ORTHOPEDICS

Dr. H. von Schroeder
Paul Kuzyk, Mark Shekhman and Adam Sidky, chapter editors
Anna Kulidjian, associate editor

AN APPROACH TO ORTHOPEDICS

HISTORY

Identification

❑ identifying data
- include: occupation, hobbies, hand dominance

❑ chief complaint

❑ past orthopedic history
- injuries, past non-surgical treatment, past surgery
- investigations: Xray, CT scan, MRI, etc.

❑ other medical history
- past surgery, medical illnesses, allergies, medications

History of Present Illness

❑ important to obtain details regarding onset and progression of symptoms

❑ pain
- **OPQRST** (**O**nset, **P**rovoking / Alleviating factors, **Q**uality, **R**adiation, **S**ite, **T**iming)
- muscular, bony, or joint pain ?
- number of joints involved and symmetry of involvement

❑ inflammatory symptoms
- morning stiffness (> 30 min), tenderness, swelling, redness, warmth

❑ mechanical/degenerative symptoms
- increased with activity, decreased with rest
- locking, giving way, instability

❑ weakness, deformity, stiffness, crepitus

❑ neoplastic and infectious symptoms
- constant pain, night pain
- fever, night sweats
- anorexia, fatigue, weakness, weight loss
- mets from (**PT B**arnum **L**oves **K**ids): **P**rostate, **T**hyroid, **B**reast, **L**ungs, **K**idney

❑ activities of daily living
- getting up, sitting down, using bathroom, combing hair, transferring

❑ referred symptoms
- shoulder pain from the heart or diaphragm
- arm pain from the neck
- leg pain from back
- back pain from the kidney, aortic aneurysm, duodenal ulcer, pancreatitis

PHYSICAL EXAMINATION

Look, Feel, Move

❑ always examine the joint above and below

❑ look - skin, shape, position - compare sides
- **SEADS: S**welling, **E**rythema, **A**trophy, **D**eformity, **S**kin changes

❑ feel - palpate soft tissue, bone, joint line
- assess: tenderness, temperature, effusion, deformity

❑ move the affected joint(s)
- active and passive range of motion (ROM), crepitus present?, instability?
- passive ROM > active ROM suggests soft tissue inflammation or muscle weakness

❑ neurovascular tests
- pulse, reflexes, power (grade with MRC scale), sensation
  (most accurate method of eliciting sensory deficits is by 'two-point discrimination')

❑ special tests depend on joint

❑ observe gait: walking, heel-to-toe, on heels, on toes

INVESTIGATIONS

Diagnostic Imaging

❑ plain X-rays: 2 views taken at 90° to each other

❑ CT/myelography, MRI, EMG (electromyelography) / NCS (nerve conduction study)

❑ 99Tc (Technetium) bone scan
- reflects osteoblastic activity or inflammatory reaction
- positive with fractures, tumours, local reaction

❑ gallium scan
- positive when uptake on gallium is greater than on 99Tc
- reflects hypervascularity, taken up by leukocytes
- positive with infection

Blood Tests for Painful, Swollen Joint

❑ CBC, ESR, Rheumatoid Factor (RF), ANA, C-reactive protein (CRP)

FRACTURES - GENERAL PRINCIPLES

❑ mechanism: remember the process leading to the fracture
- traumatic
- pathologic - tumour, metabolic bone disease, infection, osteopenia
- stress - repetitive mechanical loading

CLINICAL FEATURES OF FRACTURES

❑ pain and tenderness
❑ loss of function
❑ deformity
❑ abnormal mobility and crepitus (avoid)
❑ altered neurovascular status (important to document)

INITIAL MANAGEMENT

❑ ABCDEs
❑ limb - attend to neurovascular status (above and below)
❑ rule out other fractures/injuries (especially joint above and below)
❑ rule out open fracture
❑ take an **AMPLE** history - **A**llergies, **M**edications, **P**ast medical history, **L**ast meal, **E**vents surrounding injury
❑ analgesia
❑ splint fracture - makes patient more comfortable, decreases progression of soft tissue injury, decreases blood loss
❑ Imaging

RADIOGRAPHIC DESCRIPTION OF FRACTURES

❑ rule of 2s
- 2 sides: bilateral
- 2 views: AP and lateral
- 2 joints: above and below the site of injury
- 2 times: before and after reduction

❑ patient identification
❑ identify views
❑ open or closed (gas in soft tissue = open)
❑ site
- which bone
- if diaphyseal decribe by thirds : proximal/middle/distal
- extra-articular: diaphysis/metaphysis
- intra-articular

❑ type
- spiral - rotational force, low energy (# line > 2x bone width)
- oblique - angular and rotational force
- transverse - direct force, high energy
- comminuted (> 2 pieces) - direct force, high energy

❑ soft tissue
- calcification, gas, foreign bodies

❑ displacement (position of distal fragment with respect to proximal)
- apposition/translation - describes what percentage of surfaces remain in contact
- angulation - describes which way the apex is facing
- rotation - distal fragment compared to proximal fragment
- shortened - due to overlap or impaction

DEFINITIVE MANAGEMENT

❑ goals – "Obtain and Maintain Reduction"
- reduce
- stabilize
- rehabilitate

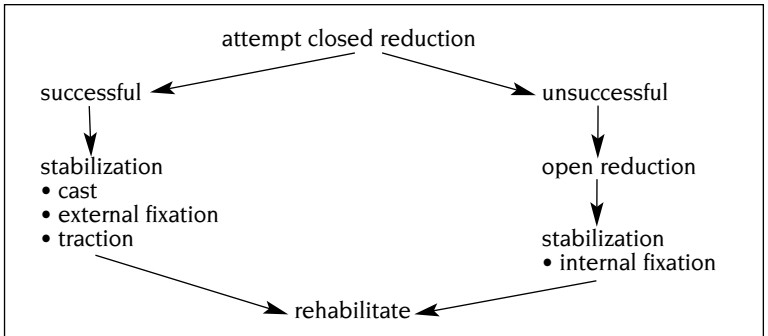


Figure 1. Fracture Management

Reduction
❑ is reduction necessary?
- may not be for clavicle, fibula, vertebral compression fractures

❑ reduce when amount of displacement is unacceptable
❑ imperfect apposition may be acceptable while imperfect alignment is rarely acceptable
❑ closed when possible
❑ indications for open reduction - remember **NO CAST**
- **N** - **N**on-union
- **O** - **O**pen fracture
- **C** - neurovascular **C**ompromise
- **A** - intra-**A**rticular fractures (require anatomic reduction)
- **S** - **S**alter-Harris III, IV, V and/or special situations depending on site
- **T** - poly**T**rauma
- others
  - failure to reduce closed
  - cannot cast or apply traction due to site (e.g. hip fracture)
  - pathologic fractures
  - fractures in paraplegics for nursing access
  - potential for improved function with open reduction with internal fixation (ORIF)
- complicatoins
  - infection
  - non-union
  - new fracture through screw holes
  - implant failure

Stabilization
❑ stabilize the fracture site but do not completely immobilize the limb if possible
❑ external stabilization
1. splints/tape
2. casts
3. traction
4. external fixator

❑ internal fixation
1. percutaneous pinning
2. extramedullary fixation (screws, plates, wires)
3. intramedullary fixation (rods) - biomechanically advantageous

Rehabilitation
❑ to avoid joint stiffness
❑ isometric exercises to avoid muscle atrophy
❑ range of motion (ROM) for adjacent joints
❑ CPM following rigid fixation of fracture allows joint motion to prevent stiffness for intra-articular fractures
❑ after cast/splint removed and fracture healed —> resistive muscle strengthening
❑ evaluate bone healing (clinical, x-ray)

OPEN FRACTURES
❑ EMERGENCY!
❑ fracture communicates with skin surface
❑ examine fracture carefully to classify (Table 1)

Table 1. Classification of Open Fractures

Size	Soft Tissue Injury	Antibiotics
Type 1 < 1 cm	Minimal	Ancef
Type 2 >1cm	Moderate; no dead soft tissue	Ancef
Type 3 >1cm	Extensive muscle damage; includes gunshot wounds, major vascular injury barnyard injury	Ancef, Gentamycin, Flagyl

❑ initial management
1. do not reduce open fractures unless there is neurovascular compromise from position of fracture
2. remove gross debris i.e. turf, rocks
3. all open fractures are contaminated, therefore obtain culture and cover wound with sterile dressing
4. administer tetanus vaccine/booster (Table 2)
5 start antibiotics
6. splint
7. NPO and prepare for O.R.

ONCE IN O.R.:
8. irrigation and debridement,
9. reduction and stabilization after I&D

- ❑ must get to O.R. within 6 hours, since risk of infection increases after this time
- ❑ wound usually left open to drain
- ❑ re-examine, with possible repeat I&D in 48 hours and closure if appropriate

Table 2. Indications for Tetanus Vaccination

Tetanus History	Clean Wound		Dirty Wound	
	Td	TIG	Td	TIG
unknown or <3 Td doses	Y	N	Y	Y
>3 Td doses	N*	N	N**	N

* Y if >10 years since last dose
** Y if >5 years since last dose
Td=0.5 mL adsorbed tetanus toxoid
TIG=250 units tetanus immune globulin

Complications of Open Fractures
- ❑ osteomyelitis
- ❑ soft tissue damage
- ❑ neurovascular injury
- ❑ blood loss
- ❑ nonunion

FRACTURE HEALING

Normal Healing

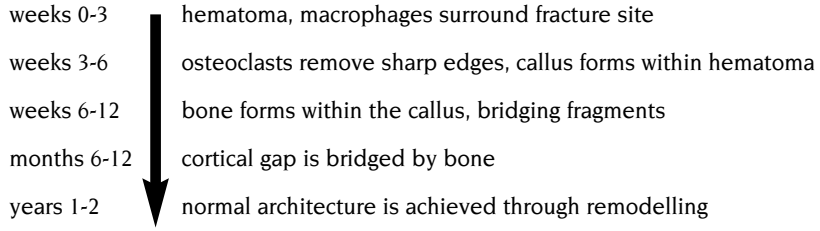


Figure 2. Stages of Bone Healing

Evaluation of Healing - Tests of Union
- ❑ clinical - no longer tender to palpation or angulation stress
- ❑ x-ray - trabeculae cross fracture site, visible callus bridging site

COMPLICATIONS OF FRACTURES

Table 3. Complications of Fractures

	Early	Late
Local	Neurovascular injury Infection Compartment syndrome Implant failure Fracture blisters	Malunion Nonunion Osteonecrosis Osteomyelitis Heterotopic ossification Post-traumatic arthritis Reflex sympathetic dystrophy (RSD)
Systemic	Sepsis Deep vein thrombosis (DVT) / pulmonary embolus (PE) Fat embolus Acute respiratory distress syndrome (ARDS) Hemorrhagic shock	

COMPARTMENT SYNDROME (see Figure 3)

- ❑ in anatomical "compartments" where muscle and tissue bounded by fascia and bone (fibro-osseous compartment) with little room for expansion (i.e. forearm, calf)
- ❑ increased interstitial pressure in compartment exceeds capillary perfusion pressure which leads to muscle necrosis and eventually nerve necrosis
- ❑ intracompartmental pressures over 30 mm Hg usually require intervention

Etiology

- ❑ fracture, dislocation
- ❑ soft tissue damage and muscle swelling
- ❑ crush injury
- ❑ arterial compromise
- ❑ muscle anoxia
- ❑ venous obstruction
- ❑ increased venous pressure
- ❑ constrictive dressing, cast, splint

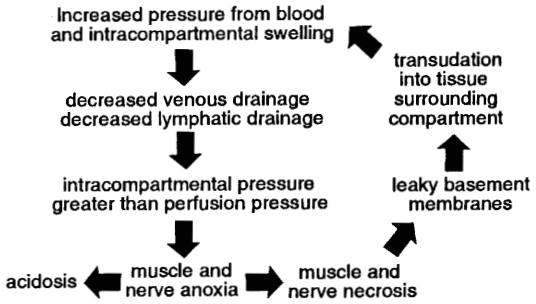


Figure 3. Pathogenesis of Compartment Syndrome

Diagnosis

- ❑ classically the tibial compartments
- ❑ also in forearm flexor compartment
  - may lead to Volkmann's ischemic contracture
- ❑ clinical signs and symptoms
  - early
    - pain
      - greater than expected for injury
      - not relieved by analgesics
      - increase with passive stretch of compartment muscles
    - pallor
      - palpable tense, swollen copmparment
  - late
    - paralysis (inability to move limb - late)
    - pulses are usually still present
    - paresthesias
  - NOT pulslessness
    - most important feature found on physical exam is PAIN out of proportion to injury (the other signs are 'late signs')
- ❑ compartment pressure monitoring
  - in unresponsive or unreliable patients
  - normal tissue pressure is about 0 mm Hg
  - pressure increases markedly in compartment syndromes.
  - when intra-compartmental pressure rises to within 10 to 30 mm Hg of patient's diastolic blood pressure inadequate perfusion and/or ischemia results
  - fasciotomy usually is indicated when the tissue pressure rises to 40-45 mm Hg in a patient who has any signs or symptoms of a compartment syndrome-even if distal pulses still present

Table 4. Signs of Compartment Syndrome in Anterior Leg and Forearm

	Anterior leg	Volar forearm
Fracture Type	Tibial fracture	Supracondylar (humerus)
Weakness	Toe, foot extension	Finger, wrist flexion
Pain	Toe, foot flexion	Finger, wrist extension
Sensory	1st dorsal web space	Volar aspect of fingers

Treatment

- ❑ remove constrictive dressings
- ❑ bivalve casts down to skin and spread open
- ❑ place limb at level of heart
- ❑ emergency fasciotomy to release compartments if difference between diastolic blood pressure and compartment pressure is less than 30 mmHg (treat within 4-6 hours of onset symptoms)

AVASCULAR NECROSIS (AVN)

Causes
- ❑ steroid use (inflammatory arthritis, inflammatory bowel disease (IBD), allergies, renal disease, asthma); NOT dose related - idiosyncratic
- ❑ alcohol
- ❑ post-traumatic fracture/dislocation
- ❑ septic arthritis
- ❑ sickle cell disease
- ❑ Gaucher's disease
- ❑ Caisson's disease - deep sea diving/the bends
- ❑ idiopathic

