * on AP
        + depressed articular surface
        + sclerotic band of bone indicating depression
        + abnormal joint alignment

on lateral

* + - * + posteromedial fracture lines must be recognized

* + - * + abnormal tibial slope

* + CT scan
    - indication
      * negative radiographs with high index of suspicion for tibial plateau fracture
      * preoperative planning

* + - * + obtain after ex-fix if definitive fixation delayed if soft-tissues are not amenable for surgery
    - findings
      * articular depression
      * degree of comminution
      * fracture plane and location
        + posterior coronal split fracture best appreciated on axial and sagittal views
      * lipohemarthrosis indicates an occult fracture

* + MRI
    - indications

identify meniscal and ligamentous pathology

* + - * occult fractures

**TREATMENT**

* Nonoperative
  + **closed reduction / immobilization**
    - indications
      * minimally displaced split or depressed fractures
      * low energy fracture stable to varus/valgus alignment
      * nonambulatory patients
      * significant comorbidites that preclude surgical intervention
    - modalities
      * patella-tendon-bearing (PTB) cast
      * knee immobilizer
      * hinged knee brace
* Operative
  + **ORIF**

* + - indications
      * articular depression > 5-10 mm
      * condylar widening > 5mm
      * varus/valgus instability >10 deg
      * medial plateau fractures
      * bicondylar fractures

postoperative infection after ORIF associated with

* + - * + male gender
        + smoking
        + pulmonary disease
        + bicondylar fracture patterns
        + intraoperative time over 3 hours
        + ligamentous instability

**external fixation/Ilizarov +/- limited open/percutaneous fixation of articular segment**

* + - indications
      * severe open fracture with marked contamination
      * highly comminuted fractures where internal fixation not possible

**arthroplasty**

* + - indications
      * consider in patients >65-years-old with osteoporotic bone
    - outcomes

* + - * earlier time to weight bearing
      * improved outcomes for primary

PRINCIPLES IN REDUCTION AND FIXATION.

Traction is used to achieve reduction many of the fragments that have soft tissue attachments will reduce spontaneously (Ligamentotaxis).

If open reduction is needed or intended, the operation should be carefully planned.

Stability is all important, no matter which method is used, fixation must be secure enough to permit early joint movement. There is little point in ending up with a pleasing x-ray and a stiff **knee.**

* **COMPLICATIONS**
  + Post-traumatic arthritis
    - incidence
      * 25-35%
        + 3-7% undergo TKA at 10+ years

* + - risk factors for arthritis
      * meniscectomy
      * malalignment > 5 deg
      * instability
    - risk factors for future TKA
      * age
      * bicondylar fracture
      * increasing comorbidities

Compartment syndrome

risk factors

* + - * Schatzker type IV
      * high-energy mechanism
      * associated fibula fracture
      * fracture length
      * associated plateau-shaft injury
    - treatment
      * emergent fasciotomy

Infection

* + - risk factors
      * poor surgical timing based on swelling
      * open fractures
      * longer operative time

treatment

* + - * irrigation and debridement + IV abx
      * removal of hardware if loose or grossly infected
        + ex-fix and staged revision ORIF
      * retain hardware if fracture still healing and implant still providing stability
  + Nonunion/malunion
  + uncommon due to rich blood supply of cancellous bone

risk factors

* + - * Schatzker type VI (metaphyseal-diaphyseal junction)
      * comminution
      * unstable fixation
    - treatment
      * revision osteosynthesis augmented with bone graft
  + Knee stiffness
    - risk factors
      * increasing age
      * higher BMI
      * severity of fracture
      * prolonged immobilization
      * involvement of tibial eminence
      * polytrauma
    - treatment
      * arthroscopic lysis of adhesions
        + indicated if unable to achieve 90 deg of flexion within 4 weeks
  + Loss of reduction
    - risk factors
      * inadequate fixation
      * severity of fracture
      * osteoporosis
    - treatment
      * revision ORIF to address inadequate fixation

Deep vein thromobosis

* + - incidence
      * nonoperative 9%
      * operative 6%

**FRACTTURE SHAFT TIBIA:**

* Diaphyseal tibial fractures are the most common long bone fracture.
* Diagnosis is confirmed by plain radiographs of the tibia and adjacent joints.
* Treatment is generally operative with intramedullary nailing. In rare cases, external fixation or ORIF is more appropriate depending on the location and orientation of the fracture
* **ETIOLOGY**

