ORTHOPAEDIC FRACTURE MANAGEMENT

Orthopaedic Fracture Management
MSK Galaxy Course
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Splinting/Casting Workshop Director, Guide to the MSK Galaxy Course

JBJS- JOPA Journal of Orthopaedics for Physician Assistants- Deputy Associate Editor

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LEARNING OBJECTIVES

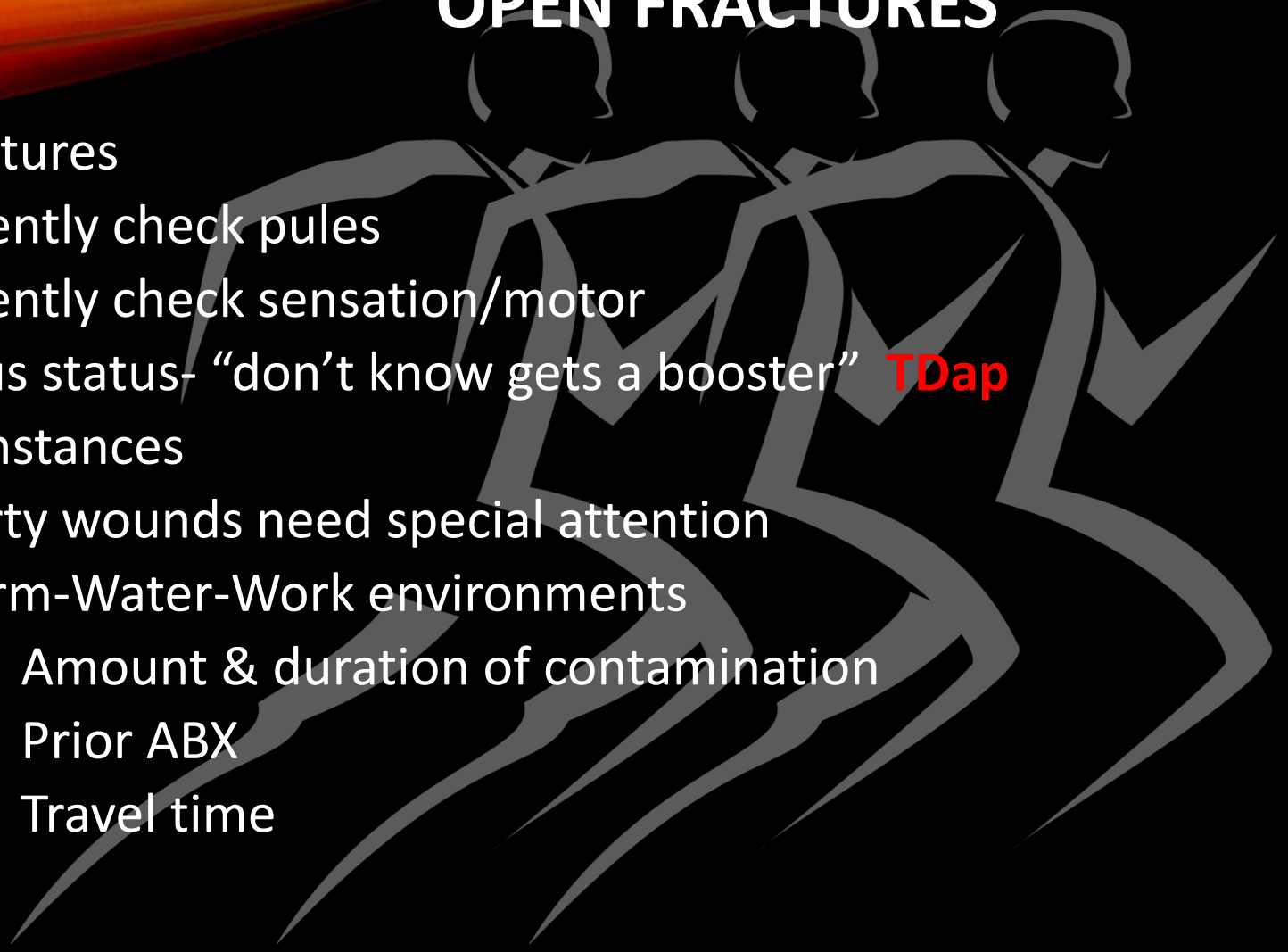
At the end of this lecture attendees will be able to :

- Describe fractures based on location, angulation, displacement & soft tissue injuries
- Recognize and describe factors associated with acute fractures
- Describe exam maneuvers essential for acute fractures
- Describe essential immobilization techniques for acute fractures
- Recognize and describe differences in fractures that require emergent treatment vs those that can be sent home and follow up in the office
- Recognize and treat Fractures of the Upper Extremity (UE)
- Recognize and Treat Fractures of the Lower Extremity (LE)

PAY ATTENTION

- Open Fractures
- Compartment Syndrome
- Necrotizing Fasciitis
- Long Bone Fractures
- Dislocations – Hip, Knee, Ankle, Shoulder Fx/Dislocation

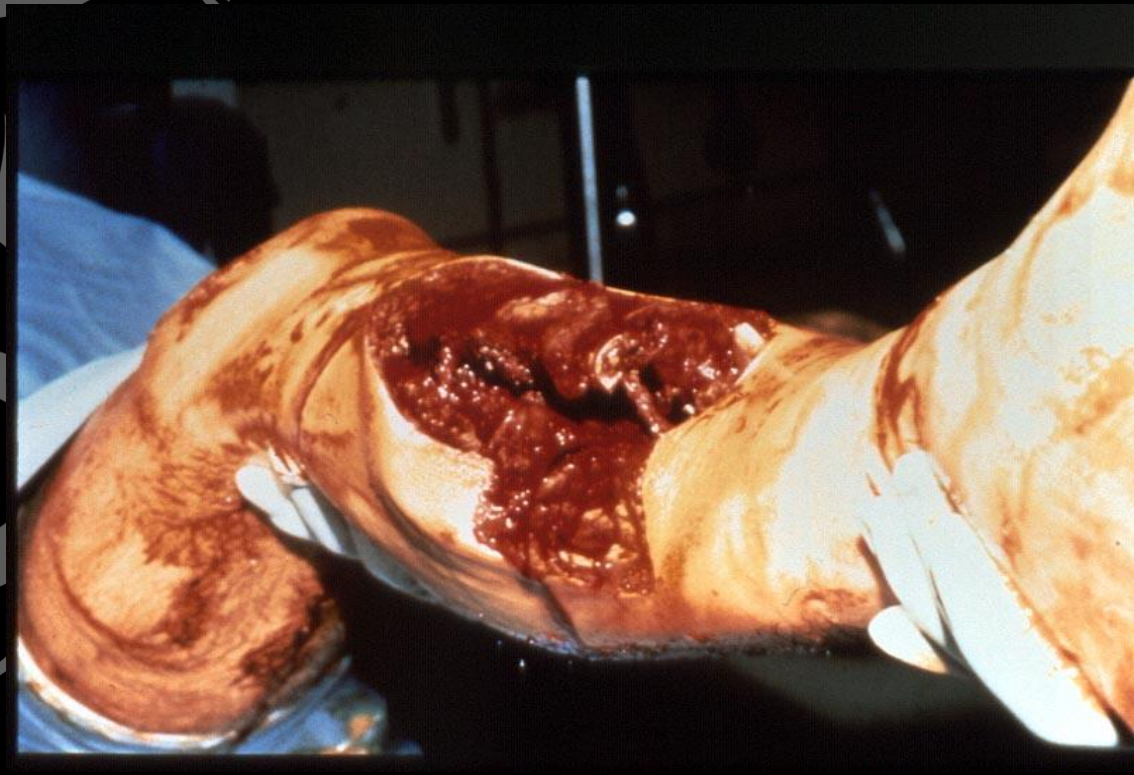
OPEN FRACTURES



- Open Fractures
  - Frequently check pules
  - Frequently check sensation/motor
  - Tetanus status- “don’t know gets a booster” **TDap**
  - Circumstances
    - Dirty wounds need special attention
    - Farm-Water-Work environments
      - Amount & duration of contamination
      - Prior ABX
      - Travel time

OPEN FRACTURES

- Pay attention to wound Size
  - Indication of injury energy
  - High energy leads to more damage
  - High energy think compartment syndrome
    - Hand
    - Forearm
    - Thigh/Gluteal
    - Low Leg
    - Foot
  - High energy think associated Injuries



GUSTILO AND ANDERSON CLASSIFICATION

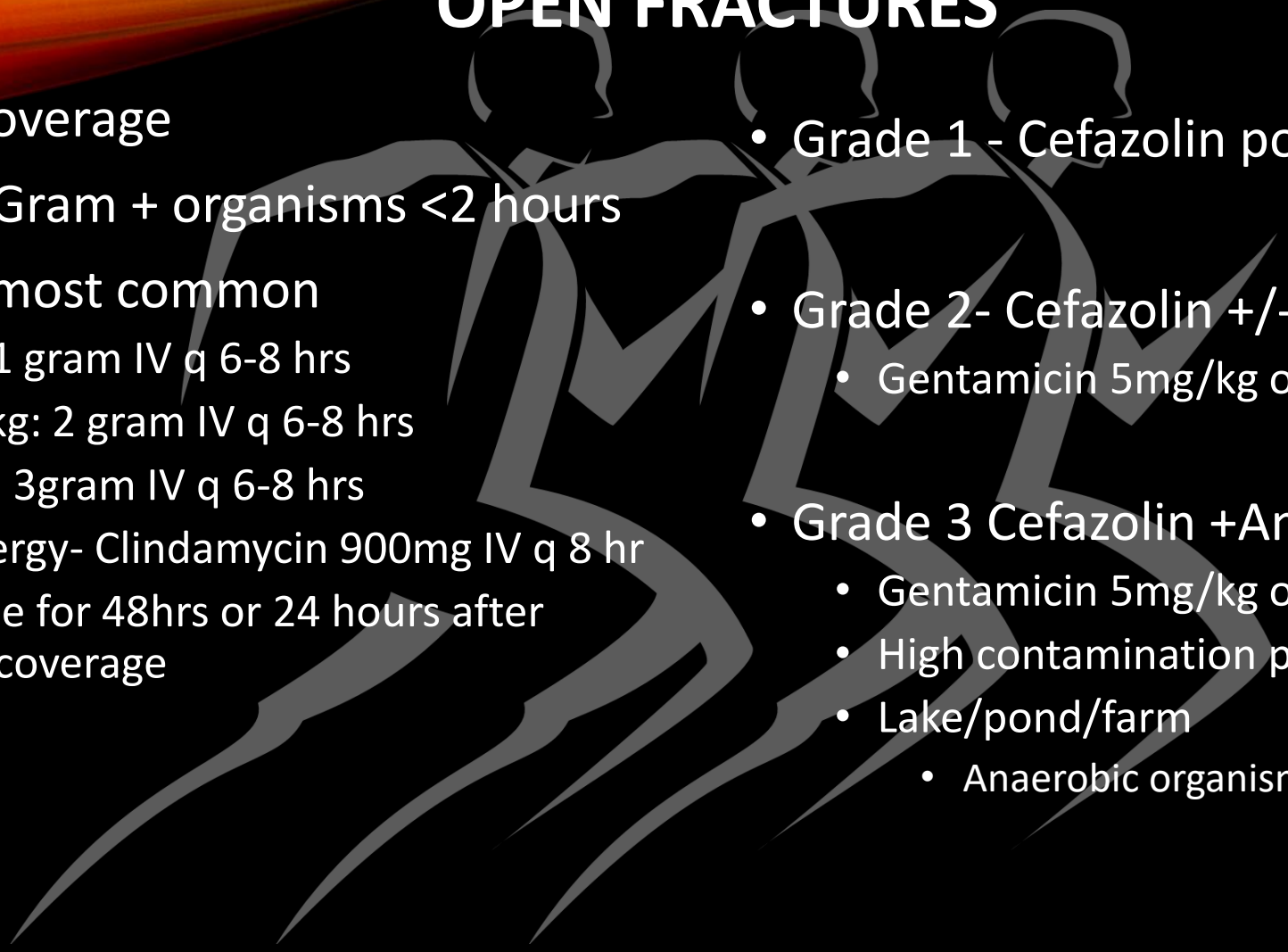
Skin injuries associated with Open Fractures

- **Grade 1**- skin opening of 1cm or less, minimal muscle contusion, usually inside out mechanism
- **Grade 2**- skin laceration 1-10cm, moderate soft tissue damage
- **Grade 3**-extensive soft tissue damage (>10cm)
  - **Grade 3a**-extensive soft tissue damage (>10cm) but adequate bone coverage
  - **Grade 3b**-extensive soft tissue injury with periosteal stripping requiring flap advancement or free flap
  - **Grade 3c**- Includes 3b injury plus vascular injury requiring repair

OPEN FRACTURES

Antibiotic Coverage

- Cover for Gram + organisms <2 hours
- Cefazolin most common
  - <50kg: 1 gram IV q 6-8 hrs
  - 50-100kg: 2 gram IV q 6-8 hrs
  - >100kg: 3gram IV q 6-8 hrs
  - PCN allergy- Clindamycin 900mg IV q 8 hr
  - Continue for 48hrs or 24 hours after wound coverage



- Grade 1 - Cefazolin popular choice
- Grade 2- Cefazolin +/- Aminoglycoside
  - Gentamicin 5mg/kg or Tobramycin 1mg/kg
- Grade 3 Cefazolin +Aminoglycoside
  - Gentamicin 5mg/kg or Tobramycin 1mg/kg
  - High contamination potential
  - Lake/pond/farm
    - Anaerobic organisms- high dose PCN

OPEN FRACTURE REMINDERS

- Complete Physical Exam – “man scan”
- Appropriate Imaging/X-rays
- Frequent follow up exams
- Frequent neuro/vascular exams
- Adequate Immobilization

FRACTURE DESCRIPTION

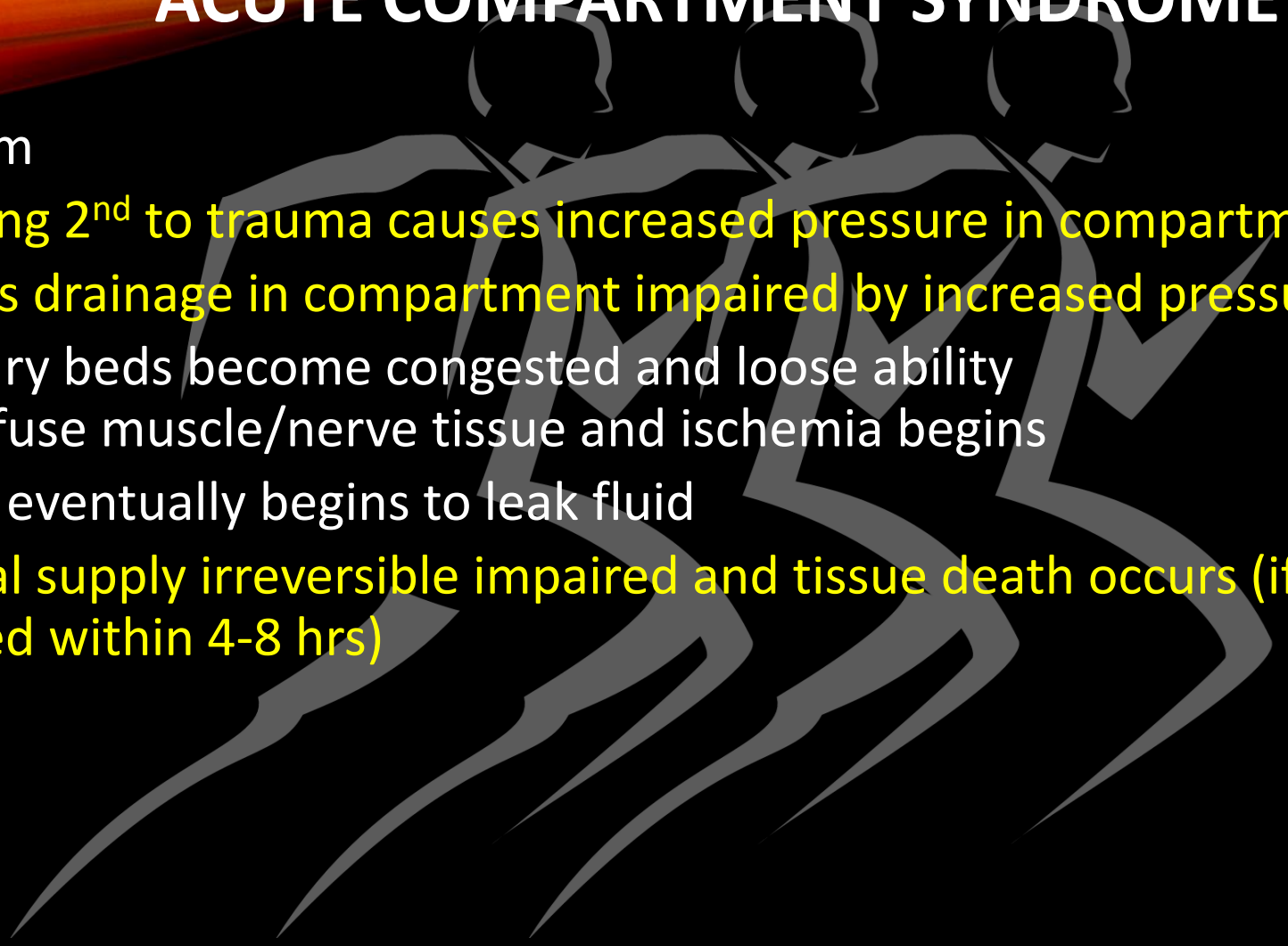
FRACTURE DESCRIPTION

- Fx location
- Open v. Closed:
  - Gustilio-Anderson classification
- Neurovascular status
- Angulation: direction fx apex
- Displacement vs. Non-displaced
- Comminution
- Impaction
- Rotation
- Articular extension

ACUTE COMPARTMENT SYNDROME

- **Acute Compartment Syndrome is a CLINICAL diagnosis**
- **ACUTE SURGICAL EMERGENCY**
- Increased pressure in confined anatomic space that can irreversibly damage tissue
- Two Causes
  - **Constriction**: Application of compression dressing/splint that does not allow tissue to swell or expand
  - **Expanding Volume**: traumatic tissue injury in confined space with bleeding/edema
    - Blunt trauma – Crush injury
    - Long bone fx (closed) Tibia most common
    - Revascularization edema
- **Forearm Fx, Hand, Tibia, Foot, Gluteal, Peds supracondylar elbow fx**

ACUTE COMPARTMENT SYNDROME

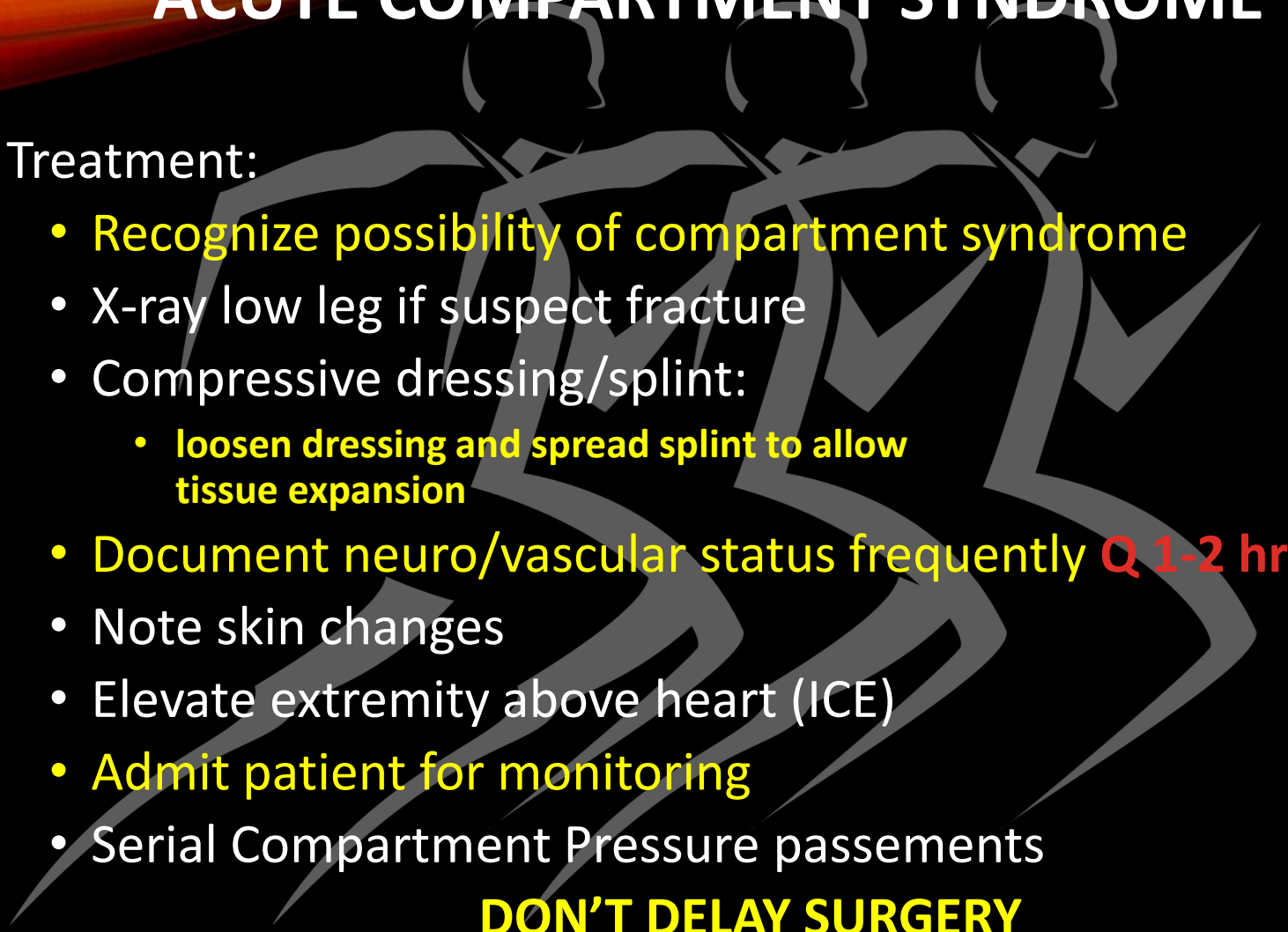


- Mechanism
  - Bleeding 2nd to trauma causes increased pressure in compartments
  - Venous drainage in compartment impaired by increased pressure
  - Capillary beds become congested and loose ability to perfuse muscle/nerve tissue and ischemia begins
  - Tissue eventually begins to leak fluid
  - Arterial supply irreversible impaired and tissue death occurs (if pressure not relieved within 4-8 hrs)

ACUTE COMPARTMENT SYNDROME

- Symptoms
  - **Recognized possibility of compartment syndrome based on trauma to low leg**
  - **4 P's**
    - **Pain- pain out of proportion to apparent injury**
    - **Paresthesias** – decreased sensation usually in Deep Peroneal nerve distribution (first)
    - **Paralysis** – loss of motor function 2nd to increased pain, compartment pressures and neurologic impairment
    - **Pulselessness** - very late sign
      - Arterial occlusion that results from marked pressure increase within compartment
  - Swollen low leg/calf
  - Shiny skin appearance
  - Painful and/or diminished ROM ankle/toes

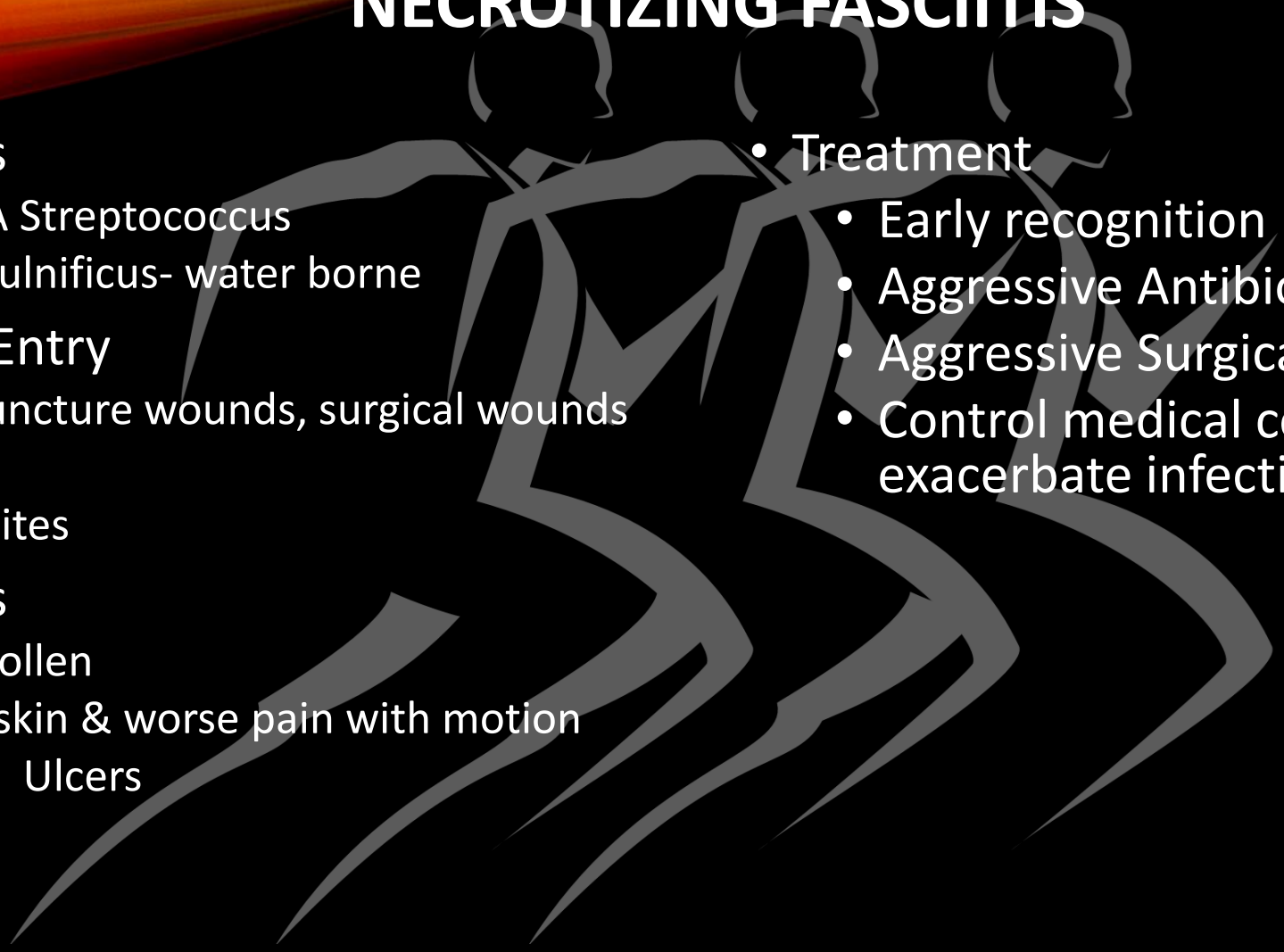
ACUTE COMPARTMENT SYNDROME



- Treatment:
  - Recognize possibility of compartment syndrome
  - X-ray low leg if suspect fracture
  - Compressive dressing/splint:
    - **loosen dressing and spread splint to allow tissue expansion**
  - Document neuro/vascular status frequently **Q 1-2 hr**
  - Note skin changes
  - Elevate extremity above heart (ICE)
  - Admit patient for monitoring
  - Serial Compartment Pressure passements

DON'T DELAY SURGERY

NECROTIZING FASCIITIS



- Organisms
  - Group A Streptococcus
  - Vibrio vulnificus- water borne
- Common Entry
  - Cuts, puncture wounds, surgical wounds
  - Burns
  - Insect bites
- Symptoms
  - Red, swollen
  - Painful skin & worse pain with motion
  - Blisters, Ulcers
  - Sepsis
- Treatment
  - Early recognition
  - Aggressive Antibiotic therapy
  - Aggressive Surgical debridement
  - Control medical conditions that can exacerbate infection

IMMOBILIZATION

IMMOBILIZATION

Importance of Immobilization

- **Reduce Blood Loss**
  - Femur Fx up to 1500 ml blood loss
  - Tibial Fx up to 1000ml blood loss
- **Pain reduction**
- **Reduce damage to soft tissues**
- **Reduce or minimize compartment syndrom**
- **Reduce spread if infection**

Reduce Fx to minimize tissue injury

IMMOBILIZATION

Fracture Blisters

- Occur 2nd to higher energy fx
- Skin adheres to bone and little subQ fat
- **Resembles 2º burn (clear v. bloody)**
- Develop 6-48 hrs
- **Staph/Strep colonization**
- Impacts treatment options
- **No consensus on Treatment**
  - **Dry dressing-Xeroform-Silvadene**
- **Delays Surgery average 7 days**
- Infection complication

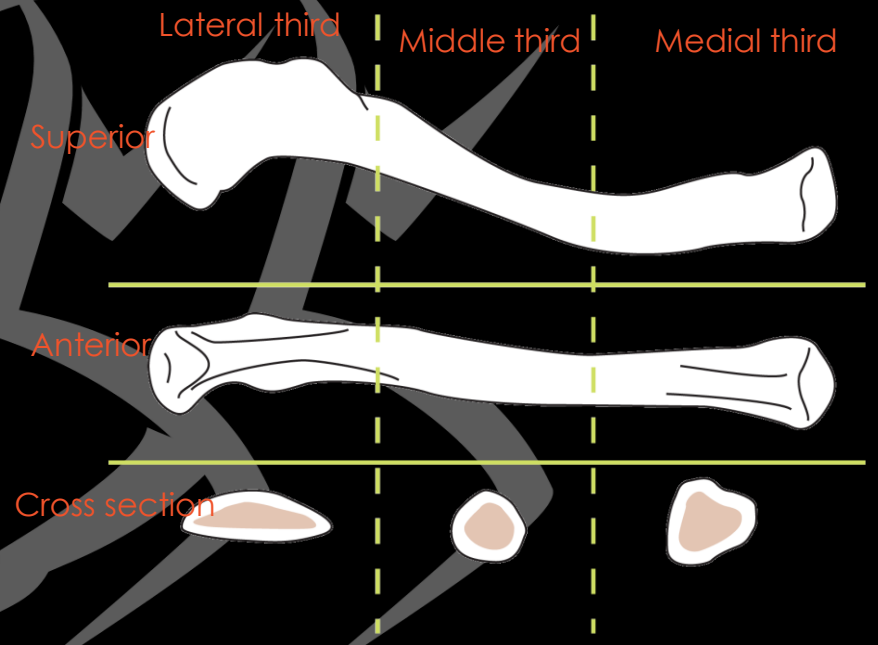
UPPER EXTREMITY FRACTURES

CLAVICLE FX

Clavicle Fracture

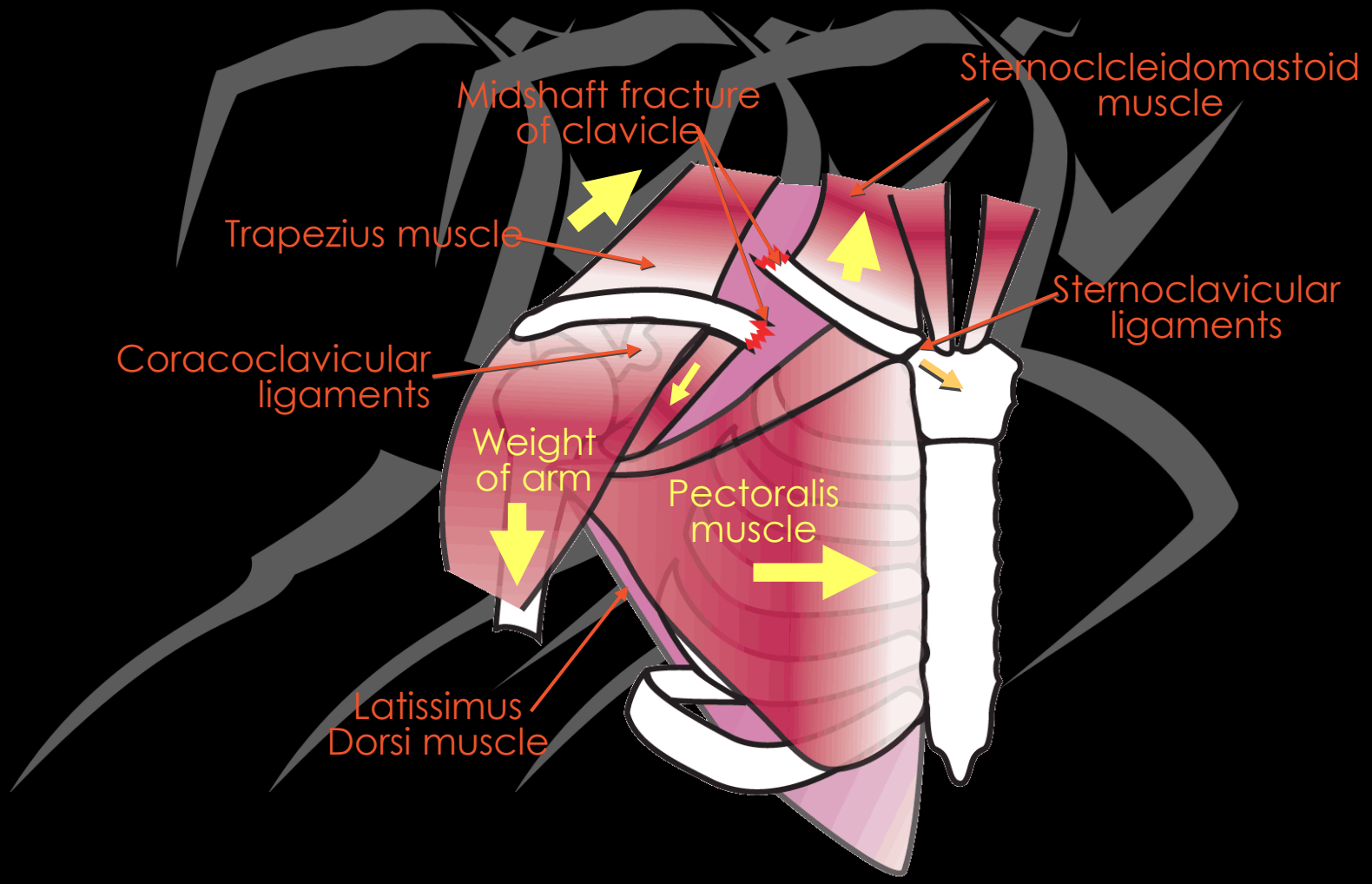
Bone –

- Triangular shaped- medial 1/3
- Tubular shaped- middle 1/3
  Flat shaped – lateral 1/3
- Most fractures occur junction of middle and distal 1/3 clavicle
  - Occurs due to change in geometry of bone
  - Thinnest part of bone
  - No muscle and ligament coverage in this area



Craig EV: Fractures of the shoulder: Part II. Fractures of the Clavicle, in Rockwood CA, Green DP, Bucholz RW, *Rockwood and Green's Fractures in Adults*, ed 3. Philadelphia, PA: JB Lippincott, 1991, vol 1 pp 928-990