Table 5. AVN Classification

Stage	Clinical Features	X-ray Features
1	Preclinical phase of ischemia and necrosis; no pain	No plain x-ray abnormality; may be detectable on MRI
2	Painful	Early radiographic changes i.e. fragment appears dense, normal bone contour
3	Painful	Radiographic changes obvious, abnormal bone contour
4	Very painful	Collapse of articular surface and signs of arthritis on both sides of the joint

Mechanism
- ❑ occurs following disruption of blood supply to bone
- ❑ occurs especially in those bones extensively covered in cartilage which rely on intra-osseous blood supply and distal to proximal blood supply, e.g. head of femur, proximal pole of scaphoid, body of talus
- ❑ results in ischemia
- ❑ pathologic changes include resorption, subchondral fractures and loss of cartilage

SHOULDER

GENERAL PRINCIPLES
- ❑ shoulder is a complex 4 part joint
  - glenohumeral joint
  - acromioclavicular (AC) joint
  - scapulothoracic joint
  - sternoclavicular joint
- ❑ examination should involve each of the joints in isolation
- ❑ the joint is highly mobile therefore decreased stability
- ❑ dislocations and subluxations following trauma are common
- ❑ rotator cuff and tendon degeneration are more common than osteoarthritis (OA)
- ❑ may be referred pain from C-spine

Physical Examination of the Shoulder
- ❑ LOOK - inspect both shoulders anteriorly and posteriorly, clavicle, deltoids, scapula (SEADS)
- ❑ FEEL - for tenderness, swelling, temperature changes, muscle characteristics (include all joints and bones)
- ❑ MOVE - Active/Passive

Active ROM
- forward flexion and abduction
- external rotation (elbows at side and flexed 90 degrees, move arms away from midline)
- internal rotation (hand behind the back, measure wrt. level of the spine)

Passive ROM
- abduction – 180 degrees
- adduction – 45 degrees
- flexion – 180 degrees
- extension – 45 degrees
- internal rotation – level of T4
- external rotation – 40 - 45 degrees

X-Ray

❑ radiographic views of the shoulder should include
- AP, trans-scapular, and axillary views (at least)
- stress views of the acromioclavicular joint where indicated

❑ look for the Mercedes Benz sign (see Figure 4)
- in the trans-scapular radiograph to look for dislocation
- humeral head should occupy the circle and be overlapping glenoid

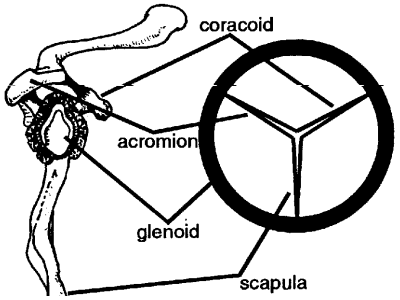


Figure 4. Mercedes Benz Sign

Adapted with permission from McRae, *Clinical Orthopedic Examination, 3rd ed. Churchill Livingstone, New York,* 1994.

ACROMIOCLAVICULAR (AC) JOINT SPRAIN

❑ AC joint is usually injured after fall onto shoulder with adducted arm
❑ 2 main ligaments which attach clavicle to scapula
- acromioclavicular (AC) ligament
- coracoclavicular (CC) ligament

❑ acromioclavicular sprains
- Type I: partial injury, no instability, no displacement (sprain of AC ligament) CC-intact
- Type II: disrupted AC ligament, sprain of CC ligament
- Type III: disrupted AC and CC ligaments with superior clavicle displacement (shoulder displaced inferiorly)
- Type IV: clavicle displaces superiorly and posteriorly through trapezius
- Type V: clavicle displaced inferior to acromion or coracoid (beware brachial plexus injury!)

❑ physical examination
- palpable step between distal clavicle and acromion
- pain with adduction (touch opposite shoulder)

❑ radiographically apparent on stress view (hold weights in hand)
❑ treat type I or II with ice, immobilization, early ROM and strengthening
❑ treat type III the same or repair if skin compromise imminent
❑ operative repair of type IV and V
- excision of lateral clavicle with reconstruction of CC and AC ligament

CLAVICULAR FRACTURE

❑ fall on shoulder or onto outstretched hand
❑ presents as pain and tenting of skin
❑ cosmetically poor but not disabling
❑ brachial plexus and arterial injuries in 10%
❑ classified by proximal, middle (most common), or distal third of clavicle
❑ treatment of proximal and middle third clavicular fractures
- closed reduction with figure-of-eight brace or sling x 1-2 weeks
- early ROM and strengthening

❑ distal third clavicular fractures are unstable and may require ORIF

ANTERIOR SHOULDER DISLOCATION

❑ over 90% of all shoulder dislocations, usually traumatic
❑ may be of two general types:
- involuntary: traumatic, unidirectional, Bankart lesion, responds to surgery
- voluntary: atraumatic, multidirectional, bilateral, rehab, surgery is last resort

❑ occurs when abducted arm is externally rotated or hyperextended
❑ recurrence rate depends on age of first dislocation
- at age 20: 80%; at age 21-40: 60-70%; at age 40-60: 40-60%; at age > 60: < 10%

❑ associated with Hill-Sachs lesion
- indentation of humeral head after impaction on glenoid rim

- ❑ also associated with Bankart lesion
  - avulsion of capsule when shoulder dislocates
  - associated bony avulsion called "Bony Bankart Lesion"
  - occurs in 85% of all anterior dislocations
- ❑ axillary nerve and musculocutaneous nerve at risk
- ❑ some associated injuries more common in elderly
  - vascular injury and fracture of greater tuberosity

Physical Examination
- ❑ "squared off" shoulder
- ❑ humeral head can be palpated anteriorly
- ❑ arm held in slight abduction and external rotation
- ❑ loss of internal rotation with anterioinferior humeral head
- ❑ axillary nerve may be damaged, therefore check sensation and contraction over lateral deltoid; for musculocutaneous nerve check sensation of lateral forearm and contraction of biceps
- ❑ apprehension test: for recurrent shoulder instability
  - with patient supine, gently abduct and externally rotate patient's arm to a position where it may easily dislocate; if shoulder is dislocatable, patient will have a look of apprehension on face

X-Rays
- ❑ humeral head anterior (to Mercedes Benz sign) in trans-scapular view
- ❑ axillary view is diagnostic
- ❑ AP view may show Hill-Sachs lesion if recurrent
- ❑ rule out associated humeral neck fracture

Treatment
- ❑ intravenous sedation and muscle relaxation
- ❑ gentle longitudinal traction and countertraction
- ❑ +/– alternating internal and external rotation
- ❑ Hippocratic Method - foot used in axilla for countertraction (not recommended - risk of nerve damage)
- ❑ Stimsons's method - patient prone with arm hanging over edge of table, weight hung on wrist (typically 5 lbs for 15-20 mins)
- ❑ X-Ray to verify reduction and check neurologic status
- ❑ sling x 3 weeks with movement of elbow, wrist, fingers
  - rehabilitation aimed at strengthening dynamic stabilizers and avoiding the unstable position (i.e. external rotation and abduction)
- ❑ recurrent instability and dislocations may require surgery

POSTERIOR SHOULDER DISLOCATION
- ❑ 5% of all shoulder dislocations
- ❑ caused by force applied along the axis of the arm
  - shoulder is adducted, internally rotated and flexed
- ❑ the four **Es** which cause posterior dislocation are:
  - **E**pileptic seizure
  - **E**thanol intoxication
  - **E**lectricity (ECT, Electrocution)
  - **E**ncephalitis
- ❑ often missed due to poor physical exam and radiographs
- ❑ if caused by seizure, often bilateral shoulder dislocations

Physical Examination
- ❑ anterior shoulder flattening, prominent coracoid
- ❑ blocked external rotation, limited abduction

X-Rays
- ❑ humeral head posterior in trans-scapular view

Treatment
- ❑ inferior traction on flexed elbow + pressure on back of humeral head
- ❑ may require reduction under general anesthetic
- ❑ splint for 3 weeks following reduction

ROTATOR CUFF LESIONS
- ❑ the rotator cuff is a sheet of conjoined tendons
  - **SITS**: **S**upraspinatus, **I**nfraspinatus, **T**eres minor, **S**ubscapularis
- ❑ stabilizes the head of the humerus in the glenoid, when arm extended or abducted
- ❑ about 80% of 80 year olds have rotator cuff lesions

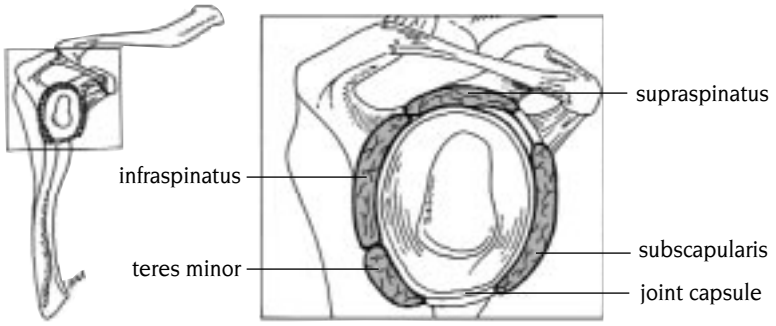


Figure 5. Muscles of the Rotator Cuff and Position at the Glenoid

Illustration by Kevin Millar

IMPINGEMENT SYNDROME

❑ also called "Painful Arc Syndrome"
❑ describes impingement of supraspinatus tendon between
- humeral head/greater tuberosity and anatomic arch between anterior edge and undersurface of acromion, AC joint and CA ligament

Physical Examination

❑ painful arc between 90-130 degrees of abduction
❑ pain on palpation of rotator cuff
❑ impingement test
- place patient's hand on opposite shoulder and lift elbow off chest - reproduces pain
- may have associated osteophytes under acromion or AC joint

Types of Impingement Syndrome

❑ mild ("wear")
- inflamed rotator cuff
- aching, reversible, +/– weakness
- treatment is non-operative (physiotherapy, NSAIDs)

❑ moderate ("tear")
- tendon is thick and fibrotic, microtears
- night pain and shoulder weakness prominent
- non-operative treatment +/– steroid injection

❑ severe ("repair")
- tear of rotator cuff, cannot start abduction
- may require surgical repair

FROZEN SHOULDER

❑ process which involves adhesive capsulitis

Primary Adhesive Capsulitis

❑ idiopathic, usually associated with diabetes mellitus
❑ may resolve spontaneously in 9-18 months

Secondary Adhesive Capsulitis

❑ due to prolonged immobilization
- "Shoulder-Hand Syndrome" - hand in cast, immobilized shoulder
- following myocardial infarction, stroke, shoulder trauma

Treatment

❑ active and passive ROM (physiotherapy)
❑ NSAIDs and steroid injections if limited by pain
❑ MUA (manipulation under anesthesia) or arthroscopy for debridement/decompression
❑ diabetics usually have poor outcomes

HUMERUS

HUMERAL SHAFT FRACTURE

❑ from falls on outstretched hand, MVAs or direct load applied to arm
❑ generally treated non-surgically
❑ complications include radial nerve injury and nonunion

Treatment

❑ undisplaced fracture +/– radial nerve palsy
- collar and cuff x 4-6 weeks, then active exercises for shoulder, wrist and hand if fracture united
- radial nerve palsy usually improves spontaneously over 3-6 months; if no improvement at 3 months then EMG

❑ displaced fracture
- apply collar and cuff or sugar-tong plaster splint cast and reassess radial nerve
- immobilize 2-3 weeks then go to frontal brace and begin active upper limb exercises
- ORIF indicated if:
  1) poor closed reduction,
  2) polytrauma,
  3) segmental fracture,
  4) pathologic fracture,
  5) neurovascular compromise,
  6) associated fracture of proximal ulna "floating elbow"

PROXIMAL HUMERAL FRACTURE

❑ especially common fracture in osteoporotic person
❑ **f**all **o**n **o**ut**s**tretched **h**and (**FOOSH**)
❑ pain, swelling and tenderness around the shoulder (especially around greater tuberosity)
❑ fracture involves
- proximal humeral diaphysis (surgical neck)
- +/– greater tuberosity
- +/– lesser tuberosity

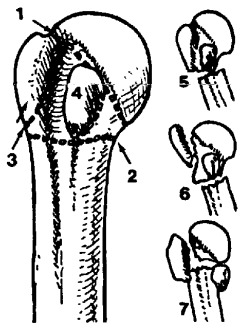
❑ classify into 2, 3, and 4 part fractures

Treatment

❑ if needed, treat for osteoporosis
❑ undisplaced
- stable/impacted, use Velpeau sling x 1 week then active ROM
- unstable (unusual), use Velpeau sling x 3 weeks then gentle ROM

❑ displaced > 1 cm or angulated > 45°
- attempt closed reduction, Velpeau sling x 2 weeks, gentle ROM
- ORIF if unsatisfactory reduction

❑ fracture with dislocation of glenohumeral joint
- high incidence of neurovascular injury and osteonecrosis
- ORIF; hemiarthroplasty may be necessary



Fractures in this region may involve
the anatomical neck (rare) (1),
the surgical neck (2),
the greater tuberosity(3),
or the lesser tuberosity (4)

Combinations of these injuries
are common and may involve
two-part (5),
three-part (6), and
four-part fractures (7)

Figure 6. Fractures of the Proximal Humerus

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ELBOW

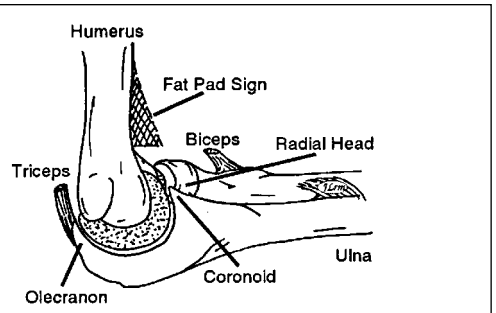

Figure 7. Anatomy of the Elbow

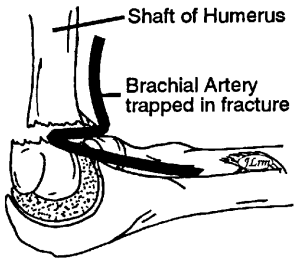

Figure 8. Displaced Supracondylar Fracture of Humerus

SUPRACONDYLAR FRACTURE

- ❑ usually in children
- ❑ fall on outstretched hand

Treatment

- ❑ children
  - closed reduction +/– percutaneous pinning in O.R. with fluoroscopy
  - cast in flexion x 3 weeks
- ❑ adult
  - undisplaced fracture, may be treated in cast
  - displaced fracture, ORIF since closed reduction usually inadequate

