Background and class intent

• Occupational Therapist (20+ years), Certified Hand Therapist (14 years). Graduated SJSU 1992 and completed CHT in 1999.
• Worked first five years in acute rehabilitation setting at County Hospital serving East Bay (Oakland etc.)
• Worked last 17 years at local community hospital working in outpatient setting treating primarily upper extremity patients.
• CEAS (Certified Ergonomic Assessment Specialist) as of 2013

Objectives:
• This course will cover the phases of fracture healing, the classification of fracture types, review common and special fractures (phalangeal, metacarpal, carpal, forearm fractures and common dislocation/tendon rupture injuries of the hand), therapy/orthotic intervention and complications.

Common Fracture Tidbits

• Chung and colleagues,[2] in a review of nearly 1.5 million fractures recorded by the National Hospital Ambulatory Medicare Care Survey, determined that 44% of fractures involved the distal radius; of these, 30% occurred from an injury at home and 47% were caused by accidental falls.
• Scaphoid fractures are the most common carpal fractures. They typically occur in young males aged 15 to 30, with an incidence of 35,000 to 50,000 annually.
• Distal phalynx fractures are reported as the most frequent of all hand fractures at a rate of 40-50%. (per Kasch, Taylor-Mullins Hand Therapy Review Course Study Guide. 1990)
Fracture classification

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Examples/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location within bone</td>
<td>Diaphyseal, Metaphyseal, Articular</td>
</tr>
<tr>
<td>Displacement</td>
<td>Measured in millimeters, Measured as diaphyseal percentage</td>
</tr>
<tr>
<td>Pattern</td>
<td>Transverse, Oblique, Spiral, Longitudinal, Stellate, Simple</td>
</tr>
<tr>
<td>Cont...</td>
<td>Comminuted, Open vs closed, Classified by soft tissue injury</td>
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Location:

- **Diaphyseal**: within the midportion of the bone shaft
- **Metaphyseal**: within the area of the bony flare close to the articular surface
- **Articular**: when it enters the end of the bone or enters the joint. Can further be subclassified
  - a. Condylar
  - b. t-condylar
  - c. Y-condylar
  - d. Articular avulsion
  - e. Articular depression

![Diagram of bone fracture locations]
Pattern or angle of fracture line

Fracture Healing

**Inflammation or Acute Stage (day 1-5)**
- Bleeding from the fracture site and surrounding soft tissues creates a hematoma.
- Vasodilatation of vessels and hyperemia in the soft tissues surrounding the fracture site occurs.
- Clinically, this stage is marked by significant localized pain and swelling.
- Fracture hematoma is gradually replaced by granulation tissue around the fracture ends.

**Reparative or Proliferative Stage (day 5-21)**
- Within 2 weeks from the time of injury.
- Swelling, pain, and tenderness generally diminish rapidly as the callus matures.
- By the fourth to sixth week in most fractures in adults (and the third to fourth week in most fractures in the hand and forearm in children).

**Remodeling or Maturation Stage (day 21-18 months)**
- The remodeling stage begins during the middle of the repair phase and continues long after the fracture has clinically healed. Remodeling allows the bone to assume its normal configuration and shape based on the stresses to which it is exposed.
- Fracture healing may be influenced by a variety of biologic and mechanical factors. The most important biologic factor in fracture healing is blood supply. Nicotine and systemic disorders like diabetes can affect healing.

Phalangeal Fractures

**Epidemiology**
- Second only to forearm fractures in incidence, hand fractures account for up to 20% of fractures in adults and children, with an annual incidence of 36/10,000 people.
- Hand fractures in both genders occur most commonly in early adolescence.
- Males have twice the risk of sustaining a hand fracture, with most of this risk occurring between the ages of 15 and 40.
- As with other “fragility” fractures, women older than 65 are at higher risk (3.5:1) for sustaining hand fractures than men.

