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Advanced Emergency Trauma Course

Orthopedic Trauma

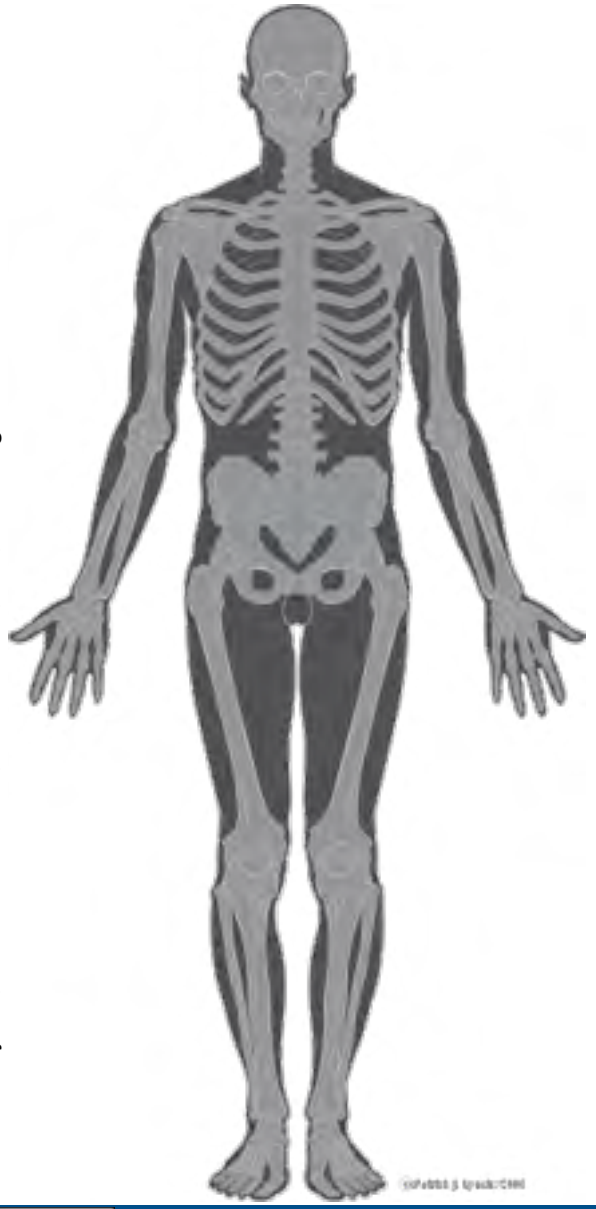
Presenter: Patrick Carter, MD

Ghana Emergency Medicine Collaborative

Patrick Carter, MD • Daniel Wachter, MD • Rockefeller Oteng, MD • Carl Seger, MD

Objectives

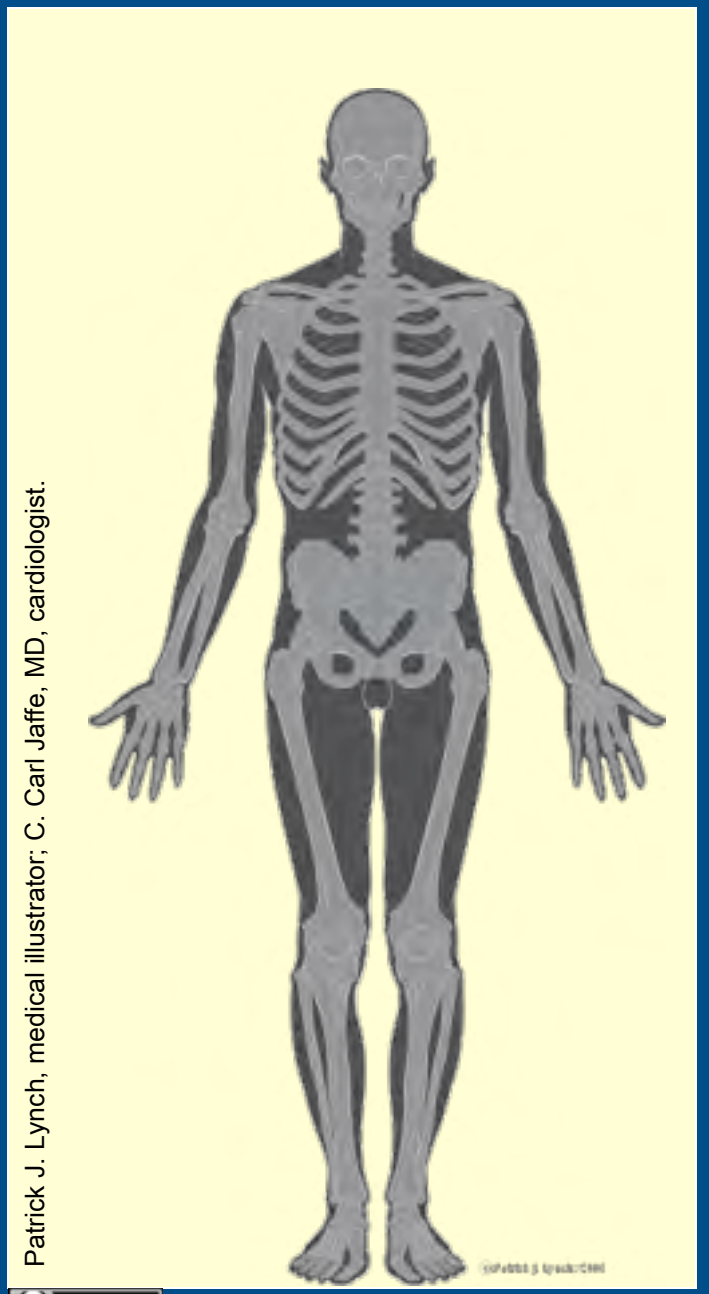
- General Principles of Fracture Management
  - Fracture Mechanisms
  - Salter-Harris Fractures
  - Fracture Complications
- Upper Extremity Injuries
  - Shoulder
  - Arm
  - Forearm
  - Wrist
  - Hand
- Lower Extremity Injuries
  - Pelvis
  - Hip
  - Femur
  - Lower leg
  - Ankle
  - Foot



Patrick J. Lynch, medical illustrator; C. Carl Jaffe, MD, cardiologist.

Wikipedia

GENERAL PRINCIPLES OF ORTHOPEDIC INJURIES



Patrick J. Lynch, medical illustrator; C. Carl Jaffe, MD, cardiologist.

Fracture Mechanisms

- Direct Trauma
  - "Tapping" Fracture – E.g. Nightstick
    - Linear fracture with two fragments and little or no soft tissue damage
  - Crush Fracture
    - Comminuted or transverse fracture
    - Extensive soft tissue damage
  - Penetrating Fracture (seen with GSW or missle wounds)
    - High velocity injuries with fragmentation of bone
    - Bone fragments act as secondary missles, causing cavitation and extensive soft tissue injury
    - Also Low velocity injuries with mild fragmentation
- Indirect Trauma
  - Traction Fracture
    - Bone is pulled apart = Transverse fracture
  - Angulation Fracture
    - Bending along the long axis of the bone = Transverse fracture with concave surface
  - Compression Fracture
    - Compression on long axis of the bone from axial loading = T or Y fractures
  - Spiral Fracture
    - Results from rotational stress and results in an oblique fracture

Types of Fractures

- Complete Fractures
  - Fracture involving both cortical surfaces
- Incomplete Fractures
  - Only one cortex is disrupted
  - Two types:
    - Torus fracture = Buckle fracture = Buckling of one cortex
    - Greenstick fracture = Break in one cortex and bending or bowing of other cortex
- Closed Fractures
  - No communication with external environment
- Open Fractures
  - Communication with external environment through break in skin and soft tissue
  - High risk for infection (Osteomyelitis)

Complete vs. Incomplete Fracture

- Complete Fracture

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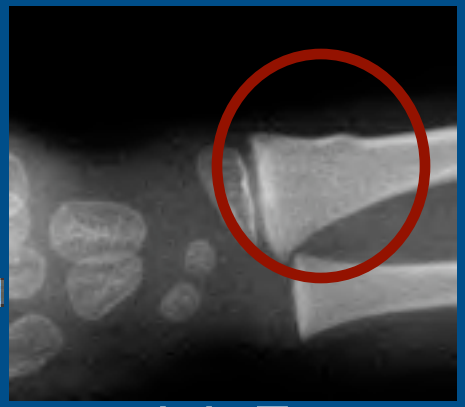
http://blogs.chron.com/realrehab/archives/2006/09/

- Incomplete Fracture
  - Torus Fracture



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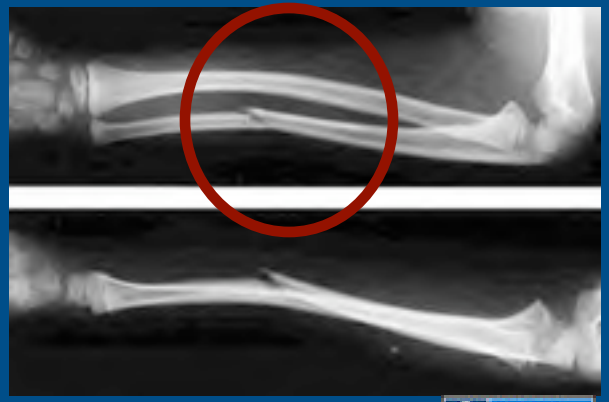
  - Greenstick Fracture



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http://www.portfolio.mvm.ed.ac.uk/studentwebs/session4/45/samplecases_files/greenstick%20fracture%20of%20the%20ulna.jpg

Closed vs. Open Fractures

- Closed Fracture

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NIH (Wikipedia)

- Open Fracture

PD-INEL http://commons.wikimedia.org/wiki/File:Left_wrist_fracture.jpg

Types of Fractures

- Pathologic Fractures
  - Bone weakness secondary to underlying disease process
  - Suspect when trivial injury results in fracture
  - E.g. Paget's disease, Tumor, Osteogenesis Imperfecta, Rickets, Scurvy
- Stress Fractures
  - Also termed "march" or "fatigue" fracture
  - Repeat of cyclical stress results in a fracture, typically in lower extremities
  - Typically accompanied by a sudden increase in level of training
- Joint Disruption
  - Dislocation = Complete disruption of articular surface
  - Subluxation = Incomplete disruption of articular surface

Other Types of Fractures

- Pathologic Fractures
  - Fx. through bone cyst

http://www.hawaii.edu/medicine/pediatrics/pemxray/v6c01.html

- Stress Fractures
  - Stress Fx. 3rd metatarsal

http://www.customfootandarch.com/foot-problems/Stress_Fract.html

Salter-Harris Fractures

- Epiphyseal growth plate is weaker than supporting ligaments
  - Growth Plate (Physis) is made up of cartilage cells that are weaker than the supporting ligaments
- Salter-Harris fractures are fractures involving long bones in children and involve the growth plate or joint surface
  - Most common in children 10-16 (80%)
  - More common in males due to delayed skeletal maturation and increased physical activity compared with females of same age
- May lead to growth complications
  - Blood supply to the growth plate comes through the epiphysis and the worse the injury to the epiphysis, the greater the likelihood of growth disturbances
- Fractures are categorized on scale 1-5 and increasing number indicates increasing potential for growth complications

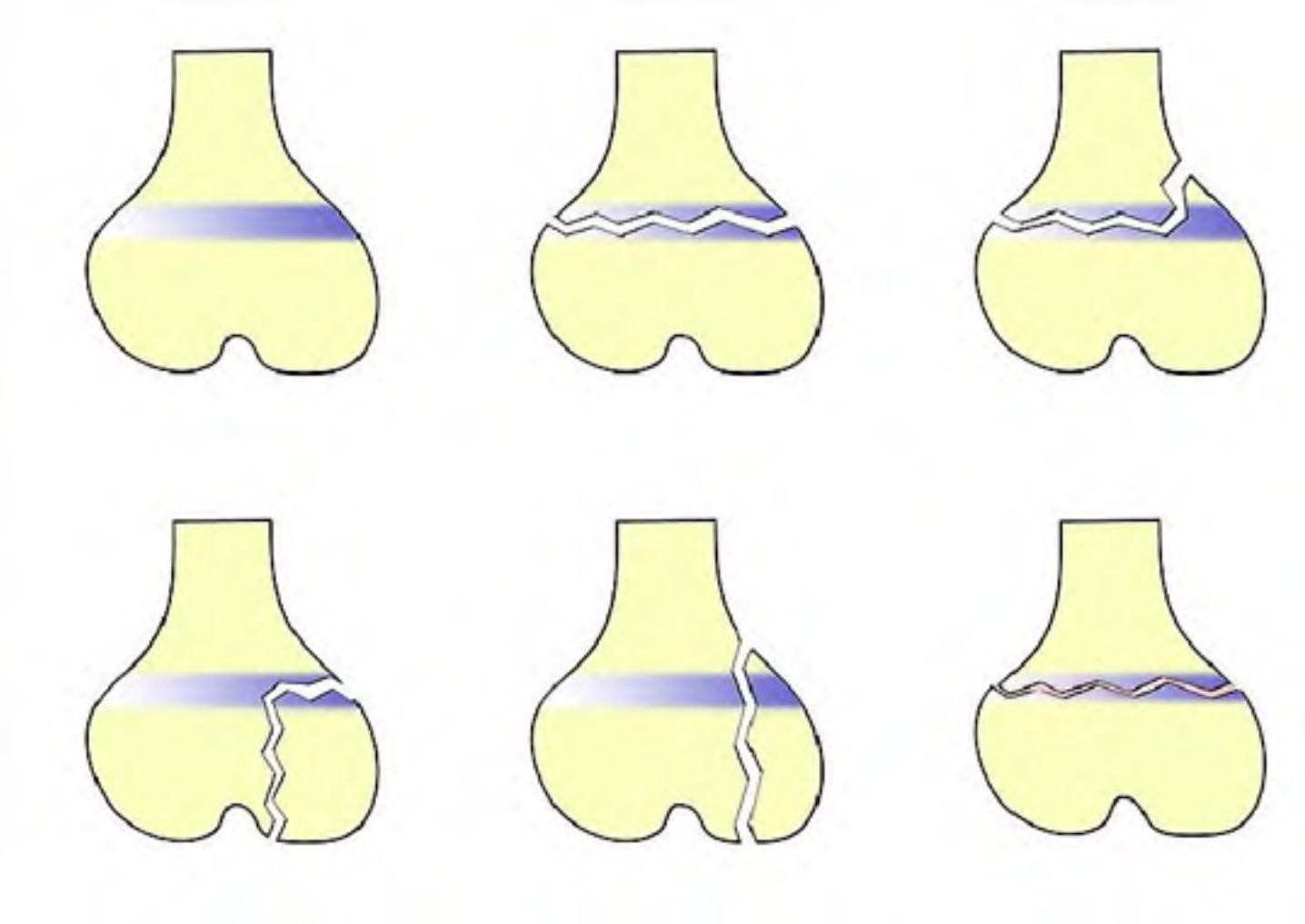
Salter-Harris Classification

- Type 1 = Fracture through Epiphyseal Plate
  - Results in separation of epiphysis
  - Good Prognosis
- Type 2 = Fracture of Metaphysis with extension through Epiphyseal plate
  - Most common type in children > 10 y/o
  - Good Prognosis
- Type 3 = Fracture of the Epiphysis with extension into the Epiphyseal plate
  - Totally Intra-articular fracture
  - Open reduction necessary
- Type 4 = Fracture through Epiphysis, Metaphysis and Epiphyseal plate
  - Complete intra-articular fracture
  - Open reduction necessary
  - Growth disturbance likely if not perfect reduction
- Type 5 = Crush Fracture of the Epiphyseal plate
  - Most common in knee and ankle
  - X-ray can be deceptively normal looking
  - Poor prognosis because blood supply to epiphysis is disrupted

Salter Harris Classification

- How to remember the classification?
  - SALTER Mnemonic
  - S = Slip through the growth plate
  - A = Above the level of the growth plate
  - L = Lower than the growth plate
  - T = Through the growth plate
  - R = Ram the growth plate

Salter-Harris Classification



Dr Frank Gaillard (MBBS, FRANZCR) (Wikipedia)

Complications of Fractures

- Immediate Complications
- Intermediate Complications
- Long Term Complications

Immediate Complications

- Hemorrhage
  - Can be extensive especially with Pelvic Fractures
- Vascular Injuries
  - Anterior Shoulder Dislocation = Axillary Artery
  - Extension Supracondylar Fracture = Brachial Artery
  - Posterior Elbow Dislocation = Brachial Artery
  - Knee Dislocation = Popliteal Artery
- Nerve Injuries
  - Anterior Shoulder Dislocation = Axillary Nerve Injury
  - Humeral Shaft Fractures = Radial Nerve Injury
  - Supracondylar Fracture = Medial, Radial and Ulnar Nerve Injury
  - Medial Epicondyle = Ulnar Nerve Injury
  - Post Elbow Dislocation = Ulnar/Medial Nerve Injury
  - Olecranon = Ulnar Nerve Injury
  - Acetabular Fracture = Sciatic Nerve Injury
  - Posterior Hip Dislocation = Sciatic Nerve Injury
  - Anterior Hip Dislocation = Femoral Nerve Injury
  - Knee Dislocation = Peroneal/Tibial Nerve Injury
  - Lateral Tibial Plateau Fracture = Peroneal Nerve Injury
- Soft Tissue/Visceral Injuries