**Pathophysiology:**

mechanism of injury

* + - * low energy (fall from standing, twisting, etc)
        + result of indirect, torsional injury

leads to spiral fracture pattern with fibula fracture at a different level

* + - * + more likely to be associated with a lower degree of soft tissue injury
      * high energy fx (MVA, fall from height, athletics, etc)
        + result of direct force

leads to wedge or short oblique fracture that may have significant comminution with fibula fracture at same level

* + - * + more likely to be associated with severe soft tissue injury

Oestern and Tscherne II / III

open fractures

pathoanatomy

* + - * proximal third tibia fractures
        + must rule out extension into tibial plateau on plain films or CT scan
        + high risk for valgus/procurvatum deformity with IM nailing
      * distal third tibia fracture
        + higher rates of ankle injury seen with distal 1/3 tibia fracture and spiral fracture pattern

posterior malleolus most common associated ankle injury which, in some cases, may affect syndesmotic stability

* + - * + extension into or adjacent to tibial plafond may require separate/additional fixation and are managed differently than tibial shaft fractures
    - associated conditions
      * soft tissue injury
        + severity of muscle injury has highest impact on eventual need for amputation
      * compartment syndrome
        + more common in diaphyseal tibial shaft fractures than proximal or distal tibia fractures

8.1% risk in diaphyseal fractures, compared to proximal (1.6%) and distal (1.4%) fractures

* + - * + can occur even in the setting of an open fracture
        + all four compartments must be examined. If patient is unable to participate in examination and concern is high clinically, intracompartmental compartment measurements should be performed
      * bone loss
      * ipsilateral skeletal injury
        + tibial plateau fractures
        + tibial plafond fractures
        + femoral shaft fractures

floating knee is an indication for antegrade tibial nailing and retrograde femoral nailing

* + - * + posterior malleolar fracture

distal 1/3 and spiral tibial shaft fractures

**CLASSIFICATION**

* Fracture classification is primarily descriptive based on pattern and location

|  |  |  |
| --- | --- | --- |
| * + OTA Classification | | |
| * + 42A | * + Simple fracture patterns |  |
| * + 42B | * + Wedge patterns |  |
| * + 42C | * + Complex/comminuted patterns |  |

|  |  |  |
| --- | --- | --- |
| * + Oestern and Tscherne Classification of Closed Fracture Soft Tissue Injury | | |
| * + Grade 0 | * + Injuries from indirect forces with negligible soft-tissue damage |  |
| * + Grade I | * + Superficial contusion/abrasion, simple fractures |  |
| * + Grade II | * + Deep abrasions, muscle/skin contusion, direct trauma, impending compartment syndrome |  |
| * + Grade III | * + Excessive skin contusion, crushed skin or destruction of muscle, subcutaneous degloving, acute compartment syndrome, and rupture of major blood vessel or nerve |  |
|  |  |  |

|  |  |  |
| --- | --- | --- |
| * + Gustilo-Anderson Classification of Open Tibia Fractures | | |
| * + Type I | * + Limited periosteal stripping, clean wound < 1 cm |  |
| * + Type II | * + Minimal periosteal stripping, wound >1 cm in length without extensive soft-tissue injury damage |  |
| * + Type IIIA | * + Significant soft tissue injury (often evidenced by a segmental fracture or comminution), significant periosteal stripping, wound usually >5cm in length, no flap required. |  |
| * + Type IIIB | * + Significant periosteal stripping and soft tissue injury, flap required due to inadequate soft tissue coverage . Treat proximal 1/3 fxs with gastrocnemius rotation flap, middle 1/3 fxs with soleus rotation flap, distal 1/3 fxs with free flap. |  |
| * + Type IIIC | * + Significant soft tissue injury (often evidenced by a segmental fracture or comminution), vascular injury requiring repair to maintain limb viability |  |
|  | * + For prognostic reasons, severely comminuted, contaminated barnyard injuries, close-range shotgun/high-velocity gunshot injuries, and open fractures presenting over 24 hours from injury have all been included in the grade III group. |  |

**IMAGING**

* Radiographs
  + recommended views
    - full-length AP and lateral views of the affected tibia
    - AP, lateral and oblique views of ipsilateral knee and ankle
    - repeat radiographs recommended after splinting or fracture manipulation

**TREATMENT**

Nonoperative

**closed reduction / cast immobilization**

indications

closed, low energy fractures with acceptable alignment

< 5 degrees varus-valgus angulation

< 10 degrees anterior/posterior angulation

> 50% cortical apposition

< 1 cm shortening

< 10 degrees rotational malalignment

certain patients who may be non-ambulatory (ie. paralyzed), or those unfit for surgery