Complications

- ❑ stiffnes most common
- ❑ see Complications of Fractures section

RADIAL HEAD FRACTURE

- ❑ mechanism: **f**all **o**n **o**ut**s**tretched **h**and (**FOOSH**)
- ❑ clinically: progressive pain due to hemarthrosis with loss of ROM and pain on lateral side of elbow aggravated by forearm pronation or supination
- ❑ careful, may not be seen radiographically
- ❑ look for "sail sign" of anterior fat pad or the prescence of a posterior fat pad on x-ray to detect occult radial head fractures

Mason Classification

- ❑ Type 1: undisplaced segmental fracture, usually normal ROM
- ❑ Type 2: displaced segmental fracture, ROM compromised
- ❑ Type 3: comminuted fracture
- ❑ Type 4: Type 3 with posterior dislocation

Treatment

- ❑ Type 1: elbow slab, sling 3-5 days, early ROM
- ❑ Type 2: ORIF radial head
- ❑ Type 3/4: excision of radial head +/– prosthesis

OLECRANON FRACTURE

- ❑ fall on point of elbow with avulsion by triceps or fall on outstretched arm
- ❑ active extension absent
- ❑ gross displacement can not be reduced closed because of pull of triceps

Treatment

- ❑ undisplaced: above elbow cast 2 weeks, early ROM
- ❑ displaced: ORIF, above elbow slab x 1 week, early ROM

ELBOW DISLOCATION

- ❑ usually young people in sporting events or high speed MVA
- ❑ > 90% are posterior or posterior-lateral
- ❑ fall on outstretched hand
- ❑ rule out concurrent radial head or coracoid process fractures

Treatment of Posterior Dislocation

- ❑ closed reduction: traction then flexion
- ❑ above elbow backslab with elbow 90 degrees and wrist pronated
- ❑ open reduction if unstable or loose body (unusual)

Complications

- ❑ stiffness
- ❑ intra-articular loose body
  - usually from joint surface cartilage
  - not obvious on x-ray
  - occasionally medial epicondyle is pulled into joint, especially in children
- ❑ heterotopic ossification (bone formation)
  - prevented by indomethacin immediately following surgery
- ❑ recurrent dislocation is extremely rare

FOREARM FRACTURES

GENERAL PRINCIPLES OF FOREARM FRACTURES

- ❑ more commonly fracture of both bones, usually displaced
- ❑ if only one bone fractured look for dislocation of other
- ❑ displaced fractures of radius or ulna mostly treated by ORIF, as non-surgical methods often result in limitation of pronation/supination
- ❑ forearm fractures in children are usually of the greenstick type, in which only one cortex is involved

COMPLICATIONS SPECIFIC TO FOREARM FRACTURES

- ❑ cross union - radius malunites to ulna
- ❑ loss of pronation/supination
- ❑ loss of extension of elbow
- ❑ difficult to reduce and maintain closed
  - accurate reduction is essential, usually requires ORIF
- ❑ shoulder-hand syndrome (frozen shoulder)

NIGHTSTICK FRACTURE (see Figure 9)

- ❑ isolated fracture of ulna, with minimal displacement
- ❑ mechanism: from holding arm up to protect face from blow
- ❑ rule out fracture clinically and radiographically
- ❑ treatment: below elbow cast 6 weeks for distal 1/3 fractures
- ❑ if angulation of proximal 2/3 severe; consider ORIF

GALEAZZI FRACTURE (see Figure 10)

- ❑ fracture of distal radius
- ❑ dislocation of distal radio-ulnar joint (DRUJ) at wrist
- ❑ treatment: immobilize in supination to reduce DRUJ, ORIF

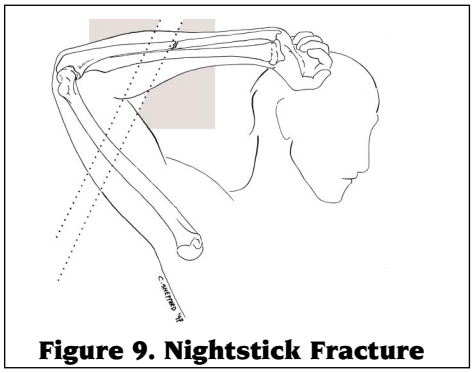

Figure 9. Nightstick Fracture

Illustration by Chesley Sheppard

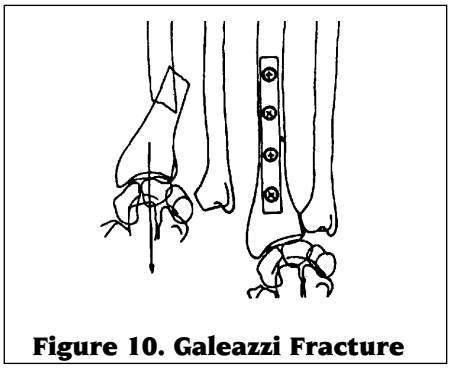

Figure 10. Galeazzi Fracture

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MONTEGGIA FRACTURE (see Figure 11)

- ❑ fracture of ulna with associated dislocation of radial head
- ❑ treatment: ORIF is recommended- open reduction of the ulna is usually followed by indirect reduction of the radius

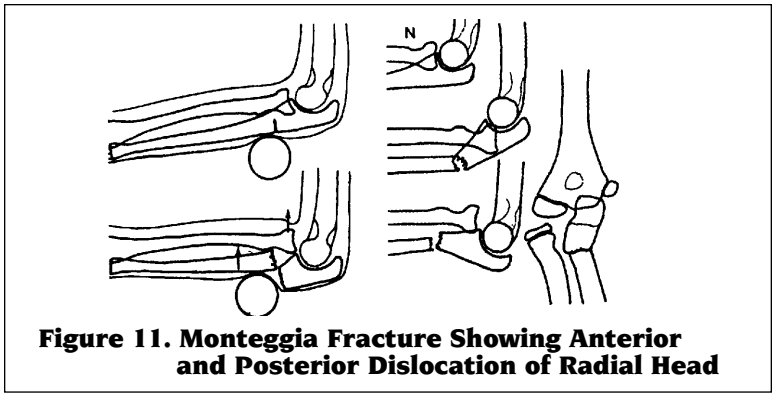

Figure 11. Monteggia Fracture Showing Anterior and Posterior Dislocation of Radial Head

Adapted with permission from McRae, Practical Fracture Treatment, 2nd ed. Churchill Livingstone, New York, 1989.

SCAPHOID FRACTURE (see Figure 12)

Etiology
- ❑ second most common carpal fracture, common in young adults
- ❑ maintain a high index of suspicion with **f**alls **o**n **o**ut**s**tretched **h**and (**FOOSH**)
- ❑ blood supply is from distal to proximal poles of scaphoid - risk of avascular necrosis (AVN)

Diagnosis
- ❑ clinical
  - pain on wrist movement i.e positive scaphoid test
  - tenderness elicited in anatomical snuff box and over scaphoid tubercle
- ❑ x-ray
  - AP/lateral/scaphoid views required
  - x-ray alone may not reveal scaphoid fracture
  - +/– bone scan and/or CT scan

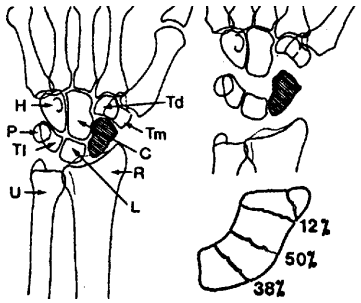

Figure 12. Scaphoid Fracture

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Treatment

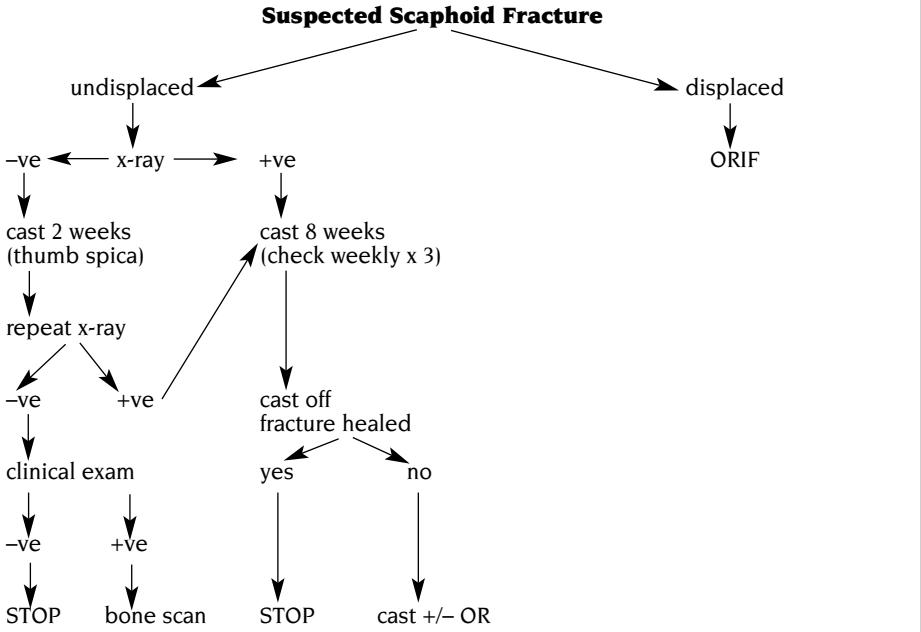


Figure 13. Scaphoid Fracture Algorithm

Complications
- ❑ nonunion +/– AVN
- ❑ highest incidence of AVN (30%) is with fracture of proximal 1/3
- ❑ high incidence of nonunion and AVN with significant displacement

COLLES' FRACTURE (see Figure 14)

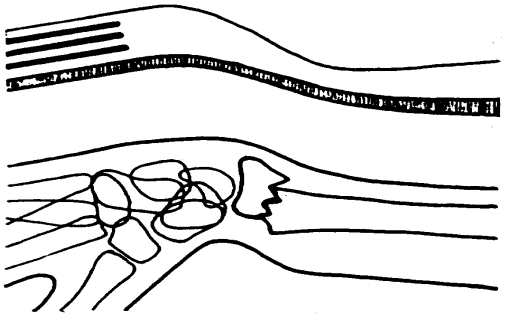


Figure 14. Colles' Fracture and Associated Bony Deformity

Adapted with permission from McRae, *Practical Fracture Treatment, 2nd ed. Churchill Livingstone, New York,* 1989.

Etiology
- ❑ most common wrist fracture
- ❑ **f**all **o**n **o**ut**s**tretched **h**and (**FOOSH**)
- ❑ most common in osteoporotic bone

Diagnosis
- ❑ clinical
  - swelling, ecchymosis, tenderness
  - "dinner fork" deformity (Figure 14)
  - assess neurovascular status (carpal tunnel syndrome)
- ❑ X-ray: distal fragment is
  1. dorsally displaced with dorsal comminution
  2. dorsally tilted fragment with apex of fracture volar
  3. supinated
  4. radially deviated
  5. shortened (radial styloid normally 1cm distal to ulna) +/– fracture of ulnar styloid

Treatment
- ❑ nondisplaced
  - short arm cast applied to wrist under gentle traction
  - neutral wrist position
- ❑ displaced
  1. anesthesia - hematoma block commonly used
  2. disimpaction - axial traction with increasing force over 2 minutes (pull on thumb and ring finger, with countertraction at the elbow)
  3. reduce by pulling hand into
     - slight flexion
     - full pronation
     - full ulnar deviation
  4. maintain reduction with direct pressure to fracture site, apply well moulded dorsal-radial slab (splint)
  5. post-reduction x-ray (AP/lateral), goal to correct dorsal angulation and regain radial length
  6. check arm after 24 hours for swelling, neurovascular status
  7. circular cast after 1-2 weeks; check cast at 1, 2, 6 weeks; cast off after 6 weeks, physiotherapy (ROM, grip strength)
- ❑ if inadequate reduction at any time
  - try closed reduction under GA
  - ORIF

SMITH'S FRACTURE (see Figure 15)

Type a Type b Type c

Figure 15. Smith's Fracture

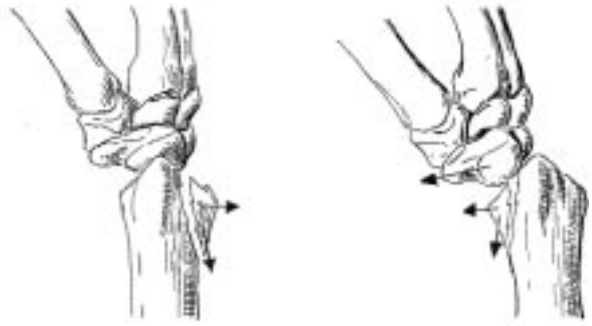
Illustration by Marc Dryer

Diagnosis
- ❑ clinical presentation and radiographic evidence
- ❑ fracture similar to Colles' but volar displacement of distal radius

Treatment
- ❑ hematoma block
- ❑ closed reduction in supination and slight flexion
- ❑ splint
- ❑ ORIF if unstable reduction

BARTON'S FRACTURE (see Figure 16)

Diagnosis
- ❑ clinical presentation and radiographic evidence
- ❑ intra-articular fracture of distal radius resulting from shearing force
- ❑ classified as dorsal or volar depending upon location of fragment



Dorsal **Ventral**

Figure 16. Barton's Fracture

Illustration by Marc Dryer

Treatment
- ❑ attempt closed reduction although rarely adequate
- ❑ dorsal: slight extension, pronation, splint
- ❑ volar: slight flexion, supination, splint
- ❑ usually requires ORIF if unstable reduction

COMPLICATIONS OF WRIST FRACTURES
- ❑ most common complications are poor grip strength, stiffness, and radial shortening
- ❑ 80% have normal function in 6-12 months
- ❑ early
  - difficult reduction +/– loss of reduction
  - compartment syndrome
  - extensor pollicis longus (EPL) tendon rupture
  - acute carpal tunnel syndrome
  - finger swelling with venous or lymphatic block
- ❑ late
  - malunion, radial shortening
  - painful wrist secondary to ulnar prominence
  - frozen shoulder ("shoulder hand syndrome")
  - post-traumatic arthritis
  - carpal tunnel syndrome
  - reflex sympathetic dystrophy (RSD)