- Phalangeal fractures (distal, middle, and proximal) account for more than 50% of hand fractures.
- Metacarpals (MCs) are the most common bones fractured, 35% to 45% of hand fractures, followed by 20% to 25% in the distal phalanx, with the middle and proximal phalanges each accounting for about 15%.
- Fractures within the fifth (little) ray make up about 40% of hand fractures, with the first (thumb) and fourth (ring) rays each accounting for about 15% to 20%.
- Extra-articular hand fractures account for 75% to 80% of hand fractures.
Proximal and middle phalynx fractures

Phalangeal neck fractures - uncommon in adults, mostly kids (slam in door), difficult to treat, often reduction with pinning 4-6 weeks.

Shaft fractures - typically stable/closed and non-displaced MD will treat with splinting or buddy taping with immediate motion.

Base fractures - tend to angulate with apex palmarly if >25 degrees can result in pIP extension lag. If reducible splint or cast with MP 70 degrees flexion with PIP's extended for 3-4 wks typical. Kids same or buddy tape for 3-4wks. ORIF or pinning common if difficult to reduce.

Proximal (P1) Fractures

Early Mobilisation
- Orthosis: MCP joint at 70 degrees of flexion (minimum) and PIP in extension
- Complications: extensor mechanism adherence or FDS adherence limiting end range finger extension limiting fist and tuck
Treatment: Proximal and Mid Phalynx Fractures

If internally fixed and absolutely stable:

- **** most critical factor is obviously stability of fracture!!!!!
- Begins 24-72 hrs post op
- Edema management, regain PIP motion (AROM), avoid flexion contracture; splint discharged 4-6wks, buddy tape for protections.
- No heavy resistance until minimum 6-8 weeks

Without absolute stability:

- No A/PROM
- Edema management, splinting
- Approx. 3-4wks AROM begins, protective splinting between exercises
- 6 weeks (with clinical fracture healing) PROM and dynamic splinting if indicated

Examples: ORIF’s of metacarpal and phalangeal shaft fractures

Most common problems:
- Limited PIP/PROM AROM
- PIP flexion contracture
- Incomplete hook fisting (superficialis finger)
- Protective blocking exercises (image at right)
Middle Phalynx Fractures (P2)

Digital shaft fracture left small finger metacarpal with 40 degrees angulation

Shaft: transverse/spiral or oblique fractures
- Malrotation: for every 1 degree of MC rotation functionally results in 5 degrees of rotation at fingertip.
- Transverse fractures tend to angulate (apex dorsally due to the intrinsic pull)

Distal Phalynx fractures (P3)

Per Kaplans Classification

Tuft
- Usually due to a crush
- Very painful
- Often associated with subungual hematoma (drained)
- Splint: alumafom splint or static finger extension splint for 2-4 weeks (DIP only)
- Typical rehab: DIP AROM and desensitization, typically PROM after 5-6 weeks

Distal phalynx fracture cont....

Shaft Fracture
- May be longitudinal or transverse
- Splint: typical 3-4 weeks with longitudinal (longer with transverse)
- Typically AROM after 3-4 weeks and PROM after 5-6
- Open fracture: fixed with k-wire followed with splint 3 weeks

Base Fracture
- Usually unstable due to pull of flexor and extensor tendons
- Closed fracture in adults : splint
- Open or unstable: k-wire
- Children: usually Salter Harris (growth plate)
- Complications: pain, hypersensitivity, DIP ROM and nail growth abnormalities
**Tendon Anatomy**

**Other DIP Joint Injuries**

**MALLET FINGER**
- Avulsion of terminal extensor tendon from distal insertion resulting in a drooping distal digit.
- Usually due to DIP in extension then forced into flexion.
- Treatment: Splint DIP in extension 4-6 weeks, weaned from splint over 2-4 weeks, monitor for extensor lag.

Mallet finger cont..
Other splinting options for Mallet finger

Stack splint

Oval eight by 3 point products

Dip: Other joint injuries cont...

DIP Hyperextension
• May cause avulsion of FDP tendon
• Treatment: typically splinted 3-4 weeks then progress ROM

Dislocations
• Less common than PIP
• If closed/reduced splint neutral or slight extension: AROM begins 2-3 weeks, splint continued for protection for 4-6 weeks
• If open/irreducible: surgical intervention

Metacarpal Fractures

Base/shaft or neck
• Most important to restore transverse and long metacarpal arches
• Prevent rotational malalignment and significant shortening (< 3-5mm can lead to intrinsic/extrinsic imbalance

Rotational Malalignment
Metacarpal fractures cont...