Intermediate/Long Term Complications

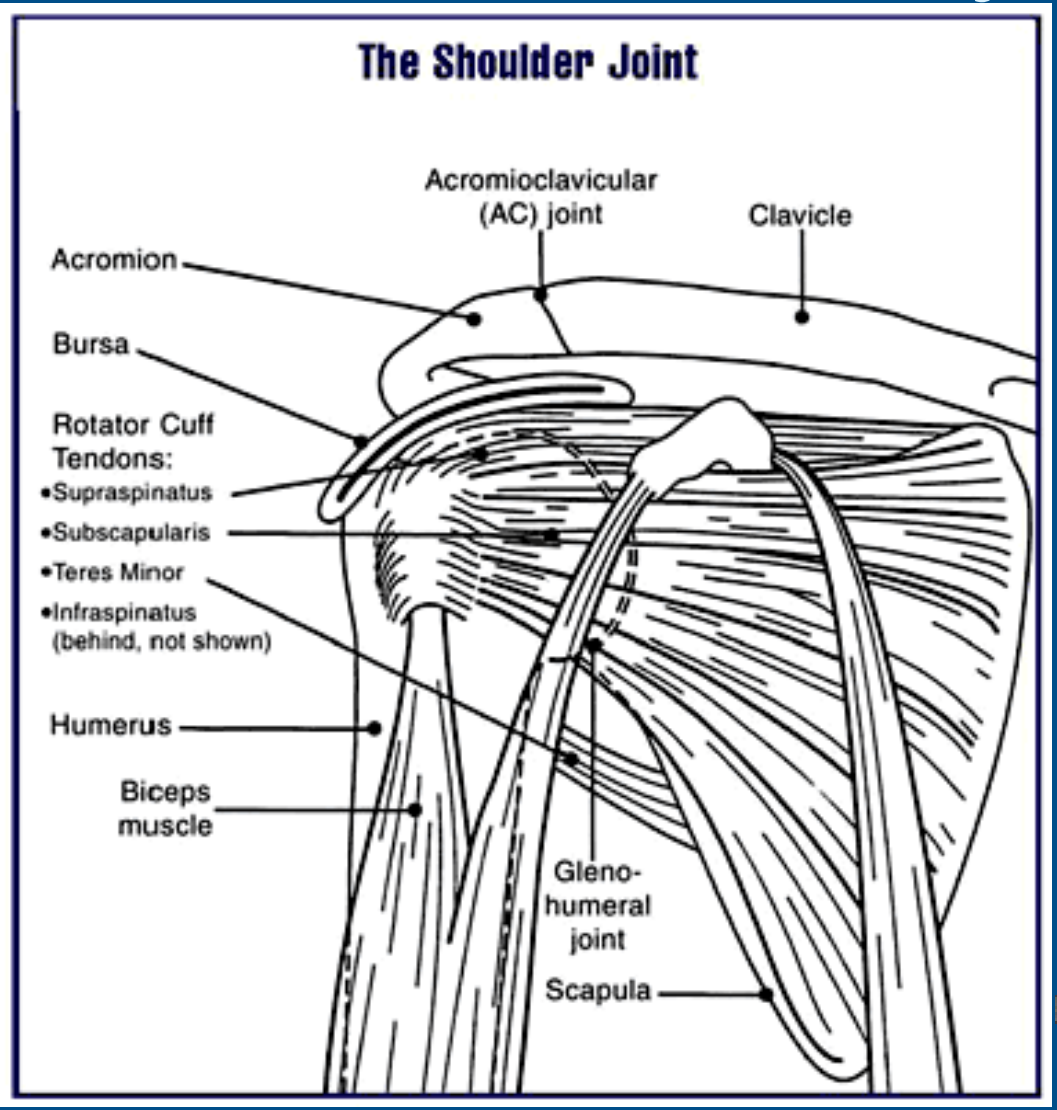
- Intermediate Complications
  - Compartment Syndrome
  - Fat Embolism
- Long-Term Complications
  - Reflex Sympathetic Dystrophy
  - Volkmann's Ischemic Contracture
  - Non-union
  - Avascular Necrosis
  - Angulation Deformities
  - Infection
  - Joint Stiffness
  - Post-traumatic Ossification or Arthritis

Compartment Syndrome

- Results from crush injury and fractures to long bones – distal radius, tibial shaft
- Swelling and bleeding in compartment increases pressure to above that able to maintain normal perfusion of affected area
- Most common = Anterior Tibial Compartment
- Symptoms = Pain, Pallor, Paresthesias, Pulseness, Paralysis (5 P's)
- Diagnosis = Compartment Pressures
  - Indication for surgery = 40-50 mmHg
- Treatment = Fasciotomy

THE SHOULDER AND UPPER ARM

Shoulder Anatomy



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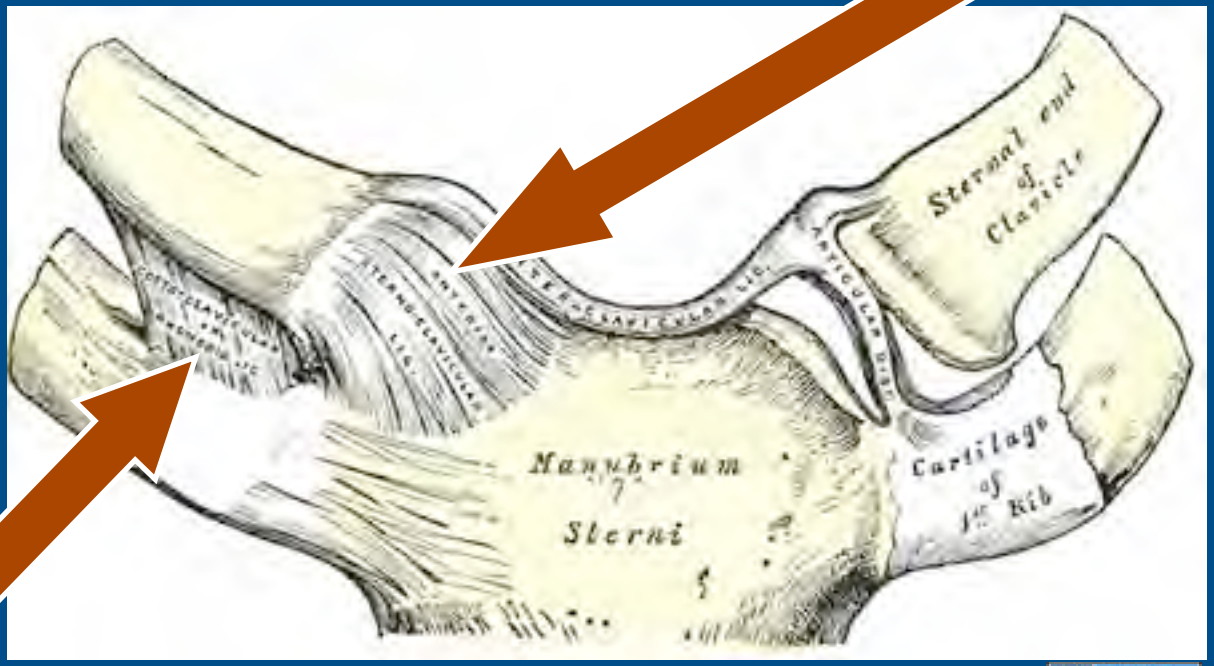
Wikipedia

Joint Injuries

- Sternoclavicular Joint Injuries
- Acromioclavicular Joint Injuries
- Glenohumeral Joint Dislocation

Sternoclavicular Joint Injuries

1 Sternoclavicular Ligament



Gray's Anatomy (Wikipedia)

2 Costoclavicular Ligament

Sternoclavicular Joint Injuries

- Classification
  - 1st Degree = Sprain = Partial tear of sternoclavicular and costoclavicular ligaments with mild subluxation
  - 2nd Degree = Subluxation = Complete tear of sternoclavicular ligament with partial tear of costoclavicular ligament
    - Clavicle subluxates from the manubrium on x-ray
  - 3rd Degree = Dislocation = Complete tear of both sternoclavicular and costoclavicular ligaments with complete dislocation of clavicle from the manubrium
    - Anterior = Most common
    - Posterior = True Emergency – 25% will have concurrent life-threatening injuries to adjacent mediastinal structures
- Mechanism of Injury
  - Direct force over sternoclavicular joint (posterior dislocation)
  - Fall onto shoulder with anterior or posterior dislocation

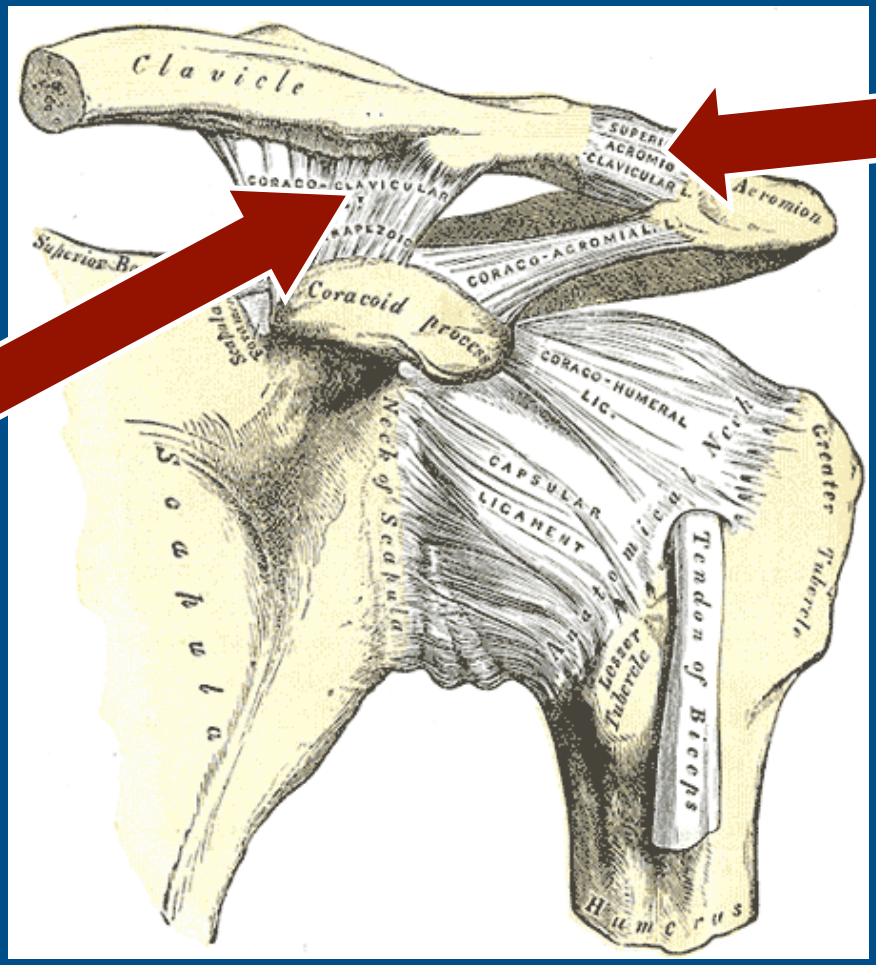
Sternoclavicular Joint Injuries

- Signs/Symptoms
  - Tenderness and pain over joint
  - Pain with movement of shoulder
  - Patients with posterior dislocation = shortness of breath, dysphagia or choking due to compression of mediastinal structures
- X-rays = Regular x-rays or CT for extensive injuries
- Treatment
  - 1st Degree = Sling x 3-4 days, Analgesia
  - 2nd Degree = Figure of Eight Clavicular Strap or Arm Sling, Orthopedic Follow-up
  - 3rd Degree = Immediate Orthopedic consultation and rapid reduction
    - Posterior dislocation may require reduction in operating theatre
    - Posterior dislocation may need to be reduced with traction on clavicle with towel clip
    - Apply figure of eight strap or arm sling

Acromioclavicular Joint

1 Acromioclavicular Ligaments

2 Coracoclavicular Ligaments



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Acromioclavicular Joint Injuries

- Classification (AC = Acromioclavicular, CC = Coracoclavicular)
  - 1st Degree = Sprain = Partial tear of AC ligament, No injury to CC ligament
  - 2nd Degree = Subluxation = Complete tear of AC ligament, CC ligament stretched or incompletely torn
  - 3rd Degree = Dislocation = Complete tears of AC and CC ligaments with dislocation of clavicle
  - 4th Degree = Displacement
    - Type IV = Displacement Posteriorly
    - Type V = Displacement Superiorly
    - Type VI = Displacement Inferiorly
- Mechanism of Injury
  - Fall on outstretched arm
  - Fall on shoulder with arm adducted (most common)
- Signs/Symptoms
  - Tenderness/Swelling over the joint
  - Pain with movement of affected extremity
  - Upward displacement of clavicle (seen with type 3 or worse)

Acromioclavicular Joint Injuries

- X-rays
  - AP views of clavicle
  - Stress views not commonly used anymore and do not alter course of treatment
  - Findings
    - 1st degree = Radiographically normal
    - 2nd degree = Increased distance between clavicle and acromion (< 1 cm)
    - 3rd degree = Increased distance between the clavicle and acromion (> 1 cm)
- Treatment
  - Type 1 = Sling x 1-2 weeks
  - Type 2 = Sling, Orthopedic referral
  - Type 3 = Immobilize in sling, Prompt orthopedic referral within 72 hours
  - Type 4-6 = Sling, Prompt orthopedic referral, Likely will require surgical management

Acromioclavicular Separation - III

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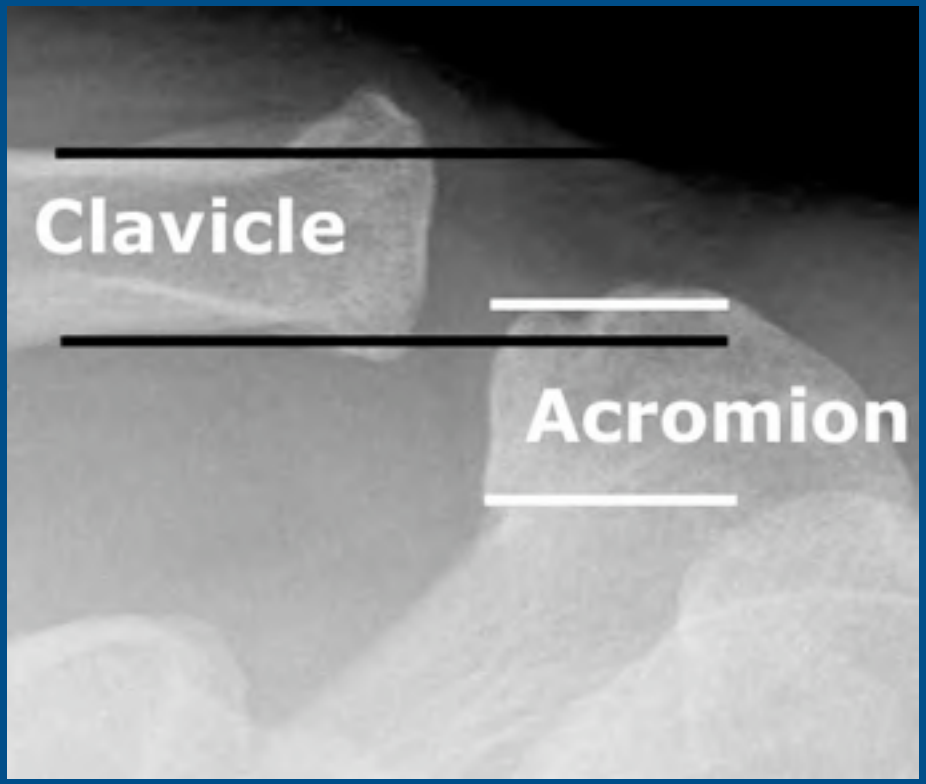
http://radiopaedia.org/uploads/images/0002/3685/23685.medium.jpg



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http://www.so.com.au/Patient_information/conditions/shoulder/acj/acj-close-up-Gd-III-2.jpg

Glenohumeral Joint Dislocation

- Shoulder Dislocation = Most Common dislocation seen in the ED
- Classification
  - Anterior (95-97%)
    - Subcoricoid, Subglenoid, Subclavicular, Intrathroracic
  - Posterior (2-4%)
    - Most commonly missed major dislocation of the body
    - Subacromial (98%), Subglenoid, Subspinous
- Mechanism of Injury
  - Anterior = Abduction, Extension and External Rotation
  - Posterior = Seizure or Electric Shock
    - Fall on forward-flexed, adducted and internally rotated arm
- Signs and Symptoms
  - Prominence of acromion process and flattening of normal contour of the shoulder (anterior)
  - Anterior flatness, posterior fullness and prominence of the coracoid process (posterior)
- X-rays
  - Standard Series = AP Shoulder + Transcapular lateral or Y view
  - Y view is diagnostic in posterior dislocation and without Y view, may be missed

Glenohumeral Joint Dislocations

- Anterior Dislocation
  - Inferior displaced humerus

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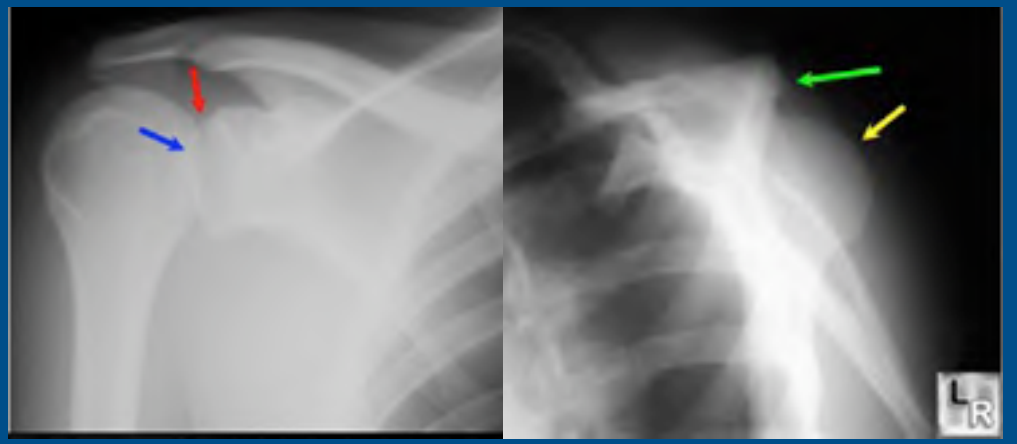
http://www.imagingpathways.health.wa.gov.au/includes/image/sh_pain/should.jpg

- Posterior Displacement
  - AP = Internal Rotation of humerus = “Light bulb sign”
  - Y view = Humeral head displaced



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http://www.learningradiology.com/caseofweek/caseoftheweekpix/cow105arrows.jpg