SPINE

DIFFERENTIAL DIAGNOSIS OF BACK PAIN
- ❑ degenerative (90% of all back pain)
  - mechanical (degenerative, facet)
  - spinal stenosis (congenital, osteophyte, central disc)
  - peripheral nerve compression (disc herniation)
- ❑ cauda equina syndrome
- ❑ neoplastic
  - primary, metastatic
- ❑ trauma
  - fracture (compression, distraction, translation, rotation)
- ❑ spondyloarthropathies
  - e.g. ankylosing spondylitis
- ❑ referred
  - aorta, renal, ureter, pancreas

Epidemiology
- ❑ common problem
- ❑ L4-5 and L5-S1 most common sites
- ❑ 10% nerve root compression
- ❑ less than 2% results from tumour, trauma, other diseases

DEGENERATIVE BACK PAIN

Pathogenesis
- ❑ loss of vertebral disc height with age results in
  - bulging and tears of annulus fibrosus
  - change in alignment of facet joints
  - osteophyte formation
- ❑ pain sensation is transmitted by branches of adjacent nerve root, which innervates disc and facet joints
  - results in both localized pain and referred pain down adjacent spinal nerve
  - radiating pain typically occurs in buttocks and down legs
- ❑ pain may originate from disc +/– facet joints
- ❑ disc herniations are most commonly posterolateral or lateral **(see Colour Atlas NS20)**
  - posterolateral herniations (most common) affect the nerve root below the disc (i.e. the L4-L5 disc compresses L5 root)
- ❑ natural history: 90% improve with non-operative treatment within 3 months
- ❑ non-operative
  - modified activity
  - back strengthening
  - NSAIDs
- ❑ surgical
  - decompression +/– fusion
  - no difference in outcome between non-operative and surgical management in 2 years

Table 6. Types of Low Back Pain

	Mechanical Back Pain		Direct Nerve Root Compression	
	Disc Origin	**Facet Origin**	**Spinal Stenosis**	**Root Compression**
Pain Dominance	Back	Back	Leg	Leg
Aggravation	Flexion	Extension standing, walking	Exercise, extension walking, standing	Flexion
Onset	Gradual	More sudden	Congenital or acquired	Acute leg ± back pain
Duration	Long (wks, months)	Shorter (days, wks)	Acute or chronic history (weeks to months)	Short episode attacks (minutes)
Treatment	Relief of strain, exercise	Relief of strain, exercise	Relief of strain, exercise	Relief of strain, exercise + surgical decompression if progressive or severe deficit

❑ spinal stenosis
- acquired stenosis best thought of as a progression or end stage degenerative disc disease, in which osteophytic growth results in a narrowed spinal canal

Table 7. Differentiating Claudication

	Neurogenic	Vascular
Aggravation	With standing or extension walking distance variable	Walking set distance
Alleviation	Change in position (usually flexion, sitting, lying down)	Stopping walking
Time	Relief in 10 minutes	Relief in 2 minutes
Character	Neurogenic ± neurological deficit	Muscular cramping

X-Rays
❑ AP, lateral, obliques
❑ indicated for new onset back pain (i.e. r/o tumour, congenital deformities)
- look for "Winking Owl sign" —> signifies tumour invasion of pedicle

❑ CT scan/myelography, MRI
- for spinal stenosis, cauda equina syndrome, disc herniation

❑ x-rays not very helpful for chronic degenerative back pain
- radiographic degeneration does not correlate well with back pain

CAUDA EQUINA SYNDROME
❑ most frequent cause is large central disc herniation
❑ progressive neurological deficit presenting with
- saddle anesthesia
- decreased anal tone and reflex
- fecal incontinence
- urinary retention
- SURGICAL EMERGENCY! will cause permanent urinary/bowel incontinence if untreated

Table 8. Lumbar Radiculopathy/Neuropathy

Root	L4	L5	S1
motor	quadriceps tibialis anterior	ankle dorsiflexion great toe extensor hip abductor	ankle plantar flexion
sensory	posteromedial	lateral calf or 1st web space	lateral aspect of foot
reflex	knee reflex	hamstring reflex	ankle reflex
test	limitation of femoral stretch	limitation of straight leg raise	limitation bowstring

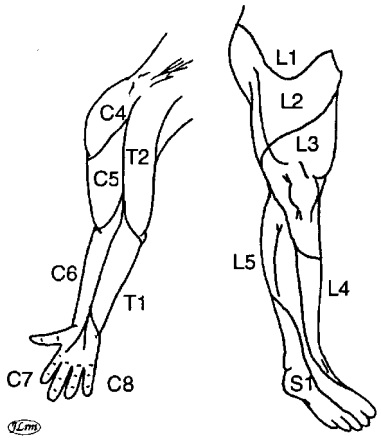


Figure 17. Dermatomes of the Upper and Lower Limbs

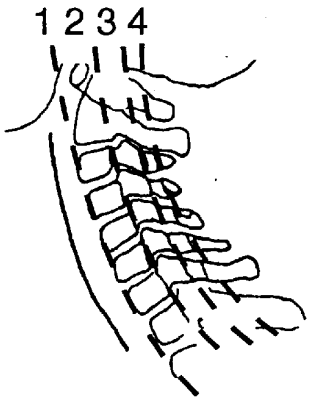


Figure 18. Alignment of Cervical Spine

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TRAUMA

C-Spine X-rays

- ❑ can you see C1 to superior portion of T1? - if not, film is INADEQUATE
- ❑ should have Swimmers view (one arm above head and one arm below head) for adequate visualization of C7-T1
- ❑ open mouth odontoid view for adequate visualization of atlanto-axial joint
- ❑ identify
  1) alignment (on lateral films - see Figure 18)
     - anterior body (1)
     - posterior body (2) should curve to anterior foramen magnum
     - facet joints (3)
     - laminar fusion line (4) should curve proximally and point to posterior base of foramen magnum
  2) vertebral bodies
     - height and width
  3) cartilage
  4) soft tissues
     - prevertebral soft tissue: C3=3-5 mm, C7=7-10 mm

Clearing C-spine X-rays

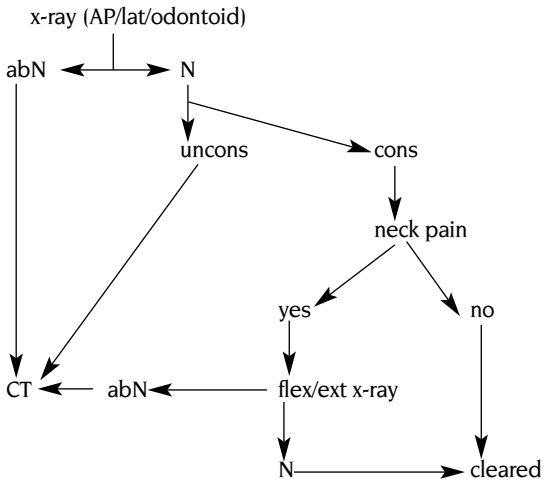


Figure 19. Algorithm for Clearing C-spine X-rays

Table 9. Cervical Radiculopathy/Neuropathy				
Root	**C5**	**C6**	**C7**	**C8**
Motor	Deltoid supraspinatus Biceps	Biceps Brachioradialis	Triceps	Digital flexors intrinsic
Sensory	Axillary nerve (middle deltoid)	Thumb and index finger	Middle finger	Ring and little finger
Reflex	Biceps Middle deltoid	Brachioradialis reflex	Triceps	Finger jerk reflex

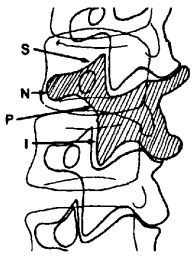
THORACIC AND LUMBAR SPINE

Table 10. Elements of 3 Column Spine		
Anterior Column	**Middle Column**	**Posterior Column**
Anterior longitudinal ligament	Posterior longitudinal ligament	Posterior body elements
Anterior annulus fibrosis	Posterior annulus fibrosis	Supraspinous, intraspinous ligaments
Anterior 1/2 of vertebral body	Posterior 1/2 of vertebral body	acet joints ligamentum flavum

Table 11. Basic Types of Spine Fractures and their Mechanisms	
Type	**Mechanism**
1. Compression • Anterior • Lateral	Flexion Anterior flexion Lateral flexion
2. Burst	Axial load +/- flexion/rotation
3. Distraction	Flexion, distraction, common in lap-belted MVC (Chance)
4. Fracture dislocation	Flexion-Rotation, Shear, Flexion Distraction

Chance Fracture of the Spine
- ❑ failure of anterior, middle, and posterior columns caused by high tensile force; most commonly seen in MVC lap-belted passenger
- ❑ CT scan to assist with diagnosis

X-Ray (see Figure 20)
- ❑ oblique views show "Scottie Dog"
- ❑ look for disruption of "Scottie Dog" to identify spondylolysis



S - superior facet
N - transverse process
P - pars interarticularis
I - inferior facet

Figure 20. Scottie Dog

Adapted with permission from McRae, Clinical Orthopedic Examination, 3rd ed. Churchill Livingstone, New York, 1994.

Treatment
- ❑ compression
  - wedge: conservative if < 50% compression
  - burst: may push material into spinal canal therefore surgical correction (distraction and IF for stabilization)
- ❑ distraction
  - Chance: if part-bony, part-soft tissue, conservative management with hyperextension orthosis
  - surgical stabilization required with extensive soft tissue, ligamentous injury
- ❑ rotation
  - burst type: inherently unstable therefore internal stabilization

HIP

DIFFERENTIAL DIAGNOSIS OF HIP PAIN IN THE ADULT

- ❑ traumatic
  - fracture (femur or pelvis), dislocation, labral tear
- ❑ arthritic
  - septic, osteoarthritis, inflammatory (see Rheumatology Chapter)
- ❑ vascular
  - AVN of femoral head
- ❑ trochanteric bursitis and gluteal tendonitis
- ❑ neoplastic
- ❑ referred
  - hip pain is felt in the groin area and anterior thigh
  - spine usually involves buttock and posterior thigh
  - knee, abdominal viscera, vascular (intermittent claudication)

X-Ray Diagnosis

❑ views: AP, lateral, Judet (oblique) views

Table 12. Radiological Diagnosis of Hip Pathology

Finding	Osteoarthritis (OA)	AVN	Hip Fracture
Loss of joint space	Localized	None	None
Subchondral Sclerosis	+++ Acetabulum and head	++ Head only	None
Osteophytes	+++	None	None
Erosions	None	None	None
Leg shortening	+/–	None	+++ if displaced

❑ Note: AVN becomes same as OA later in disease process, and hip fracture may have preexisting OA

PELVIC FRACTURES

❑ most common fracture involves pubic rami, followed by ilial, ischial, acetabular, coccygeal and sacral bones

Tile Classification (see Figure 21)

- ❑ Type A: stable, minimally displaced, includes avulsion fractures and fractures not involving pelvic ring, e.g. rami fracture
- ❑ Type B: partially unstable, rotationally unstable, but vertically stable, e.g. "open book" fracture from external rotational force to pelvis
- ❑ Type C: unstable, rotationally and vertically unstable, associated with rupture of ipsilateral ligaments, e.g. vertical shear fracture

Type A
Stable Avulsion Fracture

Type B
Open Book

Type C
Unstable Vertical Fracture

Figure 21. Illustration of the Tile Classification of Pelvis Fractures

Illustration by Seline McNamee

Diagnosis

- ❑ history of injury, high energy trauma
- ❑ examination reveals local swelling, tenderness; if unstable, may have deformity of the hips and instability of pelvis with palpation
- ❑ x-rays (i.e. AP, inlet, and outlet views)

Treatment

- ❑ ABCs
- ❑ assess genitourinary injury (rectal exam/vaginal exam mandatory)
- ❑ Type A - bedrest and mobilization with walking aids
- ❑ Type B/C - external or internal fixation

Complications
- ❑ hemorrhage - life threatening
- ❑ bladder/bowel injuries
- ❑ neurological damage
- ❑ obstetrical difficulties
- ❑ persistent sacro-iliac (SI) joint pain
- ❑ post-traumatic arthritis of the hip with acetabular fractures

HIP DISLOCATION
- ❑ mainly seen with artificial hips

1. Anterior (rare)
- ❑ blow to knee with hip widely abducted
- ❑ clinically: limb fixed, externally rotated and abducted
- ❑ femoral head tends to migrate superiorly
- ❑ attempt closed reduction under GA
- ❑ then CT of hip to assess joint congruity

2. Posterior
- ❑ severe forces to knee with hip flexed and adducted (e.g. knee into dashboard in MVA)
- ❑ clinically: limb shortened, internally rotated and adducted
- ❑ femoral head tends to migrate inferiorly/medially
- ❑ +/– fracture of posterior lip of acetabulum or intra-articular fracture
- ❑ sciatic nerve injury common especially with associated acetabular fracture
- ❑ assess knee, femoral shaft for other injuries/fractures
- ❑ +/– fracture of posterior lip of acetabulum or intra-articular fracture
- ❑ attempt closed reduction under GA +/– image intensifier
- ❑ then CT to assess congruity and acetabular integrity
- ❑ traction x 6 weeks, then ROM
- ❑ ORIF if unstable, intra-articular fragments, or posterior wall fractures

3. Central
- ❑ associated with acetabular fracture

4. After Total Hip Arthroplasty (THA)
- ❑ occurs in 1-4% of primary THA and 16% in revision cases
- ❑ about 74% of THA dislocations are posterior, 16% anterior and 8% central
- ❑ THA are unstable in the position of flexion and internal rotation

Treatment
- ❑ complete muscle relaxation is key – conscious sedation (IV fentanyl and versed) or spinal or GA
- ❑ assistant applies downward pressure to pelvis
- ❑ reduction for posterior dislocation – fully flex hip, abduct and externally rotate hip, apply upward traction on femur
- ❑ reduction for anterior dislocation – fully flex hip , adduct and internally rotate hip, apply downward pressure on femur

Complications
- ❑ post-traumatic arthritis due to cartilage injury or intra-articular loose body
- ❑ femoral head injury including osteonecrosis + fracture; 100% if nothing12 hours before reduction
- ❑ sciatic nerve palsy in 25% (10% permanent)
- ❑ fracture of femoral shaft or neck
- ❑ heterotopic ossification
- ❑ coxa magna (occurs in up to 50% of children after a hip dislocation)
- ❑ sciatic nerve palsy in 25% (10% permanent)
- ❑ fracture of femoral shaft or neck
- ❑ knee injury (posterior cruciate ligament (PCL) tear with dashboard injury)