Base
• Usually stable
• If unstable: often k wires

Shaft
• Transverse/spiral or oblique
• Tend not displace due to bound proximal and distal
• Transverse tend to angulate (apex dorsally due to intrinsic pull)
• Malrotation: for every one degree at metacarpal will be five degrees at fingertip

Common Splinting/casting
Neck Fracture

- Excessive dorsi-plantar instability or “dropped” thumb
- As with shaft fractures if severe angulatory dorsi-plantar can result in clawing

**Therapy Considerations for rigid stabilization**

- Splint: safe position including wrist
- Edema control
- ROM: EDC, isolated MP flexion and composite flexion
- 4 weeks-6 weeks O/C splint, buddy tape, gentle resistance

**Therapy considerations if stable or with semi-rigid stabilization (ex. K wire)**

- Guarded AROM normally begins around 3 weeks.
- UNSTABLE: PER MD (usually around 3-6 weeks)

Complications/considerations

- Excessive dorsi edema/extensor tendon adherence
- MP joint contracture (due to collateral ligament shortening...see image)
- Intrinsic tightness
Intra-articular Injuries: PIP Joint

• PIP joint anatomy
• Collateral ligament injuries
• Dorsal Dislocations
• Volar Dislocations
• Intra-articular fracture/dislocations

PIP Joint Anatomy

• 4 major retaining ligaments: radial collateral, lateral collateral, volar plate, and dorsal capsule with central extensor tendon
• Laterally: Capsule comprises proper and proper accessory collateral ligaments (PCL and ACL)
• Most important stabilizing structures: collateral ligament and volar plate
• Bower’s critical corner: area where VP, PCL, and ACL converge

Examples:
Collateral ligament injuries/grading

• **Cause:** Angulatory force on extended finger (radial collateral ligament most common)

• **Grade I:** Sprain with ligament intact. Stable throughout AROM. Rx: Immobilize in slight flexion approx. 3 days then buddy tape. Educate regarding symptoms perhaps lasting 3-6 months. Begin AROM after 3-5 days to prevent stiffness.

• **Grade II:** Complete disruption of one collateral ligament. Joint stable throughout AROM, < 20 degree angulation when compared to opposite digit upon stress testing. Rx: splint 3-4 wks followed by buddy tape 3-6 more weeks or until symptoms subside.

Collateral ligament cont.

• **Grade III:** Complete disruption of one collateral ligament plus volar or dorsal structure. Actively and passively unstable, closed reduction or repair required. Rx: splinting may be required post-op (6-8wks p.o. to regain mobility)

• **Main deterrent to full mobility:** Persistent swelling around capsuloligamentous tissues. If continued even with edema control measures may require iontophoresis or surgeon steroid injection.

Pip joint dislocations

**Volar Dislocations:** Rare, usually involve rupture central extensor tendon and damage to other structures. Often Grade III and require closed reductions. Complication: Flexion deformity/boutonniere

**Dorsal Dislocations**

• **Cause:** Hyperextension to extended finger (ball handling)

• **Grade I:** Proximal phalynx head damages central attachments distally while maintaining critical corner integrity.
Dislocations cont..

- Grade II: As with grade I plus damages critical corner plus proximal extension between ACL/PCL.
- Grade III: As with grade II plus volar/lateral instability (open dorsal dislocation produces a bursting palmar wound and proximal phalynx/flexor tendons may be exposed). May need surgical reduction or surgical splinting in at least 25 degrees flexion.
- Complications: redislocation, chronic hyperextension deformity (pseudoboutioneers), PIP flexion deformities <45 degrees may require surgical release.