Glenohumeral Joint Dislocation

- Treatment
  - Reduction using a variety of techniques
  - Shoulder dislocation with associated fracture should be referred to orthopedics for reduction
  - Make sure to evaluate vascular and nerve exam post reduction and obtain a post-reduction film
  - After reduction, patient should be placed in shoulder immobilizer and orthopedic follow-up arranged
- Complications
  - Recurrence = Most common complication
    - Age related (younger the patient, the more likely of a reoccurrence)
  - Bony Injuries
    - Hill-Sachs Deformity = Compression fracture or groove of posterolateral aspect of humeral head
      - Results from impact of humeral head on the anterior glenoid rim as it dislocates or reduces
    - Avulsion of greater tuberosity (Increased in patients > 45 y/o)
    - Bankart's Fracture = Fracture of the glenoid lip
  - Nerve Injuries
    - May occur during dislocation or reduction and most neuropraxias will recover over time
    - Axillary nerve (most common) or Musculocutaneous nerve
  - Rotator Cuff Tears
  - Axillary Artery Injury (rare) – suspect in elderly patients with weak pulse or rapidly expanding hematoma

Complications

- Hill Sachs Deformity

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http://www.gentili.net/signs/images/400/shoulderhillsachs.JPG

- Bankart's Fracture

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http://www.mypacs.net/repos/mpv3_repo/viz/full/18712/935613.jpg

Shoulder Reduction Techniques

- External Rotation Method (Hennipen Technique)
  - Gentle external rotation
  - If no success, slowly lift abduct arm, lifting humeral head into joint

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http://www.hawaii.edu/medicine/pediatrics/pemxray/v4c12.html

Shoulder Reduction Techniques

- Traction-Counter traction

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http://www.hawaii.edu/medicine/pediatrics/pemxray/v4c12.html

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http://www.hawaii.edu/medicine/pediatrics/pemxray/v4c12.html

Shoulder Reduction Techniques

- Scapular Manipulation

Shoulder Reduction Techniques

- Stimson or Hanging Weight

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http://www.hawaii.edu/medicine/pediatrics/pemxray/v4c12.html

Shoulder Reduction Techniques

- Kocher Method

PD-INEL http://www.hawaii.edu/medicine/pediatrics/pemxray/v4c12.html

Rotator Cuff Injuries

- Rotator cuff is made up of 4 muscles that insert tendons into the greater and lesser tuberosity of the muscles and allows abduction and internal/external rotation of the shoulder
  - SITS MUSCLES = Subscapularis, Supraspinatous, Infraspinatous, Teres minor
- Mechanisms of Injury
  - Acute tear = Forceful abduction of the arm against resistance (e.g. fall on outstretched arm)
  - Chronic teat = 90% = Results from subacromial impingement and decreased blood supply to the tendons (worsens as patient ages)
- Clinical Picture
  - Typically affects males at 40 y/o or later
  - Pain over anterior aspect of shoulder, tearing quality to pain, typically worse at night
  - PE with weak and painful abduction or inability to initiate abduction (if complete tear)
    - Drop arm test – inability to hold arm in 90 degrees abduction
  - Tenderness on palpation of supraspinatous over greater tuberosity
- Imaging
  - In ED, plain film x-rays indicated to exclude fracture and may show degenerative changes and superior displacement of humeral head
  - MRI is diagnostic (not typically done in ED setting)
- Treatment
  - Sling Immobilization, Analgesia, Ortho Referral
  - Complete tears require early surgical repair (< 3 weeks)
  - Chronic tears are managed with immobilization, analgesia and orthopedic follow-up for rehabilitation exercises and possible steroid injection

Fractures

- Clavicle Fractures
- Scapular Fractures
- Humeral Fractures

Clavicle Fractures

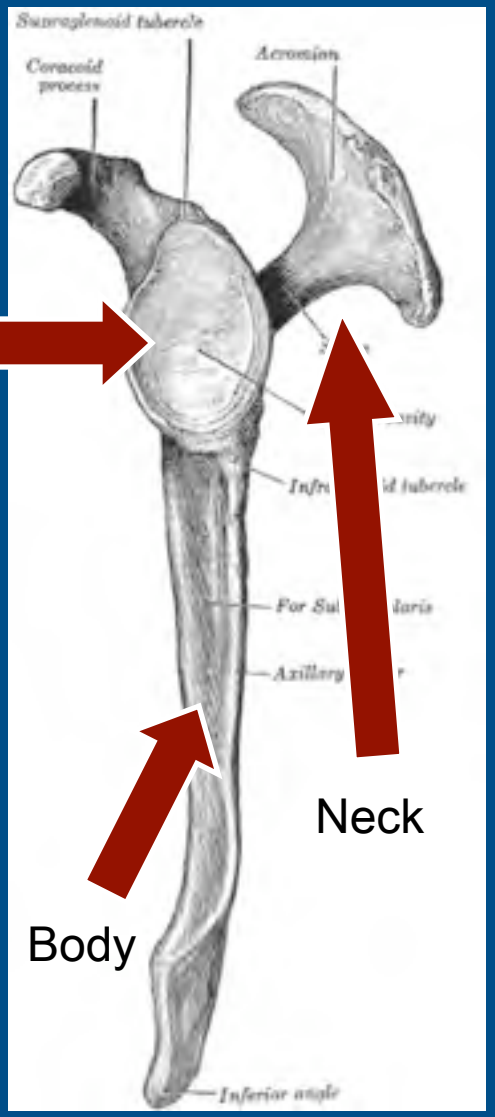
- Classification
  - Middle 1/3
    - Most common area to fracture (especially in children)
  - Distal 1/3
    - May be associated with ruptured coracoclavicular joint with medial elevation
  - Medial 1/3
    - Uncommon, requires strong injury forces
    - Consider intrathoracic injury (i.e. Subclavian Artery or Vein Injury)
- Mechanism = Fall on outstretched shoulder or direct clavicle trauma
- Symptoms/Signs = Pain, Swelling over fractured region
- Imaging = CXR or dedicated Clavicle films
- Treatment
  - Indications for surgical repair
    - Displaced distal third
    - Open
    - Bilateral
    - Neurovascular Injury
  - Treatment = Sling, Orthopedic Follow-up
    - Non-operative management is successful in 90%

Clavicle Fracture

PD-INEL Wikipedia

Scapular Fractures

- High Energy Mechanism
  - Look for associated injuries
- Classification (by location of fracture)
  - Body
  - Neck
  - Glenoid
- Mechanism of Injury
  - Direct blow to the scapula
  - Trauma to the shoulder
  - Fall on outstretched arm
- Clinical Features
  - Pain over back side of shoulder
  - Shoulder pain increased with abduction of the arm
- Imaging
  - Routine shoulder x-rays will demonstrate most scapular fractures
  - Axillary lateral view – helpful with fractures of glenoid fossa, acromion, coracoid process
  - CXR – to r/o associated lung or pulmonary injury
- Treatment
  - Sling immobilization x 2 weeks, Early range of motion exercises
  - Orthopedic referral for ORIF for severely displaced or angulated fractures



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Humeral Fractures

- Types
  - Proximal Humerus Fractures
  - Mid-shaft Humerus Fractures

Proximal Humerus Fractures

- Classification = Neer Classification System
  - Classification by amount of displacement of four segments
    - Displacement = separation > 1 cm or angulation > 45^{o}
    - Anatomic Neck
    - Surgical Neck
    - Greater Tuberosity
    - Lesser Tuberosity
  - Major Categories
    - One part fracture – No displacement (80-85%) of fractures
    - Two part fracture – Displacement of one fragment
    - Three part fracture – Displacement of two individual fragments from remaining humerus
    - Four part fracture – Displacement of all four segments
- Mechanism of Injury
  - Fall on outstretched arm (most common)
  - Direct blow to lateral aspect of arm
- Clinical Presentation = Upper arm and shoulder pain after fall
  - Most commonly seen in elderly

Proximal Humerus Fracture

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http://www.wheelessonline.com/image4/i1/prxh1.jpg

Proximal Humerus Fractures

- Imaging = Plain film x-ray imaging
- Treatment
  - One part fractures
    - Immobilization with shoulder immobilizer sling and swath, Analgesia, Ortho follow-up
  - Two/Three/Four Part fractures = Immobilize and emergent orthopedic referral
    - Many will require surgical repair
- Complications
  - Adhesive capsulitis = Frozen Shoulder = Most Common – Prevent with early mobilization
  - Neurovascular Injuries = Axillary nerve and artery, brachial plexus
  - Posterior Dislocations = Will frequently accompany lesser tuberosity fractures
  - Avascular necrosis of humeral head especially with anatomic neck fractures

Mid-shaft Humerus Fractures

- Classification
  - Typically involve middle 1/3 of the humeral shaft
- Mechanism of Injury
  - Direct Blow (Most common)
  - Fall on outstretched arm or elbow
  - Pathologic Fracture (especially Breast Cancer)
- Clinical Presentation
  - Pain and deformity over affected region
  - Associated Injuries
    - Radial Nerve injury = Wrist Drop = Inability of extend wrist, fingers, thumb, Loss of sensation over dorsal web space of 1st digit
      - Neuropraxia at time of injury will often resolve spontaneously
      - Nerve palsy after manipulation or splinting is due to nerve entrapment and must be immediately explored by orthopedic surgery
    - Ulnar and Median nerve injury (less common)
    - Brachial Artery Injury

Mid-shaft Humerus Fractures

- Imaging = Standard x-ray imaging
- Treatment
  - Most managed non-operatively (either):
    - Coaptation splint (sugar tong) plus sling and swath
    - Hanging cast
  - Operative management for patients:
    - Neurovascular compromise, pathologic fractures
- Complications
  - Delayed union
  - Adhesive capsulitis

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http://images.chron.com/blogs/realrehab/archives/pictures/Humerus%20fracture%20B.jpg

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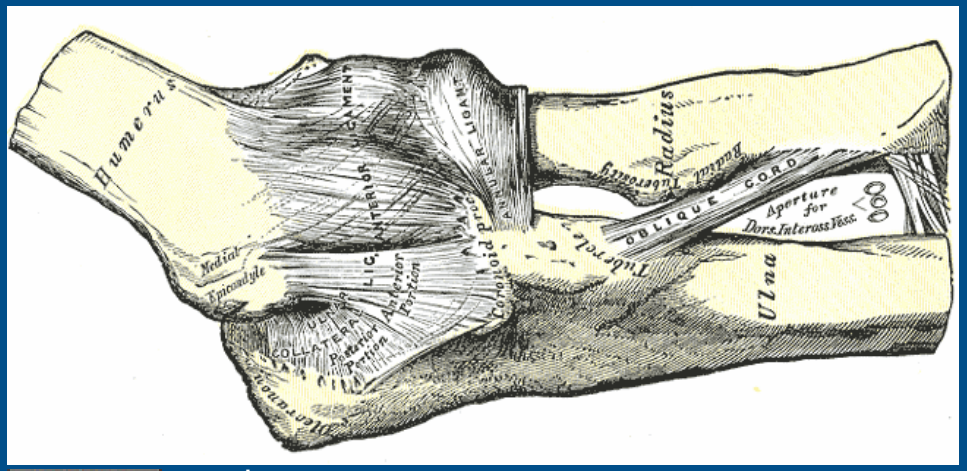
Elbow Injuries

- Elbow Fractures
  - Supracondylar Fractures
  - Olecranon Fractures
  - Condylar Fractures
  - Articular Surface Fractures
  - Epicondylar Fractures
- Dislocations
  - Posterior Elbow Dislocation
  - Anterior Elbow Dislocation
  - Radial Head Subluxation (Nursemaid's Elbow)

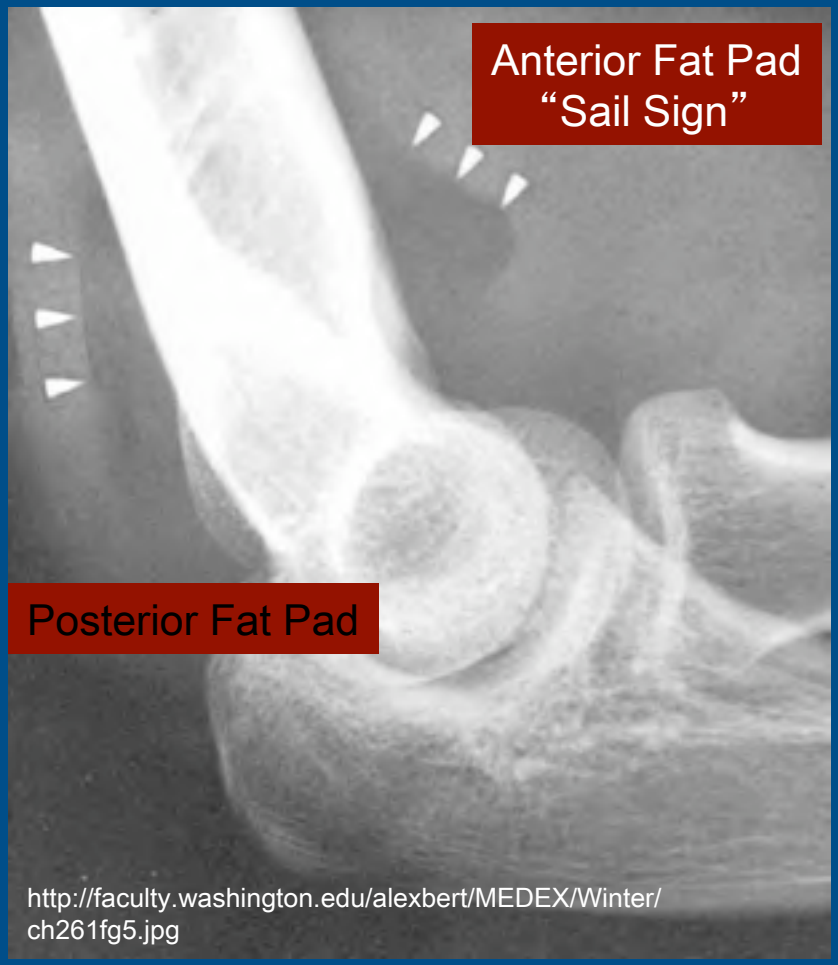


PD-EXP Gray's Anatomy (Wikipedia)

Radiographic Elbow Evaluation

- Elbow radiographic evaluation can be difficult
- True Lateral X-ray = Hourglass or Figure of 8 at distal Humerus
- Fat Pad Signs
  - Posterior Fat Pad Sign = Never seen on normal x-ray imaging
    - Indicates distension of joint capsule by effusion with likely occult fracture
    - Often associated with occult radial head fracture
  - Anterior Fat Pad Sign = Small one may be present on normal x-rays
    - Increased anterior fat pad (sail sign) is abnormal and may indicate fracture
- Anterior Humeral Line
  - Line drawn along anterior surface of humerus and extending through the elbow
  - Normally, transects the middle of the capitellum but with Supracondylar fractures, transects the anterior 1/3 of the capitellum or passes completely anterior to the capitellum
- Radial-Capitellar Line
  - Line drawn through the middle of the radius
  - Normally, transects the middle of the capitellum
  - Abnormal line may indicate radial head dislocation or subtle fracture
- Radial Head Evaluation
  - Carefully inspect the radial head.
  - Fracture may be subtle and only clue may be slight cortical irregularity
- Distal Humerus Evaluation
  - Careful inspection and evaluation of anterior humeral head line

Elbow Radiographic Evaluation



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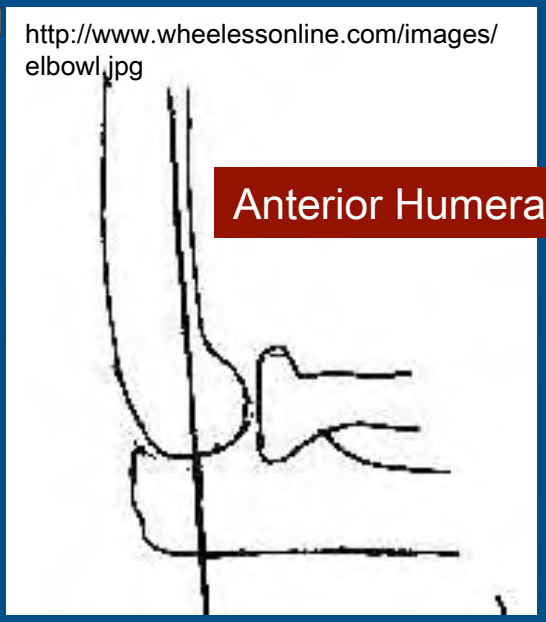

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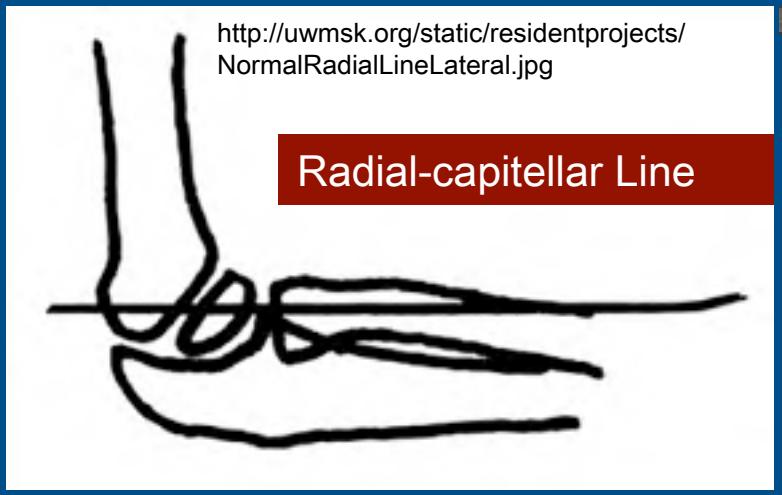