HIP FRACTURE

Epidemiology
- ❑ common fracture in elderly
- ❑ female > male
- ❑ in osteopenic individual, fracture may precede simple fall (muscle stronger than bone)
- ❑ in younger individual, fracture related to high energy injury
  - markedly displaced
  - associated with other injuries

Diagnosis
- ❑ characteristic history, unable to bear weight on affected limb
- ❑ limb shortened, externally rotated, painful ROM, antalgic gait
- ❑ obtain AP of pelvis and lateral of involved hip
- ❑ if findings equivocal - bone scan and tomograms

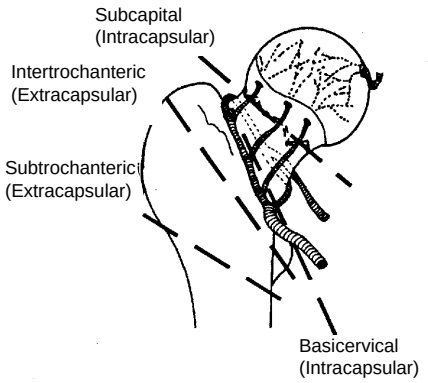


Figure 22. Blood Supply to Femoral Head and Fracture Classification

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1. Subcapital Fractures

- ❑ fracture between femoral head and intertrochanteric line
- ❑ main vascular supply to femoral head from distal arterial ring to proximal head through femoral neck
- ❑ fracture interrupts blood supply
  - articular surface restricts blood supply to femoral head
  - AVN risk depends on degree of displacement

Table 13. Garden Classification of Subcapital Fractures

Type	Extent	Displacement	Alignment	Trabeculae
I	Incomplete	Impacted	Valgus	Malaligned
2	Complete	None	Neutral	Aligned
3	Complete	Some	Varus	Malaligned
4	Complete	Marked	Varus	Aligned

Treatment

- ❑ if needed, treat osteoporosis
- ❑ restore anatomy, attempt to save head
- ❑ type of treatment depends on displacement and patient age
- ❑ undisplaced (Garden 1,2) – internal fixation to prevent displacement
- ❑ displaced (Garden 3,4) - depends on patient age and function
  - older patient, low function —> unipolar hemiarthroplasty (Moore's Prosthesis)
  - older patient, high function —> bipolar hemiarthroplasty
  - young patient, high function —> reduction with internal fixation within 12 hrs of fracture

Complications

- ❑ avascular necrosis (AVN), non-union, deep vein thrombosis (DVT)

2. Intertrochanteric Fracture

- ❑ extra-capsular fracture, therefore good femoral head viability
- ❑ fracture stability determined by number of fragments, integrity of calcar and direction of fracture line
- ❑ greater and lesser trochanters may be separate fragments
- ❑ posterior fragment may be avascular, therefore possible delayed union

Classification

- ❑ classification based on number of parts and stability
  - 2 part - stable, trochanter intact
  - 3 part - one trochanter separated, unstable if large calcar fragment
  - 4 part - unstable, both trochanters separated
  - reverse obliquity – about 15% of intertrochanteric fractures; fracture line runs inferiolaterally from lesser trochanter

Treatment

- ❑ obtain a good closed reduction under fluoroscopy on the fracture table
- ❑ after reduction obtained, internal fixation with dynamic hip screw and plate
- ❑ reverse obliquity fractures are highly unstable and require fixation with dynamic condylar screw and plate

3. Subtrochanteric Fracture
- ❑ least common hip fracture
- ❑ highly unstable
- ❑ transverse, spiral or oblique fracture passes below lesser trochanter
- ❑ younger population with high energy injuries
- ❑ x-rays show flexed and abducted proximal fragment, from pull of iliopsoas on lesser trochanter, gluteus medius and minimus on greater trochanter

Treatment
- ❑ obtain a good closed reduction under fluoroscopy on the fracture table
- ❑ internal fixation with intramedullary nail

ARTHRITIS OF THE HIP
- ❑ many causes (osteoarthritis, post-traumatic, developmental dysplasia of the hip, RA, etc.)

Diagnosis
- ❑ usually in an older individual
- ❑ gradual onset of groin/medial thigh pain, increasing with activity
- ❑ limb shortening
- ❑ decreased internal rotation/abduction of hip
- ❑ fixed flexion deformity
- ❑ positive Trendelenburg sign
- ❑ x-ray - joint space narrowing, sclerosis, subchondral cysts, osteophytes

Treatment
- ❑ non-operative
  - weight loss, walking aids, physiotherapy, analgesia (acetaminophen), NSAIDs
- ❑ surgery
  - realign - osteotomy
  - replace - arthroplasty
  - ablate - arthrodesis, excision

Trendelenberg Test (see Figure 23)
- ❑ patient stands on affected leg, normally gluteus medius muscle on ipsilateral side contracts to keep pelvis level
- ❑ a positive test is if the contralateral side drops or if patient
- ❑ compensates by leaning way over supported leg
- ❑ may occur anywhere along line "ab"
  - e.g. weak abductors, avulsion of gluteus medius, trochanteric fracture/removal
- ❑ may occur anywhere along line “bc”
  - e.g. painful hip due to osteoarthritis, femoral neck in varus, acetabular instability
- ❑ may occur anywhere along line “ac”
  - e.g. fractured pelvic side wall

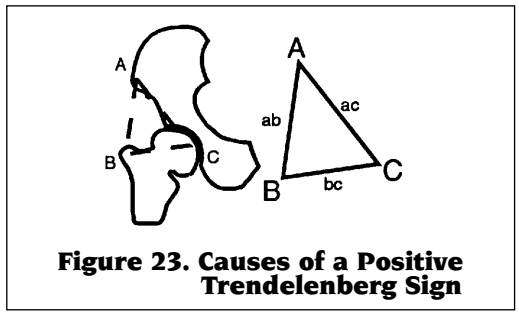

Figure 23. Causes of a Positive Trendelenberg Sign

AVN OF THE FEMORAL HEAD (see Avasular Necrosis section)

Clinical
- ❑ sudden onset of severe pain, related to weight-bearing
- ❑ worse at night
- ❑ rapid progression (compared to osteoarthritis)

Diagnosis
- ❑ x-ray - r/o hip fracture
- ❑ bone scan - see healing fracture
- ❑ MRI (best)

Treatment
- ❑ early: vascularized fibular graft to preserve femoral head, rotational
- ❑ osteotomy in young patient with moderate disease
- ❑ late: hip replacement

FEMORAL DIAPHYSIS FRACTURES
- ❑ high energy (MVA, fall from height, gunshot wounds)
- ❑ low energy (spiral fracture in children)
- ❑ high morbidity/mortality (hemorrhage, fat embolism, ARDS, MODS)
- ❑ blood replacement often required
- ❑ frequently comminuted
- ❑ soft tissue trauma

FEMUR

Clinical
- ❑ leg is shortened, externally rotated
- ❑ unable to weight bear
- ❑ assess neurovascular status
- ❑ r/o: open fracture, soft tissue compromise
- ❑ r/o: child abuse with spiral fractures in children

Treatment
- ❑ ABCs of trauma are essential
- ❑ immobilize leg with Thomas Splint
- ❑ adequate analgesia
- ❑ surgical fixation (intramedullary nail) within 24 hours
    - high rate of surgical union after 6 to 12 weeks
- ❑ early mobilization of hip and knee

SUPRACONDYLAR FEMORAL FRACTURE
- ❑ high energy, multiple trauma
- ❑ knee joint is disrupted severely with bicondylar fracture
- ❑ poor prognosis with comminuted fractures
- ❑ high incidence of post-traumatic arthritis

Treatment
- ❑ internal fixation and early knee ROM
- ❑ quadriceps strengthening

KNEE

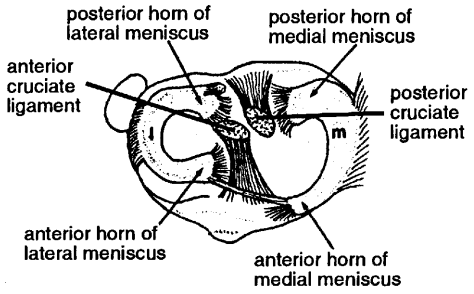

Figure 24. Diagram of Right Tibial Plateau

Adapted with permission from McRae, Clinical Orthopedic Examination, 3rd ed. Churchill Livingstone, New York, 1994.

COMMON KNEE SYMPTOMS
- ❑ locking = spontaneous block to extension
    - torn meniscus, loose body
- ❑ pseudo-locking = restricted ROM without mechanical block
    - arthritis (effusion, pain), muscle spasm following injury
- ❑ instability = "giving out"
    - torn arterior cruciate ligament (ACL), patellar subluxation, torn meniscus, loose body
- ❑ traumatic knee swelling
    - effusion, usually represents hemarthrosis
    - ligamentous injury with hemarthrosis
    - meniscal injury
    - traumatic synovitis
- ❑ non-traumatic knee swelling without trauma
    - septic or crystal-induced arthritis
    - seronegative arthritis (AS, Reiter's, Psoriatic, IBD)
    - seropositive arthritis (RA, SLE)
    - avascular necrosis
    - sickle cell disease

EVALUATION OF KNEE COMPLAINTS

History
- ❑ ligament injuries require high energy force
- ❑ meniscal injury in young person requires moderate force, while in older person only requires mild force

Physical Examination
- ❑ LOOK: **SEADS**, alignment
- ❑ FEEL: effusion, crepitus
- ❑ MOVE: gait, strength, ROM

Special Tests of the Knee
- ❑ Anterior and Posterior Draw Tests
  - demonstrate torn ACL and PCL, respectively
  - knee flexed at 90 degrees, foot immobilized, hamstrings released
  - if able to sublux tibia anteriorly then ACL may be torn
  - if able to sublux tibia posteriorly then PCL torn
- ❑ Lachmann Test
  - demonstrates torn ACL
  - hold knee in 10-20 degrees flexion, stabilizing the femur
  - try to sublux tibia anteriorly on femur
  - similar to anterior drawer test, more reliable due to less muscular stabilization
- ❑ Posterior Sag Sign
  - demonstrates torn PCL
  - may give a false positive anterior draw sign
  - flex knees and hips to 90 degrees, hold ankles and knees
  - view from the lateral aspect
  - if one tibia sags posterior than the other, its PCL is torn; loss of prominence of tibial tuberosity
- ❑ Pivot Shift Sign
  - demonstrates torn ACL
  - start with the knee in extension
  - internally rotate foot, apply valgus force to knee
  - look and feel for anterior subluxation of lateral tibial condyle
  - slowly flex while palpating knee and feel for pivot which is the tibiofemoral reduction
  - reverse pivot shift (start in flexion, externally rotate, apply valgus and extend knee) suggests torn PCL
- ❑ Collateral Ligament Stress Test
  - palpate ligament for "opening" of joint space while testing
  - with knee in full extension apply valgus force to test MCL, apply varus force to test LCL
  - repeat tests with knee in 20 degrees flexion to relax joint capsule
  - opening only in 20 degrees flexion due to MCL damage only
  - opening in 20 degrees of flexion and full extension is due to MCL, cruciate, and joint capsule damage
- ❑ test for Meniscal tear
  - Crouch Compression test is the most sensitive test
    - joint line pain when squatting
  - McMurray's test useful collaborative information
    - with knee in flexion palpate joint line for painful “pop”
    - internally rotate foot, varus stress, and extend knee to test lateral meniscus
    - externally rotate foot, valgus stress, and extend knee to test medial meniscus

X-Rays of the Knee
- ❑ AP standing, lateral
- ❑ skyline view
  - with knees in flexion, beam is aimed from anterior tibia to anterior femur
  - allows for view of patellofemoral joint
- ❑ obliques for intra-articular fractures
- ❑ 3 foot standing view
  - radiograph from hip to foot with patient in standing position
  - useful in evaluating leg length and genu varus / valgus

LIGAMENTOUS INJURIES OF THE KNEE
- ❑ may have hemarthrosis and/or effusion in acute phase
- ❑ deceleration or pivoting injury
- ❑ must check for effusion and tenderness on physical exam

ANTERIOR CRUCIATE LIGAMENT (ACL) TEAR

History
- ❑ indirect varus blow to knee
- ❑ hyperextended knee + internal rotation
- ❑ audible pop, knee instability, “giving way”
- ❑ immediate swelling
- ❑ inability to continue activity

Physical
- ❑ posterolateral joint line tenderness
- ❑ positive Lachmann, pivot shift, anterior draw
- ❑ effusion, +/– hemarthrosis
- ❑ +/– associated medial meniscus tear, MCL injury (O'Donahue's Unhappy Triad)
- ❑ associated with Segond fractures - lateral tibial avulsion fractures

Treatment
❑ based on activity and functional impairment
❑ stable with minimal functional impairment
- early mobilization
- physiotherapy and quadriceps strengthening

❑ instability with functional impairment / high demand lifestyle
- ACL reconstruction

POSTERIOR CRUCIATE LIGAMENT (PCL) TEAR
❑ much less common than ACL injury

History
❑ fall onto flexed knee with plantar flexed foot
❑ hit anterior tibia on dashboard in motor vehicle accident
❑ hyperflexion or hyperextension with anterior tibial force

Physical
❑ positive posterior sag sign
❑ false positive anterior draw
❑ true positive posterior draw
❑ reverse pivot shift sign

Treatment
❑ non-operative vs. surgical PCL reconstruction

MEDIAL COLLATERAL LIGAMENT (MCL) TEAR

History
❑ valgus force to knee
❑ +/– "pop" heard
❑ severe pain with partial tears
❑ complete tear may be painless

Physical
❑ swelling
❑ tender above and below medial joint line
❑ assess joint space opening with valgus force
- pain
- MCL laxity with end point - partial tear
- absence of end point - complete tear
- rule out ACL and medial meniscus tear

Treatment
❑ minor
- immobilize briefly, early ROM and strengthening

❑ moderate
- knee immobilizer or cast
- early physiotherapy with ROM and strengthening

❑ severe or combined
- surgical repair of associated injuries
- surgical repair of isolated MCL tear is controversial