Intra-articular fracture/dislocations PIP joint

Fracture volar middle phalynx base

- Cause: hyperextension and longitudinal compression
- If >25% joint surface involved: DBS which allows for early flexion. Amount of flexion is proportion to the % of joint injury
- If PIP joint stable at 65 degrees most likely 35 degrees of volar base if fractured therefore joint should be placed in 15-20 more flexion.
- 30-50% of articular surface damaged: Open reduction considered although DBS often.
Dorsal Blocking splint examples

Fracture Dorsal middle phalynx base
- **Cause:** Usually small avulsion injury with detachment of CET
- **Small Avulsion:**
  - Treatment: immobilize approx. 4 weeks in extension. If displaced surgery with reduction and internal fixation.
- **Exercises to digital joint to prevent lateral band adherence**
- **Monitor for extensor lag**
- **Larger dorsal fragment:**
  - Treatment will depend on amount of fracture displacement, degree of stability and comminution.
  - Remaining middle phalynx occasionally will sublux and dislocate volarly

Lateral compression fracture of middle phalynx base
- **Cause:** axial loading with resultant angulation
- **Xray may require oblique view**
- **Medical treatment:** may require bone graft and/or internal fixation
- **Treatment:** Remobilize once stable.
Fracture of proximal phalynx head

Three types
• Type I: Uni-condylar, non-displaced, stable
• Type II: oblique/intra-articular, tend to displace.
• Type III: bicondylar fracture/unstable

Treatment
• Any displacement grater than 1mm requires internal fixation
• Typically AROM after 3 weeks
• Splint: PIP in extension for minimum of 3 weeks
• Complications: extensor lag

Boutonniere

• PIP flexion with DIP extension
• Zancolli described three stages of imbalance:
  1. PIP flexion due to loss of central slip and unopposed FDS
  2. Lateral bands migrate volarly
  3. Infrinsics pull directed now at dip which leads to progressive hyperextension

Swan neck deformity

• Lax volar plate leads to hyperextension of pip joint caused by trauma or commonly RA
• Imbalance of forces on the PIP joint due to hyperextension leads to flexion of dip joint
So What Do We Do about it???

Most PIP joint injuries resolve:

- Persistent swelling
- Stiffness
- Lack of functional grip

Stiffness/ROM:

Exercise splint
Flexion splint/strap

Extension splint options

Edema
Carpal Fractures

Carpal bones

- 1/10 as frequent as distal radius fracture
- Fall on outstretched hand forces scaphoid between distal radius and radiocapitate ligament
- 60% of all carpal fractures
- Decreased blood supply put it at risk of avascular necrosis
- 70% are of the middle third

Schaphoid (navicular) bone

- Healing Times:
  - Acute: up to 3 months
  - Delayed Union: 3-6 months
  - Non-union: 6 plus months
  - Horizontal fracture: heals quickest
  - Tuberosity: 5-6 weeks
  - Avascular proximal pole: 20 weeks plus
Treatment of scaphoid fracture

- Cast/immobilization: short arm gauntlet type cast from thumb proximal phalynx to proximal forearm in slight dorsiflexion and radial deviation OR long arm thumb spica for six weeks then short arm thumb spica until fracture healed.

Scaphoid fracture complications

- Non-union which can result in arthritic changes if not addressed
- Often operative treatment needed if non-union/ Herbert Screw
- Concomitant ligament injury (scapho-lunate etc)

Triquetrium

- Second most common
- One of the anchors to the wrist with strong palmar and dorsal attachments
- Symptoms: often dorsal ulnar wrist pain/edema due to excessive wrist dorsiflexion and ulnar deviation
- Casted 4-6 weeks in short arm cast in slight dorsiflexion
Lunate Facture

- Third most common carpal fracture (7%)
- FOOSH: lunate gets caught between capitate and the distal radius
- Casting typically in short arm cast 6-8 weeks

Kienbock's Disease

- Lunate sclerosis (fragmentation/collapse or shortening)
- Significant association with negative ulnar variance creating nutcracker effect between capitate and radius.
- Other factors: fracture or repetitive force
- Rx: depends on level (prolonged immobilization, lunate excision, ulnar lengthening, arthrodesis etc)

Carpal dislocations

- Peri-lunate: most common due to violent hyperextension (carpus dislocates around the lunate).
- Lunate: violent hyper extension
- Treatment: SAC in slight flexion 6-8 weeks, ORIF if reduction lost (common with peri-lunate)
- DISI: Dorsal Intercalated Segment Instability (lunate rotates dorsally)
- VISI: Volar Intercalated Segment Instability (lunate rotates volarily)
Distal Radius Fractures

• Therapy strategies should focus on restoration of functional wrist and forearm motion.
• Digital motion can be markedly limited after high-impact injuries, after falls in the elderly, and in patients who have osteoarthritis. Therefore, careful monitoring of finger and thumb motion is important.
• Don’t forget the shoulder and scapula!!