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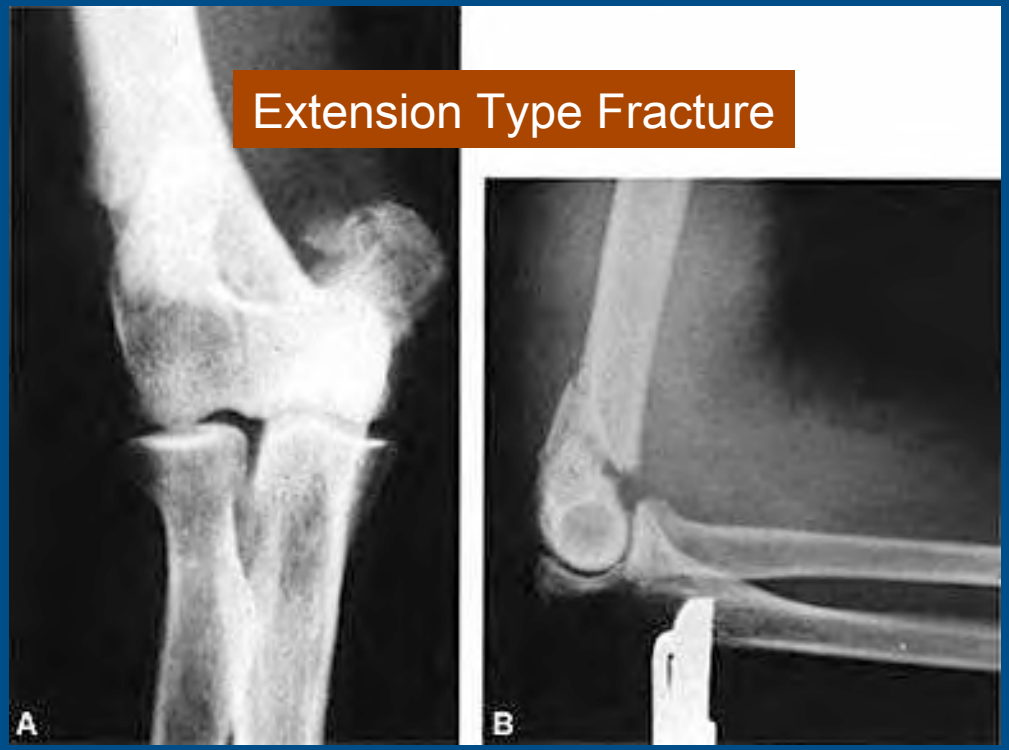
Supracondylar Fractures

- Supracondylar Extension Fractures (Most Common Type)
  - Mechanism of injury = Fall on outstretched arm with elbow in extension
  - Imaging = Distal humerus fractures and humeral fragment displaced posteriorly
    - Sharp fracture fragments displaced anteriorly with potential for injury of brachial artery and median nerve
  - Treatment
    - Emergent Orthopedic Consultation
    - Non-displaced fracture = Immobilization in posterior splint
      - May be discharged home with close follow-p
    - Displaced fracture = Prompt reduction with percutaneous pin fixation or internal fixation by orthopedic surgeon
      - If vascular compromise on evaluation, ED physician should attempt reduction
  - Complications
    - Compartment syndrome of forearm (Volkmann's ischemia)
    - Median Nerve Injury = Weakness of Flexor Muscles of Hand and loss of two point discrimination of the fingertips
      - Neuropraxias at time of injury should resolve over time

Supracondylar Fracture

- Supracondylar Flexion Fractures
  - Mechanism of Injury = Direct blow to posterior aspect of flexed elbow
  - Imaging = Distal humerus fracture displaced anteriorly
  - Treatment
    - Non-displaced fractures are treated with splint immobilization and early orthopedic follow-up
    - Displaced fractures require emergent orthopedic consultation for reduction and percutaneous pinning
  - Complications
    - Fractures are frequently open
    - Vascular injury is rare
    - Ulnar nerve injury is most common complication

Supracondylar Fracture



PD-INEL http://www.e-radiography.net/articles/ortho/Image13.jpg

PD-INEL http://boneandspine.com/wp-content/uploads/2009/07/flexion-supracondylar-fracture-lateral-view.jpg

Other Elbow Fractures

- Olecranon Fracture
  - Mechanism = Direct blow to point of Elbow
  - Clinical Feature
    - Swelling/tenderness over Olecranon
    - Inability to extend elbow against gravity
  - Associated Injury = Ulnar Nerve
  - Treatment
    - Non-displaced = Elbow immobilization in 30 degrees flexion
    - Fractures > 2 mm displacement = Emergent Ortho Referral
      - Open reduction with internal fixation
- Condylar Fracture
  - Distal Humerus comprised of medial and lateral condyles, each with articular and non-articular surface
  - Articular Surfaces
    - Trochlea (medial condyle)
    - Capitellum (lateral condyle)
  - Non-articular surface
    - Medial and Lateral Epicondyle
  - Condylar fractures involve both the articular surface and the non-articular surface
    - Lateral condyle fractures are most common
  - Treatment
    - Nondisplaced or minimally displaced = Immobilization in 90o elbow flexion with forearm supination or pronation, Outpatient ortho referral
    - Displaced Fractures (> 3 mm) = Surgical Fixation

Other Elbow Fractures

- Articular Surface Fracture
  - Trochlea and Capitellum
  - Mechanism = Typical fracture is associated with posterior elbow dislocation or from fall on outstretched hand
  - Treatment
    - Non-displaced fracture = Splint immobilization
    - Displaced (even minimal) = Emergent orthopedic referral and surgical repair
- Epicondylar Fracture
  - Seen most commonly in children
  - Medial Epicondyle
    - Avulsion fracture of medial condyle often accompanies posterior elbow dislocation
    - Associated ulnar nerve injury
    - Treatment
      - Nondisplaced = Immobilization
      - Displaced (> 3-5 mm or intra-articular) = Orthopedic referral and surgical reduction
  - Lateral Epicondyle
    - Rare, typically the result of direct blow
    - Most are non-displaced and treated with immobilization

Elbow Dislocations

- Posterior (Most Common)
  - Mechanism of Injury = Fall on extended and abducted arm
  - Clinical Findings = Marked swelling with posterior prominence of Olecranon
  - Imaging = Lateral view of elbow
  - Associated Injuries
    - Fractures (30-60% of cases)
    - Ulnar or Median nerve injury
    - Brachial artery injury – Consider angiography is suspect arterial injury
  - Treatment = Reduction
    - Traction distally at wrist with assistant immobilizing the humerus
    - While maintaining traction, flex the elbow and apply posterior pressure to the humerus
    - Elbow will exhibit “clunk” when reduced
    - Reassess ROM of elbow and neurovascular status
    - Immobilize in long-arm posterior splint in 120 degrees of flexion (i.e. full flexion)
    - Observe for delayed vascular compromise
- Anterior (Uncommon)
  - Mechanism of Injury = Blow to Olecranon with elbow in flexion
  - Clinical Findings = Elbow in full flexion
  - Associated Injuries = Much higher incidence of vascular impingement
  - Treatment
    - With humerus immobilized by second assistant, downward and backward pressure is applied to proximal forearm while in-line traction is applied to the wrist

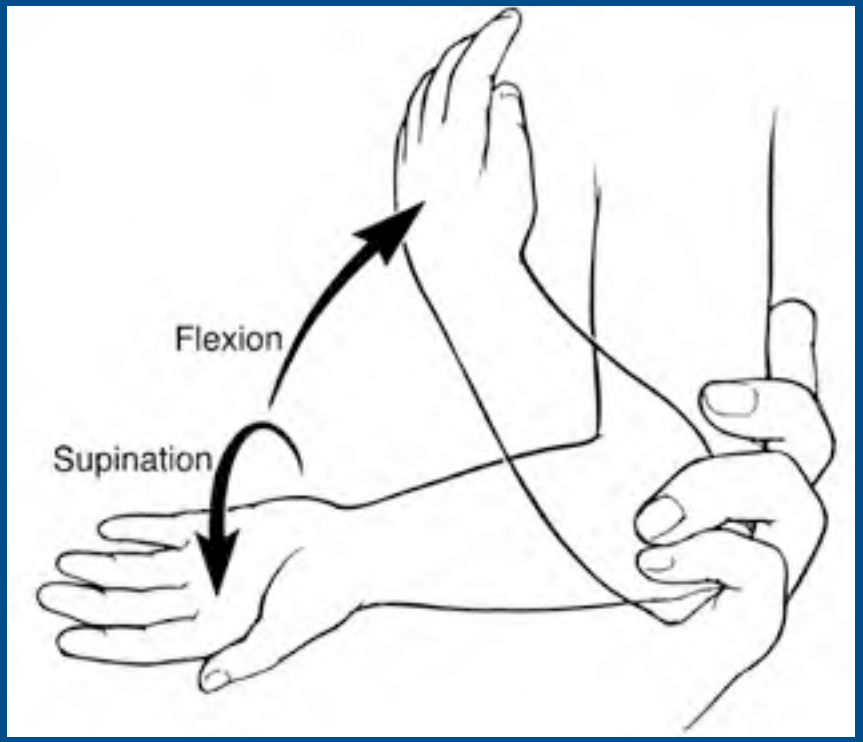
Elbow Dislocation

PD-INEL http://boneandspine.com/wp-content/uploads/2009/02/anterior_dislocation_elbow.jpg

Radial Head Subluxation

- Nursemaid's elbow = Subluxation of radial head beneath the annular ligament
- Mechanism of injury = Longitudinal traction on hand or forearm with arm in pronation
- Clinical Findings = Child with arm dangling at side and unwilling to use it
- X-rays not necessary
- Treatment = Reduction
  - Thumb over radial head with concurrent supination of forearm and flexion of elbow
  - Extension and pronation (another option for reduction)

Radial Head Subluxation



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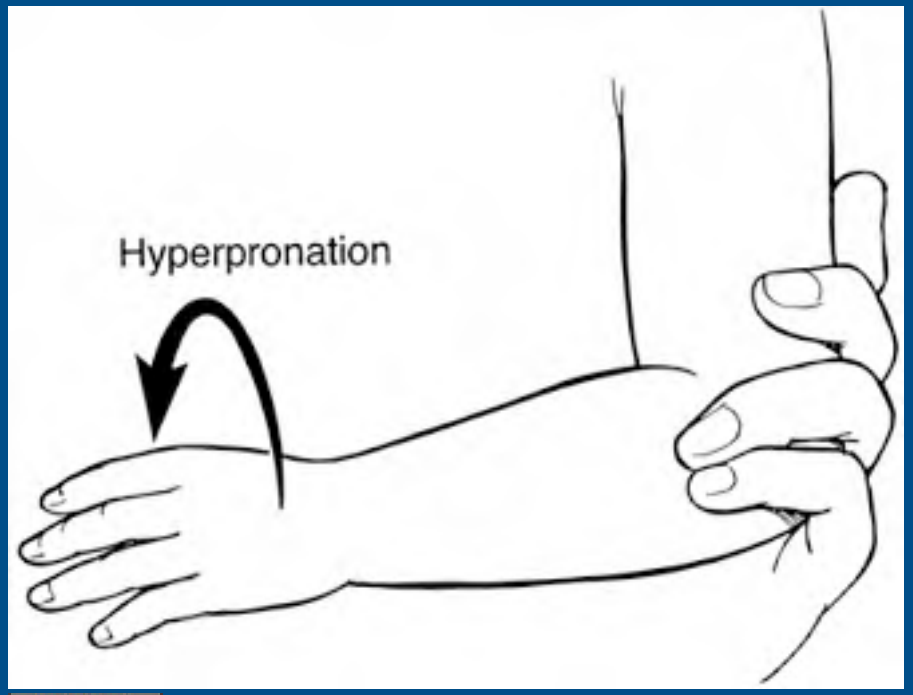
http://daddytypes.com



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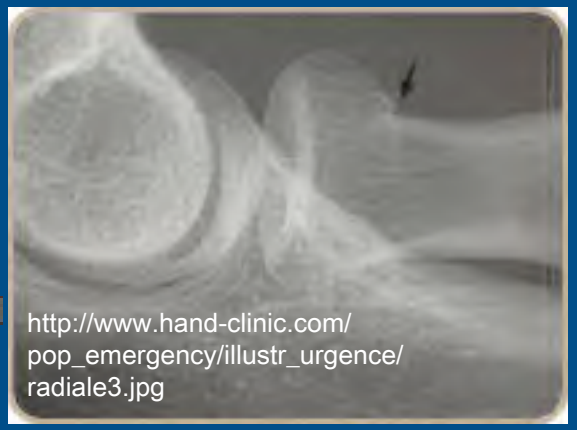
http://daddytypes.com

Forearm Injuries

- Radial Head Fracture
- Galeazzi Fracture
- Nightstick Fracture
- Monteggia's Fracture
- Both bone Forearm Fracture

Radial Head Fracture

- Mechanism of Injury = Fall on outstretched hand
- Clinical Finding = Tenderness and swelling over the radial head
- Imaging
  - May not be seen on initial x-ray
  - Evaluate for anterior or posterior fat pad which suggests diagnosis
- Associated Injuries
  - Essex-Lopresti Lesion = Distal radio lunar dissociation
  - Articular surface of capitellum frequently injured
- Treatment
  - Non-displaced = Sling immobilization, Ortho follow-up
  - Comminuted/Displaced Fractures = Immobilization in posterior long arm splint
    - Early orthopedic referral (2-5 days) for screw fixation or radial head excision, which will be done if:
      - Marked comminution of fracture
      - Angluation of articular surface
      - > 2 mm offset in two part fracture
      - Fracture involving more than 1/3 of articular surface



http://www.hand-clinic.com/pop_emergency/illustr_urgence/radiale3.jpg

Galeazzi Fracture

- Distal Radius Fracture
  - Distal radio-ulnar dislocation
- Mechanism of Injury
  - Direct blow to back of wrist
  - Fall on outstretched hand
- Complication = Ulnar nerve injury
- Treatment = ORIF

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http://www.learningradiology.com/caseofweek/caseoftheweekpix2/cow157lg.jpg

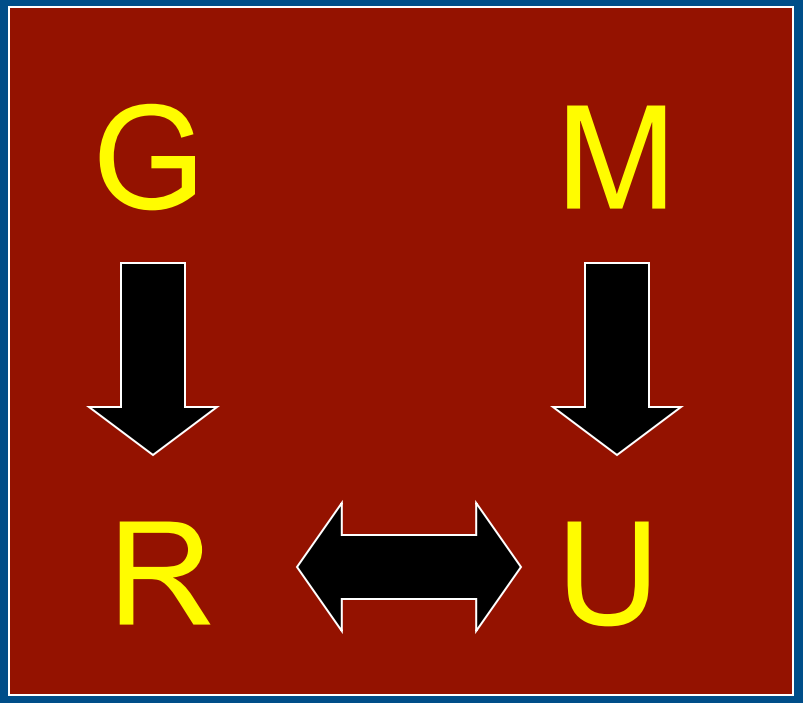
Monteggia's Fracture

- Proximal 1/3 Ulnar Fracture
  - Dislocation of radial head
- Mechanism of Injury = Direct blow to posterior aspect of ulna
  - Fall on outstretched hand
- Imaging = Elbow/Forearm x-rays
  - Radial head dislocation missed in 25% of cases
  - Carefully examine the alignment of radial head
- Associated Injury = Radial Nerve Injury
- Treatment
  - ORIF (Adults)
  - Closed Reduction/Splinting (Children)

PD-INEL http://www.radiology.co.uk/srs-x/cases/074/d.htm

Galeazzi vs. Monteggia

Galeazzi
Radial Fracture
Ulnar Fracture
Monteggia



Nightstick Fracture

- Isolated fracture of ulnar shaft
- Mechanism = Direct blow to ulna with patient raising forearm to protect face
- Treatment
  - Non-displaced = Immobilization in cast
  - Displaced
    - >10 degrees angulation or displacement > 50% of ulna
    - Orthopedic referral - ORIF

PD-INEL http://radiographics.rsna.org/content/24/4/1009/F31.small.gif

Both Bone Forearm Fracture

- Fracture of both ulnar and radius
  - Usually displaced fracture
- Mechanism of Injury = Direct blow to forearm
- Associated Injury
  - Peripheral Nerve Deficits
  - Development of compartment syndrome
- Treatment
  - Non-displaced (rare) = Immobilization in bivalved cast
  - Displaced – ORIF
    - Closed reduction may be possible in children
- Complications
  - Compartment Syndrome
  - Malunion

http://img.medscape.com/pi/emed/ckb/orthopedic_surgery/1230552-1239870-1175.jpg

Volkmann's Ischemic Contracture

- Complication of elbow and forearm fractures or casting that is too tight (compartment syndrome)
- Pressure on Brachial artery results in ischemia of muscles of forearm, typically flexor compartment
- Results in forearm pronation, flexion of wrist and digits and paralysis of intrinsic muscles
- Patient complains of pain out of proportion of injury, digit swelling and paresthesias
- Irreversible damage in 6 hours (see image)
- Consider in any patient presenting with pain and numbness in hand after casting has been performed
- Treatment
  - Removal of cast
  - Surgical decompression with fasciotomy

http://farm1.static.flickr.com/102/297117896_4d336d4854.jpg?v=0

WRIST AND HAND INJURIES

Hand and Wrist Injuries

- Wrist Injuries
  - Fractures
  - Dislocations
  - Overuse Syndromes
    - DeQuervain's Tenosynovitis
    - Carpal Tunnel Syndrome
    - Guyon's Canal Syndrome
- Hand Injuries
  - Fractures
  - Dislocations
  - Infections of the Hand/Bites
  - High Pressure Injection Injuries
  - Tendon Injuries
  - Amputated Digits