Midshaft Clavicle Fracture



MID-SHAFT CLAVICLE FRACTURE

Factors in surgical management

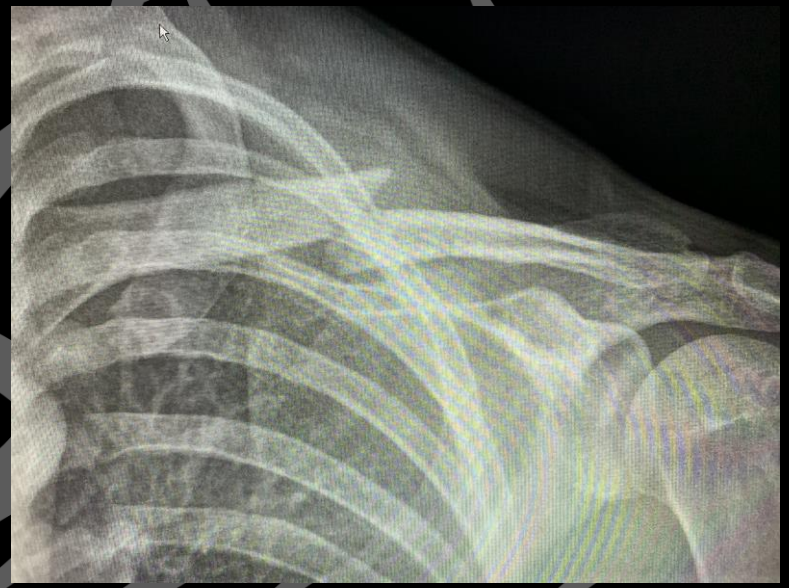
- Open or closed fracture
- Pain
- Displaced fractures (>1.5 cm)/comminuted fx
- Shoulder girdle shortening (>2 cm)
- Skin impairment
- Neuro or vascular injury
- Loss Abduction strength
- Greater cosmetic deformity/failed conservative management
- Greater demand for overhead activity

Ahn L, Sheth U, Mid-Shaft Clavicle Fractures, Orthobullets.com, 10/28/2020, https://www.orthobullets.com/trauma/1011/midshaft-clavicle-fractures, accessed November 17, 2020

MID-SHAFT CLAVICLE FRACTURE

Treatment Options:

- **Indications Non-op care**
  - Minimally displaced, < 1.5cm shortening, medically unfit for surgery
- Non-surgical management
  - **Sling vs. Figure 8**
    - Compliance issues
    - Less discomfort with sling
  - **Pain medication**
  - **Activity Limitations**
  - **F/U 1-2 weeks**



Honeycutt MW, Fisher M, Riehl JT, Orthopaedic Tips: A Comprehensive Review of Midshaft Clavicle Fractures, JBJS JOPA 2019;7(3):e0053

Andersen et al: Treatment of Clavicle Fractures: Figure 8 vs. Simple Sling. Acta Orthop Scand 1987;58:71-74

HUMERUS FX

PROXIMAL HUMERUS FRACTURES

Epidemiology

- Common fx in older adults >65 yr. old
- 2-part fx most common (Surgical neck & Greater Tubercle)
- Blood supply key to overall healing process
- High-rate osteonecrosis w/ 4-part Fx
- Female > male

Factors contributing to Proximal Humerus fractures:

- Age/sex
- Bone quality - osteoporosis
- Fracture displacement
- Diabetes

Attum B, Thompson JH. Humerus Fractures Overview. [Updated 2020 Aug 10]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK482281/

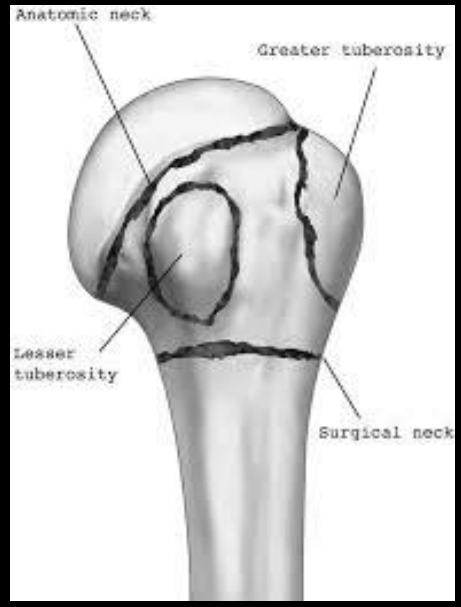
Pencle FJ, Varacallo M. Proximal Humerus Fracture. [Updated 2020 Aug 16]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan Available from: https://www.ncbi.nlm.nih.gov/books/NBK470346

Proximal Humerus Fractures

Neer Classification

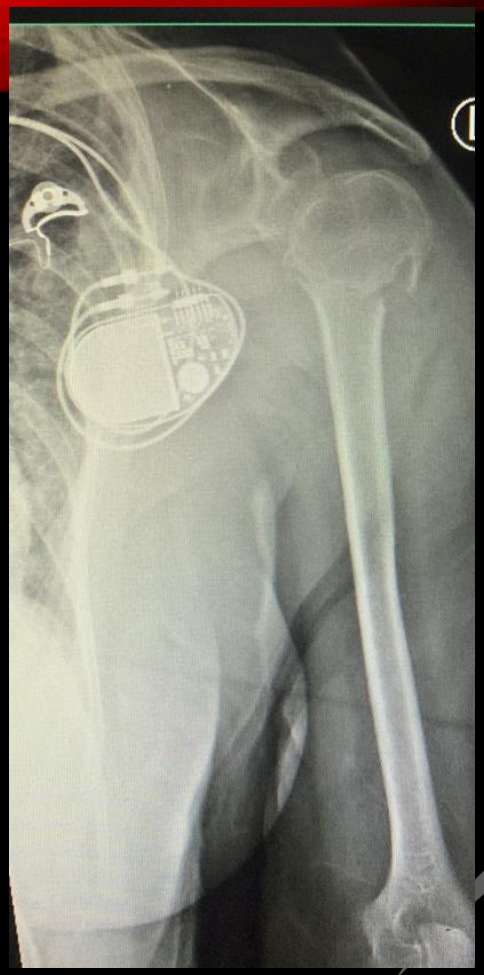
Anatomic Segments

- Shaft-Articular Head-Greater Tubercle-Lesser Tubercle
- Parts considered: >1 cm displaced, 45 degrees angulation
  - **2-part**
    - **Articular component- Fx** line thru anatomic neck
    - **Shaft Component -** Fx line thru surgical neck – most common
  - **3-Part**
    - Articular surface, thru anatomic neck, Humeral shaft & greater tubercle
    - Articular surface, thru anatomic neck, Humeral shaft & lesser tubercle
  - **4-Part**
    - Variation anatomic/surgical neck, great/lesser tubercle
    - Fracture / Dislocation



Triplet J, Proximal Humerus Fractures, Orthobullet.com, updated 7/19/2020 https://www.orthobullets.com/trauma/1015/proximal-humerus-fractures, accessed November 15, 2020

PROXIMAL HUMERUS FX



HUMERUS FX

Proximal Humerus

- Treatment considerations-
  - Multifactorial
  - Age
  - Fracture type
  - Pt expectations
- Treatment options
  - Non-op
  - ORIF
  - Hemiarthroplasty
  - Reverse TSA

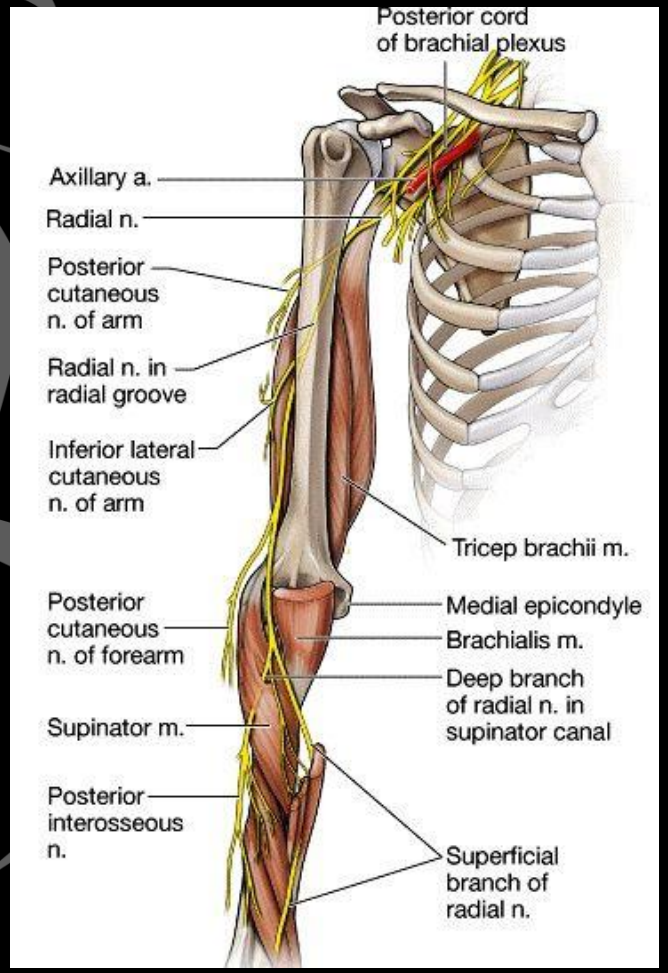
PROXIMAL HUMERUS FRACTURE

Emergent Treatment

- Majority treatment “hanging sling”
- Pain management
- Sleeping postures
- Early motion-elbow/Shoulder

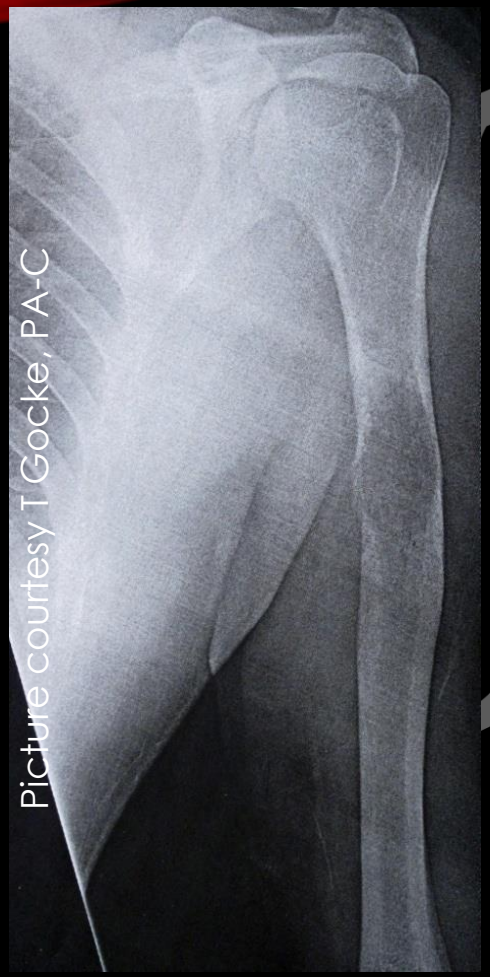
HUMERAL SHAFT FRACTURE

- Epidemiology
  - Usual treatment is non-operative
  - High Energy mechanism
  - Low Energy: high suspicion for pathology fx
  - Primary Mechanism of injury
    - Direct blow – transverse or comminuted fracture
      - MVA
    - Indirect blow – spiral or oblique fracture
      - Fall – elderly more common
      - Throwing motion– less common
  - Concern for Radial Nerve injury



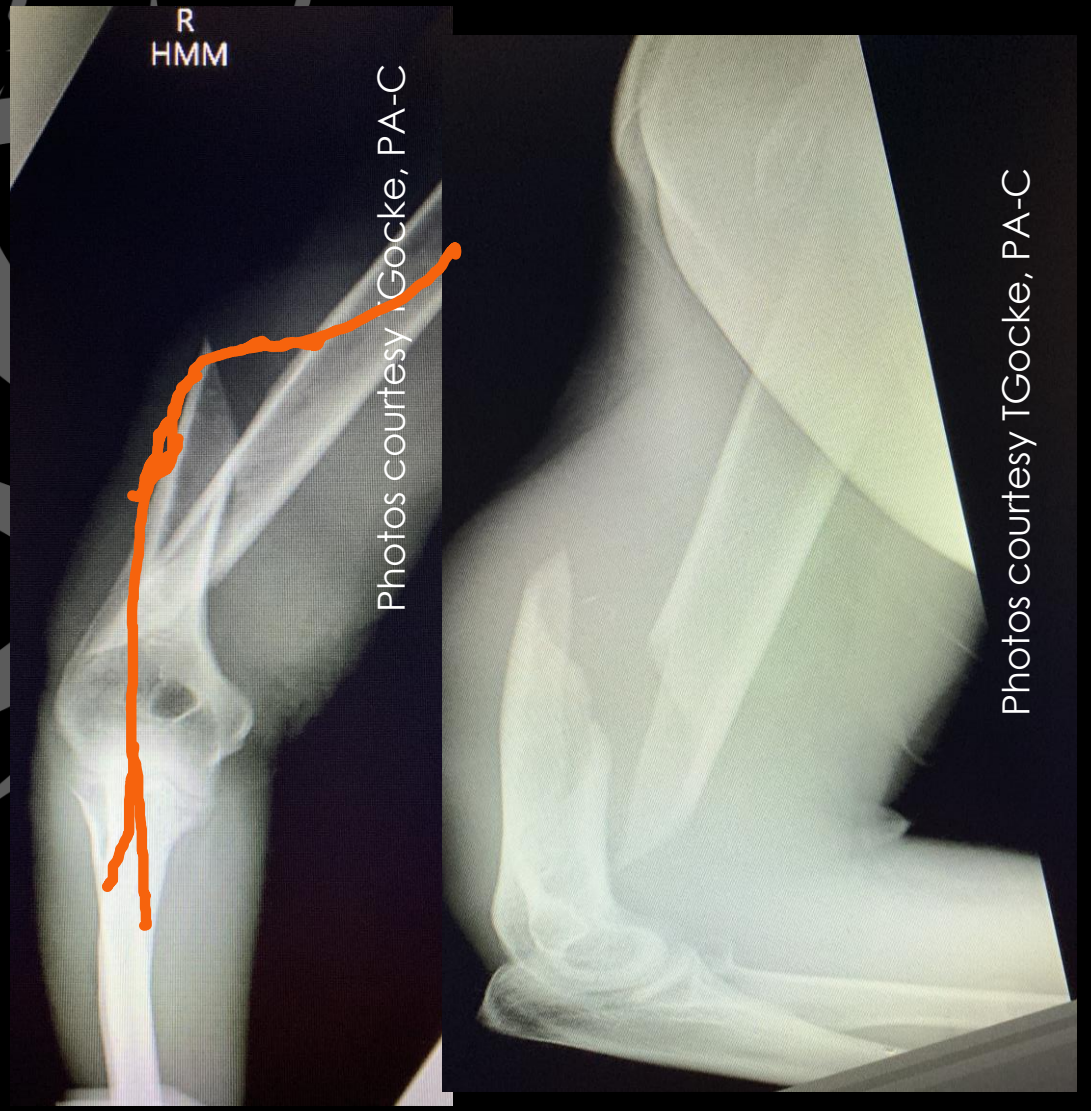
Bounds EJ, Frane N, Kok SJ. Humeral Shaft Fractures. [Updated 2020 Aug 24]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK448074/

HUMERAL SHAFT FRACTURE



Humeral Shaft Fracture

- Holstein-Lewis Fx
  - Accounts for 7% all Humeral shaft fx
  - Low Energy injury mechanism
  - Spiral Fx
  - Middle and Distal Humerus fx have higher risk of developing radial nerve palsy injuries
  - Increased risk Radial nerve palsy compared to other Humerus shaft fx.
  - Fractures occurs point where Radial nerve runs thru the intermuscular septum
  - Radial nerve contact bone and is less mobile
  - Distal fragment displaced proximal and Radial nerve entrapping or lacerating the Radial nerve
  - Outcome was excellent regardless of treatment (operative v. n on-op)
    - Fracture healing
    - Radial nerve palsy recovery
    - Return of function ability



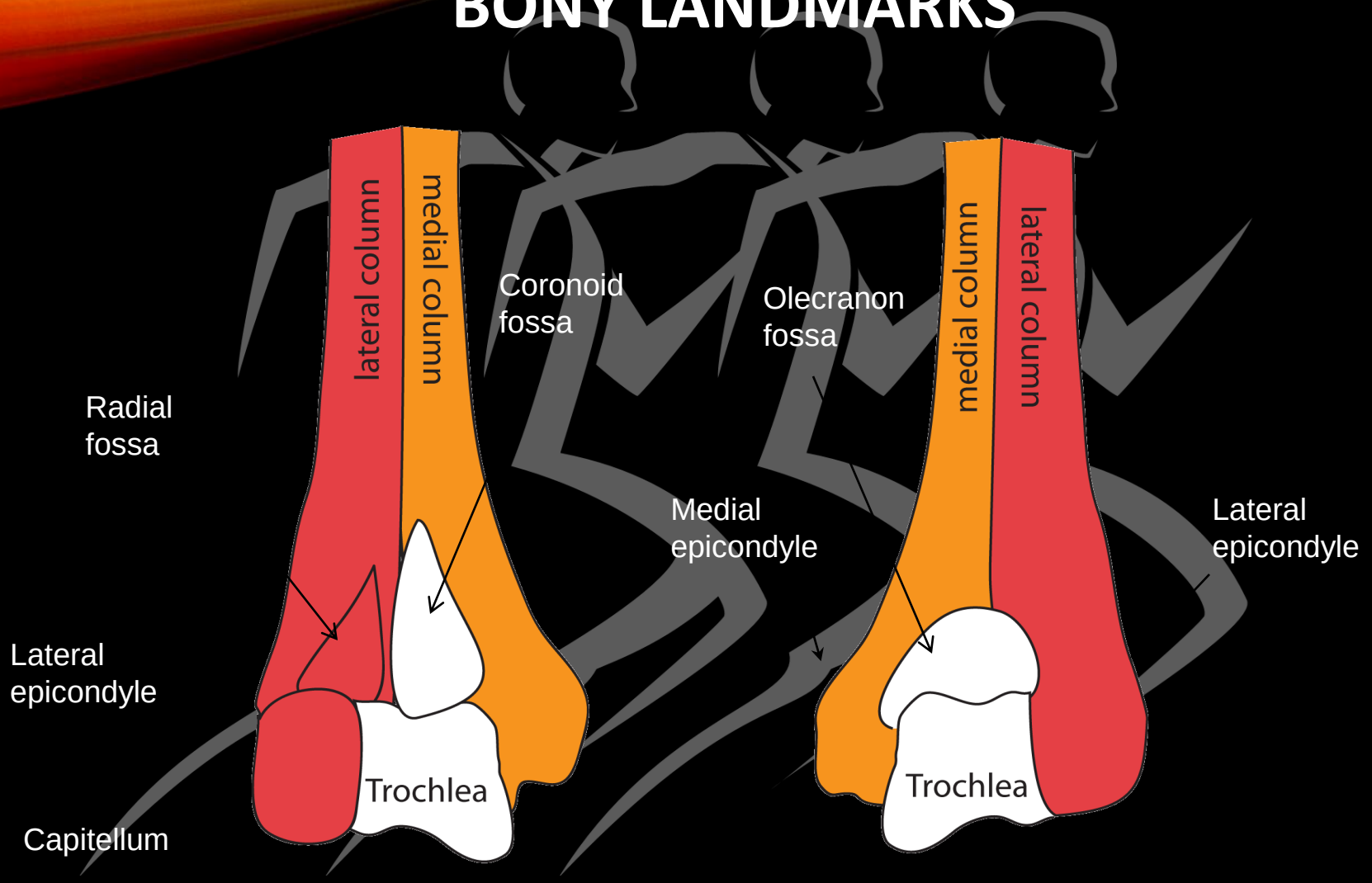
Ekholm R, Ponzer S, Törnkvist H, Adami J, Tidermark J. The Holstein-Lewis Humeral Shaft Fracture: Aspects of Radial nerve injury, Primary treatment, and Outcome. J Orthop Trauma. 2008 Nov-Dec;22(10):693-7.

Humeral Shaft Fracture

- **Treatment options- Closed Fracture**
  - Frequent follow up and adjustment of hanging arm cast/brace/splint
  - Xray weekly x 3 weeks
  - Begin early wrist/hand ROM
  - **Acceptable post reduction alignment**
    - **<20◦ anterior angulation**
    - **<30◦ varus**
    - **<15◦ malrotation**
    - **3cm shortening**
- Surgical indications
  - Open Fx\Polytrauma
  - Vascular injury
  - Floating Elbow
  - Obesity – immobilization difficulty

SUPRACONDYLAR HUMERUS FX

BONY LANDMARKS



SUPRACONDYLAR HUMERUS FX

Epidemiology

- **30% all Elbow fx**
  - Supracondylar
  - Single Column fx- Lateral
  - Bi-column fx- heavy damage
  - Young men & older female
  - Falls from standing height/high energy
- Assoc Injuries
  - Elbow dislocation
  - Terrible Triad
  - Floating Elbow
  - Volkmann Contracture - missed forearm compartment syndrome

SUPRACONDYLAR HUMERUS FX

Exam

- Neurovascular- assess frequently
  - High suspicion for vascular injury
- Grossly unstable fx – limit motion

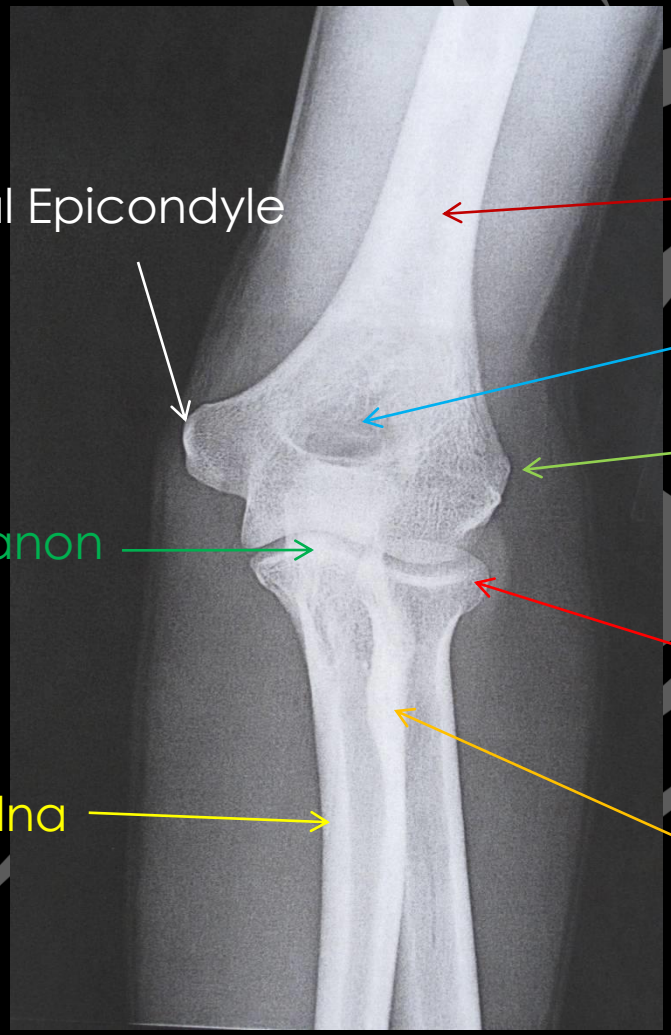
Acute treatment

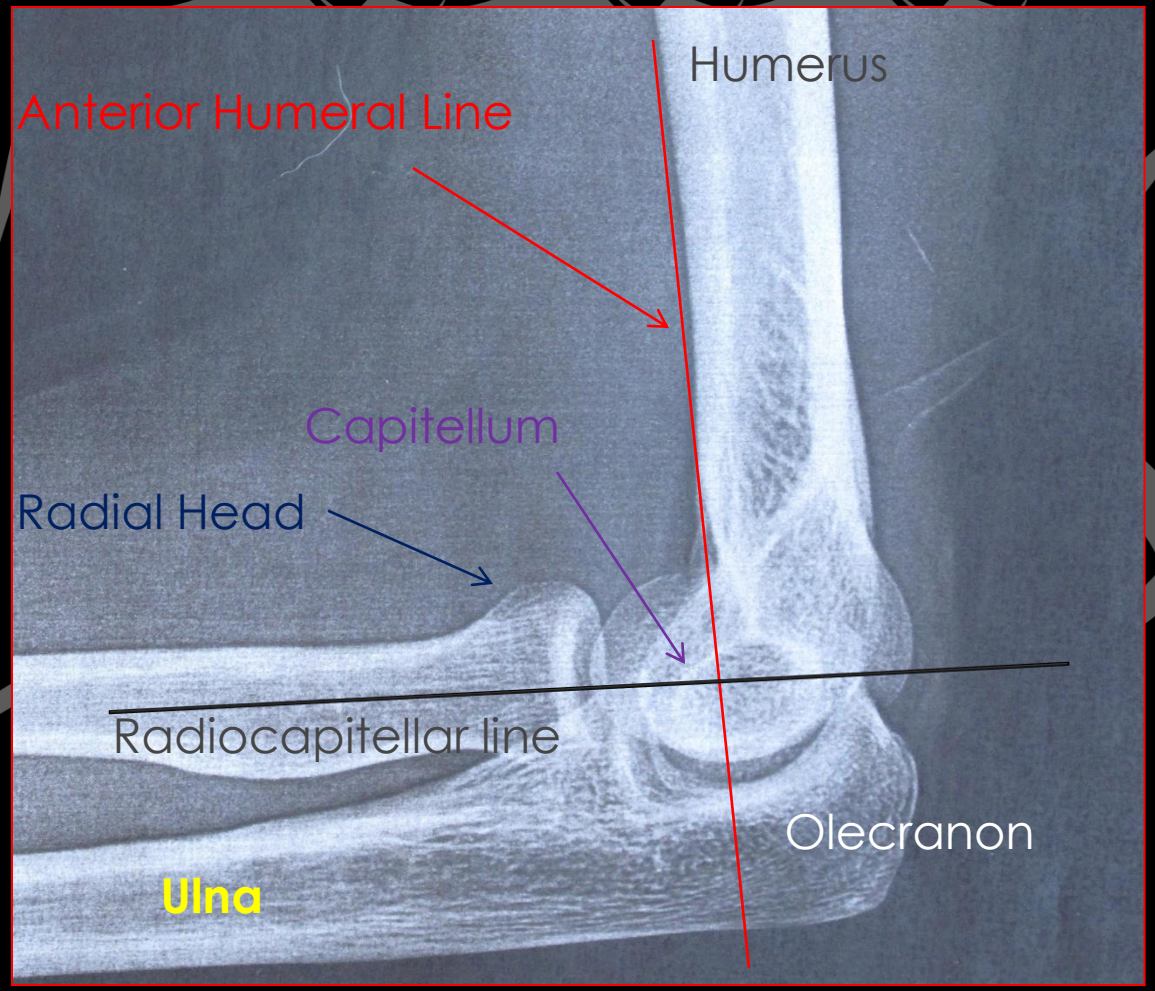
- Compromised Neurovascular
  - Emergent vascular consult/CTA
  - Concern for forearm compartment syndrome
  - Admit
- Long-arm posterior splint vs Dbl Sugar-tong
  - <90º flexion
- Sling
- Pain management
- Follow up 3-5 days
- **Most all elbow Fx require surgery**

ELBOW FX

--RADIAL HEAD
--OLECRANON

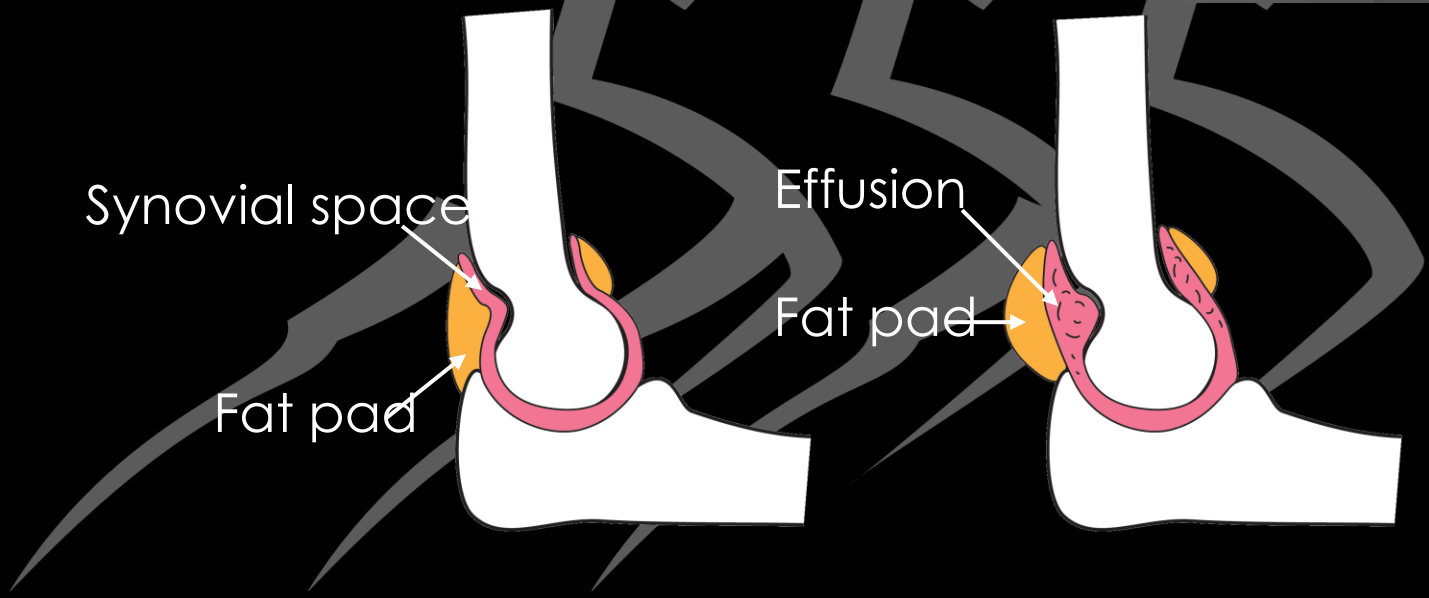
ELBOW ANATOMY





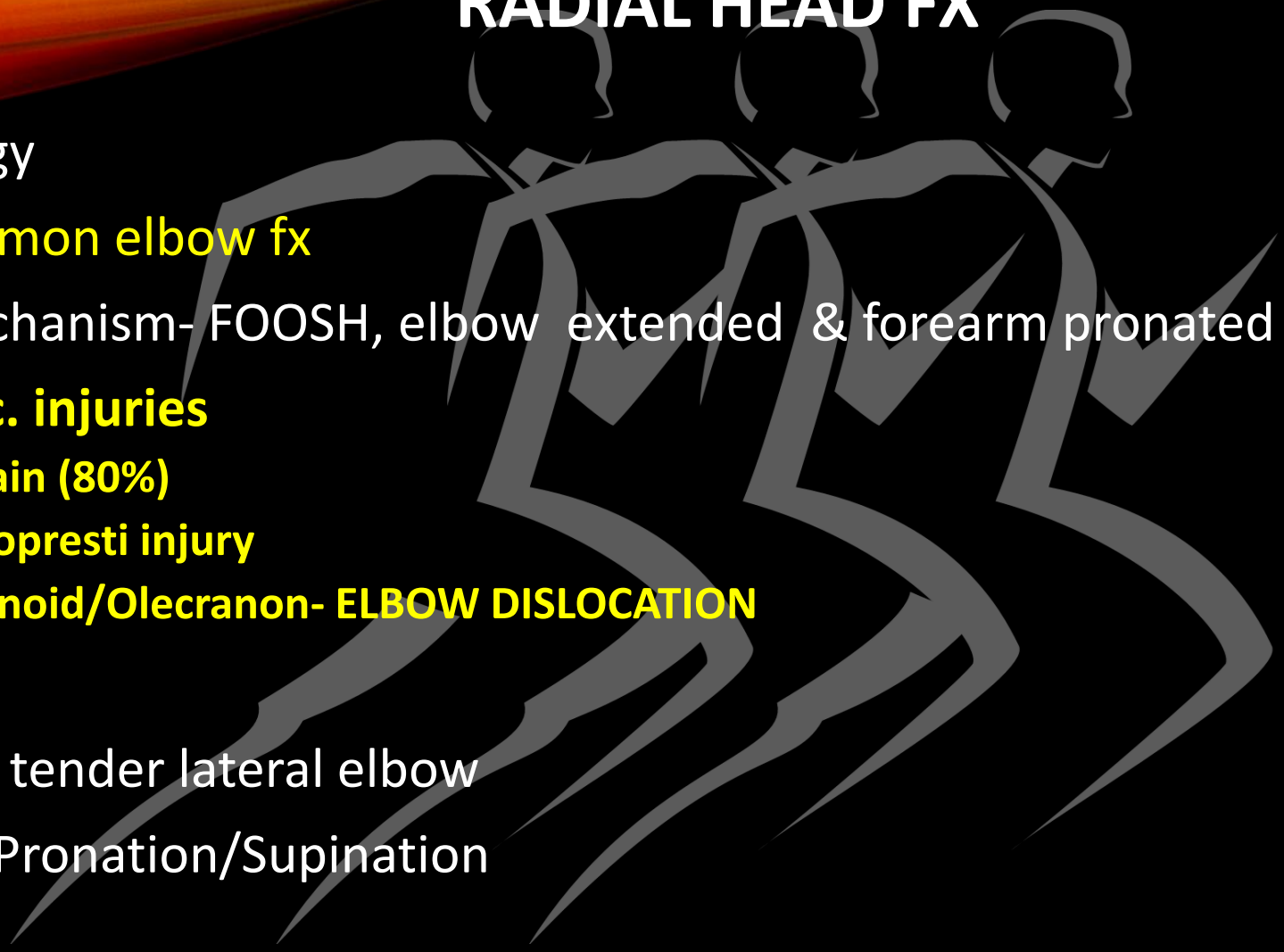
RADIOLOGY

Fat Pad Sign



RADIAL HEAD FX

RADIAL HEAD FX



Epidemiology

- Most common elbow fx
- Injury mechanism- FOOSH, elbow extended & forearm pronated
- **35% assoc. injuries**
  - **LCL sprain (80%)**
  - **Essex-Lopresti injury**
  - **Fx Coronoid/Olecranon- ELBOW DISLOCATION**