Operative

**I&D + antibiotics**

indications

all open tibia fractures require an emergent I&D

surgical debridement within 12-24 hours of injury

wounds should be irrigated and dressed with saline-soaked gauze in the emergency department before splinting

all open tibia fractures require immediate antibiotics

should be administered within 3 hours of injury

standard abx for open fractures (institution dependent)

cephalosporin given continuously for 24 hours after definitive surgery in Grade I, II, and IIIA open fractures

aminoglycoside added in Grade IIIB injuries

penicillin administered in farm injuries theoretically covers Clostridium

tetanus vaccination status should be confirmed and appropriate prophylaxis should be administered if necessary

**external fixation**

indications

damage control for polytrauma patients

open fractures with soft tissue defects/contamination

proximal or distal metaphyseal fractures

**IM Nailing**

indications

unacceptable alignment with closed reduction and casting

soft tissue injury that will not tolerate casting

segmental fx

comminuted fx

ipsilateral limb injury (i.e., floating knee)

polytrauma

bilateral tibia fx

morbid obesity

risks for nonunion:

gapping at fracture site,

open fracture

transverse fracture pattern

shorter immobilization time,

earlier time to weight-bearing,

decreased time to union compared to casting

**amputation**

indications

no current scoring system to determine if an amputation should be performed

relative indications for amputation include

significant soft tissue trauma

warm ischemia > 6 hrs

severe ipsilateral foot trauma

**COMPLICATIONS**

* + Anterior knee pain
  + Malunion
    - incidence
      * all tibial shaft fractures - between 8-10%
      * higher in proximal 1/3 tibia fractures - up to 50%
        + valgus/procurvatum deformity

* + - risk factors
      * definitive management with casting or external fixation
        + most common deformity is varus with nonsurgical management

varus malunion may place patient at risk for ipsilateral ankle pain and stiffness

* + Nonunion (no healing at 9 months)
    - risk factors
      * open fracture
      * cortical contact <50%
      * transverse fracture pattern

* + Malrotation

* + - incidence
      * highest after IM nailing of distal 1/3 tibia fractures

* + - * + increases risk of adjacent ankle arthrosis

* + Compartment syndrome
    - incidence
      * estimated between 1-9%
        + can occur in both closed and open tibia shaft fractures
    - risk factors
      * high energy injuries
      * significant soft tissue injuries

treatment

* + - * emergent four-compartment fasciotomy
  + Nerve injury
  + Infection
    - incidence
      * approximately 5%
    - risk factors
      * open fracture
      * severe soft tissue injury with contamination

* + - * longer time to definitive soft tissue coverage



**TIBIAL PLAFOND FRACTURES:**

* A tibial plafond fracture (also known as a pilon fracture) is a fracture of the distal end of the tibia, most commonly associated with comminution, intra-articular extension, and significant soft tissue injury.
* Diagnosis is typically made through clinical evaluation and confirmed with plain radiographs.
* Treatment is generally operative with temporary external fixation followed by delayed open reduction internal fixation once the soft tissues permit.



* **ETIOLOGY**
  + Pathophysiology
    - mechanism
      * high energy axial load (most common)
        + talus is driven into the plafond resulting in articular impaction of the distal tibia
        + falls from height
        + motor vehicle accidents
      * low energy rotational forces (less common)
  + Associated conditions
    - 75% have associated fibula fractures

* + - 30% have an ipsilateral lower extremity injury
    - 20% are open fractures
    - 5-10% are bilateral pilon fractures
* **CLASSIFICATION**

|  |  |  |
| --- | --- | --- |
| * + - AO/OTA Classification | | |
| 43-A | * + - Extra-articular |  |
| * + - 43-B | * + - Partial articular |  |
| * + - 43-C | * + - Complete articular |  |

|  |  |  |
| --- | --- | --- |
| * + - Ruedi and Allgower Classification | | |
| * + - Type I | * + - Nondisplaced |  |
| * + - Type II | * + - Simple displacement with incongruous joint |  |
| * + - Type III | * + - Comminuted articular surface |  |

**PRESENTATION**

* Symptoms
  + severe ankle pain
  + ankle deformity
  + inability to bear weight
* Physical exam
  + inspection & palpation
    - ankle tenderness, swelling, abrasions, ecchymosis, fracture blisters, open wounds, and chronic skin/vascular changes
  + motion
    - ankle motion limited
  + neurovascular
    - check DP and PT pulses
      * CT angiography if clinically warranted
    - look for neurologic compromise
    - check for signs/symptoms of compartment syndrome