Distal Forearm/Wrist Fractures

- Colles' Fracture
  - Transverse fracture of distal radius with dorsal displacement of distal fragment
  - Mechanism = Fall on outstretched hand
  - Most common fracture in adults > 50 years old
  - Exam = Classic Dinner Fork Deformity
  - Associated Injuries
    - Ulnar styloid fracture
    - Median Nerve Injury
  - Treatment
    - Non-displaced Fracture
      - Sugar Tong Splint, Referral to Orthopedic Surgery
    - Displaced Fracture
      - Prompt reduction – Finger traps and manipulation under conscious sedation or with hematoma block
      - Immobilization in Sugar tong splint
      - Referral to Orthopedic Surgery

Distal Forearm/Wrist Fractures

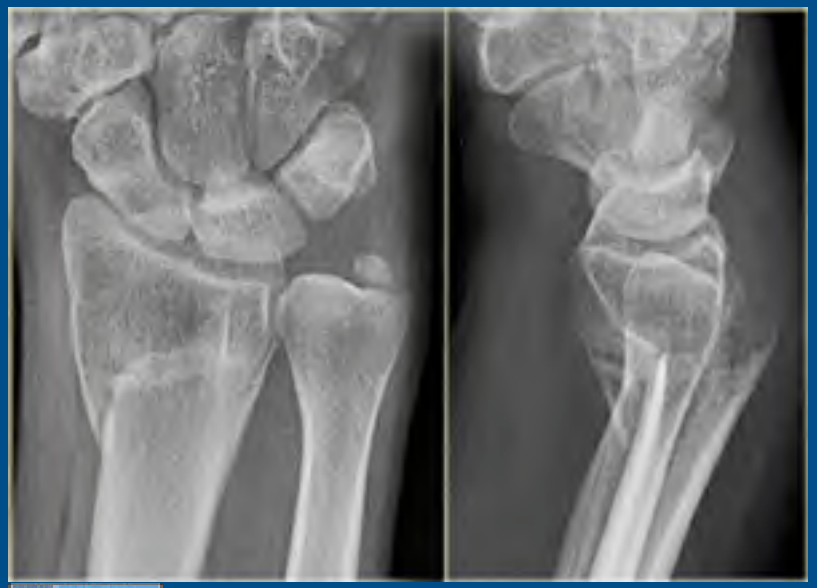
- Smith Fracture (Reverse Colles)
  - Transverse fracture of distal radius with volar displacement
  - Mechanism = Fall on outstretched arm with forearm in supination
  - Associated Injury = Median Nerve Injury
  - Treatment
    - Reduction with finger traps and manipulation
    - Immobilization in sugar tong or long arm splint
    - Orthopedic referral

Distal Forearm Fractures

- Colles' Fracture

http://www.radiologyassistant.nl/images/thmb_47764b731fc2dTEK-colles2.jpg

- Smith Fracture



http://www.radiologyassistant.nl/images/thmb_478115d48934dSmith%27.jpg

Wrist Fractures

- Carpal Injuries
  - Scaphoid Fracture (Most Common)
    - Mechanism = fall on outstretched hand
    - Imaging – Initial x-rays may fail to demonstrate fracture
      - > 10% of cases
      - Repeat Imaging in 2 weeks will often show fracture
    - Clinical findings = tenderness in anatomical snuff box
    - Treatment
      - Non-displaced or clinically suspected fracture
        - Thumb spica Splint
      - Displaced Fracture = ORIF
      - Complications
        - Avascular necrosis or proximal fragment
        - Delayed union or malunion

Wrist Fractures

- Scaphoid Fracture

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Wikipedia

Wrist Fractures

- Carpal Fractures
  - Triquetrum Dorsal Chip Fracture (2nd most common)
    - Mechanism = Fall on outstretched hand
    - Exam = Tenderness on palpation distal to ulnar styloid on dorsal aspect of wrist, painful flexion
    - Best visualized on lateral view of wrist
    - Treatment = Volar splint
  - Lunate Fracture
    - Mechanism = Fall on outstretched hand
    - Exam = Pain over mid-dorsum of wrist increased with axial loading of 3rd digit
    - Plain x-rays are often normal
    - Treatment = Immobilization in thumb spica splint, orthopedic referral
    - Complications
      - Kienbock's disease = Avascular necrosis of proximal segment

Carpal Fractures

- Triquetrum Fracture

http://www.andysleigh.com/WristAndForearm/tutorial/wrist/images/tri.jpg

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- Carpal Bone Review

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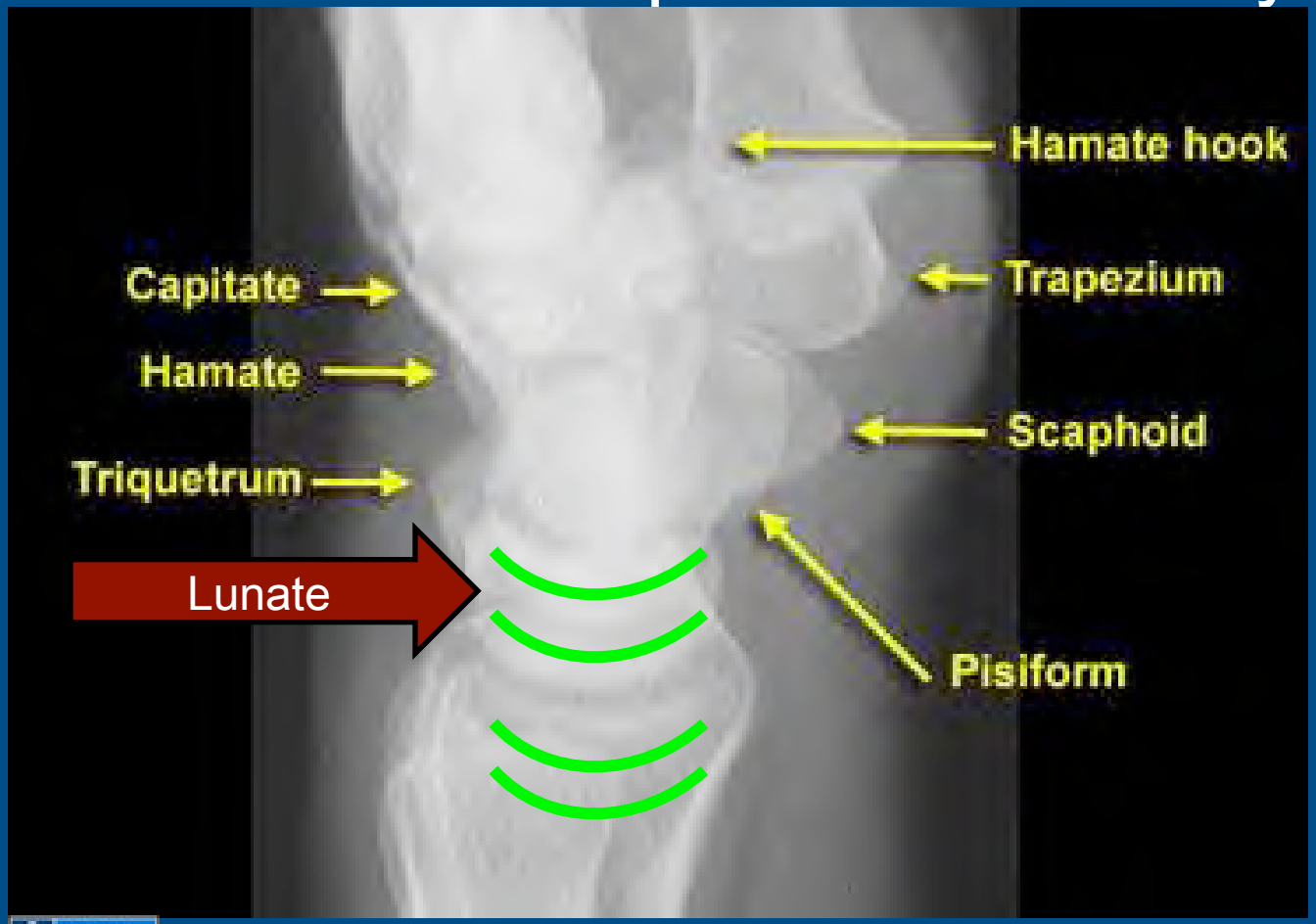
http://www.ucgc.org/segments/wrist-injury/images/xray.jpg

Carpal Dislocations

- Mechanism of Injury = Violent Hyperextension
- Treatment = Orthopedic Consultation
- Lunate Dislocation
  - Pain, swelling and loss of flexion of wrist, hand and arm when held in anatomic position
  - X-ray
    - AP View = “Piece of Pie” sign
    - Lateral View = “Spilled teacup sign”
- Perilunate Dislocation
  - May be associated with Scaphoid fracture

Lunate vs. Peri-lunate Dislocation

- 4 C's Need to line up on normal x-ray



http://www.radiologyassistant.nl/en/42a29ec06b9e8

Lunate vs. Peri-lunate Dislocation

- Lunate Dislocation
  - Capitate is centered over the radius and the lunate is tilted out
  - Tea cup deformity
- Peri-lunate Dislocation
  - Lunate is centered over the radius and capitate is tilted out

http://www.radiologyassistant.nl/images/thmb_4308223ad4bb7lunate-peri-lunate.jpg

Carpal Dislocations

- Scapholunate Dislocation
  - Most common ligamentous injury of hand and is commonly missed
  - Pain with wrist hyperextension, snapping sensation with radial/ulnar deviation
  - Radiographic signs
    - Scaphoid is foreshortened and has a dense ring shaped image around its distal edge (signet ring sign)
    - Widening of space between the lunate/scaphoid
      - > 3 mm, Terry Thomas sign
  - Treatment = Thumb spica, Hand Referral

Scapholunate Dislocation

- Terry Thomas Sign

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http://www.ucgc.org/segments/wrist-injury/images/xray.jpg

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http://faculty.washington.edu/alexbert/MEDEX/Winter/ch262fg4.jpg

Overuse Syndromes

- Carpal Tunnel Syndrome
  - Entrapment of Median nerve
  - Tinel's sign = Tapping over volar wrist produces paresthesias
  - Phalen's sign = Hyperflexion of wrist = Paresthesias
  - Risk Factors = Pregnancy, Hypothyroid, DM, RA
  - Treatment = Splinting, Rest, Surgical Decompression
- DeQuervain's Tenosynovitis
  - Overuse syndrome with inflammation of extensor tendons of thumb
  - Characterized by pain along radial aspect of wrist that is exacerbated with use of thumb
  - Finkelstein's test = Ulnar deviation of fisted hand produces pain
  - Treatment = NSAIDS, Splint, Rest
- Guyon's Canal Syndrome
  - Ulnar nerve entrapment syndrome
  - Numbness and tingling in ring and small finger
  - Causes = repetitive trauma (handle bar neuropathy), cyst
  - Treatment = Splint, Surgical Decompression

Hand Fractures

- Distal Phalanx (15-30% of hand fractures)
  - Mechanism is typically crush or shearing forces
  - Classified as Tuft, Shaft or Intra-articular fractures
  - Fractures at base may be associated with flexor or tendon injuries
  - Treatment is typically protective splinting (hairpin splint or finger splint)
- Proximal and Middle Phalanx
  - No tendon attachments
  - Mechanism
    - Direct blow = transverse or comminuted fracture
    - Twisting Mechanism = Spiral fracture
  - Fractures are typically stable
  - Treatment
    - Stable and Nondisplaced impacted or transverse fx = Buddy taping
    - Stable fractures with no angulation or rotation = Radial or Ulnar gutter splint
    - Unstable fractures = Internal fixation with Kirschner wires

Hand Fractures

- Metacarpal Fractures
  - Head
    - Mechanism = Direct blow or projectile injury with comminuted fracture
    - If laceration is present over MCP = Suspect Fight bite
    - Any displacement gives poor outcome
    - Treatment = Ice, Elevation, Immobilization in soft bulky dressing, Referral to hand surgery
  - Neck (Most common)
    - Mechanism = Direct impaction force
    - Boxer's fracture = 5^{th} MC neck fracture
    - Fractures are typically unstable with volar angulation and/or rotation
    - Acceptable angulation depends on digit
      - 2^{nd} and 3^{rd} MC < 15 degrees angulation acceptable
      - 4^{th} < 20 degrees angulation acceptable
      - 5^{th} < 40 degrees angulation acceptable
    - Rotation Exam = Look for malalignment of plane of fingernails in flexed position
    - Treatment
      - Anatomic reduction if unacceptable angulation or rotational deformity
      - Splint with wrist in 20 degree extension and MP flexed at 90 degrees

Hand Fractures

- Metacarpal Fractures (Cont'd)
  - Shaft
    - Mechanism = Direct Blow or indirect blow with application of a rotational force
    - Rotational deformity is more common than neck fractures
    - Rotational deformity is unacceptable for 2nd and 3rd MC
    - If anatomic reduction is necessary, operative fixation is typically required
    - Treatment
      - Nondisplaced fractures = gutter splint
      - Displaced or angulated fractures = Elevation, Ice, Immobilization and Consultation for reduction and follow-up
  - Base
    - Mechanism = Direct blow or force applied to hand
    - Stable injuries
    - Often associated with carpal bone fractures
    - Treatment = Bulky hand dressing or volar splint

Metacarpal Fractures

- Metacarpal fractures

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http://upload.wikimedia.org/wikipedia/commons/2/2a/Metacarpal_fractures.jpg

- Boxer's Fracture

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http://glovegame.com/gallery/boxersfracture.jpg

Hand Fractures

- Bennett's Fracture
  - Intra-articular fracture of thumb base with subluxation or dislocation of MC joint
  - Axial loading injury with hand closed
  - Treatment
    - Ice, Elevation
    - Immobilization in thumb spica splint
    - Emergent Orthopedic Consultation
      - Anatomic reduction necessary (ORIF)
- Rolando's Fracture
  - Comminuted T or Y shaped fracture involving the joint surface
  - Axial loading injury with hand closed
  - Treatment
    - Ice, Elevation
    - Immobilization in thumb spica splint
    - Emergent Orthopedic Consultation
      - Requires ORIF
    - Worse prognosis

Intra-articular Thumb Fractures

- Bennett's Fracture

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- Rolando's Fracture

Wikipedia PD-INEL

Finger Dislocation

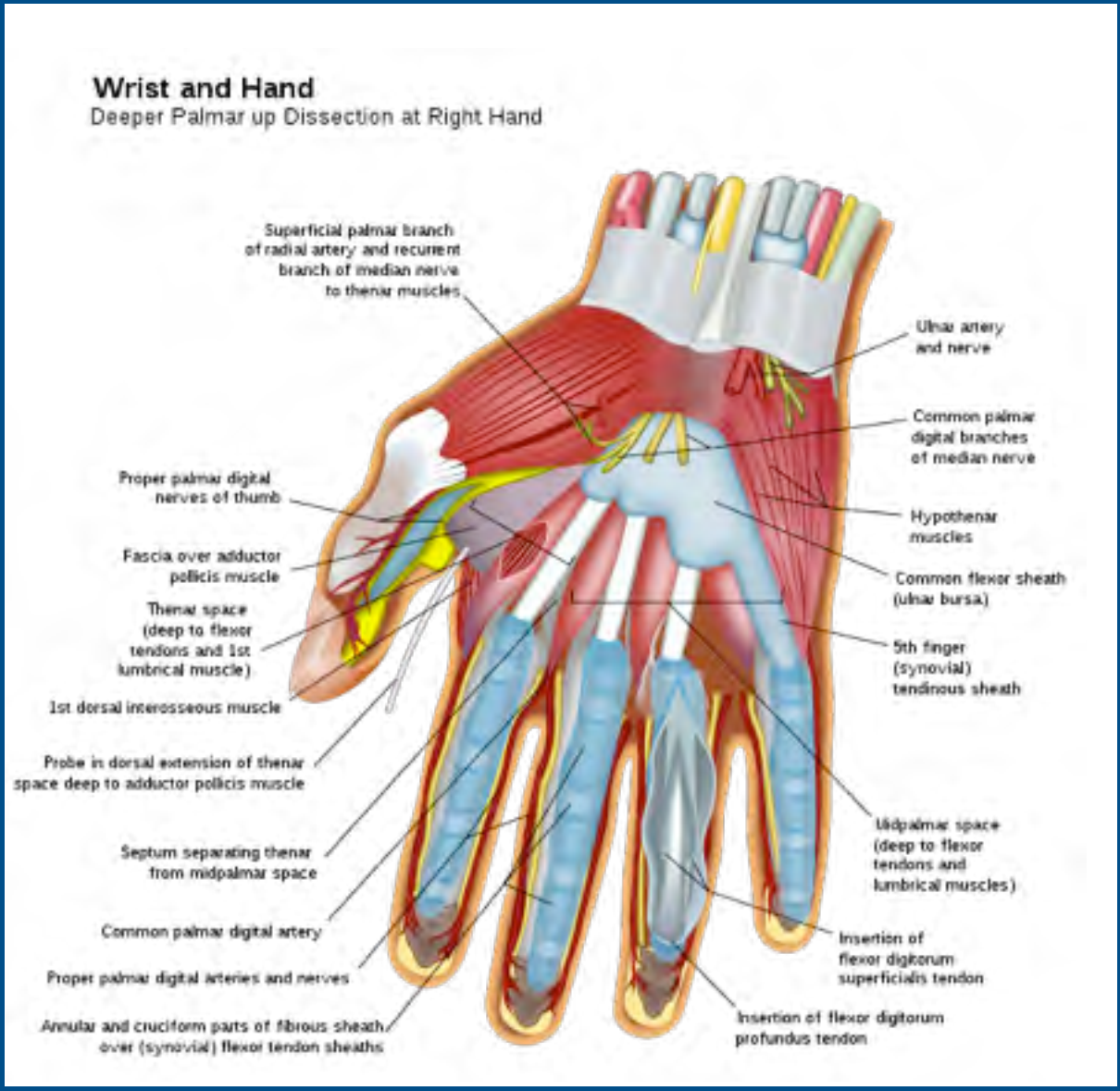
- DIP = Uncommon
- PIP = Common
  - Dorsal dislocation very common, usually due to axial load and hyperextension
  - Reduction = Distraction and slight hyperextension with repositioning
  - Splint at 30 degrees flexion for 3 weeks
  - Can't reduce = Volar plate entrapment
- MCP
  - Less common than PIP
  - Mechanism is typically due to hyperextension forces that rupture the volar plate and cause dorsal dislocation
  - Simple dislocations can typically be managed with closed reduction and splinting in flexion, referral to hand surgeon
  - Complex dislocations characterized by volar plate entrapment in joint space and makes closed reduction in these cases nearly impossible
    - Requires open reduction and repair