Exam

- Swollen & tender lateral elbow
- Pain with Pronation/Supination

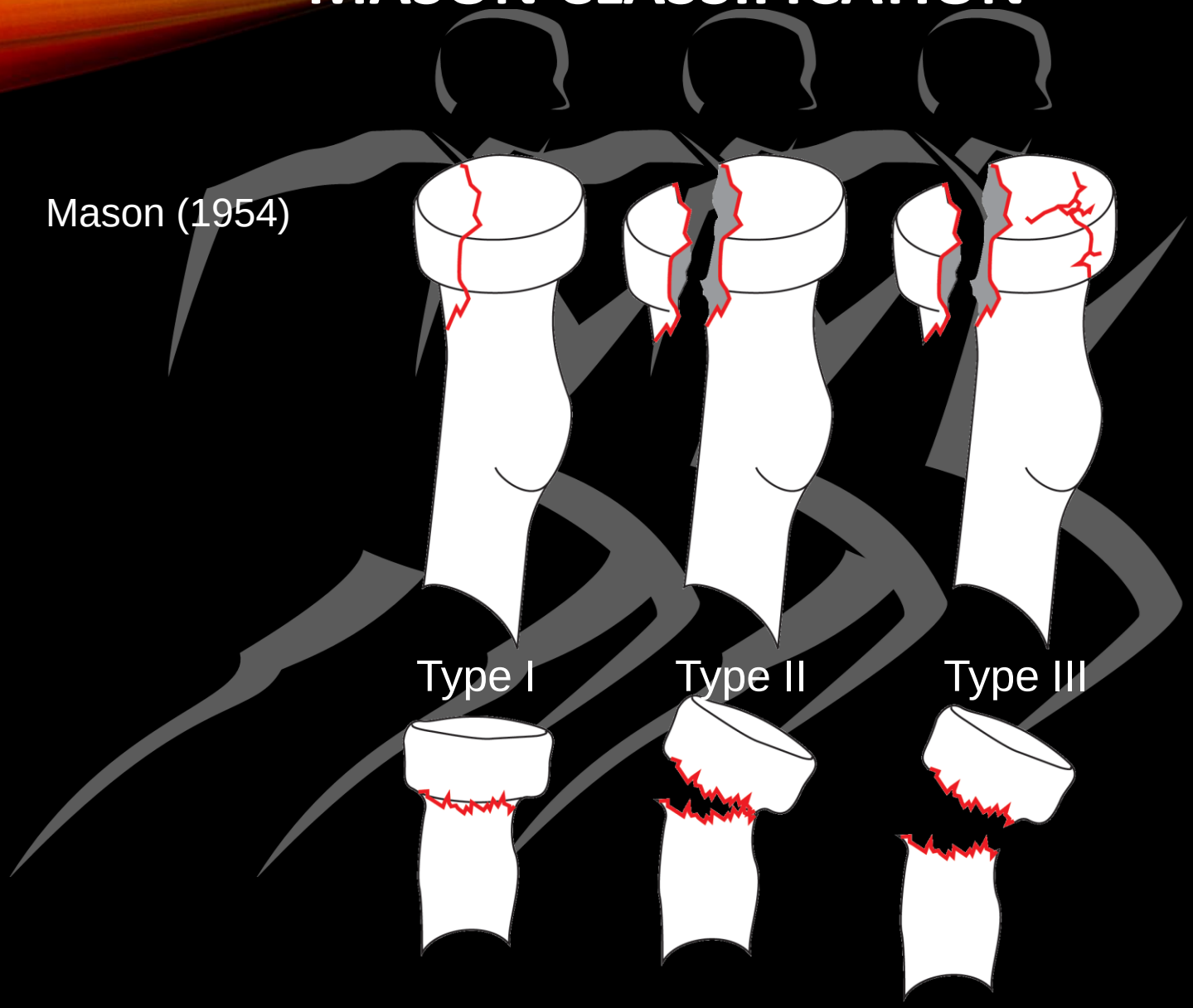
RADIAL HEAD FX

Radiographs

- AP, lateral & radial head view
  - Radial head view: oblique lateral
    - Helps see subtle fx radial head
  - Check for Fat Pad signs
  - Fx Tolerances: Rule of 3's (Radin & Riseborough, *JBJS-A*, 1966)
    - 1/3 radial head fx
    - 3mm displacement/diastasis
    - >30 degrees angulation
- CT Scan
  - Needed with comminuted fx radial head
  - Helps with surgical preplanning

MASON CLASSIFICATION

Mason (1954)



MASON TYPE I

Pictures courtesy TGocke, PA-C

MASON TYPE II

Pictures courtesy TGocke, PA-C

Pictures courtesy TGocke, PA-C

MASON TYPE III

Pictures courtesy TGocke, PA-C

RADIAL HEAD FRACTURE

Treatment

- Sling vs Sugar-tong splint
  - **Sling - low demand patient/ elderly**
  - **Sugar-ting – High demand**
    - **Athletes, laborers, non-compliant, failed sling**
    - **Sugar-tong gets a sling**
  - Pain management
  - Limit Activity
  - Follow up 1 week
    - May begin ROM exercises
  - Will need serial x-rays till healed
- All displaced comminuted Fx will require surgical stabilization or Radial head replacement

OLECRANON FX

OLECRANON FX

Epidemiology

- **Bimodal injury distribution**
  - **Young- High energy**
  - **Elderly fall standing height**
- Injury mechanism-
  - Direct blow leads to comminuted fx
  - FOOSHE Transverse fx

- 35% assoc. injuries
  - LCL sprain (80%)
  - Essex-Lopresti injury
  - Fx Coronoid/Olecranon

Exam

- Swollen & tender lateral elbow
- Pain with Pronation/Supination

OLECRANON FX

Radiographs

- AP, & Lateral Elbow
- Fracture pattern
  - Avulsion
  - Transverse
  - Oblique
- CT Scan

- Exam
  - Limited Elbow Flex\Ext ROM
  - Palpable defect olecranon
  - Skin lesion

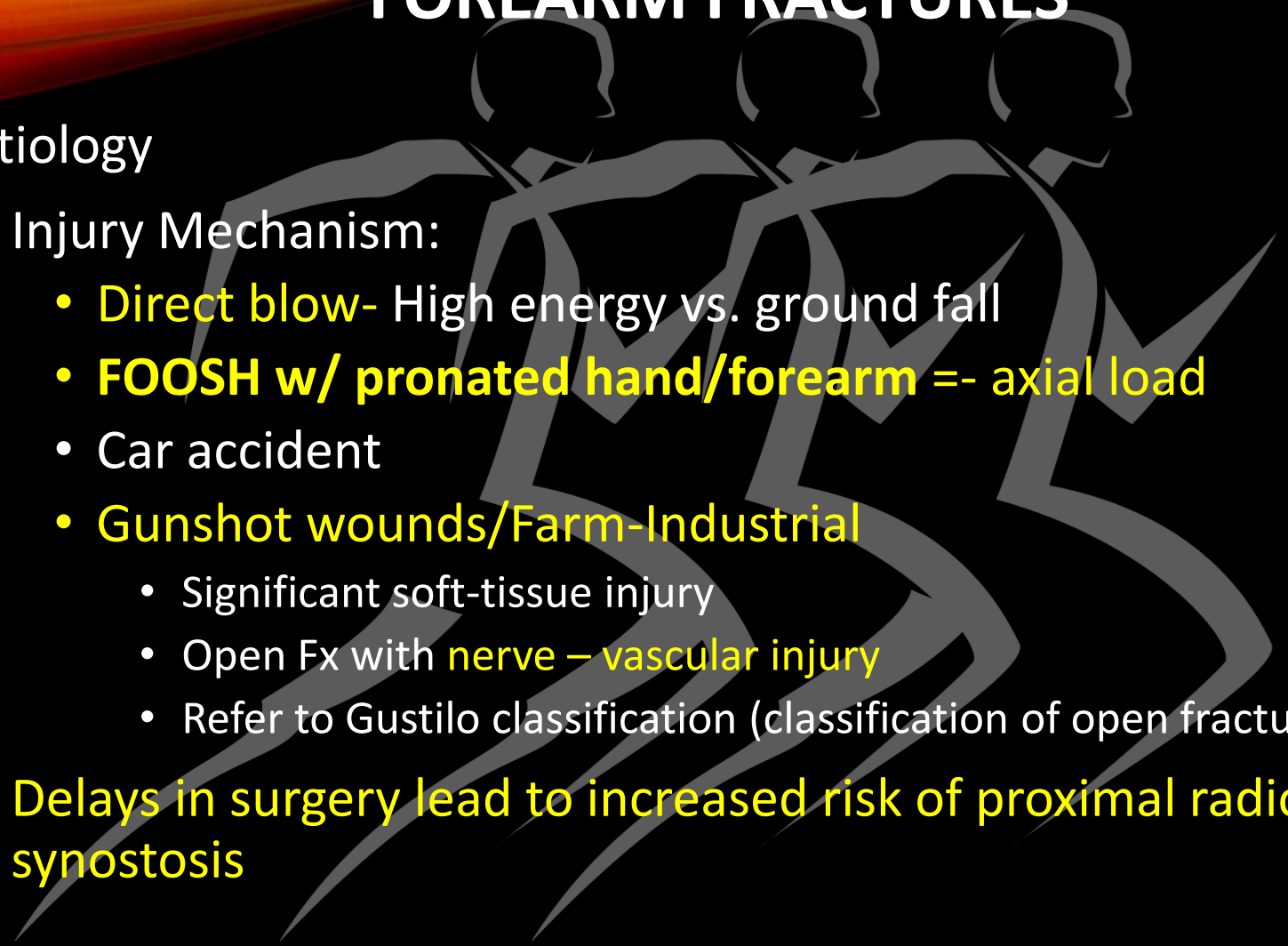
OLECRANON FX

Treatment

- **Most Olecranon fx will need surgical stabilization**
  - **Stabilization allows for earlier ROM**
- **Immobilize in Long-arm posterior splint**
  - **Elbow flexed to 45-90º**
- **Sling**
- Pain management
- Follow up 1 week

FOREARM FX

FOREARM FRACTURES



Etiology

- Injury Mechanism:
  - Direct blow- High energy vs. ground fall
  - **FOOSH w/ pronated hand/forearm** =- axial load
  - Car accident
  - Gunshot wounds/Farm-Industrial
    - Significant soft-tissue injury
    - Open Fx with nerve – vascular injury
    - Refer to Gustilo classification (classification of open fractures)
- Delays in surgery lead to increased risk of proximal radioulnar synostosis

RADIUS AND ULNA SHAFT FRACTURES

- Symptoms
  - gross deformity, pain, swelling
  - loss of forearm and hand function
- Physical exam
    - Check forearm compartments
      - High suspicion compartment syndrome
        - Pain with passive stretch of digits
        - Pain out of proportion
    - Assess radial and ulnar pulses
    - Check Median, Radial, and Ulnar nerve function
- Neurovascular
  - Median nerve: finger flex/Make a fist
    - AIN- “OK” sign (Flexor Pollicis Longus)
  - Radial nerve: Wrist/Finger extension
    - PIN: “Thumbs up” sign (Extensor Pollicis Longus)
  - Ulnar Nerve: Finger ABD/ADD

- Assess elbow & wrist for associated injury

FOREARM FRACTURES

Radiographic Exam

- AP/Lateral/Oblique views
  - **AP & lateral**:
    - Forearm to include wrist and elbow
    - radial head will bisect Capitellum
    - good radiocapitellar apposition on alignment

- **Radial fx location** predictive of DRUJ instability
  - >7.5 cm above DRUJ
  - higher likelihood of instability at DRUJ 55%

- **Look at alignment of distal ulna - lateral**
- Ulna should bisect base of 4th and 5th metacarpal
- Radius & ulna should be aligned same plane

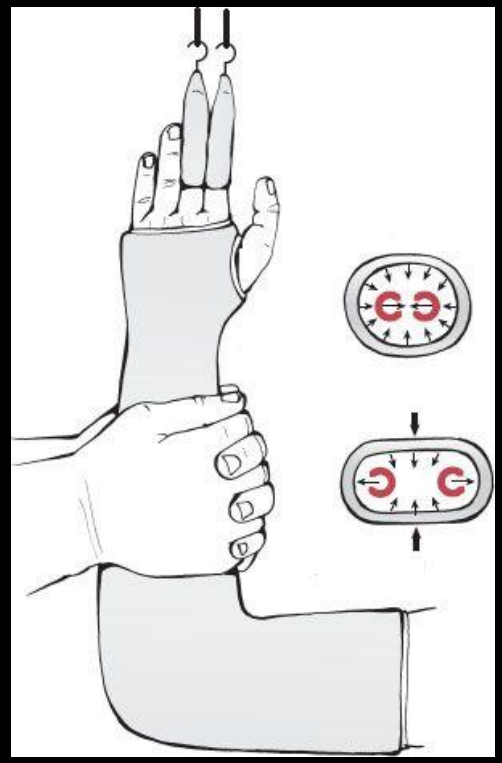
Photo courtesy TOocke, PA-C

RADIUS & ULNA SHAFT FX

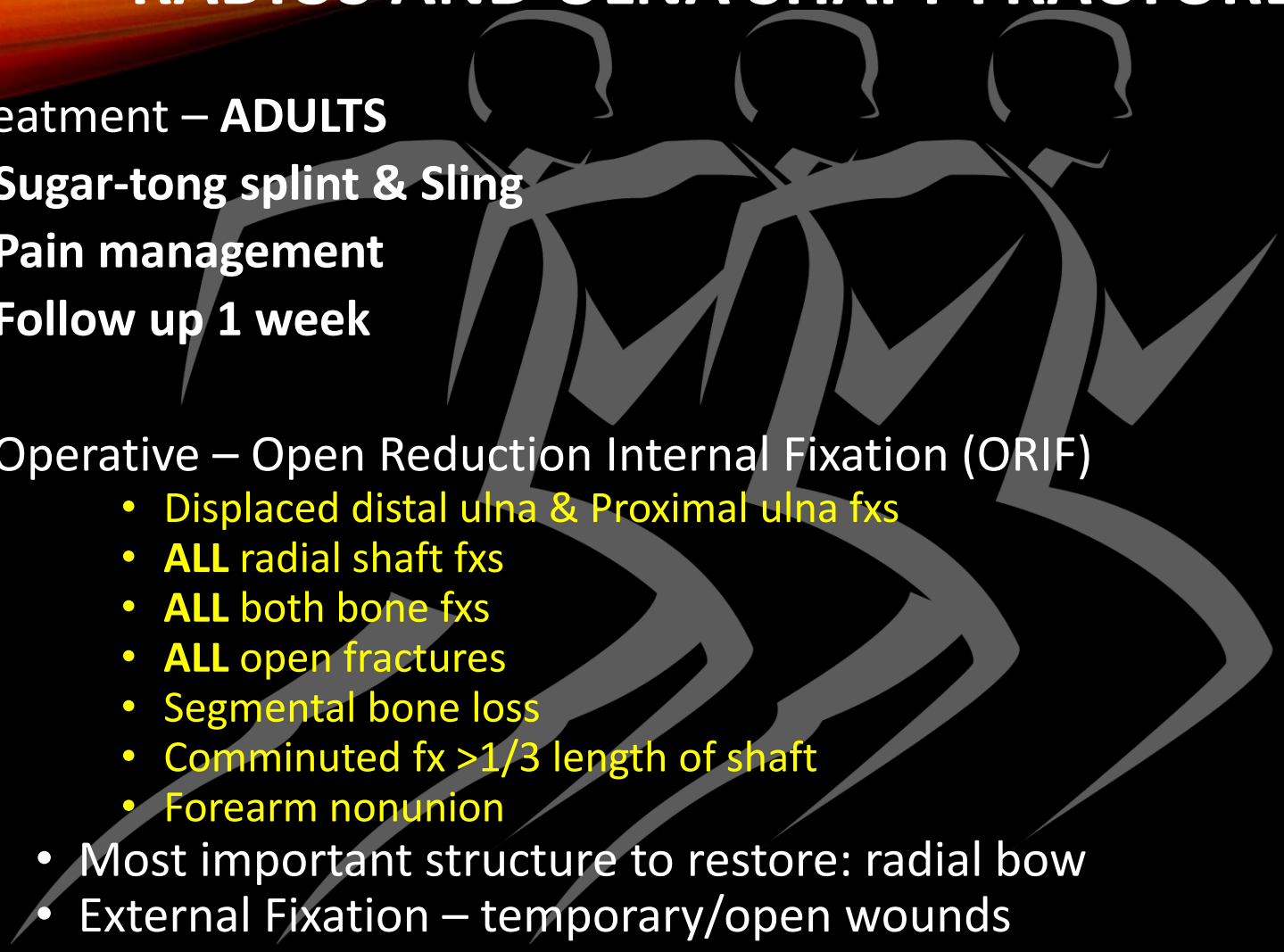
RADIUS AND ULNA SHAFT FRACTURES

Treatment

- Nonoperative - **ADULTS**
  - Isolated, nondisplaced fractures
  - Nightstick fx – isolated distal 2/3 ulna shaft fx
    - < 50% displacement and
    - < 10° of angulation
    - High union rates
  - Sugar-tong cast or functional fx brace
    - Interosseous mold: hand supinated, and forearm flattened



RADIUS AND ULNA SHAFT FRACTURES



Treatment – **ADULTS**

- **Sugar-tong splint & Sling**
- **Pain management**
- **Follow up 1 week**

- Operative – Open Reduction Internal Fixation (ORIF)
  - Displaced distal ulna & Proximal ulna fxs
  - **ALL** radial shaft fxs
  - **ALL** both bone fxs
  - **ALL** open fractures
  - Segmental bone loss
  - Comminuted fx >1/3 length of shaft
  - Forearm nonunion
- Most important structure to restore: radial bow
- External Fixation – temporary/open wounds

RADIUS AND ULNA SHAFT FRACTURES

Pediatric Fx

- **More growth & remodeling potential the better the outcome**
- **Most will be reduced with good alignment**
- **Reduction undersedation and bedside Fluoro or Anesthesia with Fluoro**
- **Long arm cast vs sugar-tong with a wrap over**
- **Serial follow- ups & x-rays**
- **Surgery**
  - **Open fx**
  - **Neurovascular compromise**

MONTEGGIA FX
&
GAELEAZZI FX

MONTEGGIA & GALEAZZI FX – MU-GR

Monteggia FX

MU-Gr

- Ulna Fx with Radial head injury
  - Radial head FX
  - Radial head Dislocation

Galeazzi Fx

Mu-**GR**

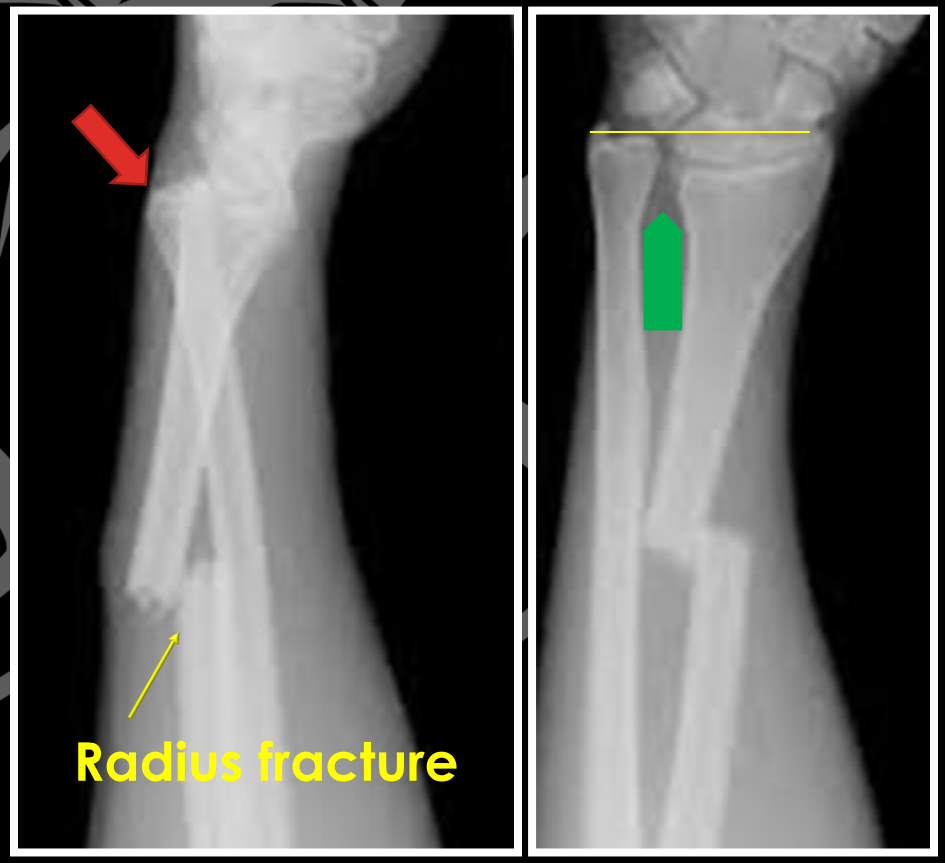
- Radius Fx
- DRUJ instability/Injury

GALEAZZI FRACTURES

- Galeazzi Fx
  - Defined as: Fracture mid to distal 1/3 radius shaft with dislocation at Distal Radioulnar Joint (DRUJ)
    - Dorsal dislocation of distal ulna most common DRUJ disruption
    - Avulsion fx at ulnar styloid is tip to be suspicious for DRUJ injury
    - Majority unstable if radial fracture is <7.5 cm from demarcation (closer to the wrist)
  - 7% all forearm fractures
  - Higher risk: sports, osteoporosis, post-menopausal
  - 40% complication rate, 2-10% mal/non-union rate
  - 1 in 4 Radial shaft fx is a true Galeazzi fx.
  - Falls
    - FOOSH wt on the pronated hand at time of injury causes sublux DRUJ & dorsal angulation of radial fx
    - Location of radial fx in proximity to DRUJ has some bearing on potential for DRUJ instability
      - More distal fracture = higher risk of instability

GALEAZZI FRACTURES

- Galeazzi Fracture
  - Radius fracture and DRUJ injury
    - Ulnar styloid fx
    - widening of DRUJ on AP view
    - dorsal or volar displacement ulna
      - Best seen lateral view
    - radial shortening (≥5mm)



MONTEGGIA FRACTURE

Monteggia Fracture

- Defined as: Proximal 1/3 ulnar fracture with associated radial head dislocation

Etiology

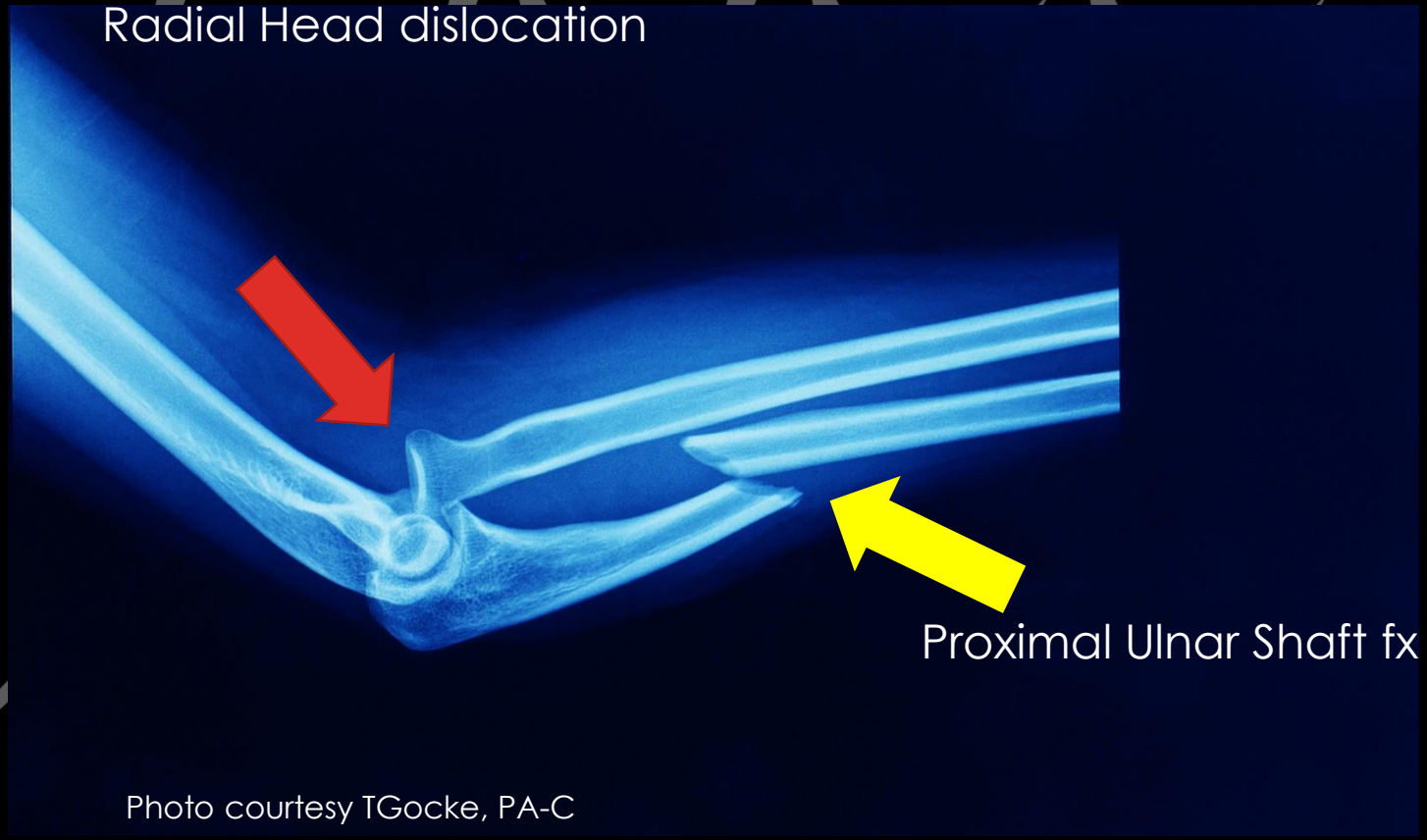
- More common in children - peak incidence 4-10yo
- Rare in adults
- Delayed diagnosis >2-3 weeks = increased risk complication

Injury Mechanism

- Fall with blow to forearm, Elbow /forearm Hyperpronated
- Energy transmitted thru Interosseous ligament
- Causes rupture of proximal Quadratus & Annular Ligament

MONTEGGIA FRACTURE

MONTEGGIA FRACTURE



MONTEGGIA FRACTURES

Treatment

- Closed reduction - temporary solution
  - Relax tension on soft-tissues
  - Radial head may not reduce 2nd to Annular ligament entrapment
    - Splint/Cast: long arm
      - Forearm neutral to supinated position
      - Elbow flexed to 100 degrees to relax biceps pull
- Surgical correction is primary means of treatment
  - Unstable fracture
  - Plate fixation Ulna & reduce Radial head
  - Long-arm splint, hand supinated
  - Concern for post-op elbow stiffness

DISTAL RADIUS FX

DISTAL RADIUS FRACTURES

Epidemiology

- Distal Radius (DR) [& Ulna] fx account for 25% all UE fx
- DR fx increasing 2%/yr men, 3.4%/yr female 50-59 yrs of age
- Bimodal distribution: younger males and older females
  - Kids<18: Peak 12-14 yrs boys, 10-12 old girls
    - Decreased level skeletal mineralization & density w/ puberty
  - Adults > 50: Peak Caucasians >65 yrs old
    - Osteoporosis common risk factor
    - Prior fx > age 50
    - Steroid use
    - >75 yrs old w/ dementia
    - Intra-articular fx more common in females w/ DM
- Contributing Factors: Obesity, osteoporosis, DM, Tobacco use

Meaike JJ, Kakar S, management of Comminuted Distal Radius Fractures: A Critical Review, JBJS Reviews 2020;8(8)e20.00010

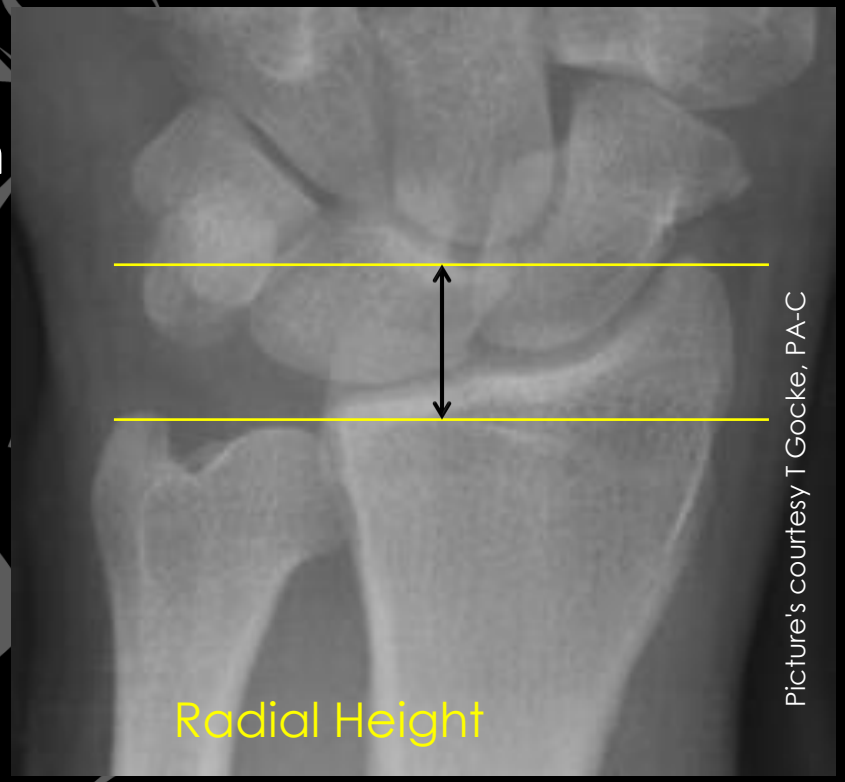
Porrino JA, Maloney E, Scherer K, et al Fracture of the Distal Radius: Epidemiology and Premanagement Radiographic Characterization, American Journal of Roentgenology 2014 203:3, 551-559

Corsino CB, Reeves RA, Sieg RN, Distal Radius Fractures, StatPearls, Treasure Island, FL, StatPearls Publishing Jan 2020

DISTAL RADIUS FRACTURE

Radiographs

- Radial Height
  - Measured from Posterior-Anterior (PA) projection
  - 2 lines perpendicular to long axis Radius
    - Parallel to Radial Styloid
    - Parallel to Ulnar articular surface
  - Normal 12 mm - approximate (ulnar negative)
  - Excessive Radial shortening ? Assoc. tear of TFCC

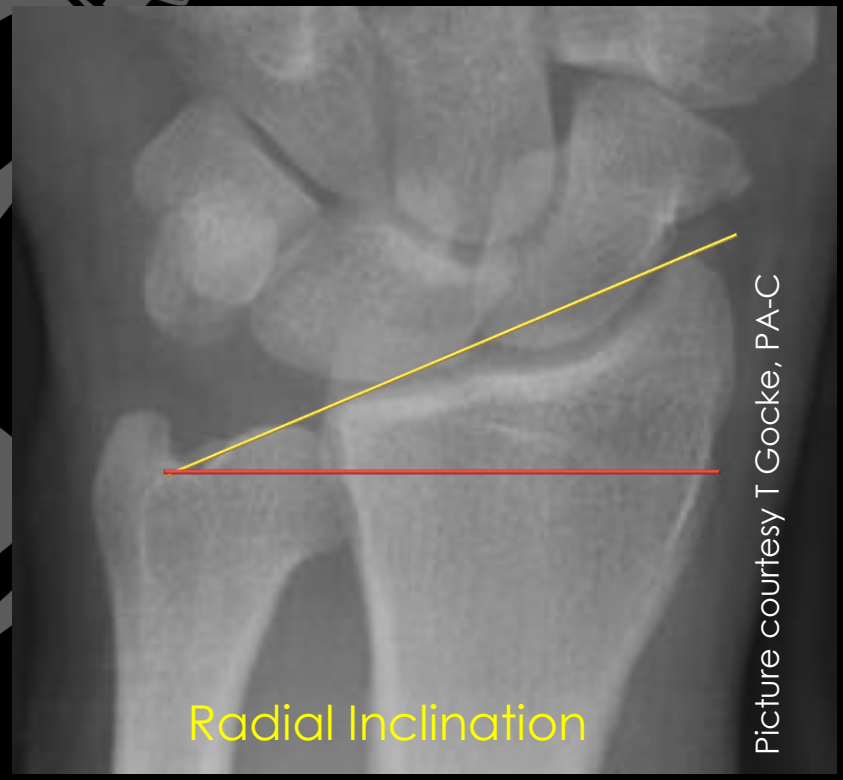


Porrino JA, Maloney E, Scherer K, et al Fracture of the Distal Radius: Epidemiology and Premanagement Radiographic Characterization, American Journal of Roentgenology 2014 203:3, 551-559

DISTAL RADIUS FRACTURE

Radiographs

- Radial Inclination
  - Defined as : angle between a line *perpendicular to the Radial central axis and a line drawn along the Radial articular surface*
  - **Articular surface Radius 23º normal Radial inclination**
  - Normal range: 13-30º
  - Loss of Radial Inclination reflects fracture v. malunion



Porrino JA, Maloney E, Scherer K, et al Fracture of the Distal Radius: Epidemiology and Premanagement Radiographic Characterization, American Journal of Roentgenology 2014 203:3, 551-559

DISTAL RADIUS FRACTURE

Radiographs

- Volar/Palmar Tilt
  - Defined as –*angle between a line perpendicular to the central Radial axis and a line connecting the dorsal and volar margins of the articular surface of the distal [as seen on lateral projection]*
  - **Loss of volar tilt is seen with acute distal Radius fx or malunion**
  - Normal 10 º

Porrino JA, Maloney E, Scherer K, et al Fracture of the Distal Radius: Epidemiology and Premanagement Radiographic Characterization, American Journal of Roentgenology 2014 203:3, 551-559

FRACTURE DESCRIPTION

- Fx location
- Open v. Closed:
  - Gustilio-Anderson classification
- Neurovascular status
- Angulation: direction fx apex
- Displacement vs. Non-displaced
- Comminution
- Impaction
- Rotation
- Articular extension

COLLES' FRACTURES

Defined as: distal radius fx, dorsal comminution-angulation-displacement, radial shortening & Ulnar styloid fx