**IMAGING**

* Radiographs
  + recommended views
    - AP
    - lateral
    - mortise
    - full-length tibia/fibula and foot x-rays performed for fracture extension

**TREATMENT**

* Nonoperative
  + **cast immobilization**
    - indications
      * stable fracture patterns without articular surface displacement
      * critically ill or non-ambulatory patients
      * significant risk of skin problems (diabetes, vascular disease, peripheral neuropathy)

**open reduction and internal fixation (ORIF)**

* indications
  + definitive fixation for a majority of pilon fractures
  + limited or definitive ORIF can be performed acutely with low complications in certain situations

**external fixation/circular frame fixation alone**

* indications
  + select cases where bone or soft tissue injury precludes internal fixation

**primary ankle arthrodesis**

* indications
  + no definitive indications
* potential indications
  + severely comminuted, non-reconstructable plafond fractures
  + select elderly populations who cannot tolerate multiple surgeries or prolonged immobilization
  + manual laborers
* **COMPLICATIONS**
  + Infection
    - incidence
      * 5-15%
    - risk factors
      * significant soft tissue swelling at time of definitive surgery
    - treatment
      * irrigation and debridement, antibiotics,
      * possible hardware removal
  + Malunion
  + Nonunion

 risk factors

* + - * metaphyseal comminution
      * open fractures
      * bone loss
      * tobacco use/NSAID use
  + Post-traumatic arthritis
  + Stiffness

**Fracture tarsal bone**

**1: NAVICULAR:**

* Tarsal Navicular Fractures are rare fractures of the midfoot that may occur due to trauma or due to repetitive micro stress.
* Diagnosis can be made with plain radiographs of the foot.

Treatment is generally nonoperative with cast immobilization and non-weight-bearing for the majority of fractures. Surgical management is indicated for

* nonunion,
* significantly displaced fractures,
* for elite athletes.
  + - **ETIOLOGY**
      * Navicular fractures can be

traumatic

stress fracture

mechanism of injury is usually due to chronic overuse

often seen in athletes running on hard surfaces

also common in baseball players

considered a high-risk injury due to risk of AVN

most common complications include delayed union and non-union

Spontaneous navicular AVN (Mueller-Weiss syndrome)

Spontaneous navicular AVN is a rare disease that and can be seen in middle aged adults with chronic midfoot pain

**ANATOMY**

* Articulations
  + navicular bone articulates with
    - cuneiforms
    - cuboid
    - calcaneus
    - talus

**CLASSIFICATION**

|  |  |  |
| --- | --- | --- |
| * + Sangeorzan Classification of Navicular Body Fractures   + (based on plane of fracture and degree of comminution) | | |
| * + Type I | * + Transverse fracture of dorsal fragment that involves < 50% of bone.   + No associated deformity |  |
| * + Type II | * + Oblique fracture, usually from dorsal-lateral to plantar-medial.   + May have forefoot ADduction deformity. |  |
| * + Type III | * + Central or lateral comminution.   + ABduction deformity. |  |

**PRESENTATION**

* + Symptoms
    - midfoot pain and swelling
  + Physical exam
    - midfoot swelling
    - tenderness to palpation of midfoot
    - usually full ROM of ankle and subtalar joint

**IMAGING**

* Radiographs
  + may be difficult to see and are often missed
  + recommended views
    - AP
    - lateral
    - oblique 45 degree radiograph
      * best to visualize tuberosity fractures

**TREATMENT OF STRESS FRACTURES**

* + Nonoperative
    - **cast immobilization with no weight bearing**

* + - * indications
        + any navicular stress fracture, regardless of type, can be initially treated with cast immobilization and nonweight bearing for 6-8 weeks with high rates of success

* + Operative
    - **open reduction and internal fixation**
      * indications
        + high level athletes
        + nonunion of navicular stress fracture
        + failure of cast immobilization and non weight bearing
* **TREATMENT OF TRAUMATIC FRACTURES**
  + Nonoperative
    - **cast immobilization with no weight bearing**
      * indications
        + acute avulsion fractures
        + most tuberosity fractures
        + minimally displaced Type I and II navicular body fractures
  + Operative
    - **fragment excision**
      * indications
        + avulsion fractures that failed to improve with nonoperative modalities
        + tuberosity fractures that went on to symptomatic nonunion
    - **open reduction and internal fixation**
      * indications
        + avulsion fractures involving > 25% of articular surface
        + tuberosity fractures with > 5mm diastasis or large intra-articular fragment
        + displaced or intra-articular Type I and II navicular body fractures