Gamekeeper's Thumb

- Ulnar Collateral Ligament tear
- Mechanism of Injury
  - Acute and forceful radial deviation of the thumb (e.g. skiing accidents)
- Examination
  - Tenderness along ulnar aspect of the thumb with weak thumb grasp and pinch
  - Must assess joint stability
    - Apply lateral stress to the MCP joint of injured thumb and compare to normal thumb
    - Presence of > 10-20 degrees of laxity suggests a complete tear
- Imaging = X-rays to r/o fractures
- Treatment
  - Incomplete tear = Thumb spica splint and ortho follow-up
  - Complete tear = Surgical Repair (best if done within 1 week)
  - Hand surgery or ortho referral is recommended for all patients with weakness of pincer function and pint tenderness over volar aspect of thumb MCP

Hand Infections

- Paronychia
- Felon
- Herpetic Whitlow
- Human Bites
- Pyogenic Flexor Tenosynovitis



Paronychia/Felon

- Paronychia
  - Infection of lateral nail fold
  - Staph/Step usual causative agents
  - Treatment
    - Incision and Drainage
    - Warm soaks
    - Antibiotics if surrounding cellulitis
  - Complications = Felon
- Felon
  - Infection of pulp space of fingertip
  - Staph aureus is typical causative agent
  - Treatment – I+D at point of maximal tenderness
    - Packing for 48-72 hours
    - Warm soaks
    - Antibiotics
  - Complications
    - Flexor tenosynovitis, osteomyelitis

Wikipedia

http://www.womenfitness.net/r_img1/felon.jpg

Herpetic Whitlow

- Viral infection of distal finger
- Caused by HSV I or II
- Clinical Findings – Localized burning, itching and pain preceded development of classic clear herpetic vesicles
- Diagnosis – Clinical
- Treatment
  - Splinting, Elevation, Pain control
  - Oral Antiviral Agent
  - Do not surgically drain

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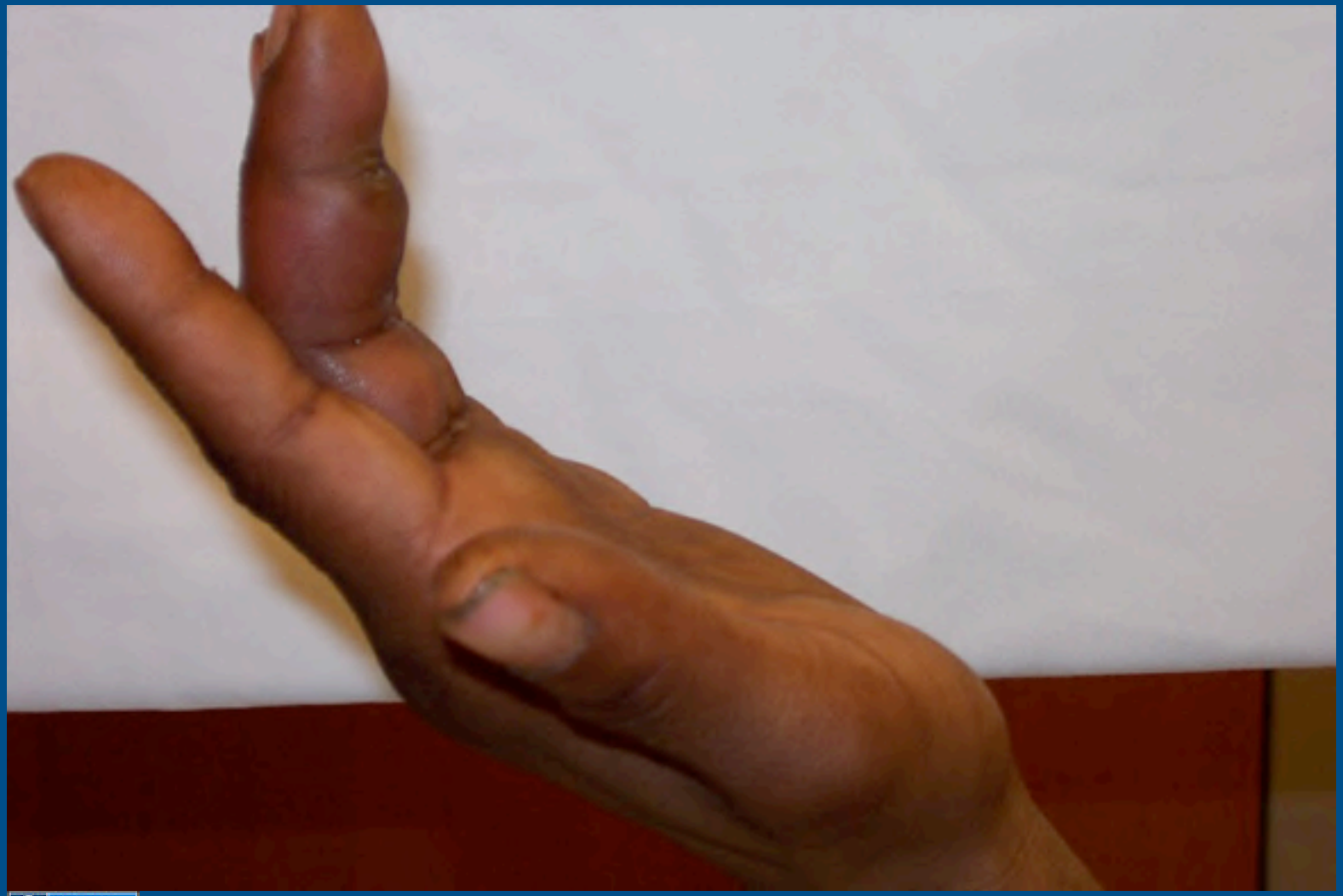
http://www.dartmouth.edu/~thabif/weeklyclinic110501/pictures/12herpeticwhitlow.jpg

Flexor Tenosynovitis

- An infection of flexor tendon sheath that typically results from a puncture wound on volar surface
- Causative agents typically Staph Aureus or Strep
- Diagnosis = 4 Cardinal Kanavel Signs
  - Finger held in slight flexion
  - Symmetric swelling of finger (termed diffuse fusiform swelling)
  - Tenderness along proximal flexor sheath
  - Pain with passive extension of finger
- Treatment
  - Hospitalization and Emergent Orthopedic Consult
  - Surgical Drainage
  - IV antibiotics
  - Elevation and Splinting
  - Tetanus update

Flexor Tenosynovitis



http://pennacademicassociate.com/img/Slideshow/5.JPG

Collar Button Abscess

- Deep web space infection of the hand that involves both palmar and dorsal side of hand
- Purulent fluid spreads between metacarpal bones and erupts dorsally creating a hand abscess
- Volar spread is limited by presence of palmar aponeurosis
- Exam noted with swelling and tenderness, more prominent on palmar surface
- Treatment involves volar and dorsal incision and drainage by orthopedics in the operating room
  - IV antibiotics

Human Bite (Fight Bite)

- Injury results from punching another person in the mouth
  - High potential for severe infection
- Infected wounds have potential for spread to deep palmar space infections, functional loss and need for amputation
- Any wound over MCP joint is considered a fight bite until proven otherwise – patients will often lie about cause of injury
- Causative agents
  - Anaerobes (especially Eikenella corrodens)
  - Staph aureus
  - Neisseria species
- Treatment
  - DO NOT SUTURE – Secondary intention healing
  - Consult Orthopedic Surgeon
  - X-rays to r/o fracture
  - Irrigate wound
  - Splint and elevate the hand
  - Hospitalize the patient and treat with IV Antibiotics (Unasyn)

High Pressure Injection Injuries

- 1-3 mm wound caused by a high pressure injection device (e.g. grease, hydraulic fluid or paint gun)
- Wound is deceptively small but fluid typically travels down tendon sheath and damages flexor tenderness and is also high risk for hand compartment syndrome
- Prognosis = Poor – 70% require some form of amputation
- Treatment
  - X-ray (especially if substance is opaque and for subcutaneous air)
  - Splint, Elevate Extremity
  - Broad Spectrum Antibiotics
  - Update Tetanus
  - Immediate Orthopedic Consult for Surgical Debridement

Hand Injuries

- Fight Bite

http://www.orthosupersite.com/images/content/OT/200706/60_image5.jpg

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- High pressure Injection Injuries

http://img.medscape.com/pi/emed/ckb/orthopedic_surgery/1230552-1241999-2338.jpg

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Tendon Injuries

- General Principles
  - Note normal posture of hand
  - Examine wound with hand and fingers in the position at the time of injury
    - Aid in determining the location of tendon injury
  - Evaluate the tendon and wound while exhibiting full range of motion of the finger/hand
- Tendon Injuries
  - Flexor Tendon Injuries
  - Extensor Tendon Injuries

Flexion Tendon Injuries

- Injury typically associated with laceration over flexor surface
- Examination
  - Flexor Digitorum Profundus Tendon
    - Immobilize PIP and MCP joints and assess patient's ability to flex tip of the finger
    - Inability to flex indicative of a profundus tear
  - Flexor Digitorum Superficialis Tendon
    - Hold un-injured fingers in extension and ask patient to flex injured finger (blocks the action of the profundus tendon)
  - Tendon needs to be tested against resistance. 90% tear will still have function but will demonstrate weakness with resistance testing
- Treatment
  - Repair of full thickness injury in OR
  - Partial tear (treatment is controversial) – Many orthopedic surgeons will treat with protective splinting

Jersey Finger

- Closed traumatic disruption of flexor tendon apparatus
- Jersey finger results from flexor digitorum profundus tendon avulsion when one football player grabs the jersey of another and his finger is caught
- Affected patient will be unable to bend finger down to palm of hand and finger will be excessively straight in position of rest
- Treatment = Surgical Repair of tendon apparatus

http://4.bp.blogspot.com/_QqqSg0x3QzY/R7bxt5LI8XI/AAAAAAAAAEg/RmSP8FtnTz0/s400/jersey.jpg

Extensor Tendon Injuries

- Mallet Finger
  - Extensor tendon laceration or disruption of DIP joint
  - Patient is unable to extend DIP joint
  - Mechanism of Injury = Blow to tip of extended finger producing sudden forceful flexion
  - Treatment
    - If no fracture – Splint DIP joint in extension to slight hyperextension for 6-8 weeks
    - If fracture = Splint DIP joint and ortho referral for possible surgical pinning with Kirschner wire fixation
  - Complication = Untreated Mallet finger results in "swan neck deformity"
    - Hyperextension of PIP joint in addition to mallet flexion deformity of DIP joint

Extensor Tendon Injuries

- Boutonniere Deformity
  - Rupture of central slip of the extensor tendon hood at the PIP
    - May be associated with avulsion fracture
  - Characterized by flexion of the PIP joint and hyperextension of DIP joint
    - Why? Lateral bands of extensor hood split and become PIP flexors
  - Mechanism is typically a direct blow (forced flexion) or laceration of the PIP joint region
  - Deformity not always present immediately and often develops over time (1-2 weeks)
  - Treatment = Splint the PIP joint in extension
    - Refer to Orthopedic Surgeon for possible operative repair

Extensor Tendon Injuries

- Mallet Finger

- Boutonniere Deformity

Amputated Digits

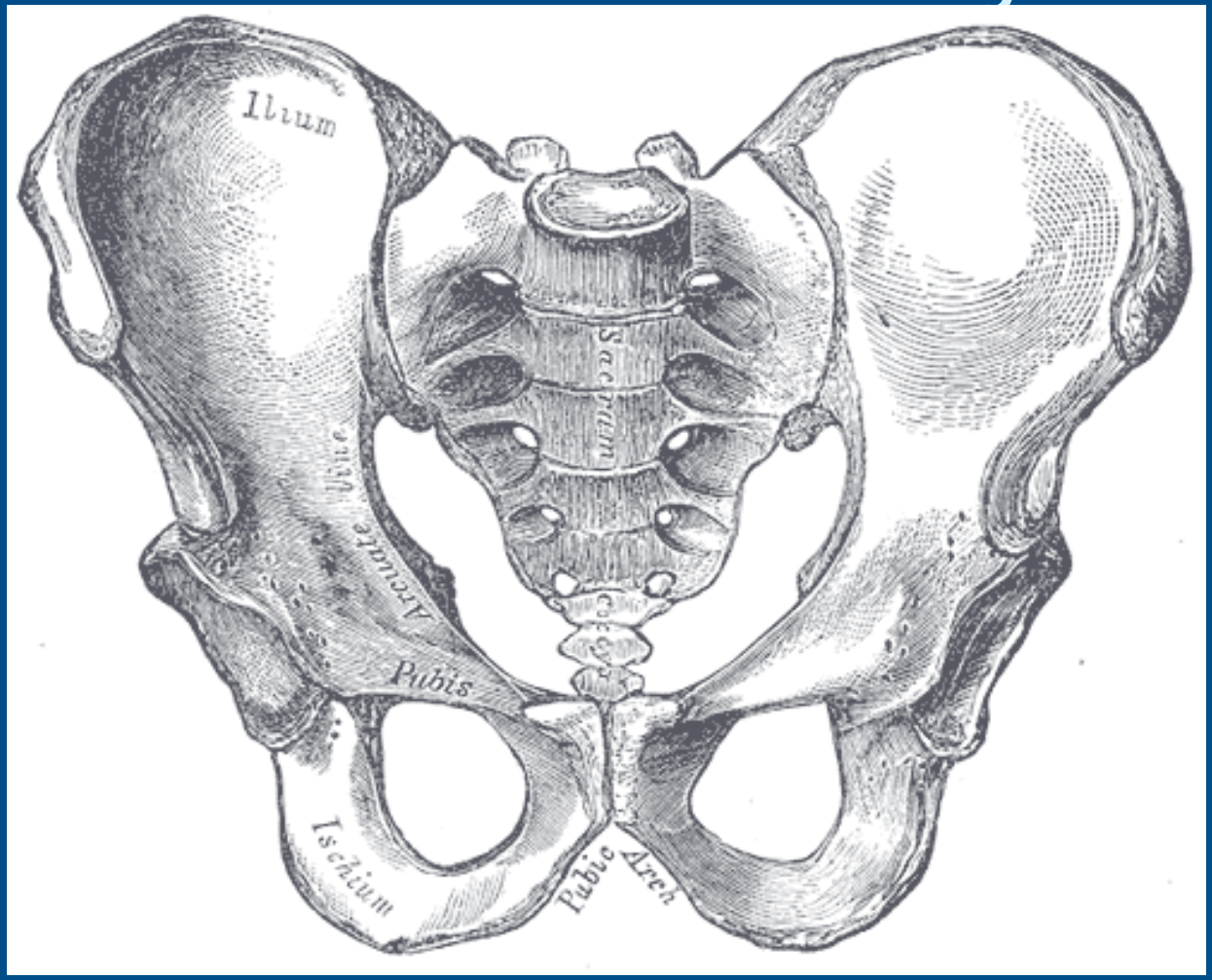
- Preservation of Amputated Digit
  - Irrigate amputated part with normal saline to remove gross contamination
  - Wrap in sterile gauze moistened with saline
  - Place in sterile water tight container
  - Store the container in ice water
- Criteria for Re-implantation
  - Young, healthy patient with normal vital signs
  - Sharply incised wound with minimal associated tissue destruction
  - Amputated thumb
  - Multiple digit amputation
  - Hand or forearm amputation
  - Amputation in child
- Contraindications to reimplantation
  - Absolute Contraindications
    - Unstable patient with severe life threatening injuries
    - Severe crush injury
  - Relative
    - Severely damaged part
    - Severely contaminated part
    - Single digit amputation
      - other than thumb
    - Avulsion Injury
    - Serious underlying medical illness that would impair wound healing
    - Prolonged warm ischemia (> 12 hrs)
    - Prior injury to affected part
    - Emotionally unstable patient

LOWER EXTREMITY INJURIES

Pelvic Fractures

- Mechanism of Injury
  - Motor Vehicle Accidents
  - Falls
  - Crush Injuries
  - Take-down injuries (Car vs. Pedestrian)
- Classification (Young Classification)
  - AP Compression
    - Type 1 – Disruption of pubic symphysis (< 2.5 cm), No posterior pelvis injury
    - Type 2 – Disruption of pubic symphysis (> 2.5 cm), Ligamentous injury
    - Type 3 – Complete disruption of pubic symphysis and posterior ligamentous complex with hemipelvic displacement
  - Lateral Compression
    - Type 1 – Posterior Compression of SI joint without ligamentous disruption, oblique ramus fracture
    - Type 2 – Rupture of posterior sacroiliac ligament, pivotal internal rotation of hemipelvis with crush injury to sacrum and oblique ramus fracture
    - Type 3 – Type 2 + AP compression injury to contralateral hemipelvis

Pelvic Anatomy



PD-EXP Gray's Anatomy (Wikipedia)

Pelvic Fractures

- Imaging = Plain film, CT imaging
  - CT superior in evaluating acetabulum, posterior arch and SI joint
- Specific pelvic fractures
  - Pubic Rami (Most common pelvic fracture)
    - Straddle injury = fracture of all 4 pubic rami
  - Iliac Crest
    - Duverney fracture = Pelvic wing fracture
    - Ilium fracture = Pelvic ring disruption
  - Malgaigne Fracture = Multiple fractured Pelvis
    - Pubic rami bilaterally and ilium or sacrum