LATERAL COLLATERAL LIGAMENT TEAR
❑ varus force to knee
❑ similar history, physical to MCL
❑ rule out common peroneal nerve injury (difficult dorsiflexion and decreased sensation at the top of the foot)
❑ treatment as for MCL

MENISCAL TEAR
❑ medial meniscus torn 8x more than lateral
❑ 1/2 are traumatic, 1/2 are degenerative
❑ usually associated with other ligamentous injuries if traumatic

History
❑ twisting force when the knee is partly or completely flexed
e.g. squatting and then rotating rapidly, skiing, football, tennis
❑ acute
- immediate pain, difficulty weight bearing, +/– locking

❑ chronic
- pain, swelling, instability

Physical
- ❑ effusion
- ❑ lack of full extension (locking)
- ❑ pinpoint joint line tenderness
- ❑ McMurray's test

Diagnosis and Treatment
- ❑ MRI is diagnostic only
- ❑ non-operative (unless locked)
  - ROM and strengthening exercises
  - NSAIDs
- ❑ failed non-operative
  - arthroscopy (diagnostic and therapeutic)

PATELLAR/QUADRICEPS TENDON RUPTURE
- ❑ low energy injury, sudden forceful contraction during attempt to stop fall
- ❑ partial or complete
- ❑ more common in patients with diabetes, SLE, RA, steroid use

History
- ❑ fall onto flexed knee
- ❑ inability to extend knee

Physical
- ❑ palpable gap between patella and quadriceps
- ❑ may have hemarthrosis / effusion of knee

Investigations
- ❑ knee radiographs to rule out patellar fracture
- ❑ joint aspirate may show hemarthrosis

Treatment
- ❑ surgical repair of tendon

DISLOCATED KNEE
- ❑ bad high energy injury
- ❑ associated injuries
  - popliteal artery intimal tear or disruption 35-50%
  - capsular, ligamentous and common peroneal nerve injury

Investigations
- ❑ angiogram

Treatment
- ❑ closed reduction, above knee cylinder cast x 4 weeks
- ❑ alternately, external fixation especially if vascular repair
- ❑ surgical repair of all ligaments if high demand patient

PATELLA

PATELLA DISLOCATION

Etiology
- ❑ commonly seen in young adults
- ❑ patella dislocates laterally over flexed knee
- ❑ predisposition - weak vastus medialis muscle and tight lateral retinaculum, valgus knees
- ❑ can be acute, chronic or recurrent
  - acute occurs with direct blow, excessive muscular forces
  - recurrent type is associated with shallow intercondylar groove or patella alta (high riding patella)
- ❑ may have associated osteochondral fracture of anterior lateral femoral condyle or avulsion of medial patella

Diagnosis
- ❑ severe pain
- ❑ difficulty extending knee
- ❑ positive patellar apprehension sign
  - sublux patella laterally over extended knee
  - pain if subluxation is reproduced, patient apprehensive
- ❑ chronic patient reports catching, giving way with walking or turning

Treatment
- ❑ acute - non-operative
  - reduce patella
  - gentle ROM
  - strengthen quadriceps, especially vastus medialis
  - support during sports activities
- ❑ chronic / recurrent
  - often non-operative treatment unsuccessful
  - lateral retinacular release (surgical) plus medial plication
  - tibial tubercle transfer corrects line of force by reinserting patella medially and distally

CHONDROMALACIA PATELLAE
- ❑ also known as patellofemoral syndrome
- ❑ commonly seen in young adults, especially females
- ❑ softening of articular cartilage, usually medial aspect of patella
- ❑ etiologies: malalignment, trauma, congenital abnormal shape of patella or femoral groove, recurrent patellar subluxation or dislocation, excessive knee strain (athletes)

History
- ❑ deep aching anterior knee pain
- ❑ exacerbated by prolonged sitting, strenuous athletic activities, stair climbing

Physical
- ❑ pathognomonic: pain with firm compression of patella into medial femoral groove
- ❑ tenderness to palpation of underside of medially displaced patella
- ❑ increased Q-angle - angle formed between thigh and patellar tendon
- ❑ pain with extension against resistance through terminal 30-40 degrees

X-Rays
- ❑ AP, lateral, skyline

Treatment
- ❑ non-operative treatment
  - physio (isometric quads strengthening)
  - NSAIDs
- ❑ surgical treatment with refractory patients
  - tibial tubercle elevation
  - arthroscopic shaving and debridement and lateral release

PATELLAR FRACTURE

History
- ❑ direct - blow to patella
- ❑ indirect - sudden muscular contraction
- ❑ immediate pain

Physical
- ❑ marked tenderness, pain
- ❑ patellar deformity
- ❑ inability to extend knee
- ❑ proximal displacement of patella
- ❑ unable to straight leg raise because disruption of extensor mechanism

X-Ray
- ❑ AP, lateral (need to exclude bipartite patella - common congenital fragmentation of the patella)

Treatment
- ❑ isolated vertical fractures - non-operative treatment - plaster cast 6 weeks, early ROM
- ❑ transverse displaced fracture - ORIF
- ❑ comminuted fracture - ORIF; may require complete or partial patellectomy

TIBIA

TIBIAL PLATEAU FRACTURE

❑ result from femoral condyle(s) being driven into the proximal tibia often due to a valgus or varus force
❑ lateral > medial

Treatment

❑ if depression is < 3 mm
  • long leg cast-brace, NWB x 2 months
❑ if depression > 3 mm, displaced or comminuted
  • ORIF +/– bone graft to elevate fragment

TIBIAL DIAPHYSIS FRACTURE

❑ high intensity injury
  • associated with crush injuries and MVAs
❑ soft tissue, nerve and vessel injury common
  • assess neurovascular status
  • rule out open fracture
❑ displacement is difficult to control
❑ good reduction is required
  • minimal shortening and angulation
❑ healing time: 16 weeks on average

Treatment

❑ ABCs
❑ closed injuries = closed reduction
  • long leg cast x 4-6 weeks
  • followed by BK cast until healed
❑ open injuries
  • ORIF with external fixator
  • wounds on anterior surface heal poorly and may necrose
❑ unstable injuries or failed closed reduction require IM nail
❑ high risk of compartment syndrome
  • closed reduction and cast; admit and observe for compartment syndrome surgery; prophylactic fasciotomy if operating on tibia fracutre

ANKLE

EVALUATION OF ANKLE COMPLAINTS

❑ history
  • ask about pain, swelling, mechanism of injury, effect on standing/walking
❑ physical examination
  • neurovascular status
  • look, feel, move (dorsiflexion, plantarflexion)
  • assess for tenderness at knee (Maisonneuve), lateral and medial malleoli
  • special test: anterior draw (for ankle), talar tilt, squeeze test, Thompson test

X-ray

❑ views
  • AP, Lateral and Mortise (15 degrees internal rotation)
  • Mortise gives true view of talus in tibiotalar joint
    • space between talus —> tibia and talus —> fibula
    • space should be symmetric and < 4 mm with no talar tilt
  • disrupted space signifies ligamentous or bony injury
❑ when to x-ray - Ottawa ankle rules
  • ankle x-ray is only required with
    • pain in malleolar zone AND
    • bony tenderness over posterior aspect of the distal 6 cm of medial or lateral malleolus OR inability to weight bear both immediately and in E.R.
  • foot x-ray series is only required with
    • pain in midfoot zone AND
    • bony tenderness over navicular or base of fifth metatarsal OR inability to weight bear both immediately and in E.R.

ANKLE FRACTURES

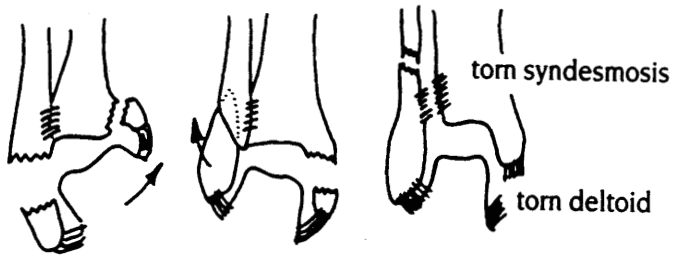

Figure 25.
Ring Principle of Ankle Fractures and Danis-Weber Classification

Adapted with permission from Dandy, Essential Orthopedics and Trauma, *2nd ed. Churchill Livingstone, New York,* 1993.

Ring Principle of the Ankle
- ❑ the ankle can be thought of as a ring (see Figure 25)
  - a: lateral malleolus
  - b: medial malleolus
  - c: posterior malleolus (posterior medial malleolus)
  - d: deltoid ligament
  - e: syndesmotic ligament (syndesmosis)
  - f: calcaneofibular ligament
- ❑ fractures of the ankle involve
  - ipsilateral ligamentous tears or bony avulsion
  - contralateral shear fractures
- ❑ pattern of fracture
  - determined by mechanism of injury
  - avulsion fractures are transverse
  - shear fractures are oblique if pure inversion / eversion
  - shear fractures are spiral if rotational force

Danis-Weber Classification
- ❑ based on level of fibular fracture relative to syndesmosis
- ❑ Type A (infra-syndesmotic)
  - pure inversion injury
  - avulsion of lateral malleolus below plafond or torn calcaneofibular ligament
  - +/– shear fracture of medial malleolus
- ❑ Type B (trans-syndesmotic)
  - external rotation and eversion
  - avulsion of medial malleolus or rupture of deltoid ligament
  - spiral fracture of lateral malleolus starting at plafond
- ❑ Type C (supra-syndesmotic)
  - pure external rotation
  - avulsion of medial malleolus or torn deltoid ligament
  - fibular fracture is above plafond
  - frequently tears syndesmosis
  - Maisonneuve fracture if at proximal fibula
  - posterior malleolus avulsed with posterior tibio-fibular ligament

Lauge Hansen Classification
- ❑ based on mechanism of injury; first word= position of foot, second word = direction of movement of the talus in relation to the leg
- ❑ Supination-External Rotation
  - most common (45-65%)
  - supination and external rotation, resulting in oblique fracture at the level of the sydesmosis
  - equivalent to Weber Type B
- ❑ Pronation-Abduction
  - sequence of injury:
    1) avulsion fracture of medial malleolus or rupture of deltoid ligament;
    2) abduction force then either ruptures the syndesmosis or avulses its bony attachment sites;
    3) lateral force from talus impacts and fractures fibula at or above level of syndesmosis and ruptures interosseous membrane
- ❑ Pronation-External Rotation
  - sequence of injury:
    1) transverse fracture of the medial malleolus or disruption of deltoid ligament;
    2) external rotation then results in rupture of the anterior tibiofibular ligament or its bony insertion;
    3) oblique or spiral fracture of fibula above the level of the joint;
    4) posterior injury with tibiofibular ligament rupture or avulsion of posterior malleolus
  - fibular fracture may be proximal (i.e., Maisonneuve fracture)
  - equivalent to Weber Type C
- ❑ Supination-Adduction
  - sequence of injury:
    1) supination force may rupture portions of lateral collateral ligaments or may avulse distal fibula, resulting in transverse fracture below the level of intact syndesmosis;
    2) adduction forces talus against the medial side of the joint, resulting in vertical fracture of the medial malleolus
  - Equivalent to Weber Type A

Treatment
- ❑ undisplaced fractures: NWB BK cast
- ❑ displaced fractures: reduction ASAP
- ❑ indications for ORIF
  - all fracture-dislocations
  - all type C fractures
  - trimalleolar (lateral, medial, posterior) fractures
  - talar shift or tilt
  - failure to achieve or maintain closed reduction
- ❑ prognosis dependent upon anatomic reduction
  - high incidence of post-traumatic arthritis

LIGAMENTOUS INJURIES

Medial Ligament Complex (deltoid ligament)
- ❑ responsible for medial stability
- ❑ usually avulses medial or posterior malleolus
  - posterior malleolus = posterior part of medial malleolus
- ❑ usually associated with syndesmotic or lateral ankle sprain

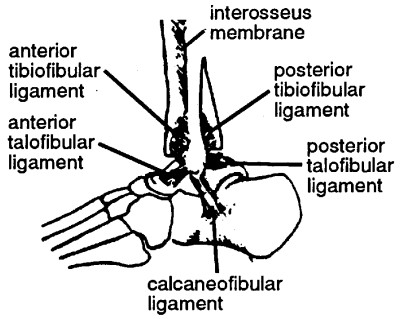

Figure 26. Lateral View of Ligaments of Left Ankle

Lateral Ligament Complex (ATFL, CFL, PTFL)
- ❑ responsible for lateral stability
- ❑ clinical: swelling and discoloration, 'pop' sound, giving way
- ❑ diagnosis: stress x-rays and mortise view
  - talar inversion produces joint separation exceeding the unaffected side by six degrees (talar tilt test)
- ❑ frequncy of injury: ATFL > CFL > PTFL

Anterior Talofibular Ligament (ATFL)
- ❑ most common ligamentous ankle injury
- ❑ sprained by inversion and while ankle is in plantar flexion
- ❑ swelling and tenderness anterior to lateral malleolus, ++ ecchymoses
- ❑ anterior draw test for ankle positive with Grade III ATFL injury
  - attempt to sublux talus anteriorly
  - if positive then stress other lateral ligaments
- ❑ talar tilt test for integrity of other ligaments

Grading and Treatment of Ligamentous Ankle Injuries
- ❑ Grade I (microscopic stretch or tear)
  - pain
  - **RICE** (**R**est, **I**ce, **C**ompression, **E**levation)
- ❑ Grade II (macroscopic tear)
  - pain on motion
  - strap ankle in dorsiflexion and eversion
  - no more than 6 weeks, physio for proprioceptive re-training
- ❑ Grade III (complete tear)
  - unstable ankle
  - talar tilt apparent on mortise view
  - BK walking cast x 3 weeks, physiotherapy for proprioceptive re-training
- ❑ surgical intervention may be required

RECURRENT ANKLE SUBLUXATION
- ❑ etiology
  - ligamentous laxity
- ❑ joint (loss of normal proprioception)
  - internal derangement of anatomy
  - intra-articular loose body
- ❑ treatment depends on cause
- ❑ strengthening and balance training for neuropathic joint
  - ligament reconstruction for lateral laxity and talar tilt
  - arthroscopy / arthrotomy for internal derangement

FOOT

EVALUATION OF FOOT COMPAINTS
❑ history
- pain, swelling, loss of function, sensory changes, deformity, mechanism of injury, activity level of patient