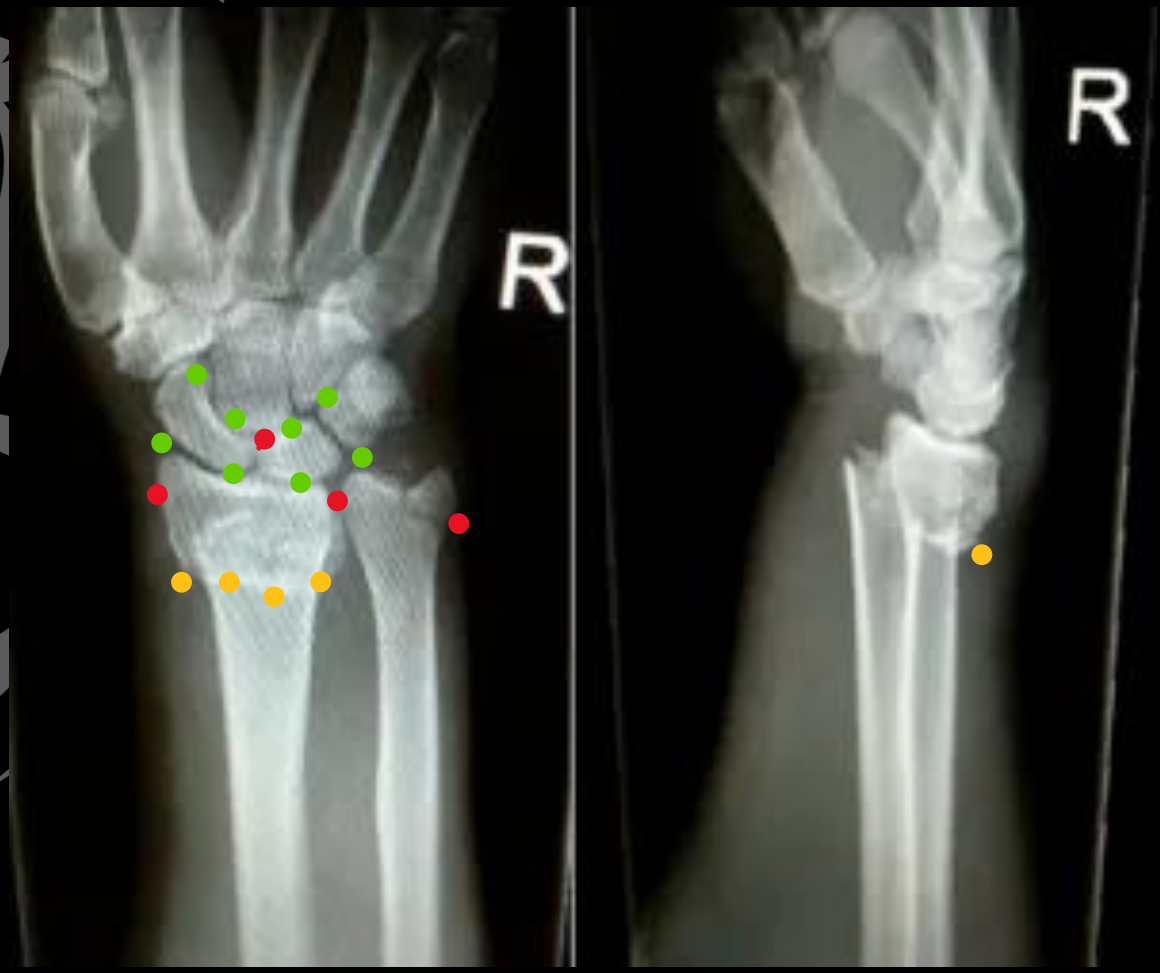
- Metaphyseal fx 1.5cm proximal to Carpal articulation
- Typically - non-articular w/ dorsal displacement
  - More severe fx considered with intra-articular comminuted appearance (dorsal)
- Dorsal displacement/angulation principle distal fx fragment
- Young- time of puberty 2nd to lower bone mineralization
    - Higher energy –sports
  - Elderly- Women > men
    - Falls
    - Osteoporosis

Summers K, Fowles SM. Colles' Fracture. 2020 Aug 10. In: StatPearls Treasure Island (FL): StatPearls Publishing; 2020 Jan

COLLES' FRACTURES

RADIOGRAPHS

- **Common X-ray views: Posterior-Anterior (PA), Lateral and Oblique**
  - **PA View - Radial shortening, Scapholunate widening, Ulnar variance, Ulnar styloid fx**
    - **2nd view Carpal Arches (Gilula's arches)**
  - Lateral X-ray wrist
    - **Loss volar/palmar tilt**
    - **Dorsal cortex comminution**
    - **Superimposed Ulna on Radius (DRUJ)**
    - **Hand follows distal radius fx fragment**
  - Oblique-
    - Dorsal cortex comminution
    - Intra-articular comminution



Porrino JA, Maloney E, Scherer K, et al Fracture of the Distal Radius: Epidemiology and Premanagement Radiographic Characterization, American Journal of Roentgenology 2014 203:3, 551-559

HEMATOMA BLOCK

- Inject Hematoma from dorsal aspect of wrist
  - 5ml 1% Lidocaine & 5ml 0.5% Bupivacaine
  - 10ml 1% Lidocaine
  - Sterile prep & technique
- Occ. need few ml's around ulnar styloid too
- No monitoring required
- Risks:
  - Infection & LA toxicity
- **Do not use once > 24hrs old as hematoma organized**

https://www.youtube.com/watch?v=-_whFCBHn-M

DISTAL RADIUS FX REDUCTION

COLLES' FRACTURE

Treatment

- Non-op
  - Majority of Colles- type distal radius fx do not need surgical intervention
  - Displaced, extra-articular, non-comminuted fx are the best with Closed reduction.
  - Reduction maneuver
    - Traction of the hand
    - Counter-traction @ the elbow
    - Re-produce deforming force – "unlock" the fracture
    - Volar-medial force applied to distal Radius fragment
    - Pronated position overcomes deforming supination force
  - Immobilize in sugar-tong splint
  - Post-reduction x-ray
  - Post-reduction exam: neurovascular intact
  - Follow up in 1 week for re-imaging

Meaike JJ, Kakar S, Management of Comminuted Distal Radius Fractures: A Critical Review, JBJS Reviews 2020;8(8)e20.00010

DISTAL RADIUS FRACTURES

Radial Styloid Process Fracture

- "Chauffer's fx", Hutchinson fx
- Intra-articular fx of Radial Styloid
- FOOSH Injury mechanism with blow to dorsal wrist
  - Causing wrist dorsiflexion-ABDuction & scaphoid compression into Radial styloid
- Radioscaphocapitate ligament avulses the Radial styloid
- Distraction forces from Brachioradalis & Wrist/finger extrinsic Flex/Ext

X-Ray Images

- Anterior-Posterior(AP) v. PA and Lateral views [Oblique optional]
- AP view w/ wrist Ulnar deviated best to see Scapholunate (SL) gap
- Clenched fist view: Longitudinal compression load widens SL gap

Corsino CB, Reeves RA, Sieg RN. Distal Radius Fractures. [Updated 2020 Aug 11]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-.

Wheeless CA, Chauffer's Fracture: Radail Styloid Fractures, Wheeless Online, https://www.wheelessonline.com/joints/chauffeurs-fracture-radial-styloid-fractures/, retrieved Jan 28, 2021

DISTAL RADIUS FRACTURES

Smith's Fracture

- Epidemiology
  - Extra-articular distal Radius w/ volar displacement
    - Intra-articular Smith's III = Volar Barton
    - Hand /wrist follows Radius fragment
    - 5% all distal Radius fractures
    - Garden Spade deformity
  - Fall backward on of palmar flexed wrist or direct blow dorsal wrist
    - Volar displacement also seen fall on palmar hand
  - Highest incident young males/older females
    - High energy falls young
    - Osteoporotic bone elderly

Picture courtesy T Gocke, PA-C

Schroeder JD, Varacallo M. Smith's Fracture Review. [Updated 2020 Aug 15]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-.

Smith's Fracture

- Xray:
  - AP, Lateral & Oblique – usual images
  - Traction view – optional
  - Pathology to identify
    - **Extra/Intra-articular, dislocation carpus**
    - **Radial deviation**
    - **Ulnar variance**
    - **DRUJ alignment**
- CT Scan
  - Comminuted intra-articular fractures
  - Clarifies fractures fragments & quantifies articular surface injury

Schroeder JD, Varacallo M. Smith's Fracture Review. [Updated 2020 Aug 15]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-.

DISTAL RADIUS FRACTURES

Dorsal Barton's Fracture

- Defined as distal Radius fx that extends thru the dorsal articular surface w/ assoc. dislocation of the Radiocarpal jt
  - No disruption of the Radiocarpal ligament
  - Articular surface fx distal Radius remain connected to proximal carpal row
- Injury pattern dependent on age
  - Elderly women, osteoporosis, falls from standing height
- Pathophysiology
  - Compression injury w/ marginal shearing fx of distal Radius
  - Fall on outstretched pronated wrist
  - Triangular fragment Radius displaced dorsally w/ carpus
  - Stabilizer's wrist: Radiocarpal ligaments, jt capsule Scaphoid & Lunate fossa

Szymanski JA, Reeves RA, Carter KR. Barton's Fracture. [Updated 2020 Jul 2]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan

Wheeless CA, Dorsal Barton's Fracture, Wheeless Textbook of Orthopaedics https://www.wheelessonline.com/trauma-fractures/dorsal-bartons-fracture-dorsal-shearing-frx/, accessed February 2, 2021

DISTAL RADIUS FRACTURES

Volar [Reverse] Barton's Fracture

- Volar displaced fx of distal Radius w/ Volar subluxation/dislocation Radiocarpal jt.
- Xray:
  - Fx extends thru intra-articular Radius [dorsal or volar]
  - Fx Fragment wedged shaped
  - Carpus displaces proximal volar 2nd to deforming forces
  - Most fx require CT scan
- Treatment
  - Most require ORIF 2nd to displacement (volar plate, buttress plate, CRPP)
  - Closed reduction fails due to palmar displacement
  - Non-displace fx most conducive to cast immobilization

Picture courtesy T Gocke, PA-C

Szymanski JA, Reeves RA, Carter KR. Barton's Fracture. [Updated 2020 Jul 2]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan

Wheeless CA, Volar Barton's Fracture, Wheeless Textbook of Orthopaedics https://www.wheelessonline.com/trauma-fractures/volar-bartons-fractures/, accessed February 2, 2021

DISTAL RADIUS FRACTURES

Die-Punch Fracture

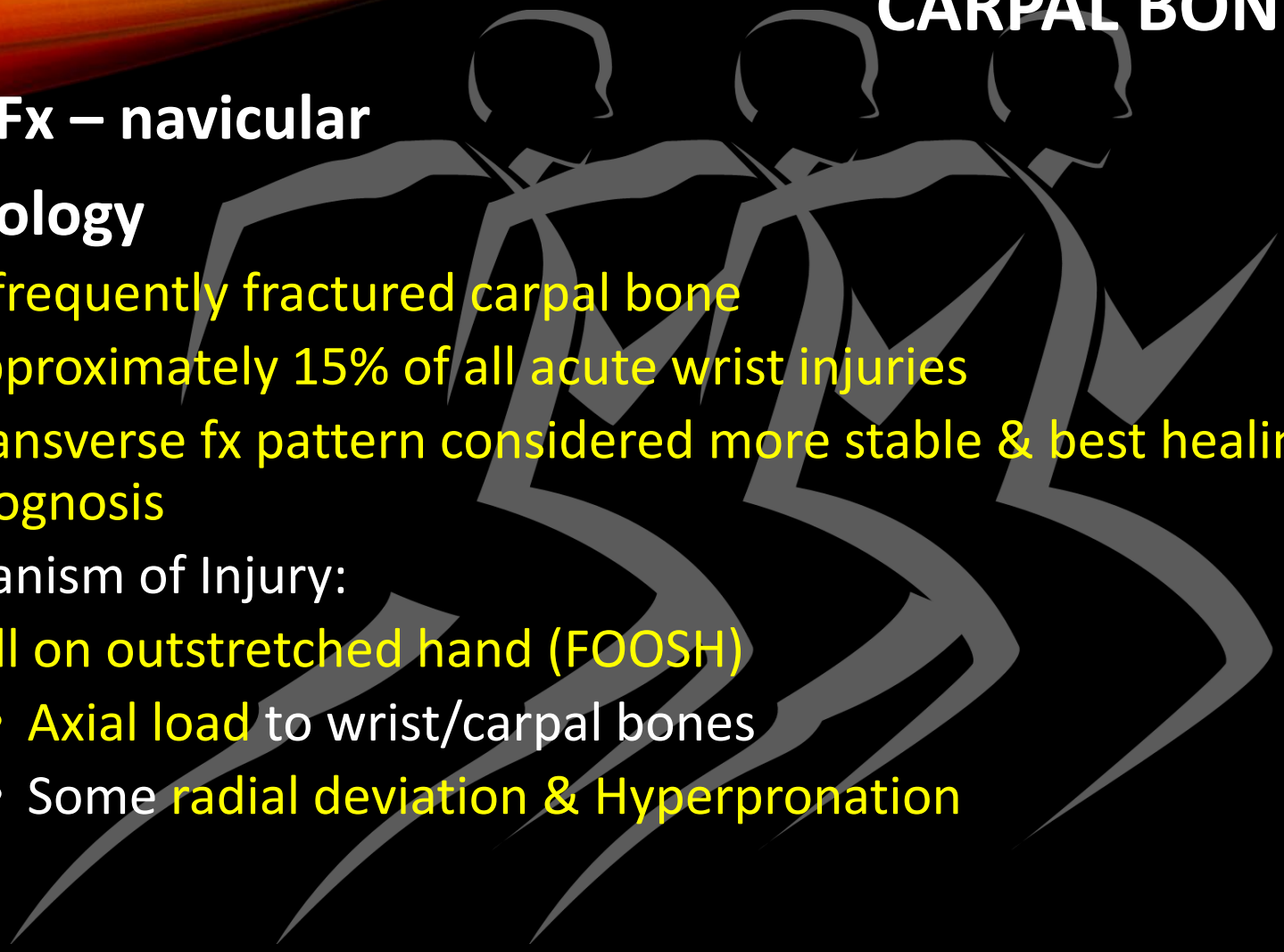
- Defined as
  - Intra-articular distal Radius fx w/ depression into Lunate fossa
- Injury Mechanism
  - Axial load distal Radius
- Radiology
  - Traditional X-ray views
  - CT scan for comminuted fx with > 2mm displacement
- Treatment
  - Surgical intervention, no non-op options
  - Elevation of articular surface w/ stabilization distal radius fx.

Picture's courtesy T Gocke, PA-C

Ahn L, Vitale M, Franko O, Distal Radius Fractures, Orthobullets, https://www.orthobullets.com/trauma/1027/distal-radius-fractures, updated 1/9/2021, retrieved 2/16/2021

CARPAL FX

CARPAL BONE INJURIES



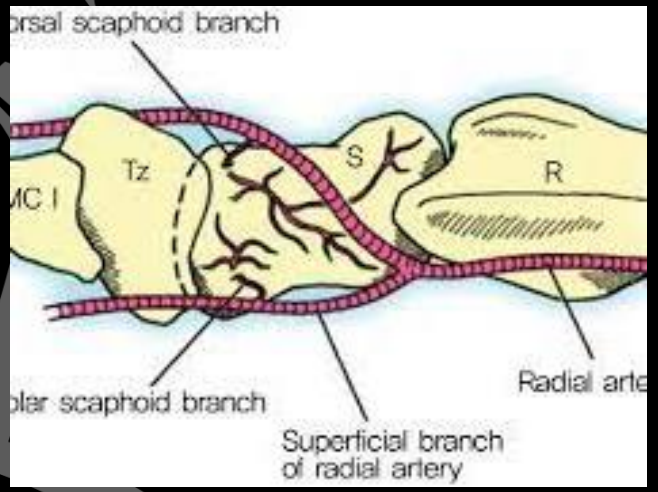
Scaphoid Fx – navicular

- **Epidemiology**
  - Most frequently fractured carpal bone
    - Approximately 15% of all acute wrist injuries
    - Transverse fx pattern considered more stable & best healing prognosis
  - Mechanism of Injury:
    - Fall on outstretched hand (FOOSH)
      - Axial load to wrist/carpal bones
      - Some radial deviation & Hyperpronation

SCAPHOID FRACTURE

3 parts: proximal & distal poles, waist

- **Most fx occur @ waist 70% all Scaphoid fx.**
- Proximal pole poor healing prognosis 2nd blood supply (highest rate AVN) [20%]
- Distal pole most common fx location in kids (ossification center) [10%]



Physical Exam

- Anatomic snuffbox tenderness
  - Volar wrist pain navicular tuberosity
  - Axial loading of the thumb – most sensitive & most specific [Gillion 2021]

CARPAL BONE INJURIES

Scaphoid Fx- Radiographs [Gillion 2021]

- Wrist x-rays: PA/PA grip, Lateral & Oblique,
  - Suspect scaphoid fx, snuffbox pain, FOOSH
    - scaphoid view: 30-degree wrist extension, 20-degree ulnar deviation
    - negative x-ray & high suspicion for fx: repeat x-ray 14-21 days
    - Osteolysis 2nd to bone healing should be present in 1-3 weeks
    - Immobilize in Thumb Spica splint/cast until follow up x-ray

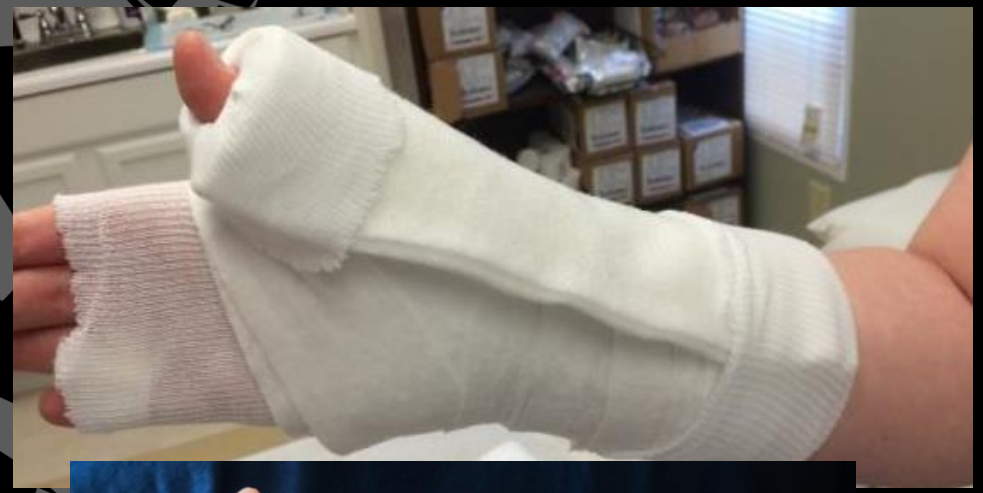
Picture courtesy TGocke, PA-C

CARPAL BONE FRACTURES

Scaphoid Fx

Treatment:

- **Important Initial treatment:**
  - ***Suspect occult scaphoid fx***
  - Initial recognition of potential injury mechanism
  - Thorough physical examination
  - Comprehensive review of initial radiographs
    - Thumb spica splint vs. cast
    - Initial immobilization for 14-21 days
    - Repeat x-ray on follow up exam



Photos courtesy TGocke, PA-C

HAND-METACARPAL FX

BONY ANATOMY

- Phalanges: 14
- Sesmoid: 2
- Metacarpals: 5
- Carpals
  - Proximal row: 4
  - Distal row: 4
- Radius and Ulna

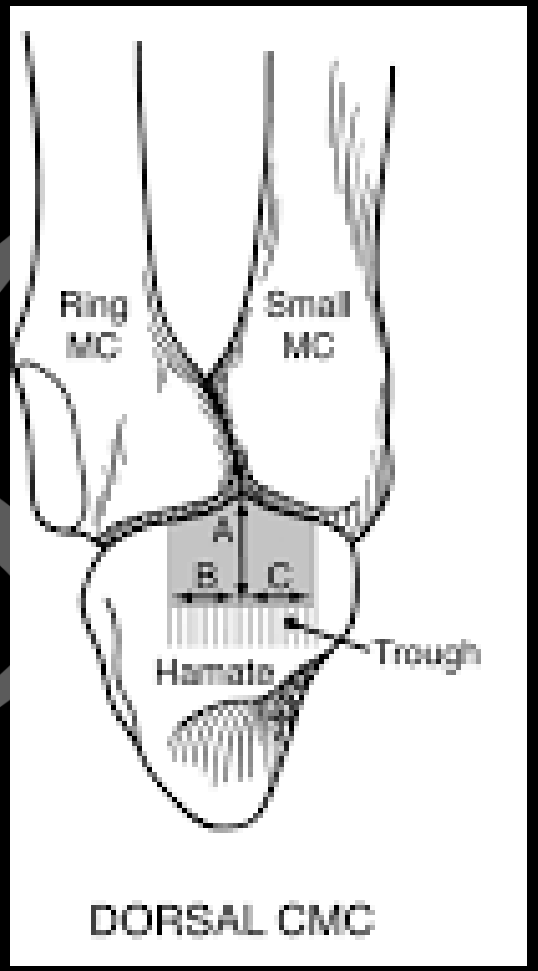
Photo courtesy TGocke, PA-C

Lister's tubercle

METACARPAL FRACTURES

Anatomy Review

- Index & Long (middle) fingers least mobile
- Ring & Small fingers more mobile & articulate with Hamate
- Thumb most mobile 2nd to articulation with carpus
- Palmar & Dorsal Interossi muscles originate for MC shafts
- Intrinsic Muscles
- Extrinsic Muscles



METACARPAL FRACTURES

Epidemiology

- Most fractures of the hand are to the metacarpal (MC)
  - Metacarpal neck most common injured & 5th metacarpal most often injured
  - 30% of all hand Fx are to the Shaft
- Men highest incidence of metacarpal injuries
- Average age injury 10-30 yrs
- Fx located by location: Head- Neck – Shaft - Base
- Treatment metacarpal fx based on finger and fx location
- Consider other injuries
  - Lacerations – open fx – compartment injuries- Infection

Borchers JR, Best TM, Common Finger Fractures and Dislocations, *Am Fam Physician 2012*, 85;(8):805-810

Wieschhoff GG, Sheehan SE, Wortman JR, et al, Traumatic Finger Injuries: What the Orthopaedic Surgeon Wants to Know, RNSA 2016;36(4):1106-1128

METACARPAL FRACTURES

Metacarpal Neck FX

- Index & Long Fingers
  - 15 degrees angulation
- Ring Finger
  - 30-40 degrees angulation
- Small Finger
  - 50-60 degrees angulation
  - Some cases 70 degrees angulation shown not to have significant impairment hand function

X-rays courtesy Tom Gocke PA-C Library

Wieschhoff GG, Sheehan SE, Wortman JR, et al, Traumatic Finger Injuries: What the Orthopaedic Surgeon Wants to Know, RNSA 2016;36(4):1106-1128

Nelson, Wongworawat: Tolerances, 3rd edition 2009

HUMAN BITE INJURY

<u>Clenched fist striking mouth/tooth – "Fight bite"</u>

- Tooth penetrates skin/joint/tendon-sheath/periosteum
- More common in adult males & boys
- Dorsal aspect hand
  - 3rd/4th MCP joint common location
  - Tendon laceration
  - Joint Capsule violated
  - Delayed presentation – grossly infected
- Surgical emergency w/ or w/o assoc. fracture
  - IV ABX
  - Tetanus
  - Hepatitis/HIV ?

Kennedy SA, Human and Other Mammalian Bite Injuries of the Hand: Evaluation and Management; JAAOS January 2015

METACARPAL FRACTURES

Metacarpal Shaft FX

- Minimal displacement
- NO malrotation
- <5mm shortening
- 10 degrees coronal angulation any MC
- Index & Long Fingers
  - 0 degrees sagittal angulation
- Ring & Small Fingers
  - 20 & 30 degrees sagittal angulation respectively

Nelson, Wongworawat: Tolerances, 3rd edition 2009

Wieschhoff GG, Sheehan SE, Wortman JR, et al, Traumatic Finger Injuries: What the Orthopaedic Surgeon Wants to Know, RNSA 2016;36(4):1106-1128

X-rays courtesy Tom Gocke PA-C Library

METACARPAL SHAFT FRACTURE

Metacarpal Shaft fx – Non-operative Treatment

- Nondisplaced metacarpal Shaft fractures
  - Transverse
  - Oblique ??
- Displaced fx with closed reduction and acceptable alignment
- Stable fx pattern pre & post reduction
- Minimal shortening metacarpal (cosmetic)
- NO malrotation

X-ray Image courtesy Tom Gocke, PA-C Library

Wieschhoff GG, Sheehan SE, Wortman JR, et al, Traumatic Finger Injuries: What the Orthopaedic Surgeon Wants to Know, RNSA 2016;36(4):1106-1128

Oetgen ME, Dodds SD. Non-operative treatment of common finger injuries. *Curr Rev Musculoskelet Med*. 2008;1(2):97–102. doi:10.1007/s12178-007-9014-

Oak N, Lawton JN, Intra-Articular Fractures of the Hand, Hand Clinic, 2013;29:535-549

METACARPAL SHAFT FRACTURE

Pictures courtesy T Gocke, PA-C

CASCADE SIGN

- Normal

Photo courtesy TGocke, PA-C

- Abnormal

Photo courtesy TGocke, PA-C

METACARPAL BASE FRACTURES

Metacarpal Base fx –

- Extra-articular: Tx like MC Shaft
- Intra-articular: Tx based on malalignment
  - Malalignment Leads premature OA, weak grip & poor ROM
  - More Ulnar MC's allow for more ROM @ CMC jts. Leading to more noticeable malalignment
- Exam
  - Assess for Rotational deformities & weakness
  - Review X-ray studies
    - If Intra-articular or appear comminuted with ? Intra-articular extension need CT scan

X-ray Image courtesy Tom Gocke, PA-C Library

Oak N, Lawton JN, Intra-Articular Fractures of the Hand, Hand Clinic, 2013;29:535-549

METACARPAL BASE FRACTURE

- Initial Treatment
  - Recognize injury seen on x-ray
  - Assessment for malrotation deformities & grip strength changes (hand dynamometer)
  - Application Ulnar/Radial gutter splint intrinsic plus position
  - Volar /dorsal blocking splint
  - Consider CT Scan hand
  - Ortho Hand/Plastics Hand follow up within <1 week of CT scan being done
  - Surgery vs. Thermoplastic splint/Cast immobilization
    - Needs close follow up if treated conservatively

Bernstein D, Metacarpal Base Fractures – Surgical vs. Conservative care, November 1, 2019 – Personal conversation

Oak N, Lawton JN, Intra-Articular Fractures of the Hand, Hand Clinic, 2013;29:535-549

METACARPAL BASE FRACTURE

FINGER FX & DISLOCATIONS

PHALANGEAL FRACTURES

Epidemiology

- Most common fracture to the hand – 50%
- Finger phalanx divided into:
  - Proximal (P1) – Middle (P2) – Distal (P3)
- Common Injury Mechanism: Axial load & Crush injury
- Injury involves Tuft-Shaft-Base
- Fx pattern: Transverse or Longitudinal
- Distal Fingertip anatomy
  - Numerous septa extend from periosteum to skin
  - Overlying nail bed
  - 50% nail Bed extends beyond P3
  - Less likely to dislocate DIP jt. due to fingertip anatomy

Wieschhoff GG, Sheehan SE, Wortman JR, Traumatic Finger Injuries: What the Orthopaedic Surgeon Wants to Know, RNSA 2016;36(4):1106-1128

PHALANGEAL FRACTURES

Treatment: Distal phalanx

- Non-operative
  - Extra-articular
  - < 10 degrees angulation
  - <2mm shortening
  - No Rotational deformity
    - Dorsal Finger splint DIP joint vs. Stack Splint
      - Swelling may limit stack splint use initially
      - Monitor for Nail matrix & nail bed laceration

Nelson S, Wongworawat M, Tolerances: an orthopaedic reference manual, 3rd edition, Loma Linda University Press, Loma Linda, CA. 2009

Wieschhoff GG, Sheehan SE, Wortman JR, Traumatic Finger Injuries: What the Orthopaedic Surgeon Wants to Know, RNSA 2016;36(4):1106-1128

PHALANX FX

Shaft Fractures

- Transverse w/o displacement considered to be stable fx can immobilize w/a splint
- Oblique & Spiral: often unstable fx patterns and require surgery
- Intra-articular fx: most displaced & require ORIF (same as P2 injury)

Base fractures

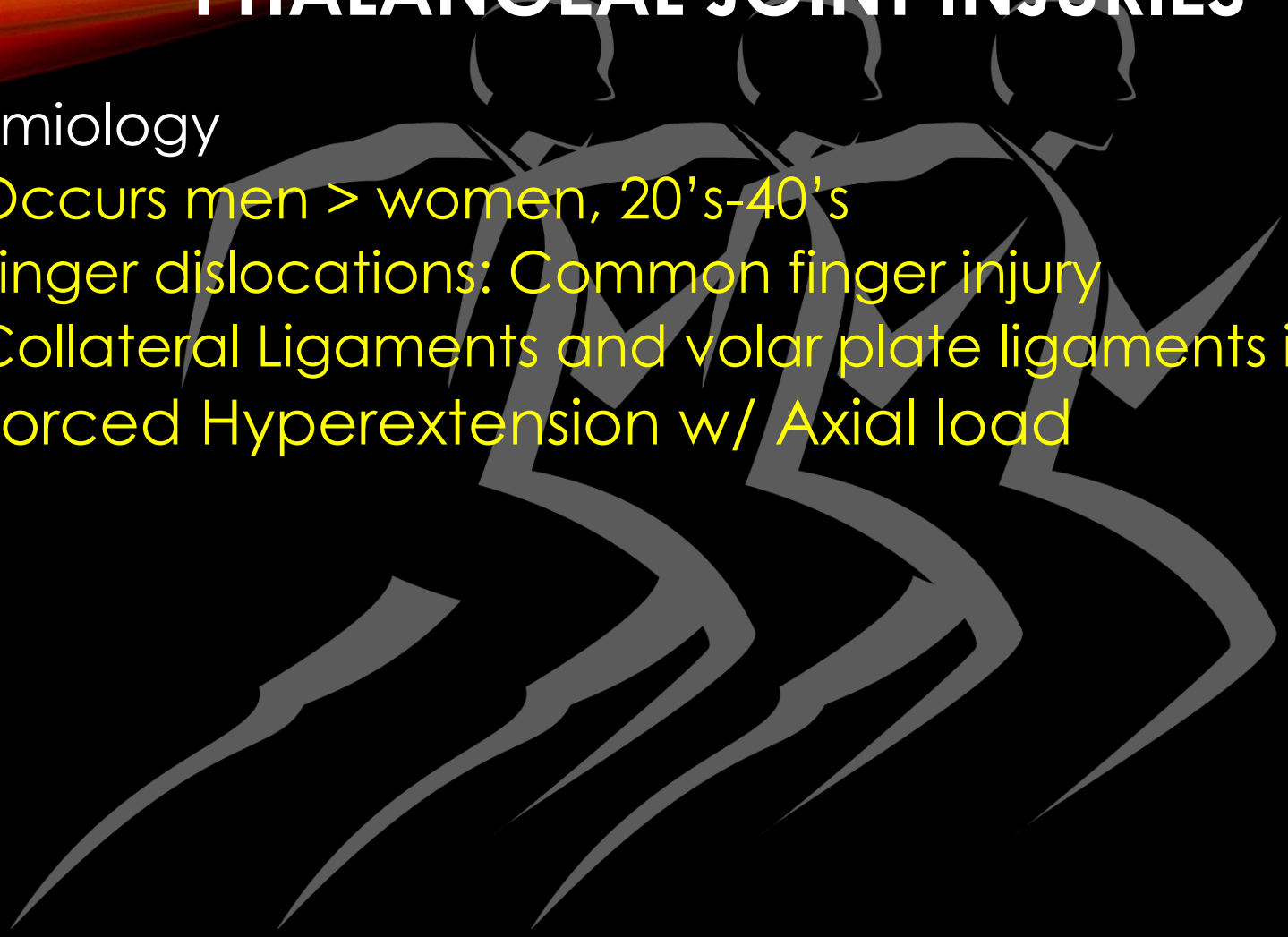
- Often need surgery 2nd to poor ability to maintain fx reduction if displaced

Immobilize in extension

Pain meds

F/U 1 week

PHALANGEAL JOINT INJURIES



Epidemiology

- Occurs men > women, 20's-40's
- Finger dislocations: Common finger injury
- Collateral Ligaments and volar plate ligaments injured
- Forced Hyperextension w/ Axial load

Wieschhoff GG, Sheehan SE, Wortman JR, Traumatic Finger Injuries: What the Orthopaedic Surgeon Wants to Know, RNSA 2016;36(4):1106-1128

FINGER DISLOCATION

Dorsally displaced PIP joint dislocation

- **Best to have pre & post reduction x-rays**
- PA View:
  - Double shadow P2 over P1
  - Appears normal alignment
- Lateral View:
  - P2 dorsally displaced @ PIP joint
  - Finger shortened 2nd to pull lumbricals and flexor/extensor tendons
  - Gross dorsal deformity on clinical exam

Oaks N, Lawton JN, Intra-articular Fractures of the Hand,Hand Clinic 2013;29:535-549

Helms CA, Fundamentals of Musculoskeletal Radiology, Fifth Edition, Elsevier, Phila., PA, 2020

Pictures courtesy T Gocke, PA-C

FINGER DISLOCATIONS

Treatment Dorsal Finger PIP joint dislocation

- Usually, closed Reduction with Longitudinal traction and recreate injury mechanism
- Unreducible fx 2nd to:
  - Interposed Volar plate ligament
  - Time from dislocation to reduction- joint stiffness & soft-tissue contraction
- Fx-dislocation w/ > 40% articular surface involved needs surgery to stabilize fragment.