**Fracture calcaneus:**

* Calcaneus fractures are the most common fractured tarsal bone and are associated with a high degree of morbidity and disability.
* Diagnosis is made radiographically with foot radiographs with CT scan often being required for surgical planning.
* Treatment is nonoperative versus operative based on fracture displacement and alignment, associated soft tissue injury, and patient risk factors.
* **CLASSIFICATION**
  + Extra-articular (25%)

* + Intra-articular (75%)

Sanders classification

based on the number of articular fragments seen on the coronal CT image at the widest point of the posterior facet

|  |  |  |
| --- | --- | --- |
| * + - * Sanders classification | | |
| * + - * Type I | * + - * Nondisplaced posterior facet (regardless of number of fracture lines) |  |
| * + - * Type II | * + - * One fracture line in the posterior facet (two fragments) |  |
| * + - * Type III | * + - * Two fracture lines in the posterior facet (three fragments) |  |
| * + - * Type IV | * + - * Comminuted with more than three fracture lines in the posterior facet (four or more fragments) |  |

Beavis classification

based on fracture morphology of the calcaneus tuberosity

|  |  |  |
| --- | --- | --- |
| * + - * Beavis Classification       * (based on fracture of tuberosity) | | |
| * + - * Type 1 | * + - * Sleeve fracture - small shell of cortical bone avulses from the tuberosity |  |
| * + - * Type 2 | * + - * Beak fracture - oblique fracture line runs posteriorly from most superior portion of the posterior facet |  |
| * + - * Type 3 | * + - * Infrabursal fracture from the middle of the tuberosity |  |

* **PRESENTATION**
  + Symptoms
    - pain
    - swelling
    - inability to bear weight
    - gross deformity
    - open fracture
  + Physical exam
    - inspection
      * ecchymosis and swelling
      * shortened and widened heel
        + may have apparent varus deformity
      * open skin lesions or fractures
      * posterior heel skin compromise
      * fracture blisters
    - palpation
      * diffuse tenderness to palpation
    - strength
      * decreased ankle plantarflexion strength with avulsion fractures
    - neurologic
      * assess for neuologic compromise due to swelling
    - vascular
      * assess peripheral pulses

**IMAGING**

* Radiographs
  + recommended views
    - AP
    - lateral
    - oblique

**TREATMENT**

* Nonoperative
  + **cast immobilization with non weight bearing for 6 weeks**

* + - indications
      * calcaneal stress fractures

* + **cast immobilization with non-weight bearing for 10 to 12 weeks**
    - indications
      * small extra-articular fracture (<1 cm) with intact Achilles tendon and <2 mm displacement
      * Sanders Type I (nondisplaced)
      * anterior process fracture involving <25% of calcaneocuboid joint
      * comorbidities
      * minimally displaced tuberosity fractures (<1 cm of displacement) without threatened soft-tissue envelope in elderly patients with reduced function or physical capacity

**COMPLICATIONS**

* Wound complications (10-25%)

* + delayed wound healing is the most common complication

Subtalar arthritis

* Compartment syndrome (10%)
  + results in claw toes

* Malunion

|  |  |  |
| --- | --- | --- |
| * + - Malunion CT Classification & Treatment | | |
| * + - Type I | * + - Lateral exostosis with no subtalar arthritis     - Treat with lateral wall resection |  |
| * + - Type II | * + - Lateral exostosis with subtalar arthritis     - Treat with lateral wall resection and subtalar fusion |  |
| * + - Type III | * + - Lateral exostosis, subtalar arthritis, and varus malunion     - Treat with lateral wall resection, subtalar fusion, and +/- valgus osteotomy (controversial) |  |

**FRACTURE METATARSALS:**

* Metatarsal fractures are among the most common injuries of the foot that may occur due to trauma or repetitive microstress.
* Diagnosis is made with plain radiographs of the foot.
* Treatment may be nonoperative or operative depending on the specific metatarsal involved, number of metatarsals involved, and fracture displacement.
* **ETIOLOGY**
  + Mechanism
    - direct crush injury
      * may have significant associated soft tissue injury
    - indirect mechanism (most common)
      * occurs with forefoot fixed and hindfoot or leg rotating
  + Associated conditions
    - Lisfranc injury
      * Lisfranc equivalent injuries seen with multiple proximal metatarsal fractures
    - stress fracture