❑ physical
- inspection, palpation, active and passive ROM, weight bearing status
- neurovascular status

❑ x-rays
- AP, lateral, oblique (as a minimum)

TALAR FRACTURE
❑ 60% of talus covered by articular surface
- decreased surface area for vascular perforation
- blood supply to talus: distal to proximal
- fractures of the neck at risk of AVN

❑ mechanism: MVA or fall from height
- axial loading or hyper-plantar flexion injury
- talar neck driven into tibial margin

❑ rule out potential associated injuries
- spinal injuries, femoral neck fractures, tibial plateau fractures

X-Rays
❑ AP/lateral films with CT scan or tomograms of talus

Treatment
❑ BK cast, NWB x 6 months
❑ ORIF: to reduce displacement and prevent AVN or non-union

Complications
❑ undisplaced: 0-10% risk of AVN
❑ displaced: 100% risk of AVN

CALCANEAL FRACTURE
❑ mechanism is axial loading (eg. fall from a height onto the heels)
❑ rule out potential associated injuries
- spinal injuries (10%)
- femoral neck fractures
- tibial plateau fractures

Physical
❑ heel viewed from behind is wider, shorter, flatter, varus tilt
❑ may be swollen, with bruising on soles

X-Rays (see Figure 27)
❑ Broden's views (oblique views of subtalar joint)
❑ Bohler's Angle decreased (normal: 20 - 40 degrees)

Treatment
❑ goal is to prevent widened heel and maintain subtalar joint congruency
❑ NWB, early ROM
❑ ORIF if depressed centrally or tongue-type fracture
❑ closed vs. open treatment is controversial

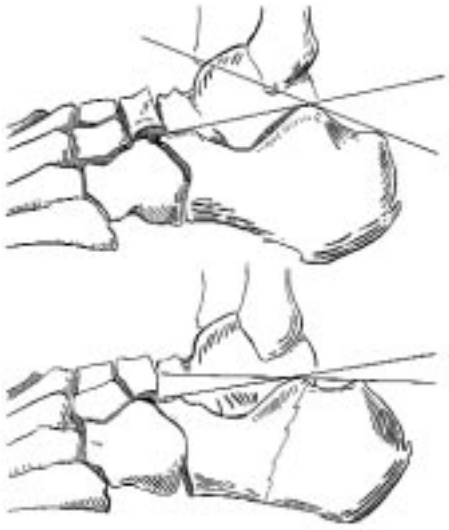

Figure 27. Bohler's Angle

Illustration by Marc Dryer

ACHILLES TENDONITIS
❑ chronic inflammation from running and shoe-wear (high heels)
❑ may develop heel bumps (inflammation of superficial bursa overlying lateral insertion of Achilles tendon into calcaneus)

Diagnosis
❑ pain, aggravated by passive stretching
❑ tenderness, swelling
❑ crepitus on plantar flexion

Treatment
❑ rest, gentle stretching, NSAIDs
❑ proper footwear +/– orthotics
❑ do NOT inject steroids (prone to rupture)

ACHILLES TENDON RUPTURE
❑ usually an audible 'pop' or a sensation of being kicked at site
❑ mid tendon or musculotendinous junction (2-6 cm from insertion on calcaneus)
❑ spontaneously ruptures
- during loading activity (e.g. squash, tennis)
- secondary to steroid injection

Diagnosis
- ❑ history of pain and inability to walk
- ❑ tenderness, palpable gap, weak plantar flexion
- ❑ apprehensive to toe-off when walking
- ❑ Thompson Test (patient lying prone)
    - squeezing calf does not passively plantar flex foot

Treatment
- ❑ low demand or elderly patient
    - cast with foot in plantar flexion to relax tendon
- ❑ high demand or young
    - surgical repair vs. cast (controversial)

PLANTAR FASCIITIS
- ❑ repetitive strain injury of plantar fascia
    - common in runners, jumpers, ballet dancers, obesity
- ❑ chronic inflammation due to microtears of plantar fascia

History
- ❑ intense pain on waking or after rest
- ❑ subsides as patient walks
- ❑ may be associated with systemic diseases
    - diabetes mellitus
    - enthesopathies including seronegative and seropositive arthritis

Physical
- ❑ swelling, local tenderness over plantar fascia
    - mostly at medial calcaneal tubercle
- ❑ pain with toe dorsiflexion (stretches plantar fascia)

X-Ray
- ❑ sometimes show heel spur at insertion of fascia into medial calcaneal tubercle
- ❑ Note: spur is reactive, not the cause of pain

Treatment
- ❑ non-operative (90% resolve)
    - rest and NSAIDs x 4-6 months
    - steroid injection
    - ultrasound and stretching exercises
    - supportive shoes with heel cup
- ❑ surgical in refractory cases (must r/o nerve entrapment as cause of pain first)
    - release of plantar fascia
    - 50% effective at pain relief
    - spur removal not required
    - can now be done endoscopically

BUNIONS
- ❑ two primary causes: heriditary, shoewear, 10x more frequent in women
- ❑ Hallux Valgus
    - may be associated with metatarsus primus varus
    - valgus alignment of MTP joint is aggrevated by eccentric pull of EHL and intrinsics
    - secondary exostosis forms with bursa and thick skin creating the bunion

Treatment
- ❑ treatment is cosmetic and for pain with shoes
- ❑ non-operative first
    - properly fitted shoes and toe spacer
- ❑ surgical
    - removal of bunion with realignment of 1st MTP joint

METATARSAL FRACTURE
- ❑ as with the hand, 1st, 4th, 5th metatarsals (MT) are relatively mobile, while the 2nd and 3rd are fixed (see Table 14)

Table 14. Types of Metatarsal Fractures

Fracture	Mechanism	Clinical	Treatment
Avulsion of Base of 5th MT	Sudden inversion followed by contraction of peroneus brevis	Tender base of 5th MT x-ray foot	Requires ORIF if displaced
Jones Fracture midshaft 5th MT	Stress injury	Painful shaft of 5th MT	NWB BK cast x 6 weeks ORIF if athlete
March Fracture shaft 2nd, 3rd MT	Stress injury	Painful shaft of 2nd or 3rd MT	Symptomatic
1st MT Fracture	Trauma	Painful 1st MT	ORIF if displaced otherwise NWB BK cast x 3 weeks then walking cast x 2 weeks
Lisfranc Fracture Tarso-MT fracture-dislocation	Fall onto plantar flexed foot or direct crush injury	Shortened forefoot prominent base	ORIF

ORTHOPEDIC INFECTIONS

OSTEOMYELITIS

❑ bacterial, viral or fungal infection of bone OR bone marrow
❑ infants, young children, patients with sickle cell anemia, septic arthritis, open fractures, diabetes and immuncompromised more susceptible than healthy adults
❑ infection can be due to direct (trauma, surgery) or hematogenous route
- S. *aureus* (most common cause of hematogenous route)
- mixed infection i.e. Staph, Enterobacteriaceae, P*seudomonas* (trauma, post-op, diabetic or IV drug use)
- S*almonella* (Sickle Cell Disease)
- H. *influenzae* (young children)
- M. *tuberculosis* (affects both sides of joint)

History

❑ asymptomatic (chronic)
❑ history of infection at another site, direct trauma to the area
❑ acute sepsis
- fever, chills, dehydration, lethargy
- MEDICAL EMERGENCY

❑ presentation is typically less acute in adults

Physical

❑ febrile
❑ local tenderness, swelling, heat at metaphysis, decreased joint motion
❑ neonates
- pseudoparalysis
- associated with septic arthritis

❑ often few signs and symptoms in the adult; usually tender, inflammation

Diagnostic Tests

❑ bloodwork
- elevated ESR, serial WBC, C-reactive protein
- blood cultures before antibiotics started (often negative in adults)

❑ cultures and gram stain from wound or bone biopsy
❑ X-rays
- acute: often normal, lucencies appear after 2-4 weeks
- chronic: onion-skin appearance

❑ CT/MRI
- reveal medullary edema and destruction, periosteal reaction, cortical destruction, articular damage, and soft-tissue involvement

❑ bone scan
- Indium, Gallium and Technetium show locally increased uptake; Gallium more specific for infection

Treatment

❑ IV antibiotics x 4-6 weeks
❑ irrigation and debridement +/- amputation of extremity
❑ antibiotic bead insertion at site of wound: tobramycin, gentamycin, or vancomycin-impregnated bone cement beads
❑ removal or replacement of prosthesis

SEPTIC ARTHRITIS

❑ routes of spread
- hematogenous (most common)
- direct spread from adjacent infection
- inoculation

Table 15. Organisms in Septic Arthritis

Age	Organisms	Antibiotic Choice
0-6 months	S. *aureus* E. *coli*	Cloxacillin Tobramycin / Gentamycin
6-36 months	S. *aureus* H. *influenzae*	Cloxacillin +/– Ampicillin
>36 months	S. *aureus* streptococci	Cloxacillin +/– Penicillin G
Adults	S. *aureus* N. *gonorrhoeae* (especially adults < 30 years)	Cloxacillin (S. *aureus*) Ceftriaxone (N. *gonorrhoeae*)

❑ N. *gonorrhoeae* - most common cause of septic arthritis; can affect multiple joints; if disseminated can have tenosynovitis, skin lesions, young adult males
❑ S. *aureus* - most common cause of non-gonococcal adults
❑ M. *tuberculosis* - often accompanies bone lesions (direct spread), also commonly via hematongenous spread
❑ others
- B. *burgdorferi* (Lyme disease)
- S. *schenckii* (most common fungal cause)
- *Salmonella* (Sickle Cell disease)
- P*seudomonas* (IV drug use)

History
❑ severe pain
❑ acute sepsis
- fever, chills, dehydration, lethargy
- MEDICAL EMERGENCY!

Physical
❑ local joint tenderness, swelling, heat
❑ neonates get pseudoparalysis
❑ joint held in slight flexion to reduce intra-articular pressure
❑ unable or unwilling to move joint

Diagnostic Tests
❑ blood and throat swab cultures
❑ joint aspirate for cultures, crystals, WBC, Gram stain, ESR, C-reative protein (CRP), glucose
❑ bone scan (hip only)
- not used to make diagnosis
- assesses viability of femoral head

Treatment
❑ medical: IV fluids and antibiotics, analgesia
❑ surgical: aspiration or open surgical debridement

Complications
❑ early
- septic dislocation
- AVN femoral head (increased intra-articular pressure due to pus)

❑ late
- cartilage and epiphyseal destruction
- osteomyelitis

Other Joint Infections
❑ Reactive Arthritis
- post infectious
- most common cause streptococci
- do not need antibiotics (culture is sterile)

❑ Viral Arthritis
- hepatitis B, rubella, mumps, parvovirus B19

PEDIATRIC ORTHOPEDICS

FRACTURES IN CHILDREN
- ❑ different from fractures in adults
- ❑ periosteum is thicker and stronger in children
- ❑ type of fracture
  - usually greenstick or buckle because periosteum is intact on one or both sides
  - adults fracture through both cortices
- ❑ epiphyseal growth plate
  - plate often mistaken for fracture and vice versa
  - x-ray opposite limb for comparison
- ❑ ligamentous injury
  - rarely occur in children
  - mechanism which causes ligamentous injury in adults causes growth plate injury in children
- ❑ anatomic reduction
  - gold standard with adults
  - may cause limb length discrepancy in children (overgrowth)
  - accept greater angular deformity in children (remodelling)
  - intra-articular fractures have worse consequences in children because they usually involve the growth plate
- ❑ time to heal
  - shorter in children
- ❑ always be aware of the possibility of child abuse
  - make sure injury mechanism compatible with injury
  - high index of suspicion, look for other signs, including x-ray evidence of healing fractures at other sites

EVALUATION OF THE LIMPING CHILD (see Pediatrics Chapter)

EPIPHYSEAL INJURY

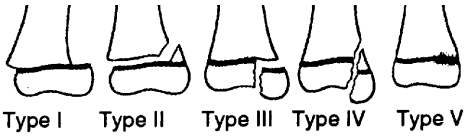

Figure 28. Salter-Harris Classification of Epiphyseal Injury

Adapted with permission from Dandy, *Essential Orthopedics and Trauma, 2nd ed. Churchill Livingstone, New York,* 1993.