Ahn L, Blomberg B Dislocated Phalanx OrthoBullets 2019

LOWER EXTREMITY FRACTURES

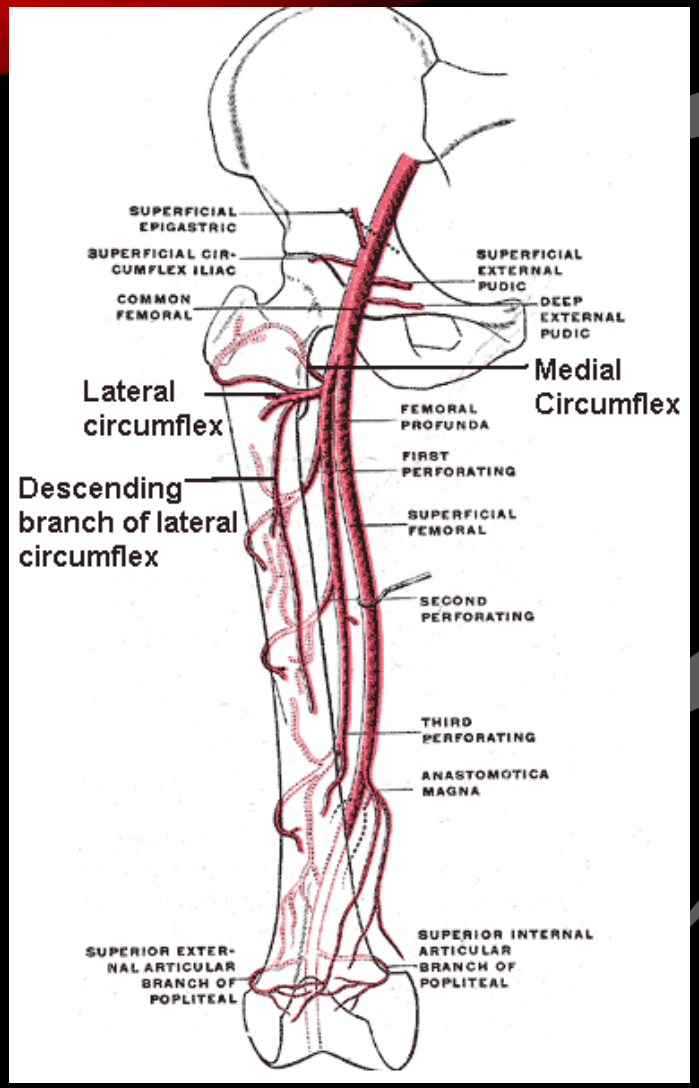
FEMUR FX

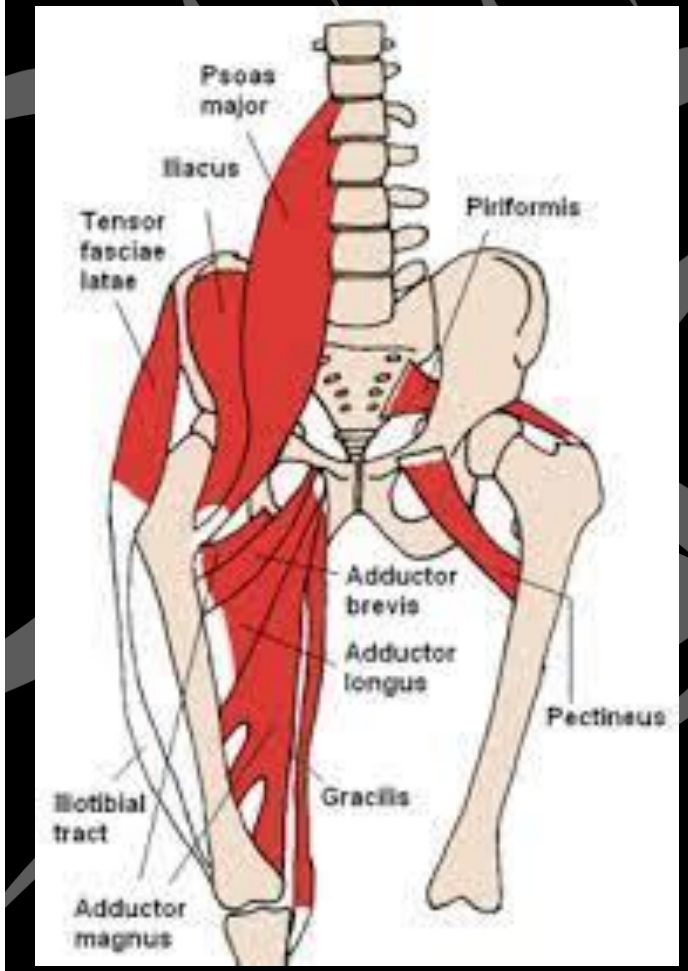
--HIP

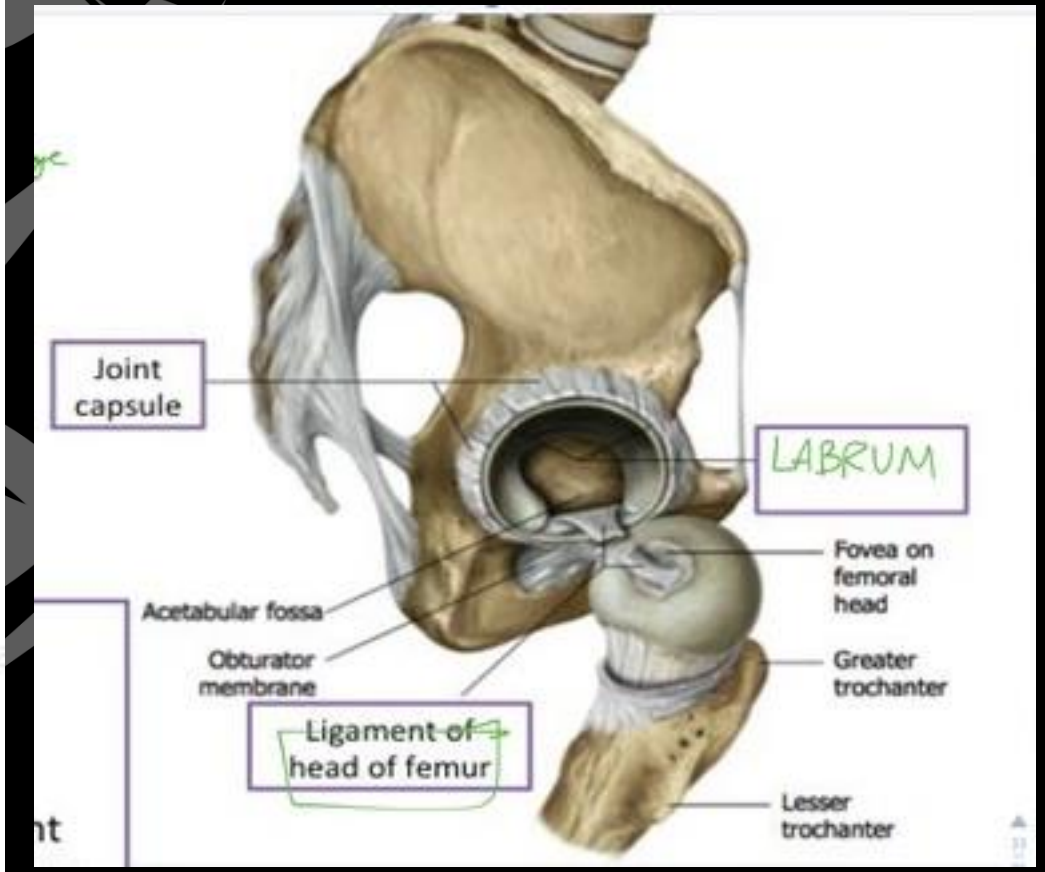
--SHAFT

--DISTAL

HIP ANAT5OMY

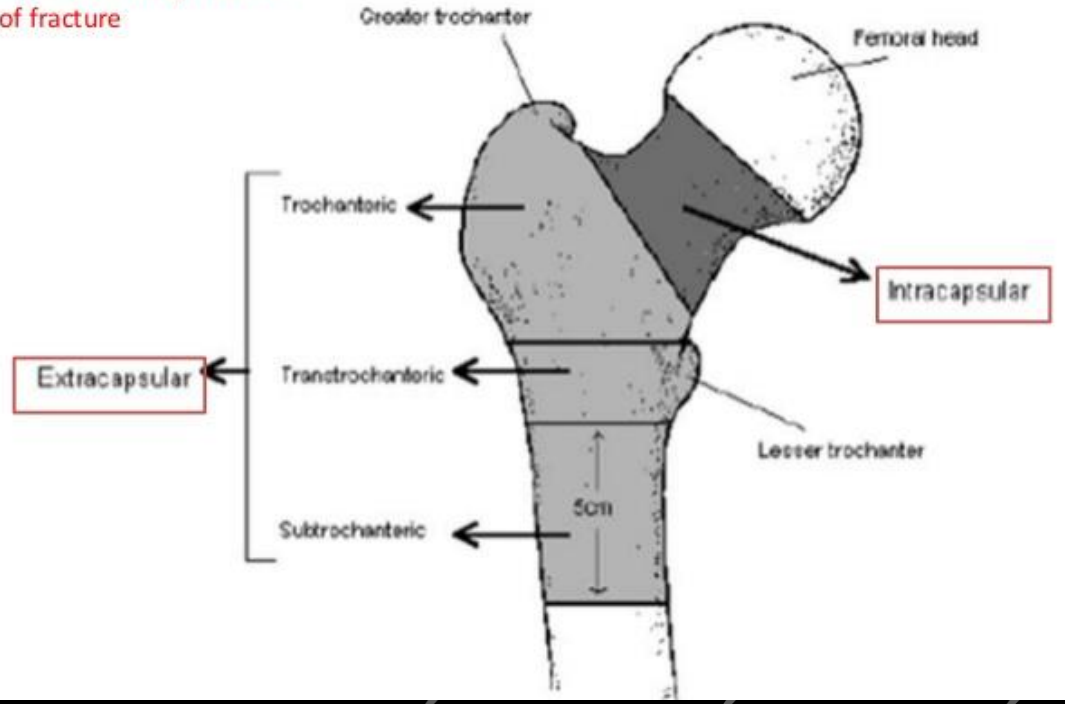


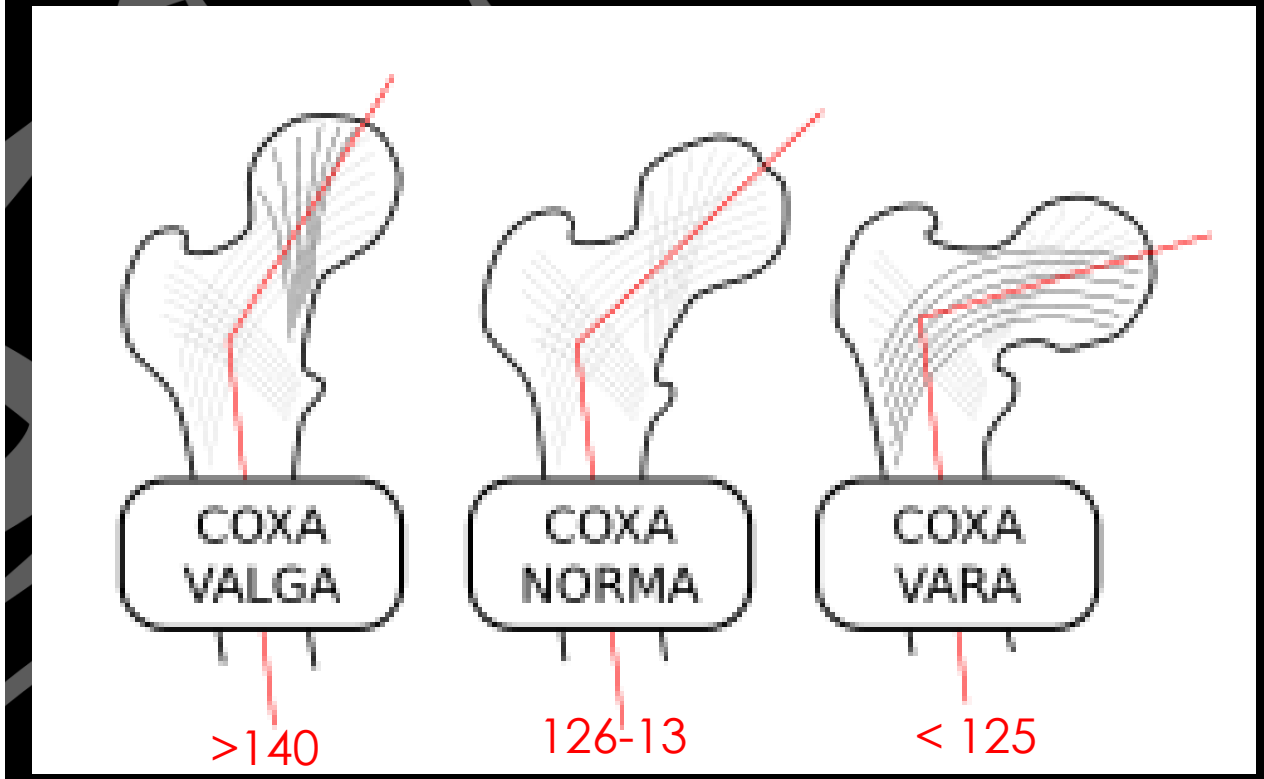


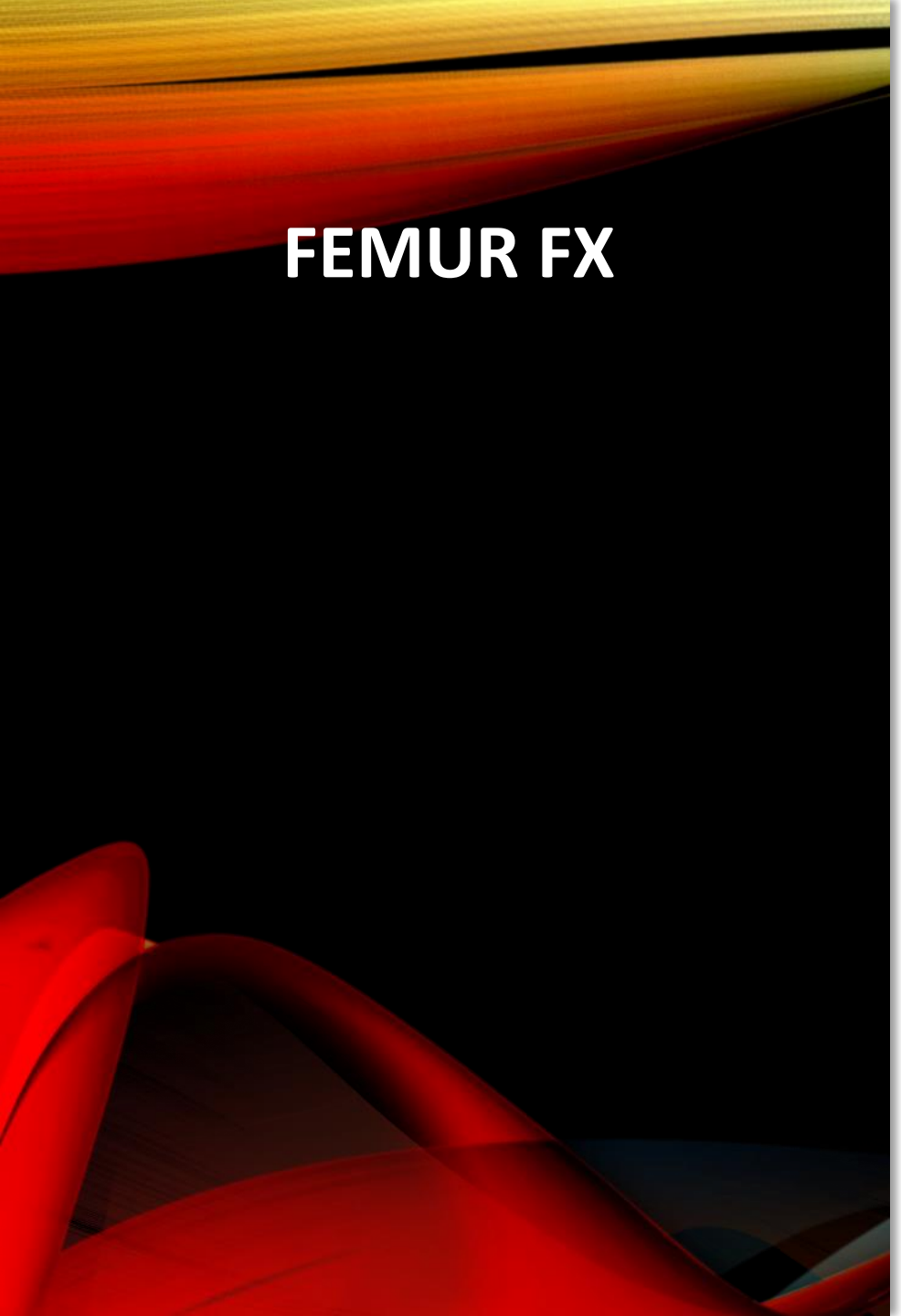


CLASSIFICATION of FEMUR FRACTURE

*based on area/location of fracture







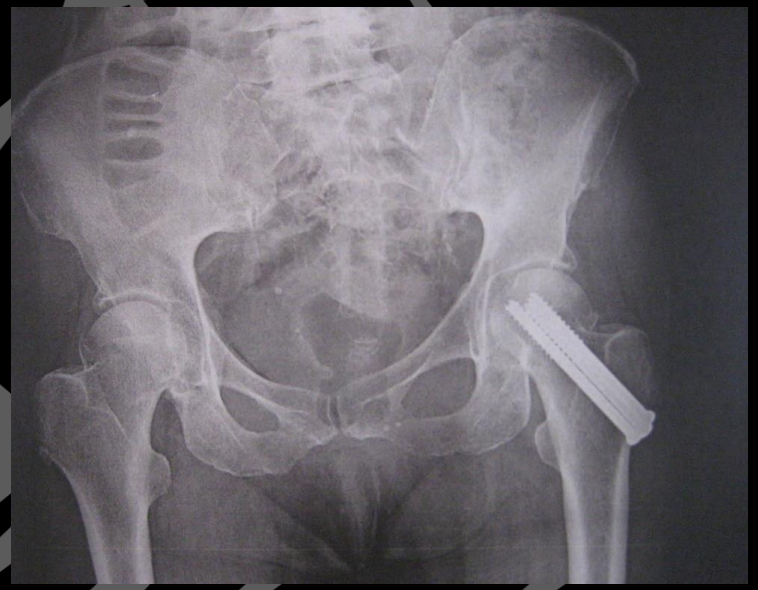
FEMUR FX

- Traumatic vs Insidious onset
- Associated Trauma
- Overall Medical status
- Comprehensive Exam
- Imaging
  - Pelvis
  - Hip
  - Femur
  - Spine?
- Osteoporosis Work-up

SUBCAPITAL FEMORAL NECK FX

Epidemiology

- Increasingly common with aging population
- Female-white-elderly-osteoporosis
- High energy-young; low energy –elderly
- Neck intracapsular
  - Low blood supply
  - Poor healing potential
- Mortality
  - 25-30% overall
  - Chronic renal failure 45% 2 yrs
  - Decrease mortality if Surgery < 24 hrs
- Treatment
  - Admit & Medical optimization
  - Surgery <24 hrs
  - Mobilize



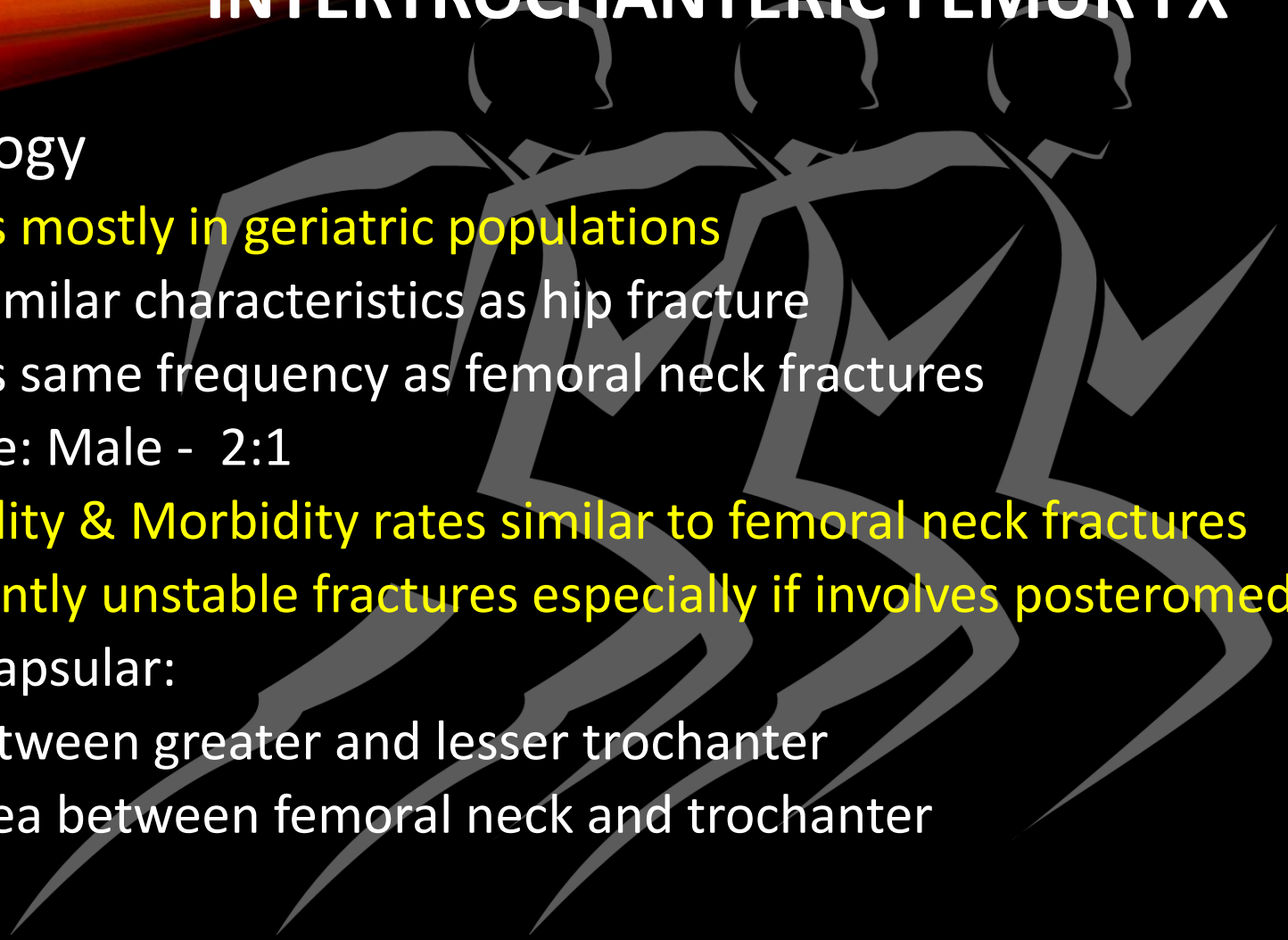
GARDEN CLASSIFICATION

Garden	Garden	Garden	Garden	Garden
Garden Classification:	Garden I: incomplete fracture, valgus impacted	Garden II: non-displaced fracture	Garden III: fracture with partial displacement	Garden IV: fracture with complete displacement

BASICERVICAL FEMORAL NECK FX

- 1.8% of proximal Femur fx
- Base of the femoral neck & Trochanteric region
- Same considerations at Subcapital Femoral Neck Fx
- Operative treatment

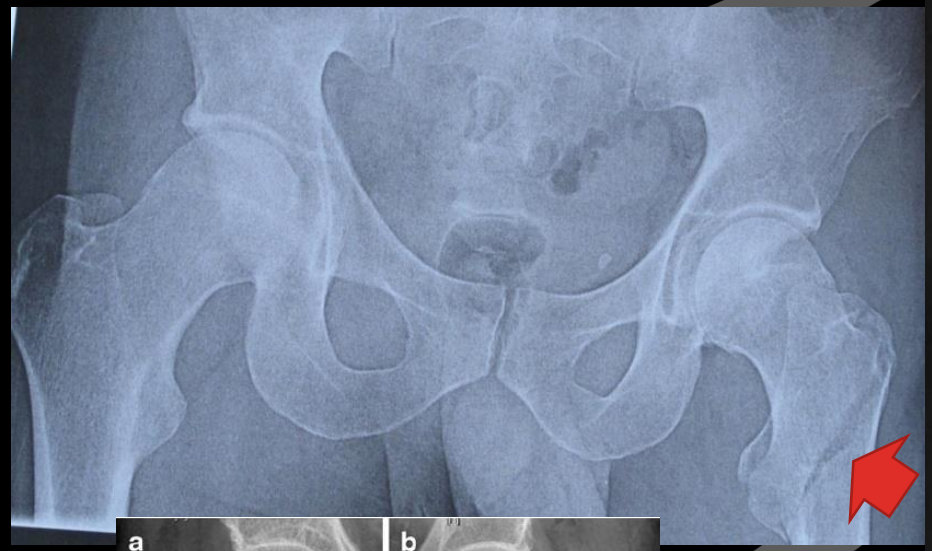
INTERTROCHANTERIC FEMUR FX

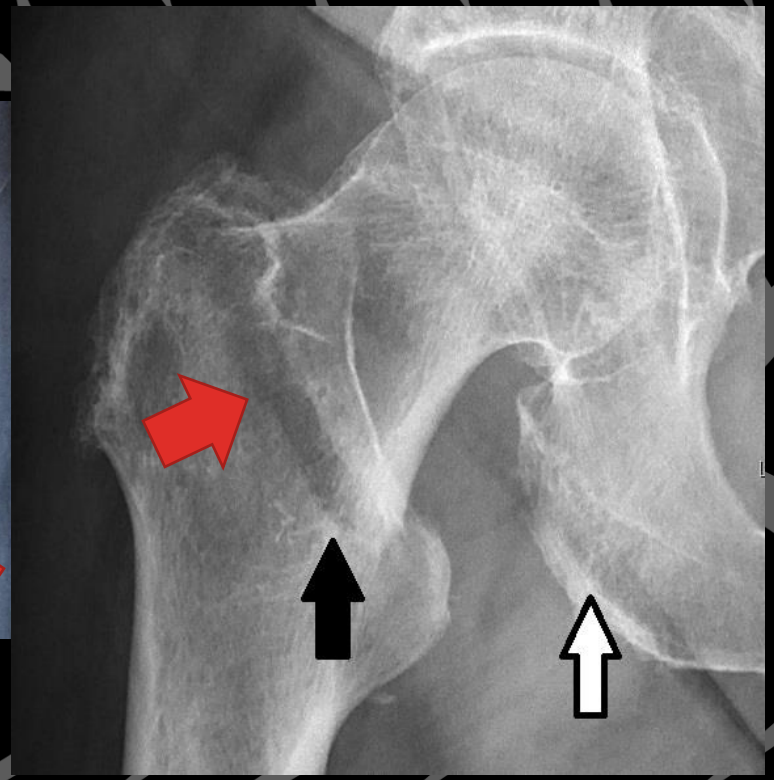


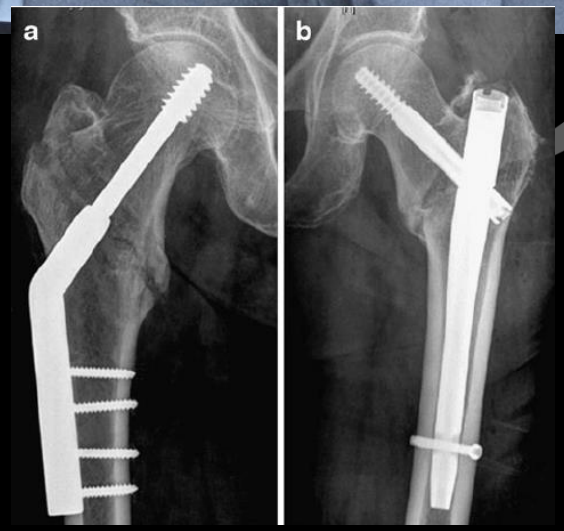
Epidemiology

- Occurs mostly in geriatric populations
- Very similar characteristics as hip fracture
- Occurs same frequency as femoral neck fractures
- Female: Male - 2:1
- Mortality & Morbidity rates similar to femoral neck fractures
- Inherently unstable fractures especially if involves posteromedial cortex
- Extracapsular:
  - Between greater and lesser trochanter
  - Area between femoral neck and trochanter

INTERTROCHANTERIC FEMUR FX



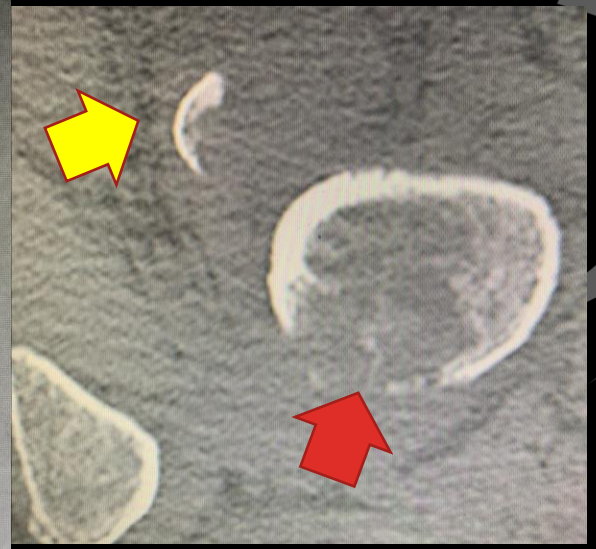




SUB-TROCHANTERIC FX

Isolated Lesser Trochanteric Fx

- Think pathologic fx
- Unusual occurrence
- Needs CT scan



Traumatic Sub Trochanteric fx

- Lesser Troch to 5cm distal
- Trauma/Bisphosphonates
- Deforming forces
  - Illiopsoas
  - ADDuctors
  - Ext. Rotators
- X-ray
  - Traction view/pelvis
  - Femur
- Treatment- Surgery

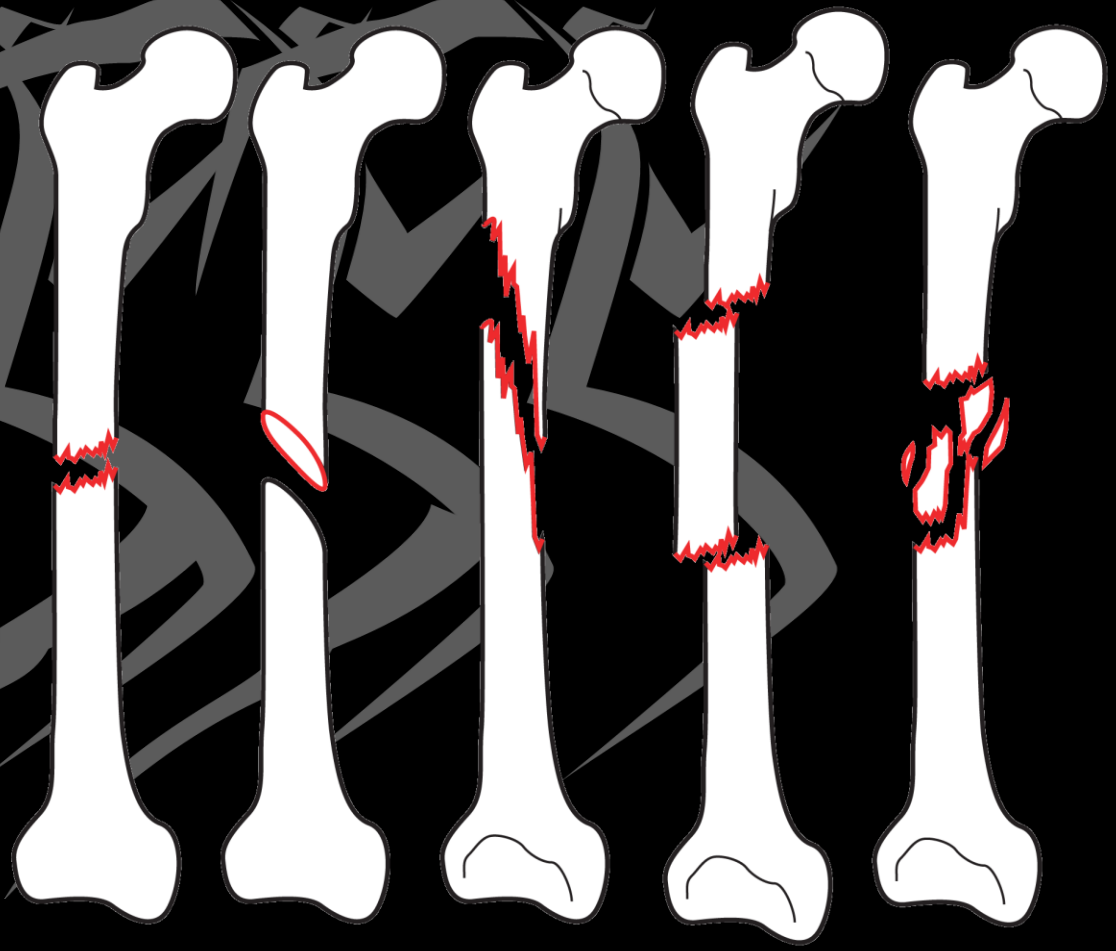
FEMUR SHAFT FX

FEMUR SHAFT FRACTURES

- General
  - Occurs more in young adults
  - High energy
    - MVA/motorcycle
    - Pedestrian vs. auto
    - Fall
    - Gunshot wound (GSW)
  - Stress Fracture
    - Runners or repetitive stress
    - Risk with increasing physical activity
    - Long-term Bisphosphonates use
  - Transverse pattern:
    - Most common femur shaft fracture
  - Fracture may involve total hip arthroplasty (THA) components

FEMUR SHAFT FRACTURES

- Fracture pattern
  - Transverse
  - Oblique
  - Butterfly
  - Segmental
  - Comminuted
- Location
  - Proximal
  - Middle
  - Distal
  - Supracondylar



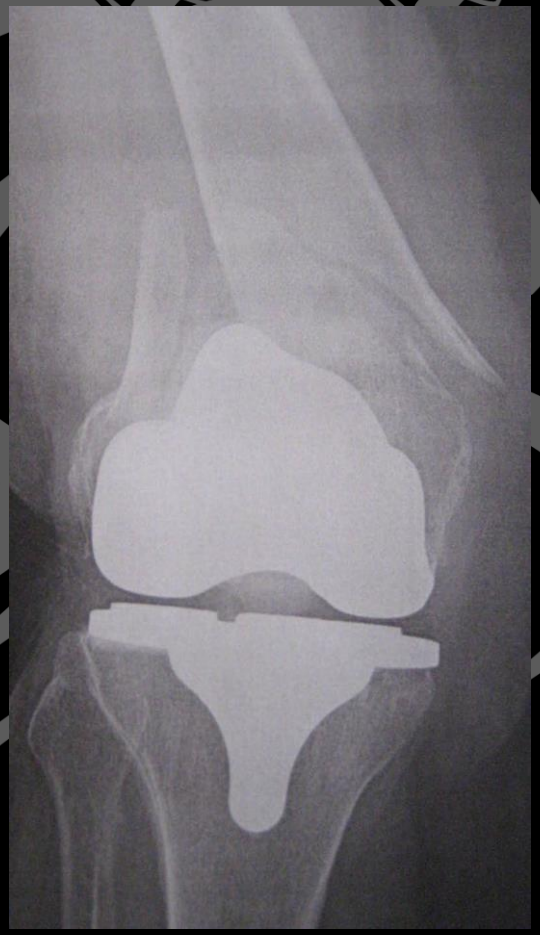
Femur Shaft Fractures

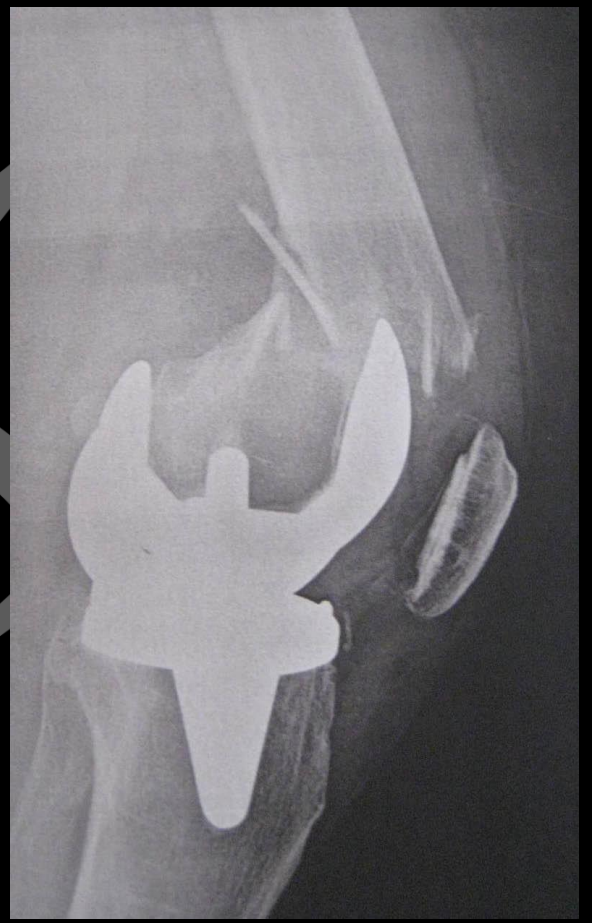
- Treatment:
  - Emergent Treatment:
    - Identify life-threatening injuries
    - Good assessment of neuro and vascular status
    - Check for associated fractures/injuries
    - Check for compartment syndrome thigh
    - Immobilize fracture until surgery
      - Immediate OR: long posterior splint (temporary measure) or traction splint
      - Prolonged OR: skeletal traction