Distal Radius Fracture Treatment

• **Early Protective Phase**
  • 1-6 weeks depending on fracture stability
  • Goals: protect fracture, control swelling/pain
  • Treatments: cast/orthosis/surgical fixation, edema control (elevation with overhead fisting, retrograde massage, compression wraps
  • Tendon gliding exercises
  • Digital rom should be attained in this phase along with uninvolved joint mobility
  • Abnormal paresthesias should be recorded along with signs of Complex Regional Pain Syndrome (CRPS: edema/pain/red)
Mobilization Phase:

- **Motion/mobilization phase**
  - Starts immediately after immobilization
  - AROM and PROM of digits, shoulder, AROM of wrist, forearm rotation (be cautious when beginning PROM at wrist/forearm and check with MD when fracture is stable…begin with AROM)
  - Dynamic splinting when ok with MD

- **Pain, swelling due to excessively vigorous ROM exercises should be avoided**

- **Excessive ROM should be avoided if any indicators of delayed healing or instability**

- **Wrist extension with digital flexion = priority**

Strength Phase:

- **Functional/Strength Phase**
  - Begun when proven healing/bone fixation
  - Increase ROM to WFL
  - Increase strength to WFL’s: isometric to isotonic exercises; resisted exercises with putty or grippers

- **Precautions: excessive discomfort /irritated tissues after exercise or functional activities**

- **Adapted from LaStayo PC, Michlovitz SM, Lee M. Wrist and hand. In: Kolt G, Snyder-Mocker L, eds. Physical Therapies in Sport and Exercise. 2nd ed. 2007.**

PIP Joint dislocation case study

- **17 year old girl, softball player dislocated left pinky finger while diving for first base. (catcher)**
  - Splinted by MD in alumafoam splint for three weeks
  - Buddy strapped after that
  - Best guess grade II dorsal dislocation

- **Problems: PIP joint inflammation**

- **Limited AROM (PIP and DIP joint)**

- **Modalities (paraffin), edema management (sleeves, contrast baths), A/PROM once cleared by MD, buddy taping, returned to softball six weeks after injury per MD**
Mallet Finger case study

- 40 year old male playing goalie on indoor soccer team
- Left middle and ring finger dip flexion and pain after stopping a ball (which he did stop the goal)
- Two weeks later went to MD since not better
- 6 weeks in dip hyperextension splint continuously
- Night time extension splint after initial 6 weeks
- A/PROM to tolerance with great attention to extensor lag (modify as needed)
- Problems: edema, progressive increase in flexion and stubborn extension lag of 15 degrees at ring finger dip

Metacarpal fracture Case Study

- 10 year old boy, foosh on concrete while diving for a football
- 5th metacarpal fracture
- (closed diaphyseal transverse fracture)
- 4 weeks before baseball opening day

Metacarpal fracture case study continued

- Inflammatory or acute phase (image)
- Soft cast with MP’s in flexion (2 weeks)
- Splinted (same position) 3 additional weeks
- Allowed controlled AROM at week 3
- Allowed to return to baseball 6 weeks
Distal radius case study

- 62 year old female foosh on right hand while vaccuming
- Casted 5 weeks
- Began therapy last week in cast due to significant digital edema/redness
- Problems: initially digital rom, then digital, wrist, forearm (supination)
- Plan: edema management including glove, a/prom, dynamic splinting for finger flexion and eventually progressive strengthening
- Difficult case: gradual functional progress allowed us to see her over 6 months

Additional general Reading:

2. Diagnosis and Treatment Manual, 4th Edition by the Indiana Hand to Shoulder Center (this is a protocol book describing nonsurgical and postsurgical rehabilitation for conditions of the upper extremity
Questions???
Thank you and good luck!!!