* + - * consider metabolic evaluation for fragility fracture
      * look for associated foot deformity
      * seen at base of 2nd metatarsal in ballet dancers
* **CLASSIFICATION**
  + Classification of metatarsal fractures is descriptive and should include
    - location
    - fracture pattern
    - displacement
    - angulation
    - articular involvement
* **PRESENTATION**
  + History
    - look for antecedent pain when suspicious for stress fracture
  + Symptoms
    - pain, inability to bear weight
  + Physical Exam
    - inspection
      * foot alignment (neutral, cavovarus, planovalgus)
      * focal areas or diffuse areas of tenderness
      * careful soft tissue evaluation with crush or high-energy injuries
    - motion
      * evaluate for overlapping or malrotation with motion
    - neurovascular
      * semmes weinstein monofilament testing if suspicious for peripheral neuropathy

**IMAGING**

* Radiographs
  + recommended views
    - required
      * AP, lateral and oblique views of the foot

**TREATMENT**

* Nonoperative
  + **stiff soled shoe or walking boot with weight bearing as tolerated**
    - indications
      * first metatarsal
        + non-displaced fractures
      * second through fourth (central) metatarsals
        + isolated fractures
        + non-displaced or minimally displaced fractures
      * stress fractures
        + second metatarsal most common
        + look for metabolic bone disease
        + evaluate for cavovarus foot with recurrent stress fractures
* Operative
  + **percutaneous vs open reduction and fixation**
    - indications
      * open fractures
      * first metatarsal
        + any displacement

no intermetatarsal ligament support

30-50% of weight bearing with gait

* **COMPLICATIONS**
  + Malunion
    - may lead to transfer metatarsalgia or plantar keratosis
    - treat with osteotomy to correct deformity

**OPEN FRACTURE MANAGEMENT:**



* Open fractures are fractures with direct communication to the external environment.
* Diagnosis is made clinically by assessing the size and nature of the external wound as well as obtaining radiographs of the bone at the location of the soft tissue injury.
* Treatment depends on location of fracture but generally requires immediate IV antibiotics and urgent irrigation and debridement followed by surgical fixation as needed.
* **Definition:**
* A fracture is open or compound when there is a wound of the skin surface leading down to the site of fracture.
* A fracture is classed as open only when a direct communication exists between the body surface and the fractured bone ends.

**TREATMENT**

* **Do primary survey – ABC**
* AIRWAY
  + Ensure airway is clear
* BREATHING
  + Make sure the patient is ventilating and if not assist (Ambu bag, oxygen)
* CIRCULATION
  + Assess for bleeding – inspect, pulse, BP
  + Start an IV line
  + Give IV fluids to restore volume
  + Stop obvious bleeding
  + Blood for grouping and cross-match, Hb, haematocrit, blood gases.



* **ETIOLOGY**
  + Pathophysiology
    - mechanism of injury
      * high-energy trauma
      * "inside-out" open fractures
  + Associated conditions
    - often associated with additional injuries (30%)
    - compartment syndrome
      * the presence of an open wound does not preclude the occurrence of compartment syndrome in the injured limb

**CLASSIFICATION**

* + - Gustilo classification
    - Tscherne classification

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| * + - Gustilo Classification | | | | | |
|  | * + - **I** | * + - **II** | * + - **IIIA** | * + - **IIIB** | * + - **IIIC** |
|  |  |  |  |  |  |
| * + - *Energy* | * + - Low | * + - Moderate | * + - High | * + - High | * + - High |
| * + - *Wound size* | * + - ≤ 1 cm | * + - 1-10 cm | * + - usually >10 cm | * + - usually >10 cm | * + - usually >10 cm |
| * + - *Soft tissue damage* | * + - Minimal | * + - Moderate | * + - Extensive | * + - Extensive | * + - Extensive |
| * + - *Contamination* | * + - Clean | * + - Moderate | * + - Extensive | * + - Extensive | * + - Extensive |
| * + - *Fracture Comminution* | * + - Minimal | * + - Moderate | * + - Severe | * + - Severe | * + - Severe |
| * + - *Periosteal Stripping* | * + - No | * + - No | * + - Yes | * + - Yes | * + - Yes |
| * + - *Skin Coverage* | * + - Local coverage | * + - Local coverage | * + - Local coverage | * + - **Free tissue flap or rotational flap coverage** | * + - Typically requires flap coverage |
| * + - *Neurovascular Injury* | * + - Normal | * + - Normal | * + - Normal | * + - Normal | * + - **Exposed fracture with arterial damage that requires repair** |