PERIPROSTHESTIC FEMUR FRACTURES

Oblique Fracture

SUPRACONDYLAR FEMUR FRACTURES

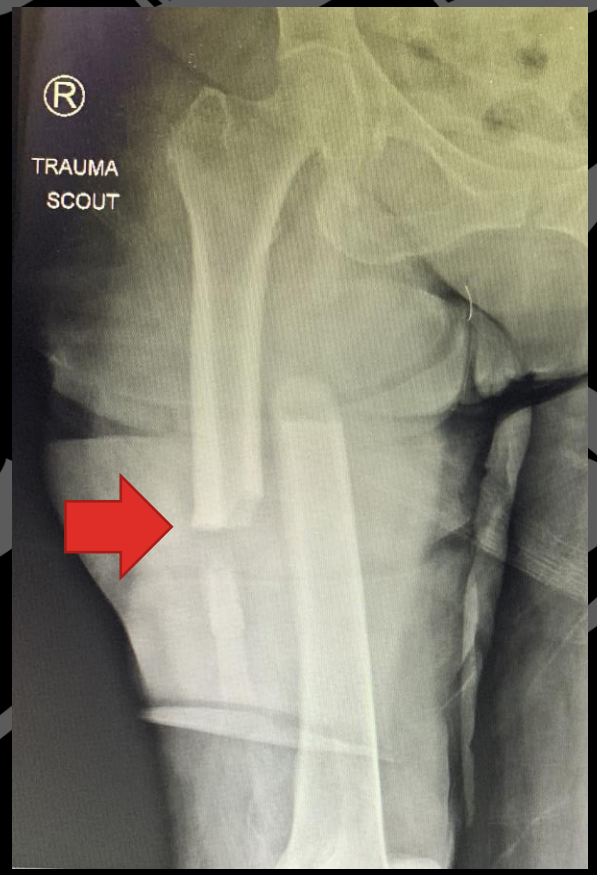


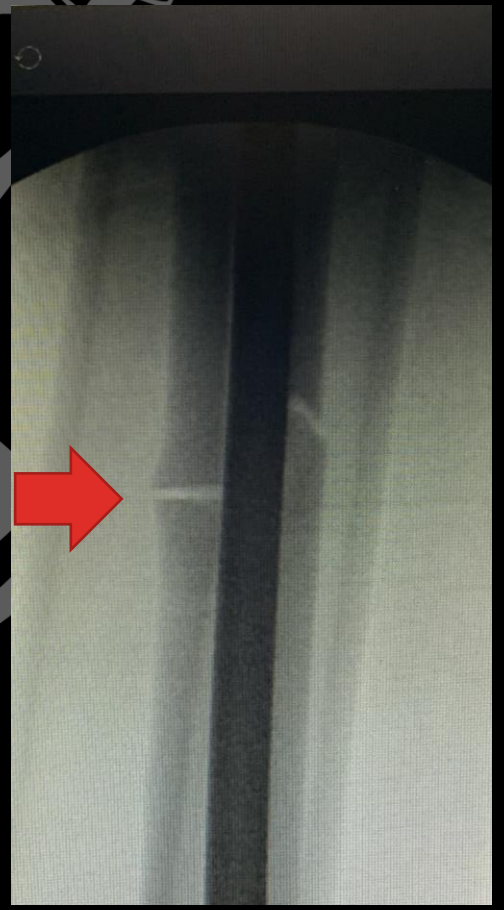


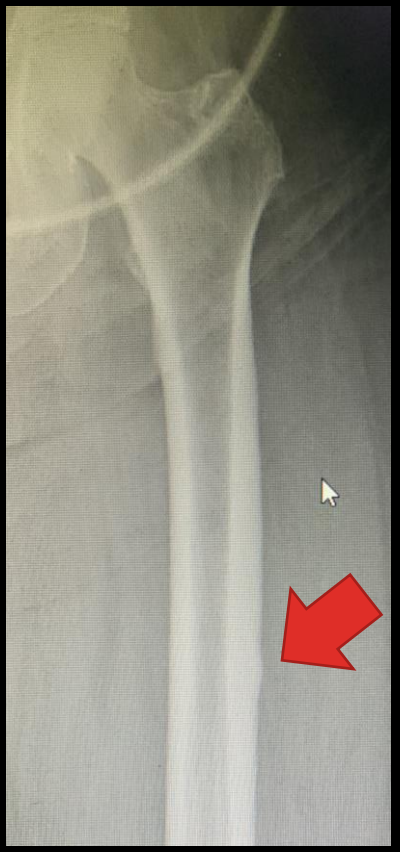
SUB-TROCHANTERIC FX

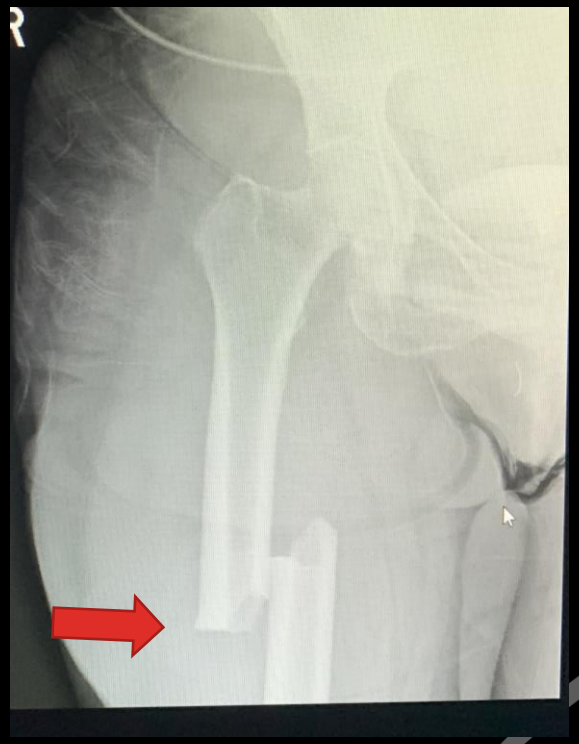
Bisphosphonate related-Fx

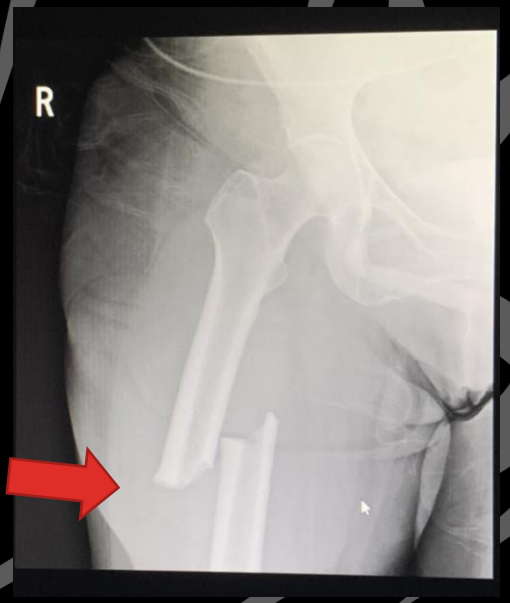
- Treat osteoporosis
- Duration >5 yrs increases risk
- Asian > White
- Shorter, Heavier
- Taking DM meds >1 yr

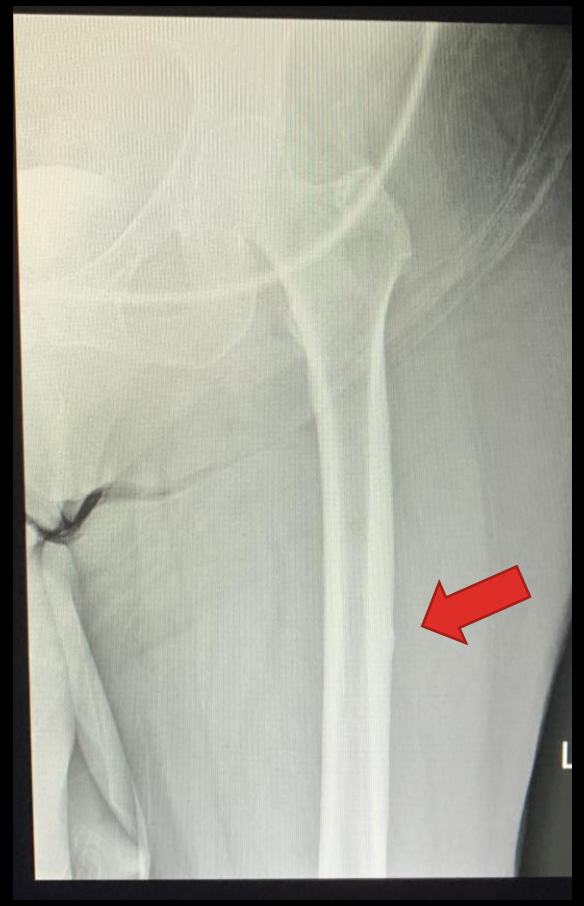












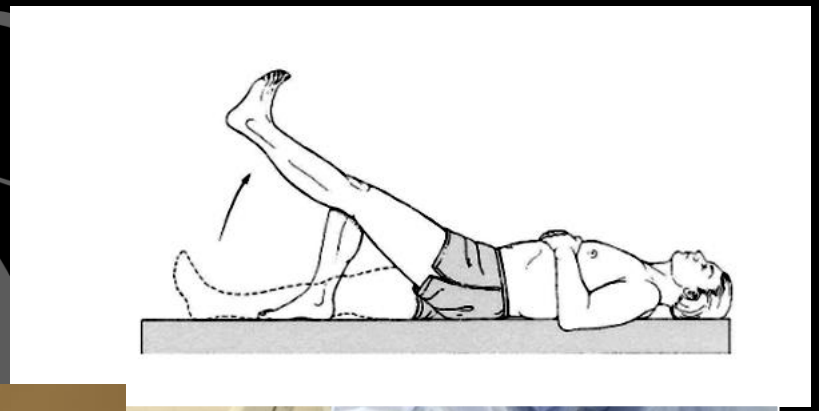
PATELLA FX

PATELLA FX

- Direct blow- primary mechanism of injury
  - High energy: dashboard/MVA is most frequent cause (78.3%)[1]
- Indirect blow-
  - Forceful knee hyperflexion & eccentric quadriceps contraction
    - Example: Jump/fall with patient landing on their feet combined with an eccentric contraction of the quads[3]
  - 35% indirect blow fractures do not disrupt extensor mechanism
- Periprosthetic patella fractures after TKA[4]
    - 0.68% in non-resurfaced patella
    - 21% in resurfaced patella

PATELLA FX

- Visible/ palpable defect between bone fragments
- Hematoma/ hemarthrosis that communicates with joint
- Complete inability to actively extend the knee (likely also correlates with tearing of the medial/ lateral retinaculum)
  - If retinaculum is intact, patient may be able to extend knee with a patella fracture



PATELLA FX

PATELLA FRACTURES

- Sleeve fracture
  - Seen only in pediatric age pts.
  - Osteochondral injury where articular cartilage of patella and tendon separate from patellar body
  - Ossification patella begins between age 3-5 yrs
  - Distal pole patella most common location (superior)
  - Commonly seen kids ages 8-15yrs
    - Peak age 12-13 yrs age
    - Boys 3:1 ratio vs. girls

Image courtesy of pediatricimaging.wikispaces.com

PATELLA FRACTURES

- Bipartite patella
  - Asymptomatic congenital anomaly
  - 8% population
  - 50% bilateral
  - Failure of ossification center to close
  - Often confused with patella fracture
  - Most common in the Superolateral patella
  - No treatment required asymptomatic knee

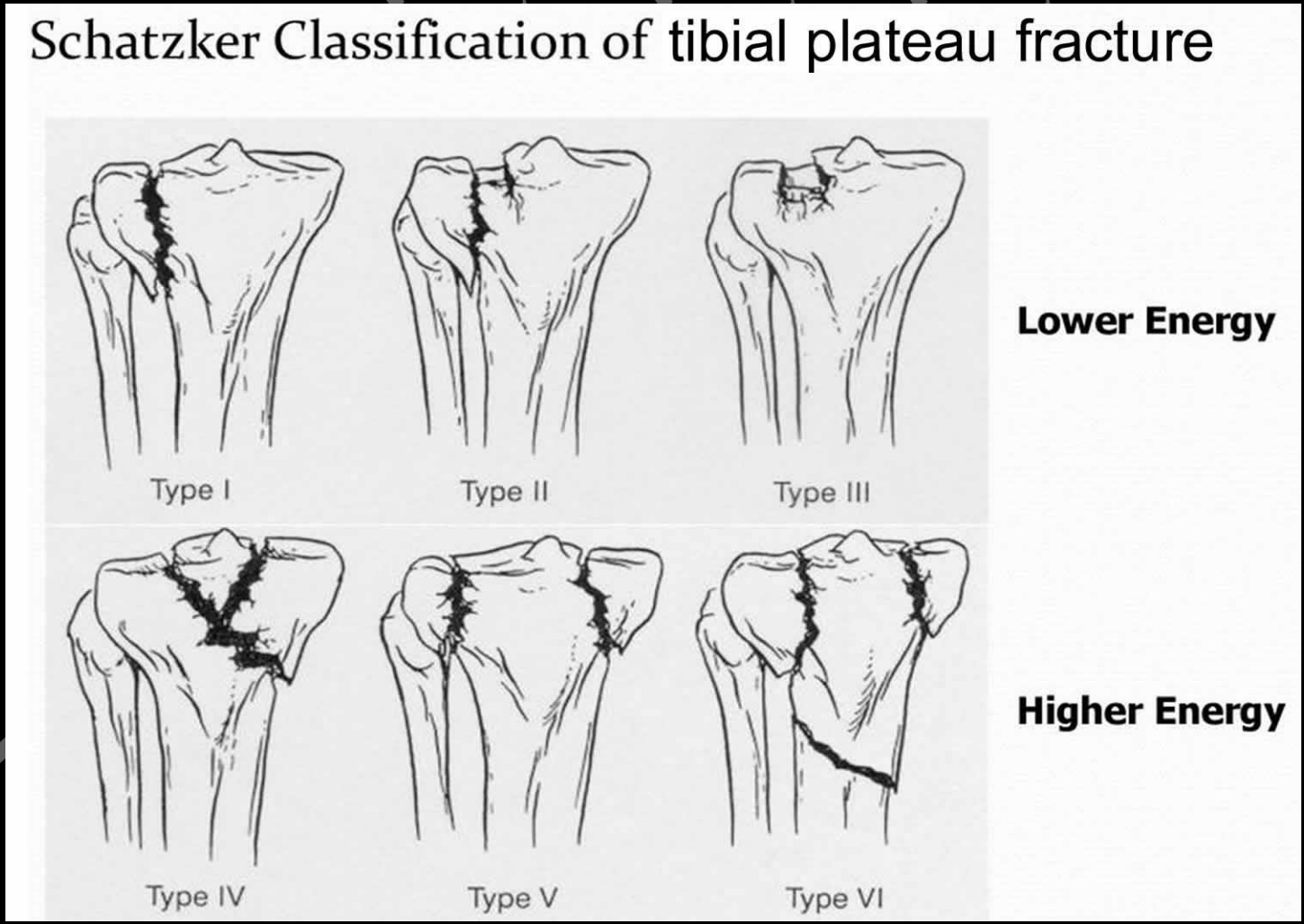
PATELLA FX

TIBIA FX

TIBIAL PLATEAU FRACTURES

- Compartment syndrome major concern
- Common Fracture patterns
  - **Younger age – splitting – high energy**
  - **Older age – depression (impaction) osteoporosis**
- Women > Men 2nd to osteoporosis
- Injuries to cruciate and collateral ligaments of the knee
- **Skin problems common 2nd to thin coverage at proximal tibia**
- Neurovascular injuries
- Surgical Treatment
  - Delayed – Ex-Fix
  - Definitive- ORIF

TIBIAL PLATEAU FX



TIBIAL PLATEAU FX

TIBIAL PLATEAU FX

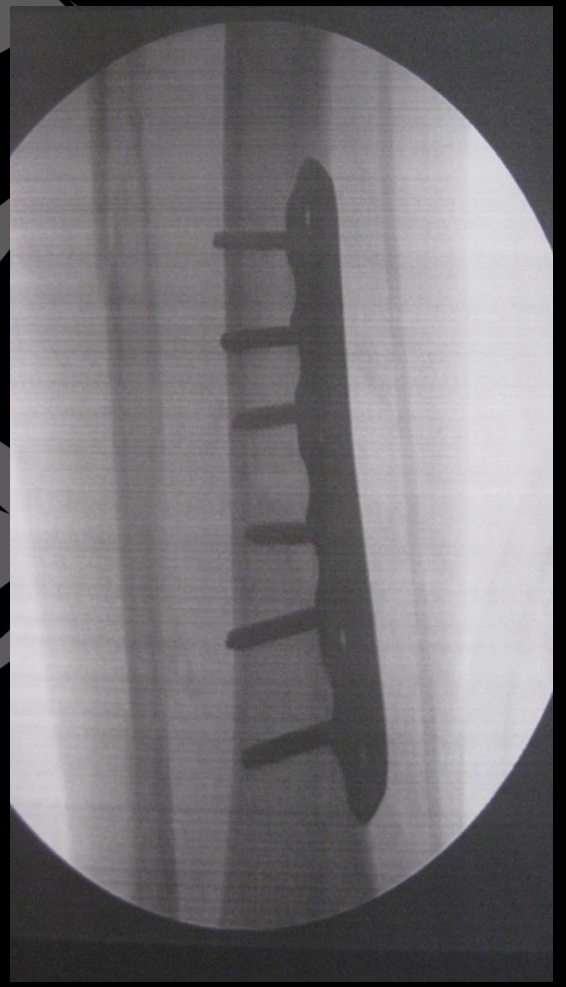
Treatment

- **High energy Tibial Plateau fx Need Ex-Fix**
  - **Restore length and protects tissue**
- Admit & Compartment checks
- Think about knee dislocation
- Vascular Assessment
  - Ankle Brachial Index (ABI)

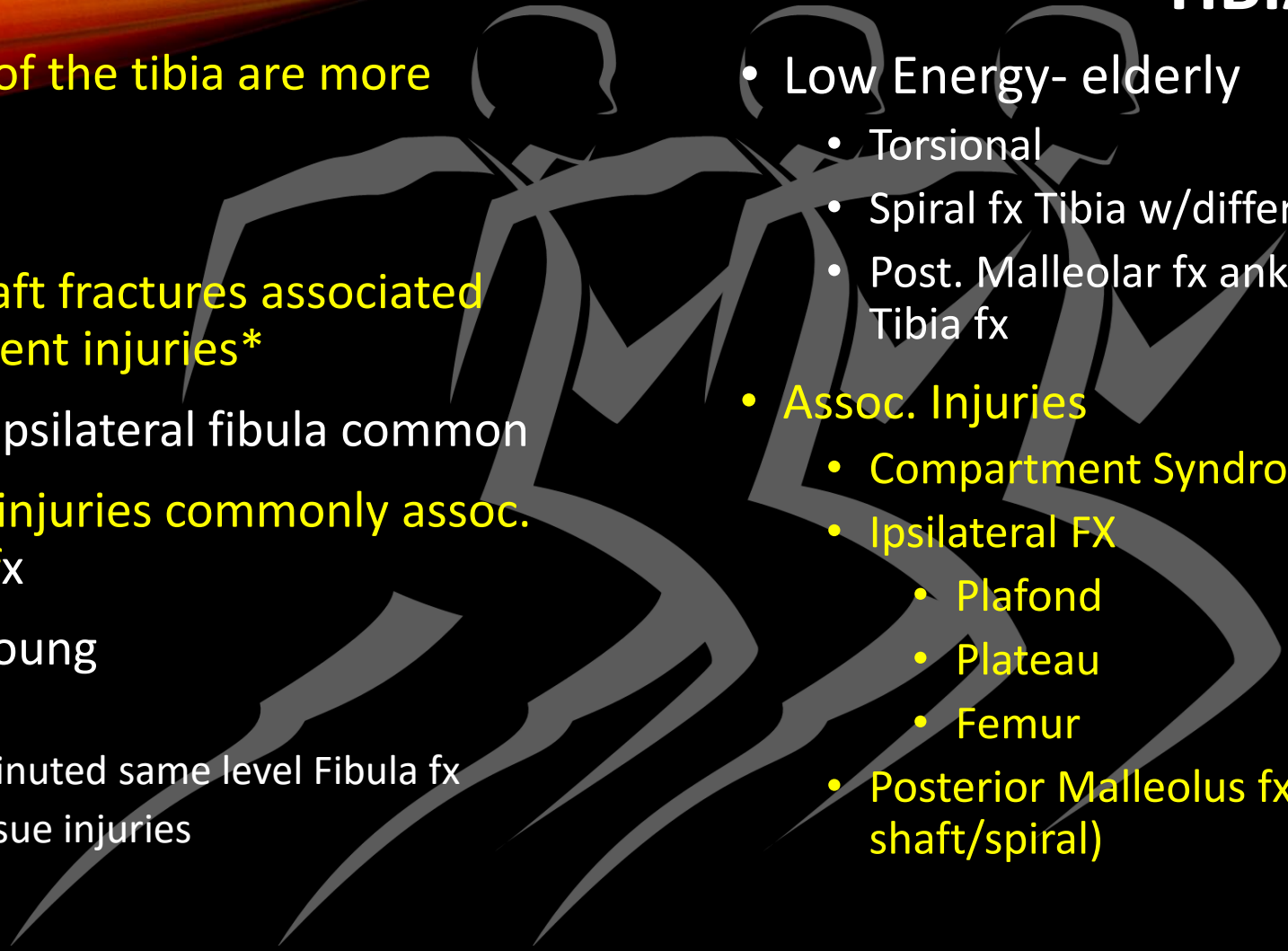
  Systolic BP LE

  Systolic BP UE
  - < 0.9 need CTA
- Delay Definitive fixation 5-10 days
  - Skin

TIBIA SHAFT FRACTURES



TIBIAL SHAFT FX



- Open fractures of the tibia are more common
- M>F
- 25% all Tibia shaft fractures associated with knee ligament injuries*
- Fracture of the ipsilateral fibula common
- Peroneal nerve injuries commonly assoc. W/ Tibial shaft fx
- High energy – young
  - Direct blow
  - Wedge/comminuted same level Fibula fx
  - Severe soft tissue injuries
- Low Energy- elderly
  - Torsional
  - Spiral fx Tibia w/different level Fibular fx
  - Post. Malleolar fx ankle assoc. w/ spiral Tibia fx
- Assoc. Injuries
  - Compartment Syndrome
  - Ipsilateral FX
    - Plafond
    - Plateau
    - Femur
  - Posterior Malleolus fx (distal 1/3 shaft/spiral)

TIBIA SHAFT FX

TIBIA SHAFT FX

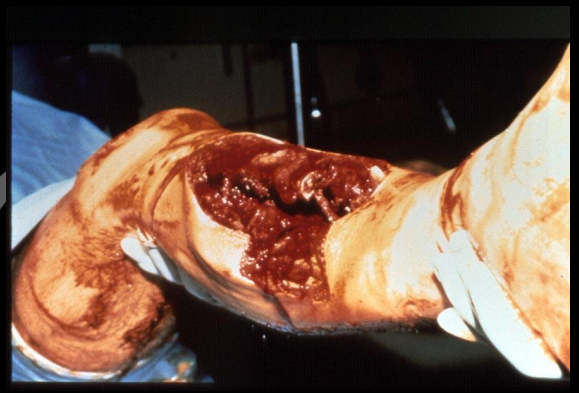
Tibia Shaft Fracture

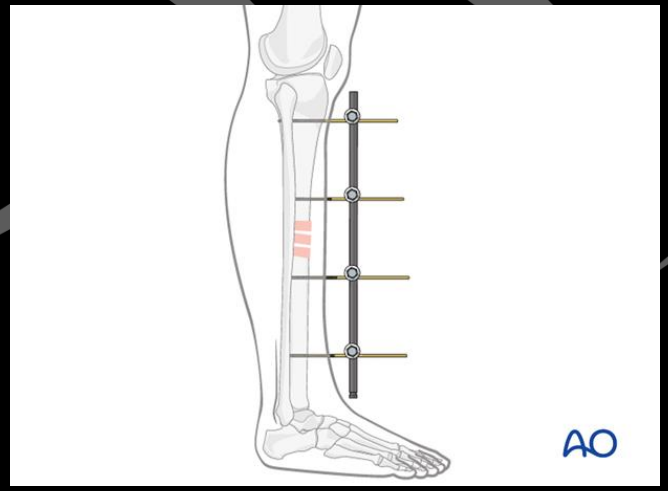
- Priorities:
  - ABC'S- "Man Scan"
  - Stabilize patient
  - Associated Injuries
    - Polytrauma
    - Ipsilateral long bone fractures
    - Neurovascular injuries
  - Tetanus
  - Antibiotics
    - Cephalosporins-Staph/Strep
    - Aminoglycosides- gram negatives
    - PCN-Clostridium (Farm injuries)
  - Wound Care- saline gauze
  - Immobilization- splint till OR

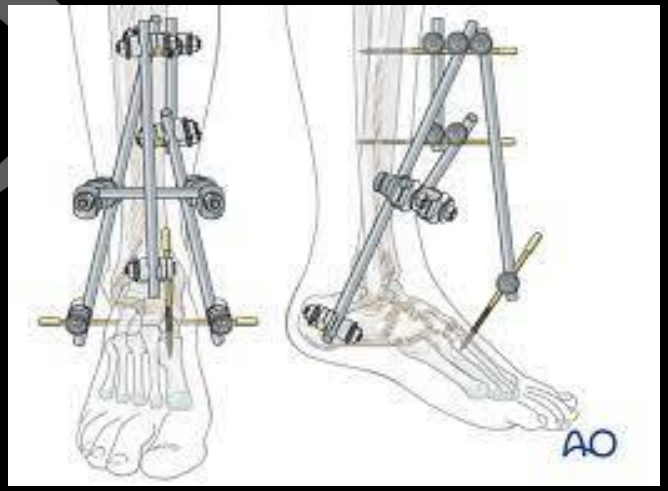
TIBIA SHAFT FX

Immobilization

- "Water Ski" position
  - Low Leg & Sugar-tong
    - Mid-shaft/Distal
  - Long leg
    - Proximal
- Compartment checks
- Soft-tissue injury
- Neurovascular checks
- Admit/Observation
- Open Fx/High Energy
  - OR for Irrigation
  - Ex Fix
  - Protect skin







TIBIAL PLAFOND FRACTURES

TIBIAL PLAFOND FX

- **Plafond**: anatomic location on the distal tibia
- **Pilon (**Pylon): describes force of injury
  - Most times used interchangeably
  - Described as any distal tibia fx extending into articular surface vs. comminuted fx of the tibial plafond
- Male > Female
- Increased incidence of pilon fx 2nd to higher survival rates from MVA
- ¼ all pilon fx open
- Increased soft-tissue trauma assoc. with pilon fractures
- Fracture blisters commonly associated with pilon fx
- Fibula fx commonly seen with pilon fx

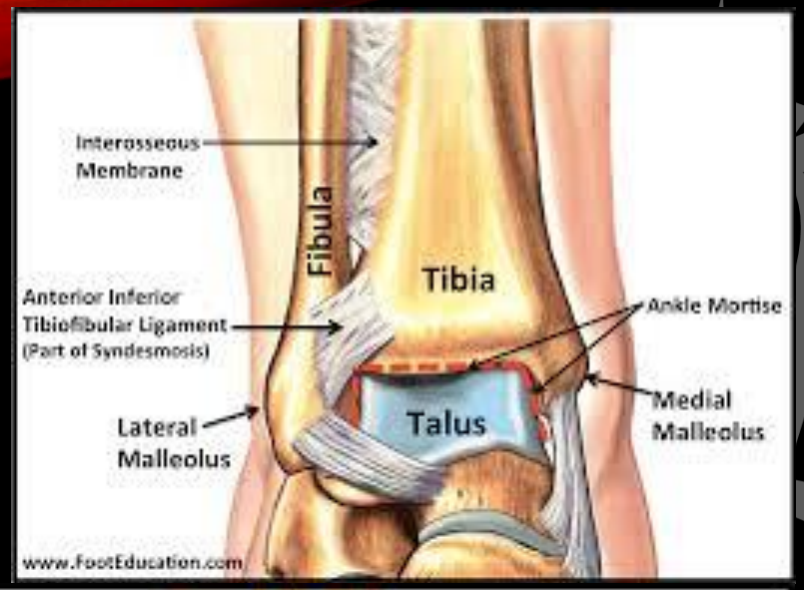
TIBIAL PLAFOND FX

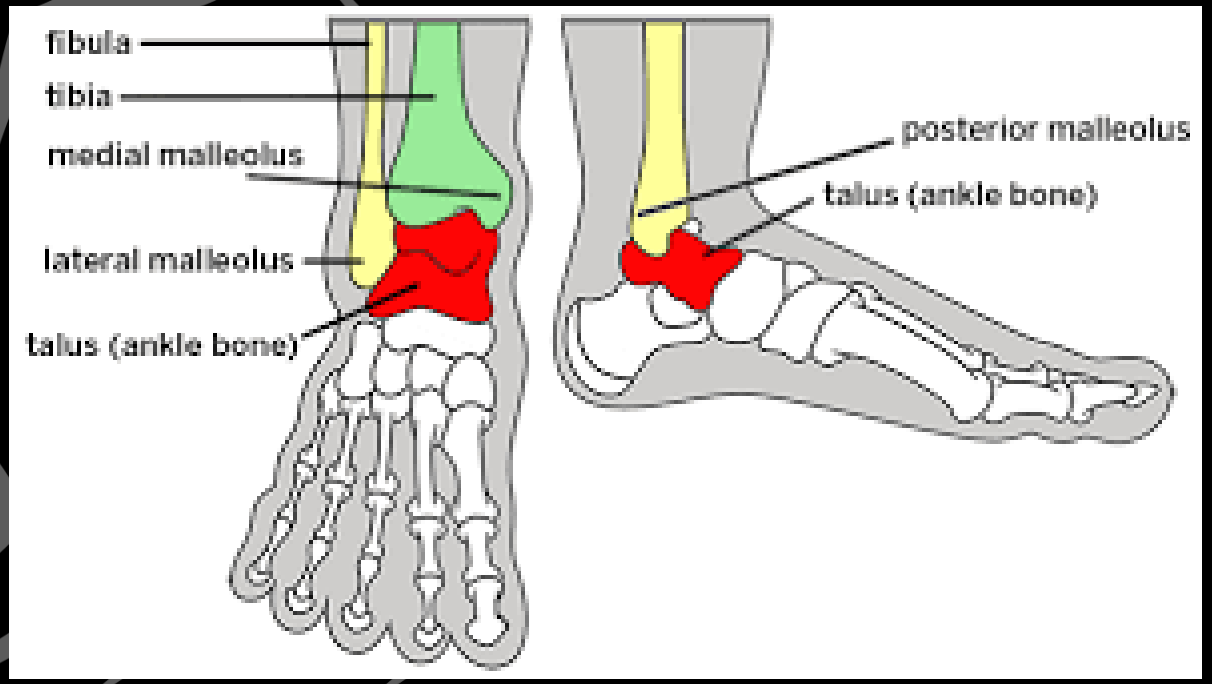
TIBIAL PLAFOND FX

- 25% open fx
  - Gustillio- soft-tissue injury
  - “Man Scan”
- Assoc. Injuries
  - Compartment syndrome
  - L spine compression fx
  - Calcaneous- Plateau-Hip-Pelvis
- Open fx protocol
  - Admit
  - Tetanus
  - ABX coverage
  - Wound care
  - Immobilize
    - Splint
    - Ex-Fix

ANKLE FX

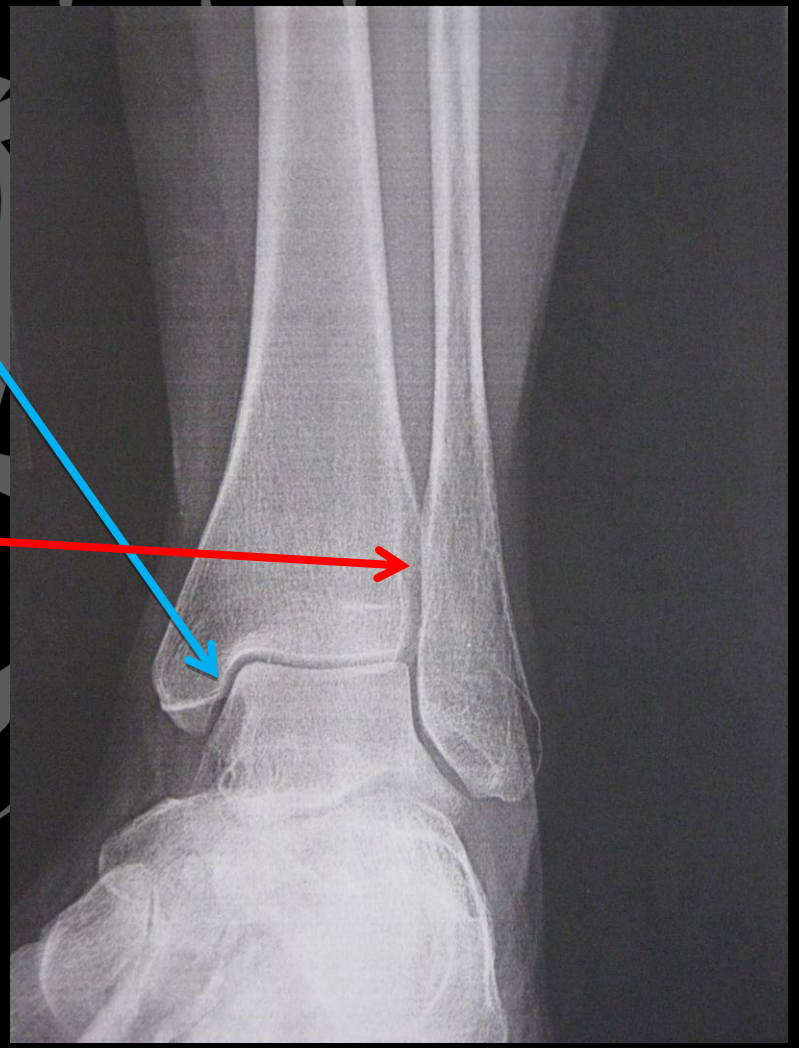
ANKLE ANATOMY





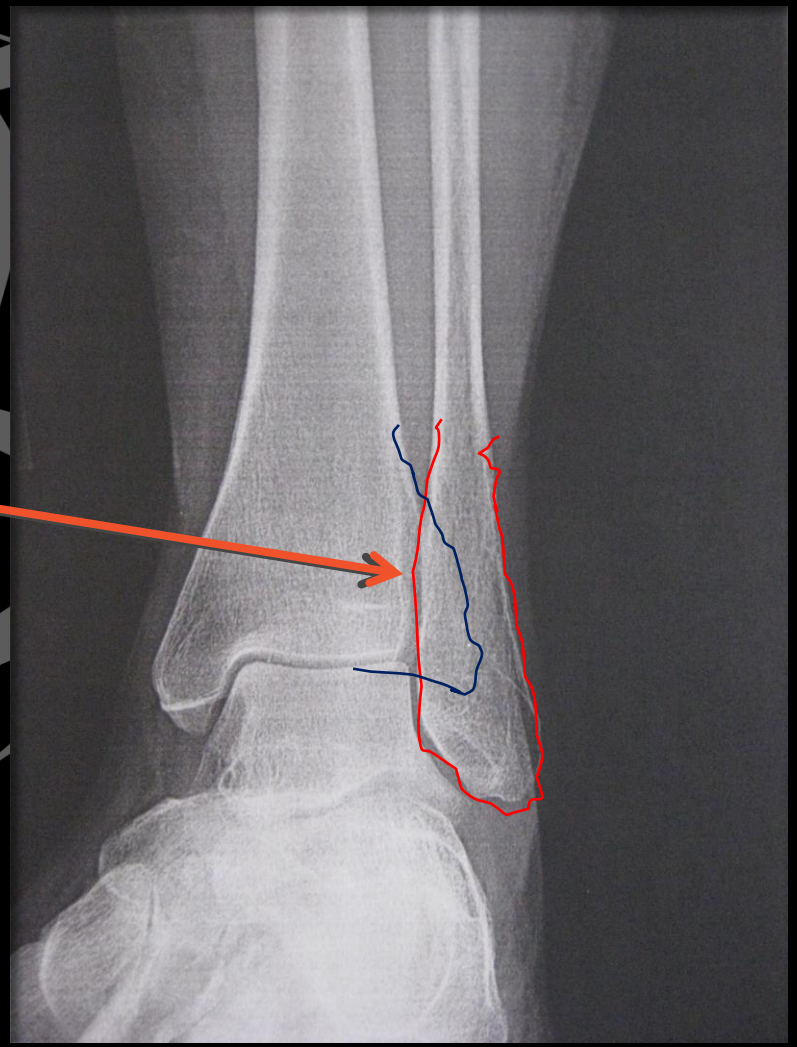
RADIOGRAPHS

- Ankle (medial) clear space
  - Normal range <4 mm between tibia
- Tibiofibular clear space
  - Normal range <5 mm between tibia & fibula