Pelvic Fracture

- AP Compression Type Injury

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- Lateral Compression Type Injury

http://emedicine.medscape.com/article/394515-overview PD-INEL

Pelvic Fractures

- Associated Injuries
  - Hemorrhage
    - 1st cause of death from pelvic fx
    - Up to 6L of blood in retroperitoneum
    - 50% of patients require transfusion
  - Urethral and Bladder Injuries
    - Most commonly associated injuries
  - Vaginal Laceration or rupture
  - Nerve Injury
  - Ruptured Diaphragm
  - Rectal Injuries
  - Thoracic Aortic Rupture
    - 8 times more likely in patients with pelvic fractures
- Treatment
  - Evaluation for secondary injuries
  - Avoid excessive movement
  - Antishock pelvic clamp in patients with evidence of fracture and instability
  - Type I – Conservative treatment
  - Type 2 – Single Ring Fractures
    - Conservative treatment
  - Type 3 – Double Ring Fractures
    - Unstable, Immobilize, External or Internal Fixation, Orthopedic Consultation, Embolization of hemorrhage
  - Type 4 – Acetabulum fracture = Displaced fractures require surgical repair
- Complications
  - Sepsis
  - Thromboembolic complications
  - Malunion or Delayed Union
  - Chronic Pain

Pelvic Binder

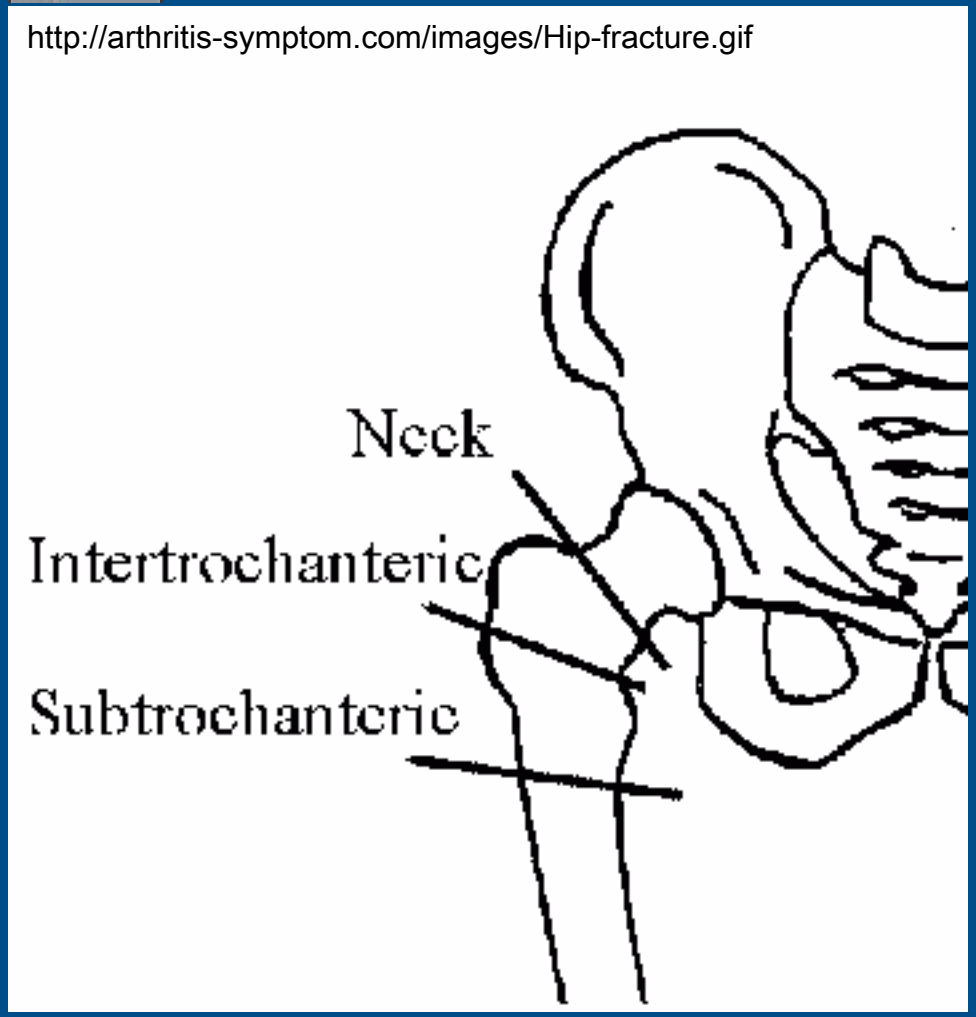
PD-INEL http://www.aaos.org/news/aaosnow/jul09/clinical8.asp

PD-INEL http://www.aaos.org/news/aaosnow/jul09/clinical8.asp

Hip Fractures

- Classification
  - Intracapsular
    - Femoral Head, Subcaptital or Neck Fracture
  - Extracapsular
    - Trochanteric, Intertrochanteric or Subtrochaneteric
- Clinical Presentation
  - External rotation, flexion, shortened leg
  - Pain with attempted ROM – especially internal/external rotation
- Imaging
  - Plain films will diagnose most hip fractures
  - CT or MRI for patients with occult fracture
    - Patients with negative plain films who cannot ambulate should be examined with CT or MRI imaging
- Treatment
  - Orthopedic Consultation
  - ORIF
- Complications = Bleeding, Aseptic Necrosis

Hip Fracture Types



Hip Fractures

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http://images.quickblogcast.com/80618-70584/hip_fracture2.jpg

PD-INEL http://www.health-res.com/EX/07-28-07/hipp301.jpg

Hip Dislocations

- Anterior Hip Dislocation (10%)
  - Mechanism of Injury = Extreme abduction pushes femoral head out through tear in anterior capsule from auto accident or fall
  - Clinical Features = Slight abduction, external rotation
  - Associated vascular injuries with diminished femoral or distal pulses indicates need for immediate reduction
- Posterior Hip Dislocation (80-90%)
  - Mechanism of Injury = Majority are due to auto-accidents with direct force applied to flexed knee, pushing femoral head through the posterior capsule
  - Clinical Features = Shortened, Adducted and Internally Rotated
  - Associated Physical Findings
    - Acetabular or Femoral Fractures
    - Sciatic Nerve Injury
    - Knee Injury
- Treatment
  - Early reduction to avoid Avascular necrosis of the femoral head
  - Closed Reduction should be attempted in ED, operative repair if unsuccessful
- Complications
  - Anterior dislocation = Femoral Artery, vein, nerve injury
  - Posterior dislocation = Sciatic Nerve injury

Hip Dislocation

- Anterior Hip Dislocation

http://www.ispub.com/ispub/ijos/volume_6_number_1_19/ipsilateral_anterior_hip_and_posterior_knee_dislocation_with_common_paroneal_nerve_palsy_a_peculiar_mode_of_trauma_in_a_case/hip-fig1a.jpg

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- Posterior Hip Dislocation

http://www.worldortho.com/dev/images/morfeoshow/gallery____s-3404/big/Dislocation.Posteriorhipdislocationskierwashardtoreduceintheskiclinic.jpg

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Femur Fracture

- Typically, male patients suffering fall or MVA
- Clinical Presentation – Severe pain, unable to bear weight
- Treatment
  - Hair Traction Splint
  - Orthopedic Consultation
  - ORIF
- Complications
  - Hemorrhage
  - Neurovascular Injury
  - Fat Emboli

Flickr

Knee Injuries

- Mechanism
  - Valgus Stress (Abduction) = MCL, ACL, Medial Meniscus
  - Varus Stress (Adduction) = LCL, Lateral Meniscus
  - Hyperextension Stress = ACL, PCL
  - Anterior/Posterior Stress on the tibia = ACL, PCL
  - Rotational Stress = ACL, MCL
- Evaluation
  - Ligamentous stress testing
- Imaging = X-ray to r/o fracture
- Treatment
  - Knee Immobilizer
  - Orthopedic Referral
  - MRI as outpatient if no improvement on re-evaluation

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http://www.breg.com/files/xl/KNEE-IMMOBILIZER.gif

Knee Injury

- ACL Testing
  - Lachman's Test
  - Anterior Drawer Test
- PCL
  - Posterior Drawer Test
- Medial and Lateral Collateral Tests
  - Knee valgus stress test (MCL)
  - Knee varus stress test (LCL)
- Meniscal Tests
  - McMurrey's Test
  - Apley Compression Test

Football Triad Injury

- Football triad results from lateral aspect of the knee
- Results in:
  - Medial Collateral Ligament Tear
  - Medial Meniscus
  - ACL Tear
- Clinical Presentation: Swelling or pain around knee with moderate to severe pain
- Treatment
  - Knee Immobilization
  - Surgical Repair

Ottawa Knee Rules

- Patient needs an x-ray of knee if:
  - Age > 55 y/o
  - Isolated tenderness of patella
  - Tenderness at head of fibula
  - Inability to flex 90 degrees or inability to bear weight in the ED (at least 4 steps)
  - Rules are valid in children or adults

Knee Injuries

- Baker's Cyst
  - Inflammation of the semi-membranous or medial gastrocnemius bursa produced by protrusion of synovial membrane through the posterior aspect of the knee's capsule
  - Patients present with knee swelling and local discomfort
  - Exam with tense posterior painful knee with painful fluid filled sac
  - Rupture of the cyst causes pain and swelling (may mimic DVT)
  - Treatment = Correction of underlying joint pathology
- Osgood-Schlatter's Disease
  - Repetitive microscopic injury that produces inflammation of apophysis of the tibial tubercle an leads to partial avulsion and separation of the tibial tubercle
  - Commonly seen in adolescent males who are active in sports
  - Treatment = Ice, NSAIDS, Decreased sports

Knee Dislocation

- Mechanism of Injury = Violent trauma from MVA or vehicle pedestrian accidents
- Classification
  - Classified by direction of tibial displacement compared with femur
  - 5 types: Anterior, Posterior, Medial, Lateral, Rotary
  - Most common = Anterior and Posterior (50-60%)
- Diagnosis
  - Complete disruption of all major ligaments
  - Popliteal artery injury is common (21-32%), especially in anterior/posterior dislocation
  - Peroneal nerve injury is also common (25-35%)

http://sfghed.ucsf.edu/Education/ClinicImages/Knee%20disloc..jpg

Knee Dislocation

- Diagnostic Caveats
  - Knee with complete disruption may demonstrate less swelling and pain than a less severely injured knee
  - Knee may reduce spontaneously – Any patient who presents with grossly unstable knee following trauma should be assumed to have a spontaneously reduced dislocation
- Clinical Management
  - Immediate reduction – Longitudinal Traction
  - Pulses should be checked before and after reduction
  - Following reduction, knee should be immobilized in posterior splint in 15 degrees of flexion
  - Arteriogram should be performed in all patients who have had a knee dislocation
  - Immediate orthopedic and vascular surgical consultation
  - Immediate surgical intervention for Popliteal artery injuries, open dislocations and irreducible dislocations

Patellar Fracture

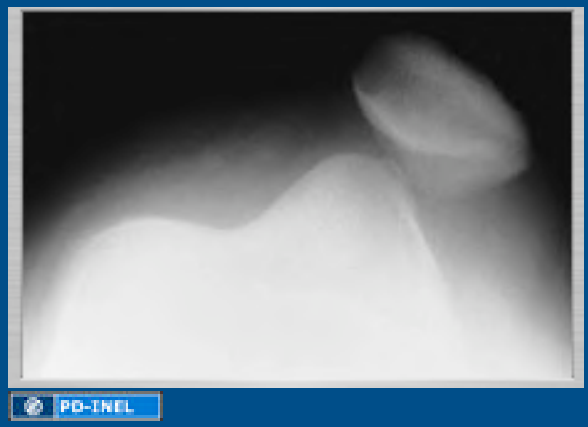
- Classification
  - Transverse fractures most common (50-80%)
- Mechanism of Injury
  - Direct blow (e.g. dashboard injury)
  - Forceful contraction of quadriceps muscle
- Clinical Presentation
  - Tenderness and swelling over the patella
  - Limited painful knee extension
- Imaging
  - AP, Lateral X-rays
  - Sunrise or skyline view
- Treatment
  - Nondisplaced fracture with intact extensor mechanism = Immobilization in full extension, Partial weight bearing and orthopedic referral
  - Displaced or loss of extensor function = Orthopedic referral for surgical intervention

http://boneandspine.com/wp-content/uploads/2008/02/fracture_patella.jpg

Patellar Dislocation

- Lateral subluxation or dislocation is most common
- Mechanism of Injury
  - Sudden flexion and external rotation of tibia on the femur with contraction of the quadriceps
  - Direct blow to the patella with knee in flexion or extension
- Clinical Features
  - Typically occurs in adolescent females with chronic patellofemoral anatomic abnormalities
- Clinical Management
  - AP and Lateral x-rays of the knee
  - Reduction = Flexion of hip and gentle medial pressure over the lateral aspect of the patella while extending the knee
  - Immobilization in full extension
  - Crutches
  - Orthopedic Referral
  - Frequently re-occur

http://www.conquestchronicles.com/special/the_dislocated_patella



http://www.conquestchronicles.com/special/the_dislocated_patella

Quadriceps Tendon Rupture

- More common in old debilitated patients or patients on steroids or fluoroquinolones
- Mechanism
  - Typically results from fall onto knee
- Clinical Presentations
  - Forced knee flexion with inability to extend knee
  - Patient may be able to stand but will not be able to walk
- Treatment
  - Early Orthopedic Consultation
  - Complete Rupture = Early Surgical Repair
  - Incomplete Rupture = Immobilization in full extension

Tibial Plateau Fracture

- Mechanism = Strong valgus stress with axial loading
  - Fall from height
  - Auto/Pedestrian (bumper vs. knee)
- Most condylar fractures involve the lateral plateau
- Imaging = X-ray
  - CT may be needed for diagnosis
- Complications -Vascular complications
  - Anterior tibial artery
  - Popliteal artery

http://z.about.com/d/orthopedics/1/0/1/2/tibialplateau2.jpg

Lower Leg Injuries

- Tibia Fractures
  - Mechanism
    - Torsional injury = Spiral fracture
    - Bending force = Transverse or oblique fracture
    - Direct force from crush injury
  - Treatment
    - Avoid Infection – Antibiotics for open fractures, emergent ortho consult if open for subsequent OR irrigation and debridement
    - Most closed fractures that are minimally displaced can be treated with orthopedic reduction and immobilization
    - Most patients require admission for pain control and further fracture care and monitoring for compartment syndrome
- Fibula Fractures
  - Isolated fibula fractures typically result from a direct blow
  - Nondisplaced fractures can be treated with immobilization with either elastic wrap (distal fibula), knee immobilizer (proximal fibula) or splinting if significant pain

Lower Leg Injuries

- Tibial Fracture

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www.wheelessonline.com/image2/ptib36.jpg

- Fibular Fracture

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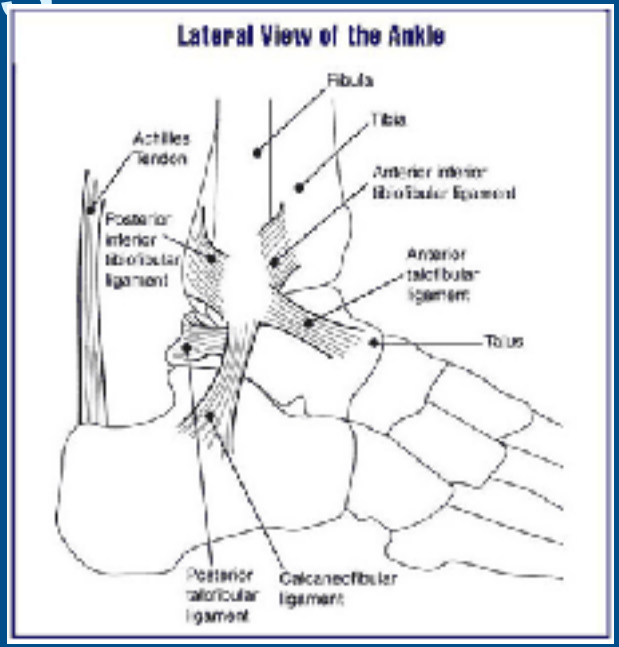
Ankle Injuries

- Anatomy
- Ankle Sprains
- Ankle Fractures
- Ankle Dislocation
- Tendon Injuries
  - Achilles Tendon Rupture



Wikipedia PD-GOV

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Ankle Sprain

- Types
  - Lateral Collateral Ligament Sprain (85-90%)
    - Inversion and internal rotation injury
  - Medial Collateral Ligament Sprain
    - Eversion and external rotation injury
- Classification
  - First Degree
    - Mild localized tenderness
  - Second Degree
    - Moderate swelling and tenderness, moderate functional loss
  - Third Degree
    - Marked tenderness, swelling, inability to bear weight, significant functional loss

Ottawa Ankle Rules

- Patients need ankle x-rays if:
  - Inability to bear weight
    - Either after injury or in ED
  - Bony tenderness along posterior edge of distal 6 cm of lateral or medial malleolus
  - Point tender over navicular bone