Salter-Harris Classification (see Figure 28)
- ❑ SALT(E)R
- ❑ Stable (Type I)
  - transverse through growth plate
- ❑ Above (Type II, most common)
  - through metaphysis and along growth plate
- ❑ Low (Type III - involves articular surface)
  - through epiphysis to plate and along growth plate
- ❑ Through (Type IV - involves articular surface)
  - through epiphysis and metaphysis
- ❑ Ram (Type V)
  - crush injury of growth plate

Treatment of Epiphyseal Injury
- ❑ Type I and II
  - closed reduction and cast immobilization
  - heals well, 95% do not affect growth
- ❑ Type III and IV
  - anatomic reduction by ORIF since intra-articular, and also to prevent growth arrest
- ❑ Type V
  - high incidence of growth arrest
  - no specific treatment

PULLED ELBOW
- ❑ annular ligament slips between radial head and capitellum
  - follows pull on child's forearm
  - rule out child abuse
- ❑ 2-6 years old, due to underdeveloped radial head
- ❑ forearm is pronated, painful and “will not move”
  - point tenderness over radial head
  - pseudoparalysis of arm
- ❑ radiographs
  - not for diagnosis, but to rule out fracture
- ❑ treatment
  - gentle supination while moving from extension to flexion
  - pain relieved and function returns immediately
  - may immobilize x 1 day in sling for comfort

DEVELOPMENTAL DYSPLASIA OF THE HIP (DDH)

- ❑ formerly called congenital dysplasia of the hip (CDH)
- ❑ due to ligamentous laxity and abnormal slope of acetabular roof
- ❑ predisposing factors (6**F**s)
  - **F**amily history, **F**emales (> males), **F**rank breech, **F**irst born, le**F**t side
- ❑ spectrum of conditions
  - dislocated femoral head completely out of acetabulum
  - dislocatable head in socket
  - head subluxes out of joint when provoked
  - dysplastic acetabulum, more shallow and more vertical than normal
- ❑ if painful suspect septic dislocation

Physical

- ❑ diagnosis is clinical
- ❑ limited abduction of the flexed hip (< 50-60 degrees)
- ❑ affected leg shortening results in asymmetry in skin folds and gluteal muscles, wide perineum
- ❑ Barlow's test (unstable but located hip)
  - flex hips and knees to 90 degrees and grasp thigh
  - fully adduct hips, push posteriorly
- ❑ Ortolani's test (for dislocated hip)
  - initial position as above but try to reduce hip with fingertips during abduction
  - palpable clunk if reduction is a positive test
- ❑ Galleazzi's Sign
  - difficult test if child < 1 year
  - knees at unequal heights when hips and knees flexed
  - dislocated hip on side of lower knee
- ❑ Trendelenburg test and gait useful if older (> 2 years)

Imaging

- ❑ can U/S in first few months to view cartilage
- ❑ follow up radiograph after 3 months
- ❑ CT scan (rarely done)

Treatment and Complications

- ❑ 0-6 months: Reduce hip using Pavlik harness to maintain abduction and flexion
- ❑ 6-18 months: reduction under GA, hip spica cast x 2-3 months (if Pavlik harness fails)
- ❑ > 18 months: open reduction; pelvic and/or femoral osteotomy
- ❑ complications
  - redislocation, inadequate reduction, stiffness
  - AVN of femoral head

LEGG-CALVE-PERTHES DISEASE

- ❑ self-limited AVN of femoral head
- ❑ etiology unknown, 20% bilateral, males more common increased incidence with family history, low birth weight, and abnormal pregnancy/delivery
- ❑ male:female = 4:1
- ❑ key features: AVN of proximal femoral epiphysis, abnormal growth of the physis, and eventual remodeling of regenerated bone
- ❑ clinical picture
  - limping child usually 4-10 years old
  - tender over anterior thigh
  - flexion contracture; decreased internal rotation, abduction
- ❑ x-ray
  - may be negative early
  - eventually, characteristic collapse of femoral head (diagnostic)
  - subchondral fracture
  - metaphyseal cyst
- ❑ treat to preserve ROM and preserve femoral head in acetabulum
  - physiotherapy for ROM
  - brace in flexion and abduction x 2-3 years
  - femoral or pelvic osteotomy
- ❑ prognosis better in
  - males < 5 years old, < 1/2 head involved, abduction > 30°
  - 50% of involved hips do well with conservative treatment
- ❑ complicated by early onset osteoarthritis and decreased ROM

SLIPPED CAPITAL FEMORAL EPIPHYSIS

- ❑ Type I Salter-Harris epiphyseal injury
- ❑ most common adolescent hip disorder, peak at 12-15 years
- ❑ risk: male, obese, hypothyroid
  - acute (sudden displacement) and chronic (insidious displacement) forms

Etiology is Multifactorial

- ❑ genetic (autosomal dominant, Blacks > Caucasians)
- ❑ cartilaginous physis thickens rapidly under growth hormone (GH) effects
- ❑ sex hormone secretion, which stabilizes physis, has not yet begun
- ❑ overweight - mechanical stress

History

- ❑ acute - sudden, severe pain with limp
- ❑ chronic - limp with medial knee or anterior thigh pain

Physical
- ❑ Whitman's sign: with flexion there is an obligate external rotation of the hip
- ❑ restricted internal rotation, abduction, flexion
- ❑ pain at extremes of ROM
- ❑ tender over joint capsule

X-Rays
- ❑ need AP and frog-leg lateral views
- ❑ posterior and medial slip
  - if mild slip, AP view may be normal or slightly widened growth plate compared with opposite side

Treatment and Complications
- ❑ acute - gentle reduction, possible ORIF
- ❑ chronic- ORIF of slip to fix in current position and prevent progression
  - complications - AVN (most common), chondrolysis, pin penetration, premature OA, chronic loss of ROM

CONGENITAL TALIPES EQUINOVARUS (CTEV)
- ❑ also known as club foot
- ❑ 3 parts to deformity
  - Talipes: talus is inverted and internally rotated
  - Equinus: ankle is plantarflexed
  - Varus: heel and forefoot are in varus (supination)
- ❑ may be idiopathic, neurogenic, or syndrome-associated
  - examine hips for associated DDH
  - examine knees for deformity
  - examine back for dysraphism (unfused vertebral bodies)
- ❑ 1/1,000 newborns, 50% bilateral, occurrence M > F, severity F > M
- ❑ treat by changing cast q 2-3 weeks
  - correct deformities in order
  - forefoot adduction, ankle inversion, equinus
- ❑ surgical release in refractory case (50%)
  - delayed until 3-4 months of age
  - 3 year recurrence 5-10%
  - mild recurrence common; affected foot is permanently smaller/stiffer that normal foot, with decreased calf circumference

SCOLIOSIS

Table 16. Etiology of Scoliosis

Type	Cause
Idiopathic	Most common (90%)
Congenital	Vertebrae fail to form or segment
Secondary	Leg length discrepancy, muscle spasm
Neuromuscular	UMN or LMN lesion, myopathy
Other	Osteochondrodystrophies, neoplastic, traumatic

- ❑ age: 10-14 years
- ❑ appears to be multifactorial with evidence of idiopathic scoliosis being a single –gene disorder following Mendelian patterns with variable penetrance and heterogeneity
- ❑ more frequent and more severe in females

Physical
- ❑ asymmetric shoulder height when bent forward
  - Adam's Test: rib hump when bent forward
- ❑ scapulae prominent, flank creased, pelvis asymmetric
- ❑ associated posterior midline skin lesions
  - cafe-au-lait spots, dimples, neurofibromas
  - axillary freckling
  - hemangiomas, hair patches
- ❑ pelvic obliquity
- ❑ associated pes cavus or leg atrophy
- ❑ apparent leg length discrepancy

X-Rays
- ❑ 3 foot standing films
  - use Cobb's method to measure curvature
- ❑ may have associated kyphosis

Treatment Based on Degree of Curvature
- ❑ < 20 degrees: observe for changes
- ❑ > 20 degrees or progressive: bracing (many types)
- ❑ > 40 degrees, cosmetically unacceptable or respiratory problems
  - require surgical correction

BONE TUMOURS

- ❑ primary bone tumours are rare after 3rd decade
- ❑ metastases to bone are relatively common after 3rd decade

Diagnosis
- ❑ pain, swelling, tenderness
- ❑ routine x-ray - describe by:
  - location (which bone, diaphysis, metaphysis, epiphysis)
  - size
  - involvement (cortex, medulla, soft tissue)
  - radiolucent, radiodense or calcified
  - reaction of surrounding bone (sclerosis, borders)
  - margin
  - any pathological fracture
- ❑ malignancy is suggested by rapid growth, warmth, tenderness, lack of sharp definition
- ❑ staging should include
  - bloodwork
  - CT chest
  - liver function tests
  - bone scan
- ❑ as much information as possible on anatomic extent of tumour (including plain films, tomography, bone scanning, angiography,CT, +/– MRI if necessary) should be obtained prior to biopsy
- ❑ should be referred to specialized centre prior to biopsy
- ❑ "if you are not going to resect it don't biopsy it"
- ❑ classified into benign, benign aggressive, and malignant

BENIGN BONE TUMOURS

1. Osteoid Osteoma
- ❑ age 10-25 years
- ❑ small, round radiolucent nidus (< 1 cm) surrounded by dense bone
- ❑ tibia and femur; diaphyseal
- ❑ produces severe intermittent pain, mostly at night
- ❑ characteristically relieved by ASA

2. Osteochondroma
- ❑ metaphysis of long bone
- ❑ cartilage-capped bony spur on surface of bone ("mushroom" on x-ray)
- ❑ may be multiple (hereditary form) - higher risk of malignant change
- ❑ generally not painful unless impinging on neurovascular structure
- ❑ malignant degeneration occurs in 1-2 %

3. Enchondroma
- ❑ age 20-40 years
- ❑ 50% occur in the small tubular bones of the hand and foot; others in femur, humerus, ribs
- ❑ benign cartilage growth, develops in medullary cavity
- ❑ single/multiple enlarged rarefied areas in tubular bones
- ❑ lytic lesion with specks of calcification on x-ray

4. Cystic Lesions
- ❑ includes unicameral bone cyst, aneurysmal bone cyst, fibrous cortical defect
- ❑ children and young adults
- ❑ local pain, pathological fracture or accidental detection
- ❑ translucent area on metaphyseal side of growth plate
- ❑ cortex thinned/expanded; well defined lesion
- ❑ treatment of unicameral bone cyst with steroid injections +/– bone graft

Treatment
- ❑ in general, curettage +/– bone graft

BENIGN AGGRESSIVE BONE TUMOURS

1. Giant Cell Tumours
- ❑ 80% occur > 20 years, average 35 years
- ❑ distal femur, proximal tibia, distal radius
- ❑ pain and swelling
- ❑ cortex appears thinned, expanded; well demarcated sclerotic margin
- ❑ 1/3 benign, 1/3 invasive, 1/3 metastasize
- ❑ 30% reccur within 2 years of surgery

2. Osteoblastoma
- ❑ aggressive tumour forming osteoid
- ❑ lesions > 2 cm in size and grow rapidly
- ❑ painful
- ❑ most frequent in spine and long bones (humerus, femur, tibia)

Treatment
- ❑ controversial, should do metastatic work up
- ❑ wide local excision +/– bone graft

MALIGNANT BONE TUMOURS

Table 17. Most Common Malignant Tumour Types For Age

Age	Tumour
1	Neuroblasotma
1 - 10	Ewing's of tubular bones
10 - 30	Osteosarcoma, Ewing's of flat bones
30 – 40	Reticulum cell sarcoma, fibrosarcoma, parosteal osteosarcoma, malignant giant cell tumour, lymphoma
>40	Metastatic carcinoma, multiple myeloma, chondrosarcoma

1. Osteosarcoma
- ❑ bimodal age distribution
  - ages 10-20 (60%)
  - > 50 with history of Paget's disease
- ❑ invasive, variable histology; frequent metastases
- ❑ predilection for distal femur (45%), tibia (20%) and proximal humerus (15%)
- ❑ history of trauma common
- ❑ painful, tender, poorly defined swelling
- ❑ x-ray shows Codman's Triangle: characteristic periosteal elevation and spicule formation representing tumour extension into periosteum with calcification
- ❑ treatment with complete resection (limb salvage, rarely amputation) adjuvant chemo, radiotherapy

2. Chondrosarcoma
- ❑ primary: previous normal bone, patient over 40; expands into cortex to give pain, pathological fracture, flecks of calcification
- ❑ secondary: malignant degeneration of preexisting cartilage tumour such as enchondroma or osteochondroma
- ❑ occurs in pelvis, femur, ribs, shoulder
- ❑ x-ray shows large exostosis with calcification in cap
- ❑ highly resistant to chemotherapy, treat with aggressive surgical resection

3. Ewing's Sarcoma
- ❑ thought to be undifferentiated member of a family of neural tumours distinct form neuroblastoma
- ❑ most occur between 5 - 20 years old
- ❑ florid periosteal reaction in diaphysis of long bone; ages 10-20
- ❑ present with mild fever, anemia, leukocytosis and elevated ESR
- ❑ moth-eaten appearance with periosteal "onion-skinning"
- ❑ metastases frequent
- ❑ treatment: chemotherapy, resection, radiation

4. Multiple Myeloma
- ❑ most common primary malignant tumour of bone in adults
- ❑ 90% occur in people > 40 years old
- ❑ anemia, anorexia, renal failure, nephritis, ESR elevated
- ❑ osteoporosis, punched out lesions, compression fracture
- ❑ weakness, bone pain
- ❑ diagnosis
  - serum/urine protein electrophoresis
  - bone marrow aspirate
- ❑ treatment: resection, chemotherapy, radiation

5. Bone Metastases
- ❑ see “bonezine ring” (see Figure 29)
- ❑ **PT B**arnum **L**oves **K**ids
- ❑ 2/3 from **B**reast or **P**rostate
- ❑ also consider **T**hyroid, **L**ung, **K**idney
- ❑ usually osteolytic; prostate occasionally osteoblastic
- ❑ bone scan may be helpful
- ❑ stabilization of impending fractures
  - internal fixation
  - IM rods
  - bone cement

1. Thyroid
2. Lung
3. Breast
4. Renal
5. Adrenal
6. Prostate
7. Melanoma

Figure 29. Bonezine Ring

SLIDING HIP SCREW INSERTION

Objective
❑ to reduce and stabilize a hip fracture.

Indications
❑ intertrochanteric fractures

Landmarks
❑ palpate the greater trochanter and the shaft of the femur.

Procedure
❑ fracture reduction
- the patient is positioned supine on an orthopaedic fracture table
- traction is placed on the fractured leg and the distal portion of the leg is abducted and internally rotated to obtain an anatomical reduction of the fracture
- an image intensifier (fluoroscope) is used to ensure the fracture is properly reduced
- obtaining a good closed reduction prior to the surgery is crucial

❑ incision
- an Incision is made over the middle of the greater trochanter and extended distally down the lateral side of the thigh
- the length of the incision depends on the length of the plate

❑ approach
- the fascia lata is incised in line with the skin incision
- the fascial covering of the vastus lateralis muscle is incised
- this exposes the vastus lateralis muscle
- this muscle is divided by blunt dissection in line with its fibers
- finally, the periosteum is incised and divided to expose the lateral aspect of the femoral shaft
- Note: care must be taken to coagulate the perforating branches of the profunda femoris arteries that are divided during this approach

❑ screw insertion
- a guide wire is inserted just distal to the greater trochancter (distal to the fracture site) and angled at 135° into the femoral neck and head
- the guide wire should run into the femoral neck just superior to the calcar
- Note: the guide wire must not enter the hip joint
- the image intensifier is used to ensure the position of the guide wire is correct
- ext a reamer is used to drill a hole over the guide wire
- finally, the lag screw is advanced into the femoral head over the guide wire
- the guide wire is removed and the lag screw remains in place

❑ plate insertion
- the proximal end of the plate articulates with the end of the lag screw
- this allows for dynamic compression across the fracture site
- the plate is fixed to the lateral aspect of the femoral shaft using bicortical screws

❑ closure
- the plate is buried under the vastus lateralis muscle
- the fascia of the vastus lateralis and the fascia lata are sutured closed
- finally the skin is closed

Complications
❑ varus collapse with lag screw cut out (migration of the lag screw into the hip joint)
❑ avascular necrosis of the femoral head
❑ deep vein thrombosis and pulmonary embolism

REFERENCES

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