|  |  |  |  |
| --- | --- | --- | --- |
| * + - Antibiotics based on Gustilo Classification | | | |
|  | * + - Grade I and II | * + - Grade IIIA, IIIB and IIIC | * + - Special considerations |
|  |  |  |  |
| * + - *Antibiotics* | * + - 1st generation cephalosporin (e.g. cefazolin) | * + - 1st generation cephalosporin for gram positive coverage     - Aminoglycoside (such as gentamicin) for gram negative coverage | * + - Penicillin should be added if concern for anaerobic organism (farm injury)   Flouroquinolones (e.g. ciprofloxacin) should be used for fresh water wounds or salt water wounds (can be used if allergic to cephalosporins or clindamycin    Doxycycline and 3rd or 4th-generation cephalosporin  (e.g. ceftazidime) can be used for salt water wounds |

* **ANTIBIOTIC INDICATIONS FOR OPEN FRACTURES**
  + Gustillo type I and II
    - 1st generation cephalosporin
  + Gustillo type III
    - 1st generation cephalosporin + aminoglycoside
      * traditionally recommended, but there is controversy about this regimen
  + With farm injury / bowel contamination
    - 1st generation cephalosporin + aminoglycoside + PCN
    - add PCN for clostridia

* + Duration
    - initiate as soon as possible
      * increased infection rate when antibiotics are delayed > 3 hours from time of injury
    - continue for 24-72 hours after I&D
  + Tetanus booster if not up to date (no booster in last 5 years)

|  |  |  |
| --- | --- | --- |
| * Oestern and Tscherne classification of soft tissue injury in closed fractures | | |
| * Grade 0 | * Minimal soft tissue damage * Indirect injury to limb (torsion) * Simple fracture pattern |  |
| * Grade 1 | * Superficial abrasion or contusion * Mild fracture pattern |  |
| * Grade 2 | * Deep abrasion * Skin or muscle contusion * Severe fracture pattern * Direct trauma to limb |  |
| * Grade 3 | * Extensive skin contusion or crush injury * Severe damage to underlying muscle * Compartment syndrome * Subcutaneous avulsion |  |

**PRINCIPALS OF OPEN FRACTURE TREATMENT:**

* Clean the wound by performing a thorough surgical toilet.
  + Remove all dead and devitalized tissue
  + Remove all extraneous material
  + Aim at leaving healthy, well-vascularized tissues that are able to fight infection from any remaining contaminating organisms.
* The wound should not be subjected to repeated examination, but should be covered with sterile dressing.
* Avoid immediate skin closure

**Technique of operation for major wounds:**

* Enlarge the skin wound to display clearly the extent of the underlying damage
* Flush the wound with copious quantities of water or saline to remove all contaminating dirt.
* Pick out with forceps any foreign matter e.g. shreds (pieces) of clothing.
* Excise any tissues that are obviously dead
* Remove dead or devascularised muscle in order to reduce the risk of gas gangrene.
* Remove bone fragments that are small and completely detached.
* Large bone fragments, which usually retain some soft tissue attachments, should be preserved.
* The bone ends must be inspected.
* When debriding bone, the fracture edges are curetted and all dirt and non-viable bone are removed.
* Damage to major blood vessels is dealt with by:
* Ligation
* Suture
* Or vein grafting
* The ends of severed nerve trunks may be tucked lightly together with one or two sutures to facilitate later definitive repair.
* Tourniquets should be avoided when possible to prevent additional ischemic injury to the soft tissues.
* Necrotic tissue is removed and only viable tissue is left behind. The exception is skin, where none is removed unless obviously necrotic.
* The quality of the muscle tissue is assessed using the classic 4 C’s:
* Color (red or brown)
* Consistency (how does the muscle feel)
* Capillary Circulation (does it bleed?)
* Contractility (responds to pinch or electro-cautery)

**skin closure:**

* The wound should be left unsutured after surgical toilet and dressed with sterile covering.
* Delayed closure should be done as soon as infection has been aborted or overcome (delayed primary suture).

methods of skin closure:

* Direct suture of the skin edges if feasible, depending upon the amount of skin destroyed and lost in the injury.
  + If the skin loss is negligible and the skin edges can be brought together without tension, direct suture should be done.
* A free split-skin graft is used if the skin edges will not come together easily.
* Full-thickness skin graft
* soft-tissue flaps

tratment of the fracture:

* Once the wound has been dealt with, the fracture itself should be treated following the general principles of managing closed fractures.
* There should be greater reluctance to resort to operative methods of fixation, due to increased risk of infection.
* If the fracture is unstable and unsuitable for treatment by traction or by simple splintage, external fixation should be done.

external fixation:

* Provides temporary stabilization
* Minimizes additional soft-tissue injury.
* This fixation facilitates access to the wound for inspection between debridements.
* Once the wound has healed, the fracture can be immobilized in plaster for the remaining duration of treatment.