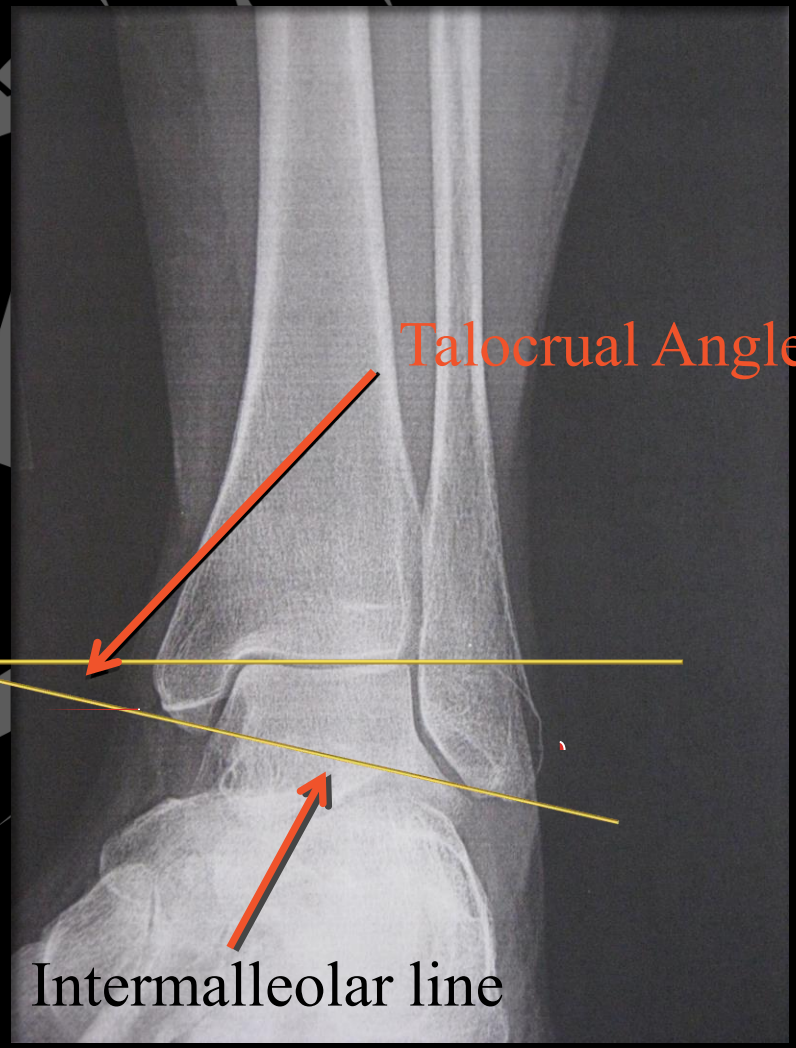
RADIOGRAPHS

- Tibiofibular overlap
  - Normal range >8-10 mm between tibia & fibula
  - Fibular notch



RADIOGRAPHS

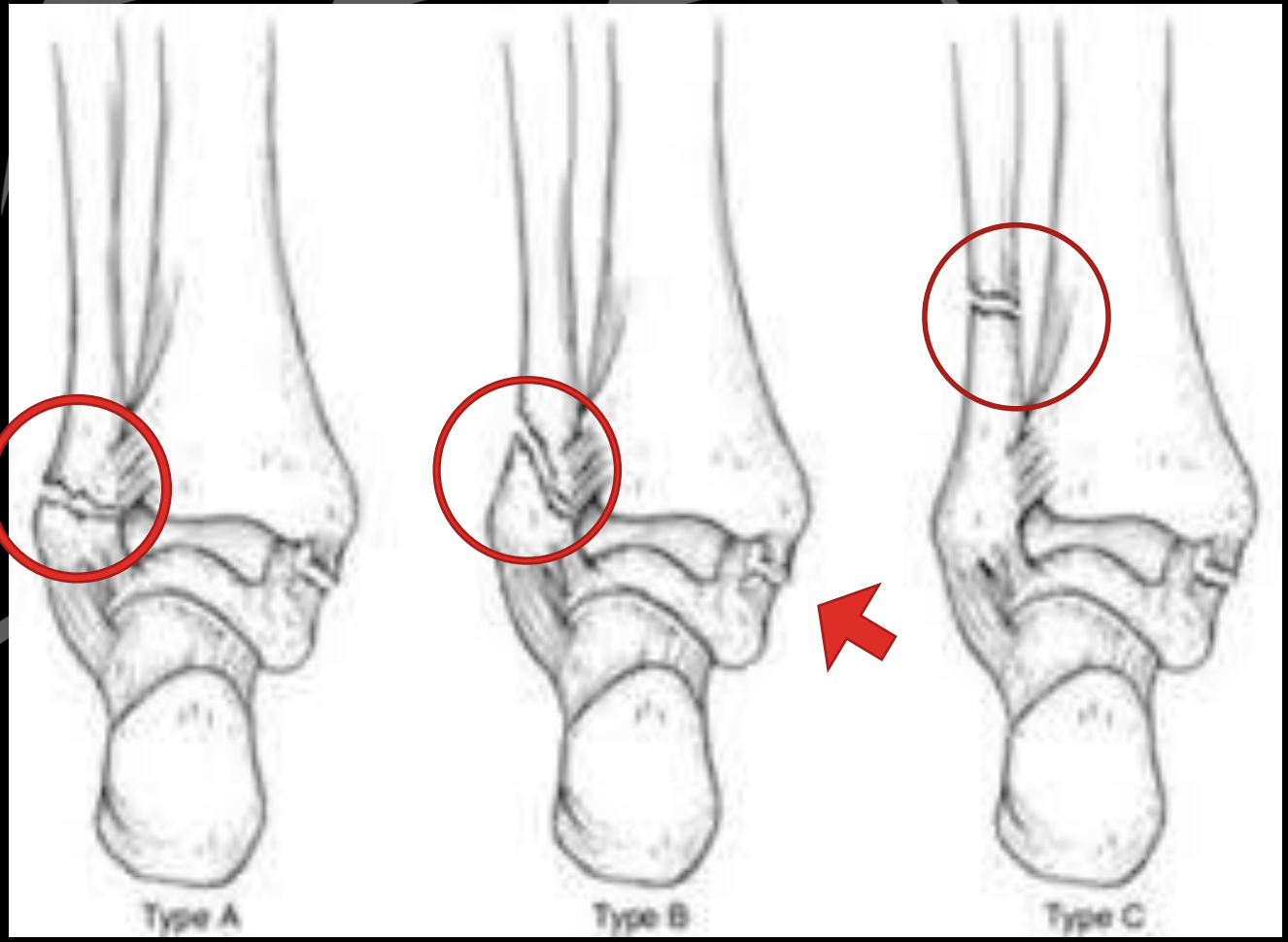
- Talocrual Angle
  - Normal measurement 8-15 degrees
  - Strong indicator of syndesmosis disruption, because the fibula will be shortened and externally rotated
  - Talocrual Angle should be compared to the contralateral normal side



ANKLE X-RAY

ANKLE FX

WEBER Classification

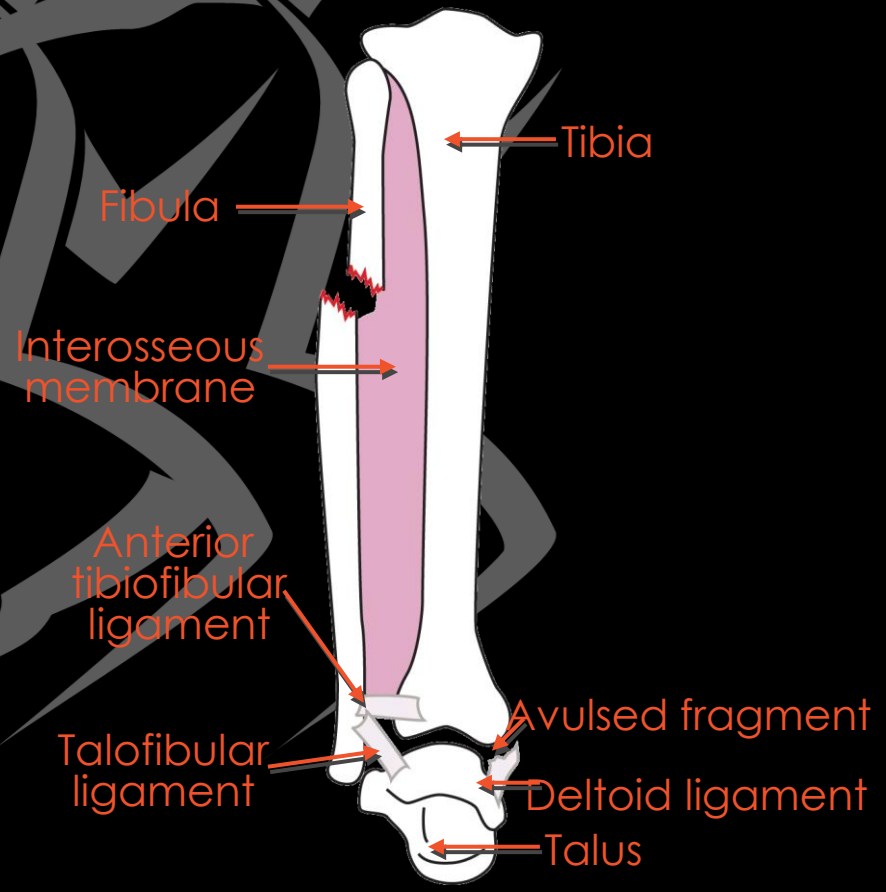


ANKLE FX

- Unimalleolar Fx – 68%
  - Isolated Fibular fx
  - Normal Mortise
- Bimalleolar Fx – 25%
  - Medial & Lateral Malleolus
  - Bimalleolar equivalent – Fibula Fx & Medial Ligament injury
  - Wide Mortise ?
- Trimalleolar Fx –
  - Medial-Lateral-Posterior
  - Wide Mortise
- Ankle Fx/Dislocation
  - Disruption Ankle Mortise
  - Talus displaces from Plafond
  - Look @ Syndesmosis

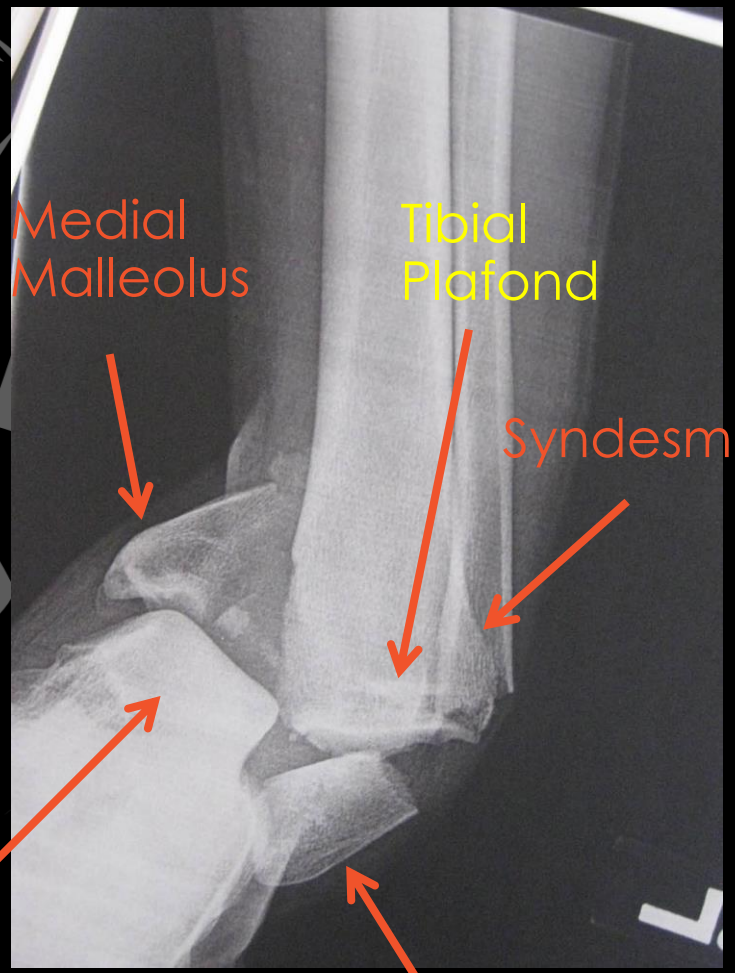
MAISONNEUVE'S FRACTURE

- Maisonneuve's fracture involves fracture of the proximal fibula
  - Associated medial Malleolus fracture
  - Deltoid ligament injury and/or
  - Injury to the syndesmosis
- Medial malleolus fracture & force transmitted through interosseous membrane and exits at proximal fibula
- Do not assume medial malleolus fractures is isolated
- Palpate proximal Fibula



ANKLE FRACTURE-DISLOCATION

- Associated with Bimalleolar or Trimalleolar ankle fractures
- Talus and foot translated completely out of mortise
- Obvious deformity to ankle and foot
- Open vs. Closed
- Play close attention to pre & post reduction neuro and vascular exams



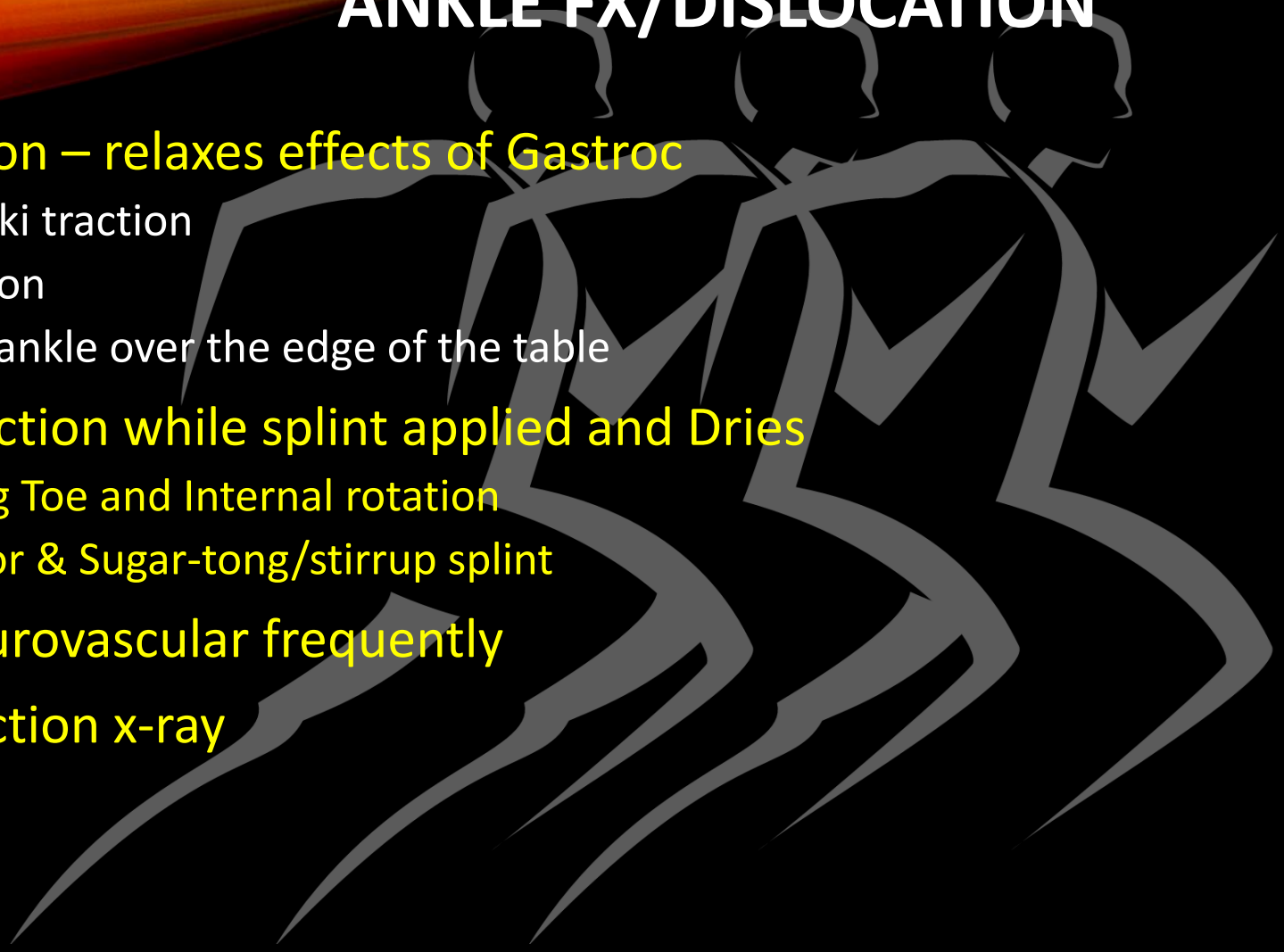
ANKLE FX/DISLOCATION





REDUCTION AS SOON AS POSSIBLE PROTECTS SKIN

ANKLE FX/DISLOCATION



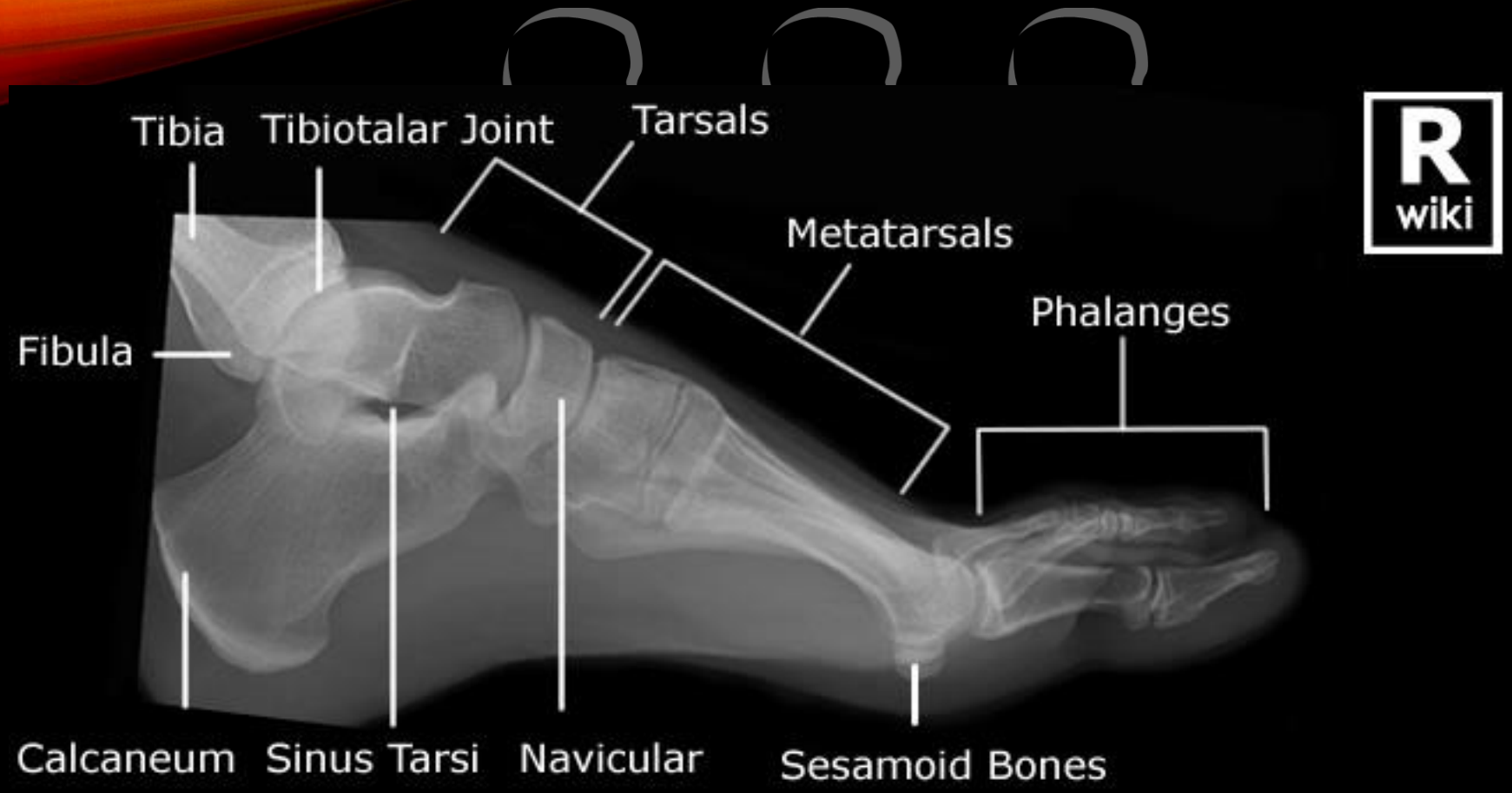
- Knee flexion – relaxes effects of Gastroc
  - Water ski traction
  - Reduction
  - Dangle ankle over the edge of the table
- Hold reduction while splint applied and Dries
  - Hold Big Toe and Internal rotation
  - Posterior & Sugar-tong/stirrup splint
- Check Neurovascular frequently
- Post reduction x-ray

ANKLE FX/DISLOCATION REDUCTION

https://www.youtube.com/watch?v=p8BgYKli0DI

FOOT ANATOMY

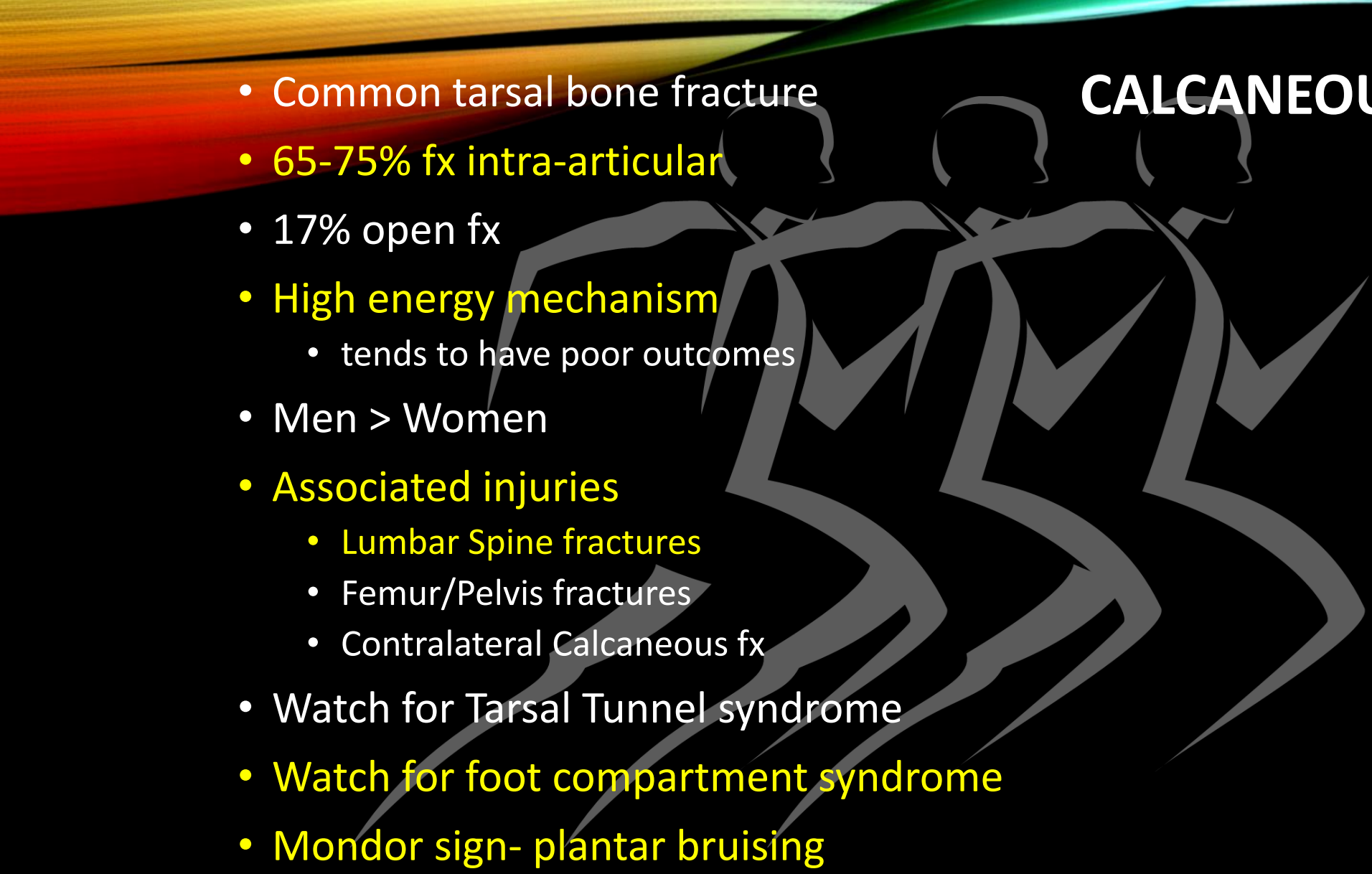
Images courtesy Michael J. Fuller-WikiRadology



Images courtesy Michael J. Fuller-WikiRadology

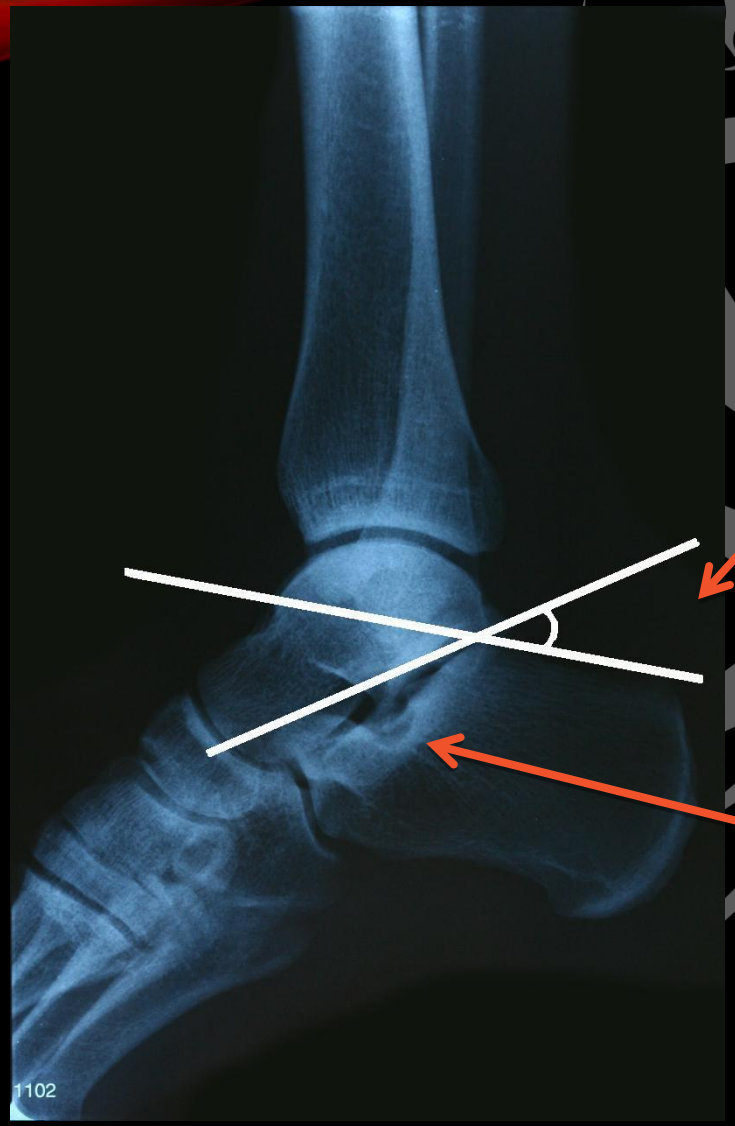
CALCANEOUS FX

CALCANEOUS FRACTURES



- Common tarsal bone fracture
- 65-75% fx intra-articular
- 17% open fx
- High energy mechanism
  - tends to have poor outcomes
- Men > Women
- Associated injuries
  - Lumbar Spine fractures
  - Femur/Pelvis fractures
  - Contralateral Calcaneous fx
- Watch for Tarsal Tunnel syndrome
- Watch for foot compartment syndrome
- Mondor sign- plantar bruising

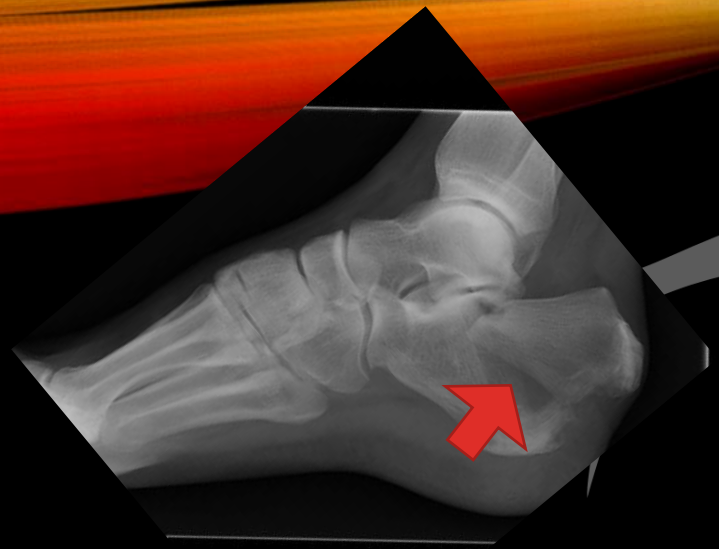
BÖHLER'S ANGLE & ANGLE OF GISSANE



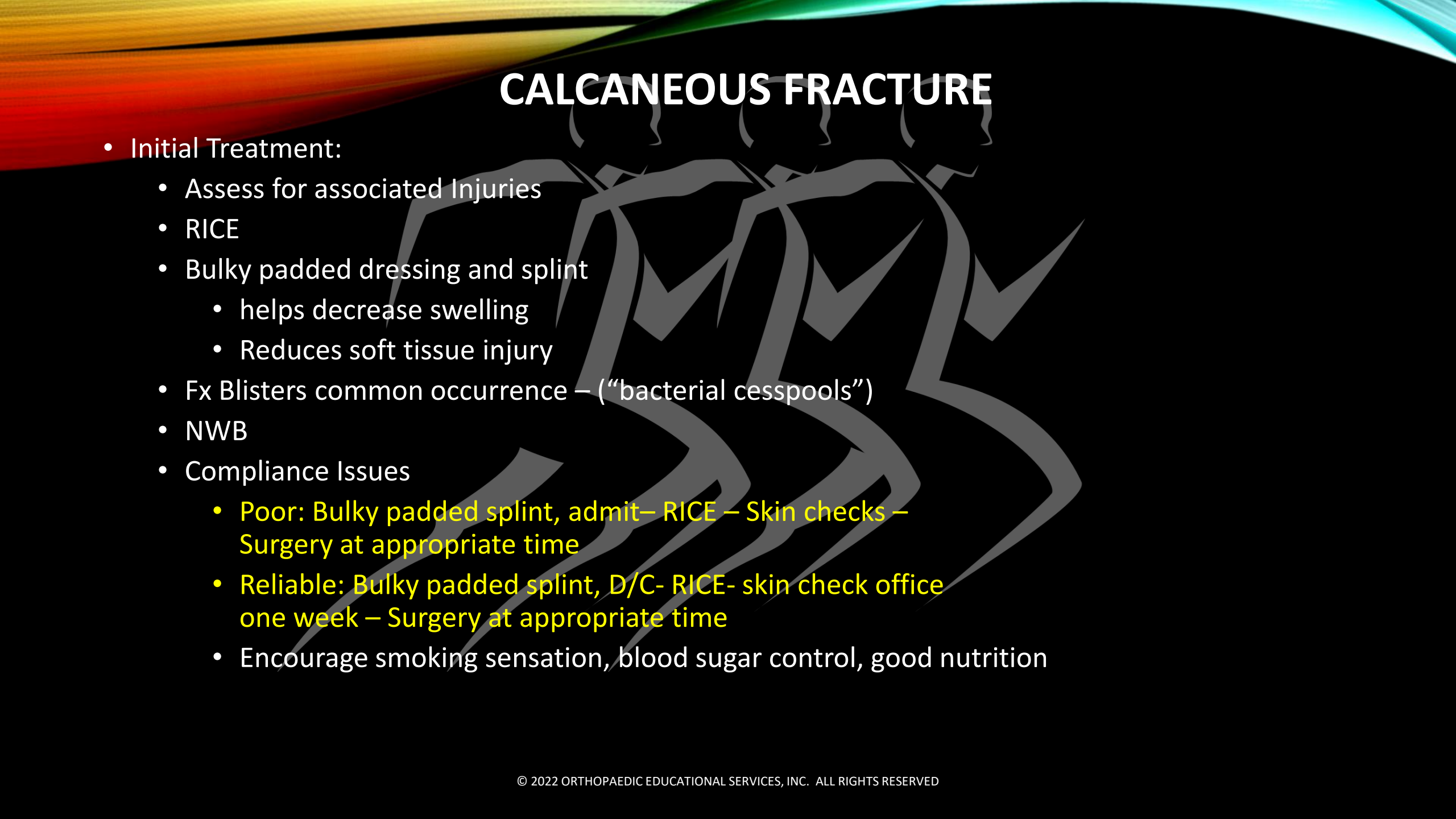
Bohler's Angle 20-40 degrees
Decreased angle represents posterior facet fracture