Ankle Sprain

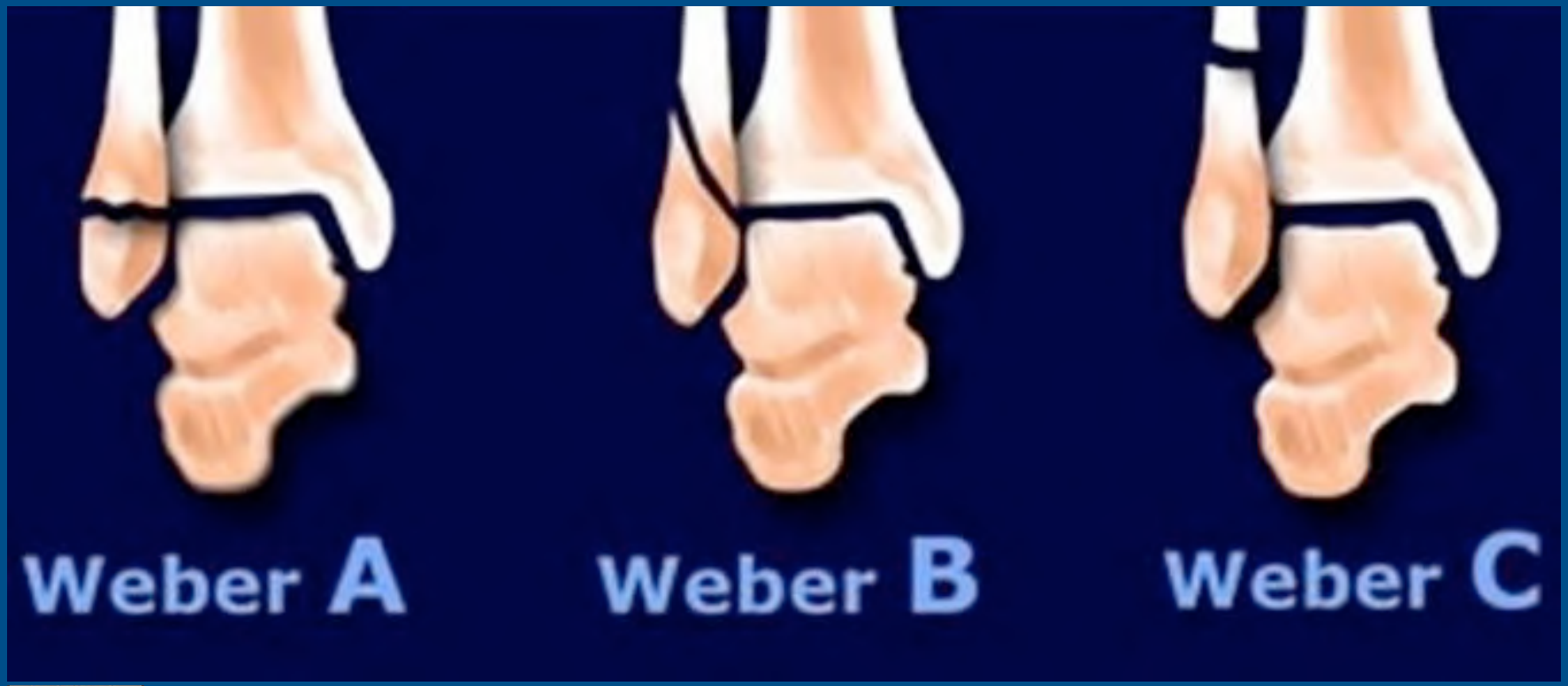
- Associated Injuries
  - Medial Collateral Ligament Strain often associated with fracture of fibular head (Maisonneuve fracture)
- Stress Test for Ankle Stability
  - Anterior drawer test
    - Indicative of rupture of anterior talofibular ligament
  - Inversion stress (talar) test
    - Only do if anterior drawar test is positive
    - Positive test indicates rupture of both the anterior talofibular and calcaneofibular ligaments
  - External rotation test
    - Pain at the syndesmosis or sensation of lateral talar movement
- Treatment
  - Ice, Elevation, Compression
  - Immobilization, Crutches
  - Early orthopedic referral for type 2 or type 3 injuries
  - Type 3 injuries will sometimes need surgical repair

Ankle Fracture

- Classification
  - Lauge-Hansen Classification (two word)
    - Two word classification scheme
      - First word = Position of the foot
      - Second Word = Motion of the foot
    - Supination-Adduction
    - Supination-External Rotation
    - Pronation-Abduction
    - Pronation-Eversion
    - Pronation-Dorsiflexion
  - Danis-Weber Classification
    - Based on the level of fracture of the fibula
    - Type A - Fracture of fibula below the syndesmosis
    - Type B – Fibular fracture at the level of the syndesmosis
    - Type C – Fibular fracture above the level of the syndesmosis
  - Radiographic Classification
    - Unimalleolar, Bimalleolar, Trimalleolar

Weber Classification

- Higher level = Greater disruption of syndesmosis – Greater instability



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Ankle Joint Stability

- Ankle joint is a ring which is maintained in stability by bony structures and ligaments
- Disruption of one part of the ring allows for continued stability of the joint
- Disruption of two parts of the ring results in instability of the joint

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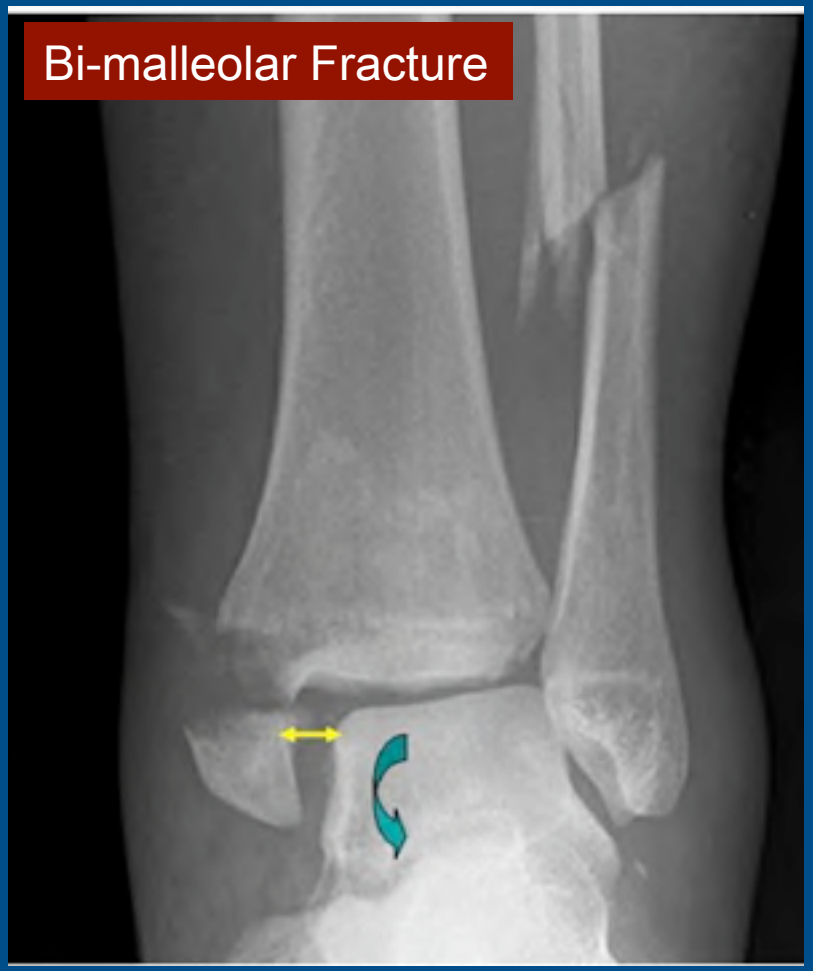
Ankle Fractures



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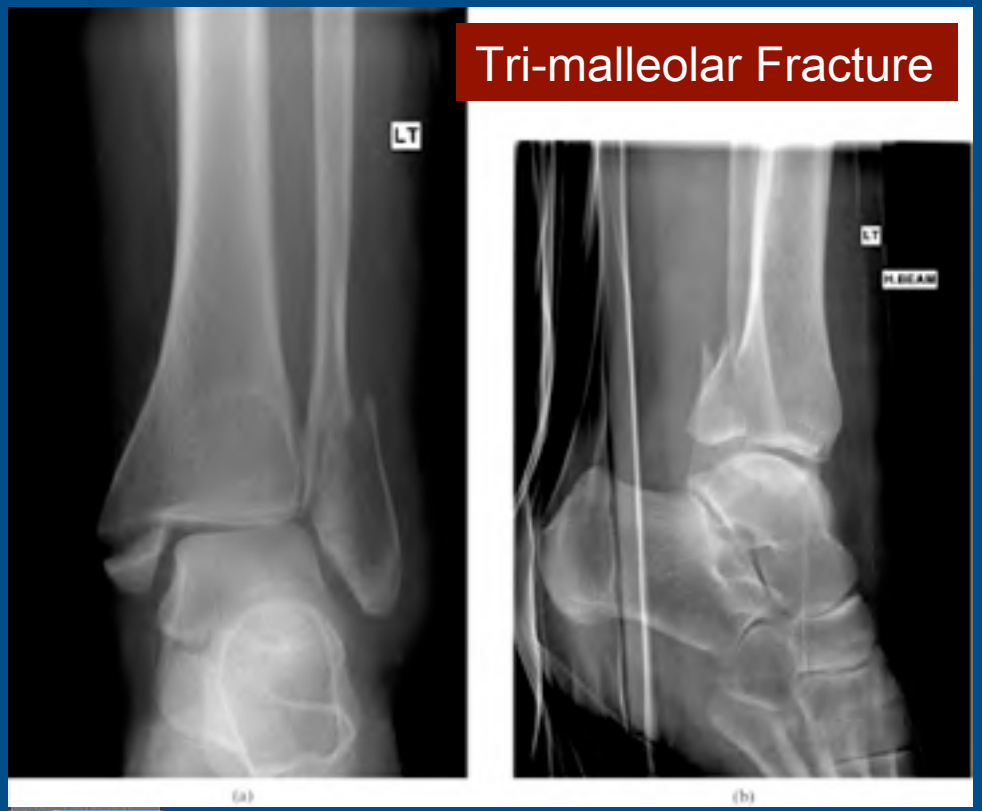

PD-INEL http://imaging.birjournals.org/cgi/content-nw/full/15/4/324/F3

Treatment

- Avulsion fractures with no displacement, smaller than 3 mm in diameter with no evidence of medial ligamentous injury may be treated similarly to sprain
- All other ankle fractures require immobilization by either cast or surgical reduction with subsequent casting
- Non-displaced fractures with normal anatomic relationship of ankle
  - Talus anatomically aligned
  - Joint line has to be parallel to the ground
  - Articular surface must be smooth
- Most fractures with exception of Unimalleolar will require ORIF
- Orthopedic consultation for non-displaced ankle fractures is based on local preference
- Displaced fractures require anatomic alignment/reduction and orthopedic reduction

Ankle Dislocation

- Dislocation in one of four planes
  - Anterior, Posterior, Lateral, Superior (upward displacement of talus)
- Pure ankle dislocation uncommon
  - Typically associated with malleolus fractures
- Treatment
  - Immediate neurovascular assessment
  - Reduction immediately if evidence of neurovascular compromise or skin tenting
  - Reduction with in-line traction
  - Reassess neurovascular status after reduction
- High incidence of complications
  - Neurovascular Compromise
  - Conversion of closed to open
  - Avascular necrosis

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http://www.sports-injury-info.com/images/shauns-fractured-fibula-compound-ankle-dislocation-playing-baseball-warning-graphic-fracture-image-21135429.jpg

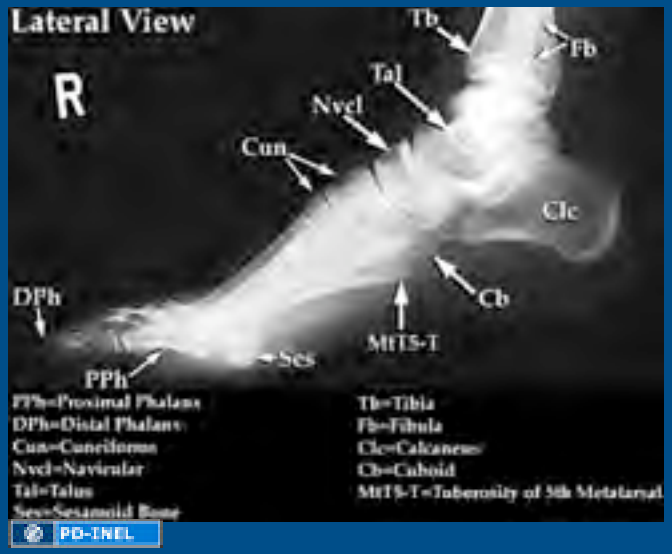
Achilles Tendon Injury

- Achilles Tendon Rupture
  - Sudden excruciating pain at back of ankle that then lessens after injury
  - Commonly, an injury of sedentary middle aged males (weekend warriors)
  - Mechanism of injury
    - Forceful dorsiflexion of the foot with ankle in relaxed state
    - Direct trauma to taut tendon
  - Examination
    - Swelling of distal calf
    - Palpable defect in tendon proximal to calcaneal insertion
    - Weak plantar flexion
    - Thompson's squeeze test
  - Diagnosis
    - Clinical with Thompson test
    - Ultrasound or MRI can confirm
  - Treatment
    - Initial Management = Ice, Elevation, Analgesia, Immobilization in posterior splint in plantar flexion
    - Orthopedic follow-up within 48-72 hours
    - Definitive care is controversial (casting vs. surgical repair)

http://www.sportsinjuryclinic.net/cybertherapist/back/backlowerleg/rehabcalf/thompson_test.jpg

Foot Injuries

- Foot Anatomy
  - Hind part
    - Calcaneus, Talus
  - Midpart
    - Navicular, Cuboid, Cuneiforms
  - Forepart
    - Metatarsals, Phalanges
- Joints
  - Hind part – Midpart
    - Chopart Joint
  - Midpart – Forepart
    - Lis Franc Joint



htt://www.e-radiography.net/technique/foot/footlat.htmp

http://www.e-radiography.net/technique/foot/footdp.htm

Calcaneal Fractures

- Calcaneal Fracture
  - Most frequently fractures tarsal bone
  - Mechanism = Compression/Axial Injury
    - “Jumper’s Fracture”
  - Exam = Swelling, tenderness, Ecchymosis of hind foot with inability to bear weight on fracture
  - Rule of 10’s
    - 10% are bilateral
    - 10% are associated with compression fractures
  - Bohler’s Angle – Formed by intersection of two lines on the lateral film
    - Superior margin of posterior tuberosity through the superior tip of the posterior facet
    - Superior tip of the anterior process through superior tip of the posterior facet
    - Angle normally = 20-40 degrees
    - Angle < 20 degrees = depressed fracture
  - Treatment
    - Early orthopedic consultation
    - Intra-articular or displaced calcaneal fracture = Controversial (immediate reduction vs. non-operative management)
    - Non-displaced or extra-articular fracture = Ice, elevation, immobilization in posterior splint, crutches, orthopedic follow-up

Calcaneal Fracture

- Calcaneal Fracture

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http://cz7asm.wz.cz/fyz/obrazky/pv/Calcaneus_Fracture.jpg

- Bohler's Angle

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http://eorif.com/AnkleFoot/ImagesAnkleFoot/Bohlers.jpg

Lisfranc Fracture Dislocation

- Mechanism of Injury
  - Axial load = Fall on the plantar flexed foot
  - Compressive forces = Crush Injury
  - Rotational forces = Twisting of body around foot
- Exam = Midfoot swelling and pain, Decreased ROM and inability to bear weight
- Imaging
  - Evaluate x-ray for normal alignment along the medial aspect of the middle cuneiform with the medial aspect of the base of the 2nd metatarsal
  - 2nd Metatarsal functions as primary stabilizing force and fracture at base of 2nd MT is indicative of disrupted Lisfranc joint (Fleck's sign)
- Treatment
  - Closed reduction under anesthesia or ORIF
  - Orthopedic consultation in ED is required

Lisfranc Fracture-Dislocation

- Normal Lisfranc Joint

http://www.latrobe.edu.au/podiatry/Radiology/newradiolpics/3dmovies/NormalFootAP.jpg

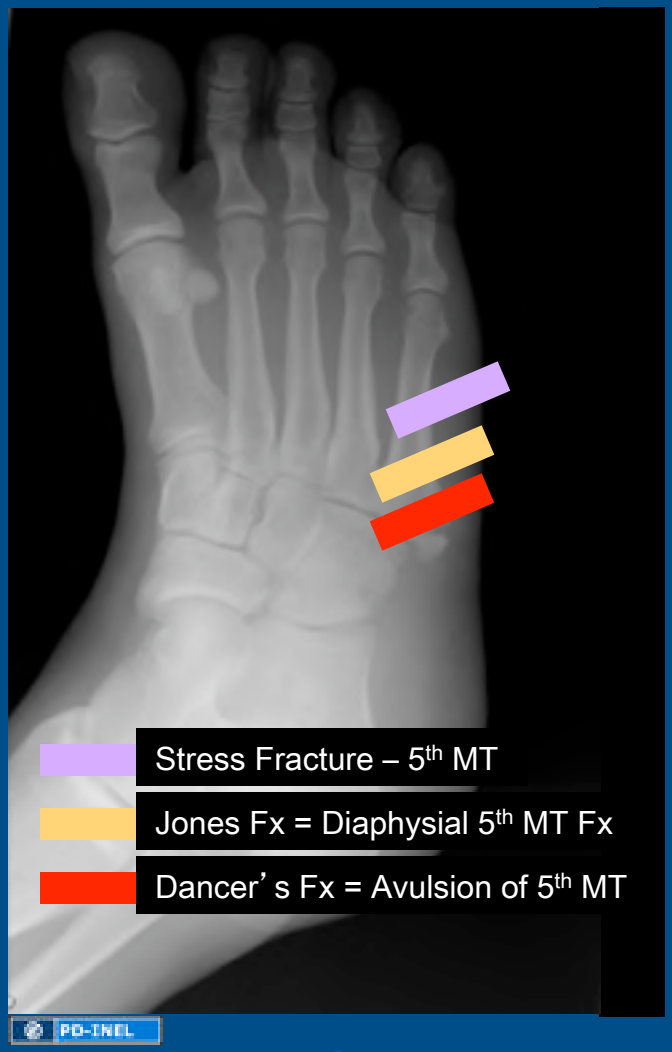
- Fracture

Wikipedia

Jones Fracture

- Diaphyseal Fracture of 5th Metatarsal
- Mechanism of Injury = Forceful load applied to the ball of the foot – Running or Jumping Sports
- Note: Dancer's Fracture
  - Avulsion fracture at 5th MT where peroneus brevis attaches
  - Inversion Injury
  - Cast shoe only (Cam Walker Boot)
- Clinical findings
  - Pain over 5th MT
  - Delayed healing compared with avulsion fractures
- Treatment
  - Emergent Orthopedic Consultation
  - Non-displaced fracture = Immobilization in non-weight bearing short leg fracture
  - Displaced fractures = Surgical management

Jones Fracture



Questions?

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