**AO CLASSIFICATION OF FRACTURES:**

* **Comprehensive classification of the long bone Fractures**
* The system allows consistent in detail description of a fracture in defined terminology by creating a 5-element alphanumeric code:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Localisation | | Morphology | | |
| Bone | Segment | Type | Group | Subgroup |
| 1/2/3/4 | 1/2/3/(4) | A/B/C | 1/2/3 | .1/.2/.3 |

**Localisation**

* First, each fracture is given 2 numbers to describe which bone it affects, and where in the bone:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 1 | 2 | 3 | 4 |
| Bone | Humerus | Radius and Ulna | Femur | Tibia and fibula |
| Segment | Proximal segment | Diaphyseal segment | Distal segment | *Malleolar segment (only used with tibia and fibula)* |

**Type**

* Each fracture is next given a letter (A, B or C) to describe the joint involvement of the fracture:

|  |  |  |  |
| --- | --- | --- | --- |
| Segment | A | B | C |
| 1 | Extra-articular | Partial articular | Complete articular |
| 2 | Simple | Wedge | Complex |
| 3 | Extra-articular | Partial articular | Complete articular |

**The exeption to this step include:**

|  |  |  |  |
| --- | --- | --- | --- |
| Localisation | A | B | C |
| 11 - Proximal humerus | Extra-articular, unifocal | Extra-articular, bifocal | Articular |
| 31 - Proximal femur | Extra-articular, trochanteric | Extra-articular, neck | Articular, head |
| 44 - Malleoli | Infrasydesmotic | Transyndesmotic | Suprasyndesmotic |

**Groups & Subgroups**

* Finally, the fracture is given 2 further numbers to denote the fracture pattern and geometry.

For segment 2 (diaphyseal) fractures

|  |  |  |  |
| --- | --- | --- | --- |
| Type | Group | | |
| 1 | 2 | 3 |
| A - simple | Spiral | Oblique | Transverse |
| B - wedge | Spiral | Bending | Multifragmentory |
| C - complex | Spiral | Segmental | Irregular |

* For segment 1 and 3 (epiphyseal and metaphyseal) fractures:

|  |  |  |  |
| --- | --- | --- | --- |
| Type | Group | | |
| 1 | 2 | 3 |
| A - extra-articular | Simple | Wedge | Complex |
| B - partial articular | Split | Depression | Split-depression |
| C - articular | Simple articular, simple metaphyseal | Simple articular, complex metaphyseal | Complex articular, complex metaphyseal |

OTA/AO Classification

* The Orthopaedic Trauma Association (OTA) Committee for Coding and Classification initially published their classification system covering the whole skeleton in 1996.
* In 2006they published a revision, unifying the Muller/AO and OTA systems into a single alphanumeric classification, which has been further updated in 2018:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Localisation | | | | | Region/Bone | |
| Bone | | Segment | | |
| 1 | | 4 | | | Scapula | |
| 5 | | | Clavicle | |
| 3 | | 4 | | | Patella | |
| 5 | | 1 | | | Cervical spine | |
| 2 | | | Thoracic spine | |
| 3 | | | Lumbar spine | |
| 6 | | 1 | | | Pelvic ring | |
| 2 | | | Acetabulum | |
| Localisation | | | | Region/Bone | | | |
| Bone | Segment | | |
| 7 | 1 | | | Lunate | | | |
| 2 | | | Scaphoid | | | |
| 3 | | | Capitate | | | |
| 4 | | | Hamate | | | |
| 5 | | | Triquetrum and Pisiform | | | |
| 6 | | | Trapezium and Trapezoid | | | |
| 7 | | | Metacarpus | | | |
| 8 | | | Phalanges | | | |
| 9 | | | Multiple fractures | | | |
| Localisation | | | | | | Region/Bone | | |
| Bone | | | Segment | | |
| 8 | | | 1 | | | Talus | | |
| 2 | | | Calcaneus | | |
| 3 | | | Navicular | | |
| 4 | | | Cuboid | | |
| 5 | | | Cuneiforms | | |
| 7 | | | Metatarsus | | |
| 8 | | | Phalanges | | |
| 9 | | | Multiple fractures | | |
| 9 | | | 1 | | | Craniomidface | | |
| 2 | | | Mandible | | |