Angle of Gissane 130-45degrees
Increased angle represents posterior facet fracture

CALCANEAL FRACTURE



CALCANEOUS FRACTURE



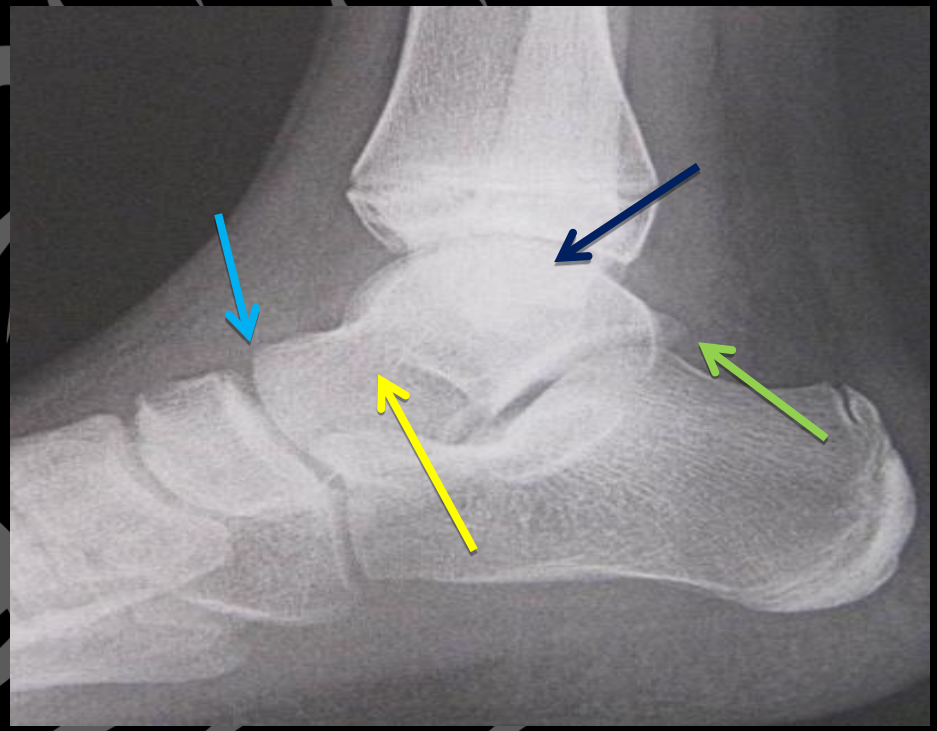
- Initial Treatment:
  - Assess for associated Injuries
  - RICE
  - Bulky padded dressing and splint
    - helps decrease swelling
    - Reduces soft tissue injury
  - Fx Blisters common occurrence – (“bacterial cesspools”)
  - NWB
  - Compliance Issues
    - Poor: Bulky padded splint, admit– RICE – Skin checks – Surgery at appropriate time
    - Reliable: Bulky padded splint, D/C- RICE- skin check office one week – Surgery at appropriate time
    - Encourage smoking sensation, blood sugar control, good nutrition

TALUS FX

TALAR FRACTURES

- 3 Anatomic parts of the Talus
  - Head
  - Neck
  - Body
    - Posterior process Os Trigonum
- Body articulates with tibia/fibula

  to form ankle mortise
- Head of the Talus articulates with the tarsal navicular



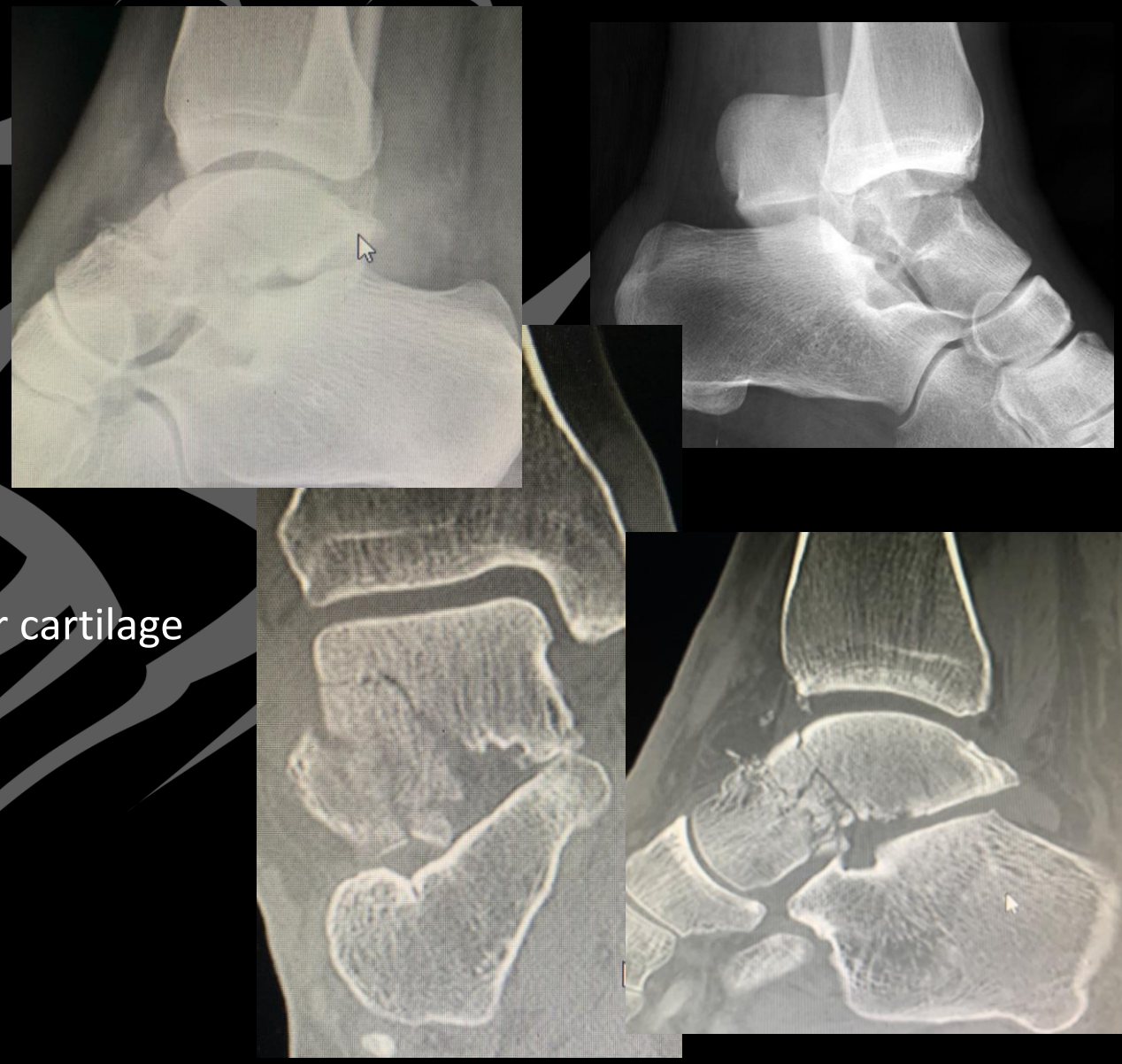
TALAR NECK/BODY FX

Talar neck fx

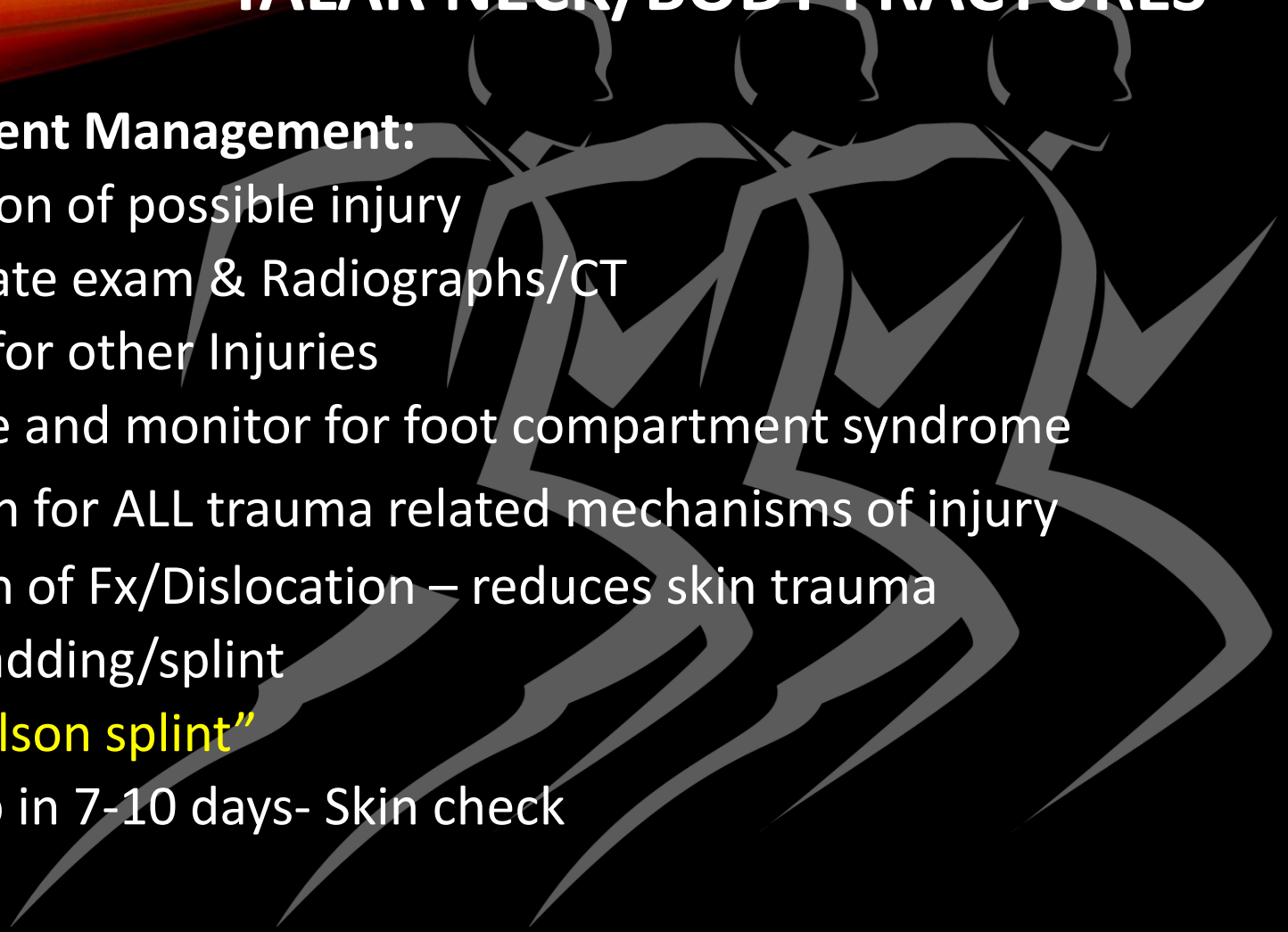
- Account for 50% all Talus fractures
- Injury Mechanism: high velocity
- **> Fx displacement = > risk osteonecrosis**

Talar Body fx

- 25% all talus fractures
- Associated with poor outcome
- Associated w/ high energy injury mechanism
  - Osteochondral injuries big concern
- Concerns for osteonecrosis
- Anatomic components of the Talar Dome:
  - 60% talus covered with hyaline articular cartilage
- Ipsilateral lower extremity fractures common
- Consider other Trauma
  - Lumbar spine
  - Tibial Plateau
  - Femur/Hip



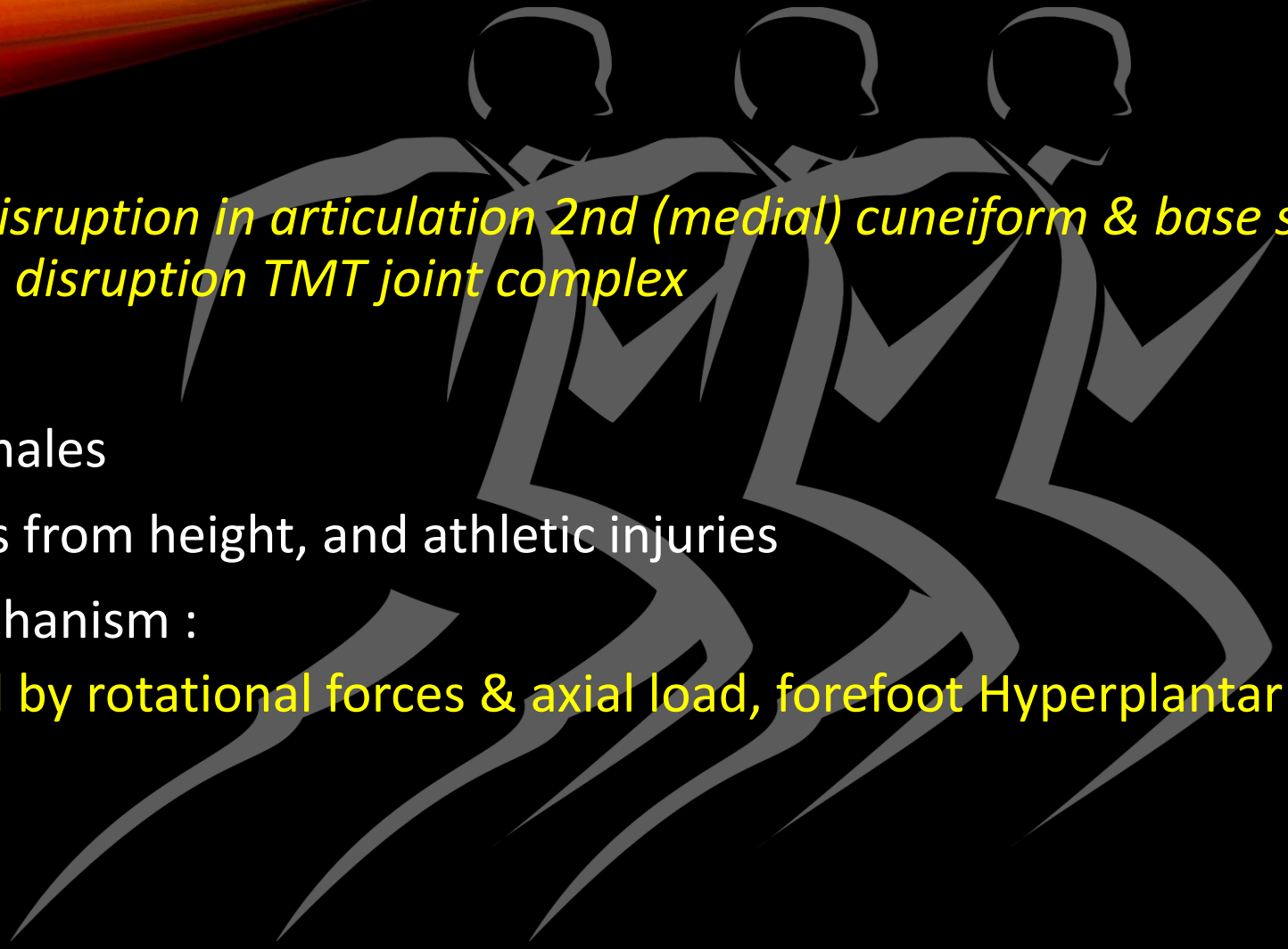
TALAR NECK/BODY FRACTURES



- **Initial Emergent Management:**
  - Recognition of possible injury
  - Appropriate exam & Radiographs/CT
    - Look for other Injuries
  - Recognize and monitor for foot compartment syndrome
  - Evaluation for ALL trauma related mechanisms of injury
  - Reduction of Fx/Dislocation – reduces skin trauma
  - Lots of padding/splint
    - "Charlson splint"
  - Follow up in 7-10 days- Skin check

LISFRANC INJURY

LISFRANC FRACTURE



- Defined: *disruption in articulation 2nd (medial) cuneiform & base second metatarsal leading to disruption TMT joint complex*
- Age- 30”s
- Males>females
- MVAs, falls from height, and athletic injuries
- Injury mechanism :
  - caused by rotational forces & axial load, forefoot Hyperplantar flexed

RADIOGRAPHS

- Foot: AP, LATERAL & OBLIQUE
  - WT-BEARING –best to assess:
    - Hallux valgus angle (HVA
    - Intermetatarsal angle (IMA)
    - CHARCOT foot
    - Lis-franc – pain/swelling allows
- **Key x-ray signs indicating Lisfranc injury**
  - Malaligned **1-2-3** MT -cuneiforms
  - Malaligned 4TH & 5TH MT-CUBOID
  - Widening space Great and 2nd metatarsal
  - Dorsal subluxation MT base (lateral)
  - Disruption Medial column

LISFRANC FRACTURE

Normal x-ray

Obvious

Subtle Injury

LISFRANC FRACTURES

Physical Examination:

- **History**
  - Severe pain
  - Unable to wt bear
  - “told they had a sprained foot”
  - “negative x-rays”
- **Exam**
  - plantar bruising --Mondor sign
  - swelling throughout midfoot
  - tenderness over tarsometatarsal joint
  - Loss of motion & stability
- Treatment
  - Similar to Calcaneous/Talus Fx
  - Most require surgical intervention

Picture courtesy T Gocke, PA-C

Picture courtesy T Gocke, PA-C

METATARSAL FX

METATARSAL FRACTURES

- Metatarsal fractures common injuries of the foot
- 5th metatarsal most commonly fractured
- 2nd and 5th decade of life
- 3rd metatarsal fractures rarely occur in isolation
  - fracture of 2nd or 4th metatarsal
- Most trauma related to crush injury or direct blow
- Most are non or minimally displaced/angulated
- Intact Great toe & 5th Metatarsal leads to stability of fx central 3 Metatarsals
- When fx displace-plantar direction
  - 2nd to pull by toe flexors & intrinsic muscles

METATARSAL FRACTURES

Radiographs

- Most oblique or transverse fx pattern
- More displacement at neck 2nd to flexor & intrinsic muscle
- > displacement & angulation if 1st MT fx
- <20 degrees varus/valgus angulation acceptable
- > 4mm plantar/dorsal displacement - reduce
- > 10 degrees dorsal angulation - reduce

METATARSAL FRACTURES

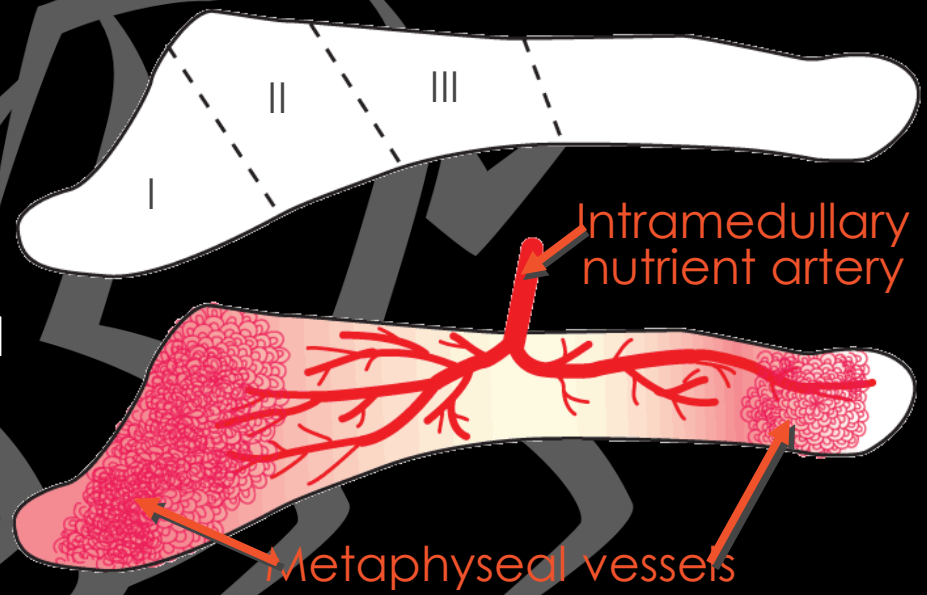
- Treatment
  - Monitor foot compartment syndrome
  - Well padded Jones dressing & splint/fx boot/ post op shoe
  - Neuro/vascular checks
  - NWB – WBAT depending on fx and swelling
  - **FX beyond acceptable limits**
    - Finger/toe traps for closed reduction and splint
    - Repeat x-ray – good alignment then can D/C
    - Make NWB till follow up exam

METATARSAL FRACTURES

- **Unable to improve alignment**
  - Manipulate under anesthesia/ankle block
  - Closed reduction and reassess
  - CRPP and reassess
  - Padded dressing and splint/fx boot
- Healing time all FX
  - 4-6 weeks
  - Associated factors can slow or impede healing

5TH METATARSAL FRACTURES

- **3 Zones base 5th MT**
- Zone I- articular surface for the metatarsocuboid joint
- Zone II – articulation of the 4th and 5th metatarsals (Jones Fracture)
- Zone III – extends 1.5 cm distal to zone II



Dameron, TB: Fractures of the Proximal Fifth Metatarsal: Selecting the best Treatment option; JAAOS 3(2), March/April 1995.

5TH METATARSAL FRACTURE

- Zone I
  - Most proximal and is considered the base of the 5th MT
  - Peroneus Brevis and lateral cord of plantar aponeurosis
  - Fx starts lateral cortex and extends medially into the metatarsocuboid joint
  - Good healing associated w/ Zone I injuries
  - **X-ray - > 3mm dorsal displacement may need surgical fixation**
    - **Symptoms subside long before healing seen on x-ray**
    - **Asymptomatic non-union not uncommon**

5TH METATARSAL FRACTURE

- Zone II
  - More distal part tuberosity
  - Strong ligament attachment dorsal / planta for 4th-5th MT
  - **Fx this area extend into articulation of 4-5 MT**
  - More painful than zone I injury
  - Symptoms dependant on activity level
  - No improvement on healing WBAT vs. non-Wt-bear – Controversial
  - **Higher incidence asymptomatic non-union**

5TH METATARSAL FRACTURE

- Zone III
  - Most often assoc w/ stress fx mechanism
  - Fx distal to ligament attachment binding
    4/5 MT together
  - Slow healing
  - Responds better to ORIF
    - Intramedullary 4.5 cancellous lag screw
    - Non-union may need grafting
  - SLWC 4-6 wks

TOE FX

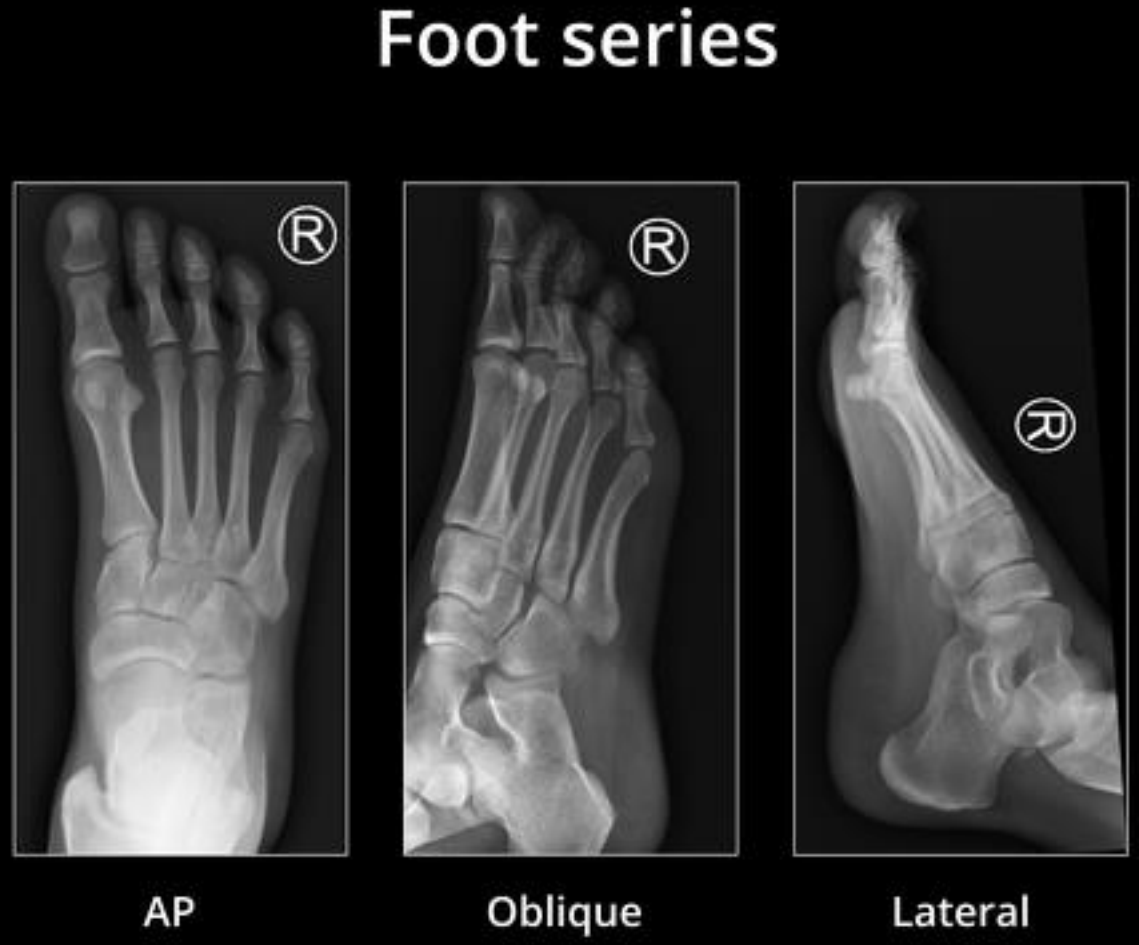
TOE FRACTURES

- Toe Fx Account for < 7% all fx seen in Primary care setting
- Lesser Toe fx 4x m ore likely vs Great toe fx
- Most Lesser Toe fx are non-displaced
- Great toes Fx
  - involves >25% articular surface need close F/U & ? Surgery
  - Comminuted
  - Displaced
- Injury Mechanism:
  - Axial load – Jammed toe
  - Crush injury
  - Jt. Hyperextension

TOE FRACTURE

Radiology

- 3 views: AP, Lateral, Oblique
- Clear views of injured toes
  - Spiral & Transverse fx – angular deformity
  - Oblique fx – shortening
  - Avulsion fx
- Post –reduction images as needed
- Treatment
  - Open fx go to the OR/ABX/Tetanus
  - Reduce angulated/deformed toes
  - Digital/hematoma block as needed
  - Buddy Tape
  - Post op Shoe
  - Follow up 1 Week



FRACTURE GREAT TOE PROXIMAL PHALANX

TOE FX

THE END

QUESTIONS ?

Thank you!!!!!!

Tom@orthoedu.com

REFERENCES

- Uebbing CM, Walsh M, Miller JB, Abraham M, Arnold C. Fracture blisters. West J Emerg Med. 2011;12(1):131–133. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3088393
- Ahn L, Sheth U, Mid-Shaft Clavicle Fractures, Orthobullets.com, 10/28/2020, https://www.orthobullets.com/trauma/1011/midshaft-clavicle-fractures, accessed November 17, 2020
- Honeycutt MW, Fisher M, Riehl JT, Orthopaedic Tips: A Comprehensive Review of Midshaft Clavicle Fractures, JBJS JOPA 2019;7(3):e0053
- Andersen et al: Treatment of Clavicle Fractures: Figure 8 vs. Simple Sling. Acta Orthop Scand 1987;58:71-74
- Triplet J, Proximal Humerus Fractures, Orthobullet.com, updated 7/19/2020 https://www.orthobullets.com/trauma/1015/proximal-humerus-fractures, accessed November 15, 2020
- Bounds EJ, Frane N, Kok SJ. Humeral Shaft Fractures. [Updated 2020 Aug 24]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK448074/
- Ekholm R, Ponzer S, Törnkvist H, Adami J, Tidermark J. The Holstein-Lewis Humeral Shaft Fracture: Aspects of Radial nerve injury, Primary treatment, and Outcome. J Orthop Trauma. 2008 Nov-Dec;22(10):693-7.

REFERENCES

- Bounds EJ, Frane N, Kok SJ. Humeral Shaft Fractures. [Updated 2020 Aug 24]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK448074/
- Liman MNP, Avva U, Ashurst JV, et al. Elbow Trauma. [Updated 2019 Jun 23]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK542228/
- Sullivan CW, Hayat Z. Olecranon Fracture. [Updated 2020 Jan 17]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK537295/
- Layson J, Best BJ. Elbow Dislocation. [Updated 2019 Nov 11]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK549817/
- Schulte, LM, Meals CG, Neviaser RJ, Management of Adult Diaphyseal Both-bone Forearm Fractures, J AM Acad Orthop, Surg 2014;22:437-446
- Allen, D, Galeazzi Fracture, OrthoBullets, updated 1/19/20109, https://www.orthobullets.com/trauma/1029/galeazzi-fractures, retrieved April 10, 2020

REFERENCES

- Johnson NP, Silberman M. Monteggia Fractures. [Updated 2019 Jul 30]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2020 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK470575/
- Meaike JJ, Kakar S, management of Comminuted Distal Radius Fractures: A Critical Review, JBJS Reviews 2020;8(8)e20.00010
- Porrino JA, Maloney E, Scherer K, et al Fracture of the Distal Radius: Epidemiology and Premanagement Radiographic Characterization, American Journal of Roentgenology 2014 203:3, 551-559
- Corsino CB, Reeves RA, Sieg RN, Distal Radius Fractures, StatPearls, Treasure Island, FL, StatPearls Publishing Jan 2020
- Miller D, Sarwark J. (2019, April 1). Visual Guide to Splinting [NUEM Blog. Expert Commentary by Pirotte M]. Retrieved from http://www.nuemblog.com/blog/splinting
- Buijze G, Goslings JC, Rhemrev JS, et al. Cast immobilization with and without immobilization of the thumb for non-displaced scaphoid waist fractures: a multicenter, randomized, controlled trial. J Hand Surg Am. 2014;39:621

REFERENCES

- Wieschhoff GG, Sheehan SE, Wortman JR, et al, Traumatic Finger Injuries: What the Orthopaedic Surgeon Wants to Know, RNSA 2016;36(4):1106-1128
- Bloom J, Overview of Metacarpal Fractures, UpToDate,updated May 10, 2021, https://www.uptodate.com/contents/overview-of-metacarpal-fractures#H48141897 retrieved Feb 21, 2021
- Guo J, Dong W, Jin L, et al. Treatment of basicervical femoral neck fractures with proximal femoral nail antirotation. *J Int Med Res*. 2019;47(9):4333-4343. doi:10.1177/0300060519862957
- Yoo JI, Cha Y, Kwak J, Kim HY, Choy WS. Review on Basicervical Femoral Neck Fracture: Definition, Treatments, and Failures. *Hip Pelvis*. 2020;32(4):170-181. doi:10.5371/hp.2020.32.4.170
- Black DM, Geiger EJ, Eastelli R, et al, Atypical Femur Fracture Risk versus Fragility Fracture Prevention with Bisphosphonates, N Engl J Med 2020; 383:743-753
DOI: 10.1056/NEJMoa191652, retrievedon May 2, 2021
www.nejm.org/doi/full/10.1056/NEJMoa1916525

REFERENCES

- Ahn L, Patella Fracture, Orthobullets,updated 5/25/2021 https://www.orthobullets.com/trauma/1042/patella-fracture, retrieved 6/2/2021
- van Leeuwen, C., Haak, T., Kop, M. *et al.* The additional value of gravity stress radiographs in predicting deep deltoid ligament integrity in supination external rotation ankle fractures. *Eur J Trauma Emerg Surg* **45,** 727–735 (2019).
- Ehrlichman LK, Gonzalez TA, Macaulay AA, Ghorbanhoseini M, Kwon JY. Gravity Reduction View: A Radiographic Technique for the Evaluation and Management of Weber B Fibula Fractures. *Arch Bone Jt Surg*. 2017;5(2):89-95.
- Karadsheh M, Taylor BC, Forsthoefel C, Femoral Shaft Fractures, OrthoBullets, updated May 27, 2021, https://www.orthobullets.com/trauma/1040/femoral-shaft-fractures, retrieved June 2, 2021
- Blomberg J, Femoral Neck Fractures, OrthoBullets, updated June 1, 2021, https://www.orthobullets.com/trauma/1037/femoral-neck-fractures, retrieved June 4, 2021

REFERENCES

- Kojima KE, Ferreira RV. TIBIAL SHAFT FRACTURES. *Rev Bras Ortop*. 2015;46(2):130-135. Published 2015 Dec 6. doi:10.1016/S2255-4971(15)30227-5
- Torlincasi AM, Lopez RA, Waseem M. Acute Compartment Syndrome. [Updated 2021 Feb 10]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK448124/
- Macey, Lance R. MD; Benirschke, Stephen K. MD; Sangeorzan, Bruce J. MD; Hansen, Sigvard T. Jr MD Acute Calcaneal Fractures: Treatment Options and Results, Journal of the American Academy of Orthopaedic Surgeons: 1994:2 (1);36-43
- Whitaker C, Turvey B, Illical EM. Current Concepts in Talar Neck Fracture Management. *Curr Rev Musculoskelet Med*. 2018;11(3):456-474. doi:10.1007/s12178-018-9509-9
- Lee C, Brodke D, Perdue PW Jr, Patel T. Talus Fractures: Evaluation and Treatment. J Am Acad Orthop Surg. 2020 Oct 15;28(20):e878-e887. doi: 10.5435/JAAOS-D-20-00116. PMID: 33030854.
- Moracia-Ochagavía I, Rodríguez-Merchán EC. Lisfranc fracture-dislocations: current management. *EFORT Open Rev*. 2019;4(7):430-444. Published 2019 Jul 2. doi:10.1302/2058-5241.4.180076

REFERENCES,

- Smidt KP, Massey P. 5th Metatarsal Fracture. [Updated 2021 Apr 12]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021, https://www.ncbi.nlm.nih.gov/books/NBK544369/
- Sarpong NO, Swindell HW, Trupia EP, Vosseller JT, Metatarsal Fractures, Foot and Ankle Orthopaedics, AOFAS, 2018:1-8
- Gravlee JR, Hatch RL, Toe Fractures in Adults, UpToDate 2020; https://www.uptodate.com/contents/toe-fractures-in-adults, Retrieved 6/2/2021