

## HAND + BOARDS

### HAND/WRIST ANATOMY

#### *Thumb MCP Joint*

Proper collateral ligaments tight in flexion (*NB*: Stener lesion exam with MCP in flexion)

Accessory collateral ligaments tight in extension

Ulnar MCP collateral ligament injured in Stener's lesion, with interposed Adductor Pollicis tendon

#### *Thumb Opposition*

**Prime muscle of thumb opposition is AbPB**

Opponens pollicis and FPB are involved

Trapeziometacarpal joint abduction, flexion, pronation

Although Median nerve is major source of thumb opposition (AbPB;OP:FPB), Ulnar nerve produces opposition via Adductor pollicis muscle. Consequently, *combined ulnar nerve and high median nerve* injuries (proximal to AIN) leads to inability to oppose thumb

#### **Treatment**

Opponensplasty (Work Horse Procedures)

- **FDS (RF) using FCU as pulley to PP of thumb: Best option**
- EIP using Ulna as pulley: Indicated for combined Ulnar/Median nerve injury
- Abductor Digiti Minimi (Huber): Indicated for congenital etiology b/c it restores thenar mass

#### *Hand Intrinsic Muscles*

Responsible for 50% of grip strength

Ulnar motor neuropathy results in hand weakness

#### *Carpal Tunnel (10 Structures)*

9 flexor tendons

1 nerve (median nerve)

### SHOULDER ANATOMY

#### *Quadrilateral Space*

Borders: Teres minor, teres major, long head of triceps, humeral shaft

Axillary nerve, Posterior circumflex humeral artery (PCHA)

#### *Triangular Space*

Borders: Teres minor, teres major, long head of triceps

Posterior circumflex scapular artery (PCSA)

#### *Triangular interval*

Borders: Teres major, long head triceps, humeral shaft

Deep brachial artery, radial nerve

### HAND JOINT FLEXION + EXTENSION

<i>Joint</i>	<i>Flexion</i>	<i>Extension</i>
MCP	IO, Lumbricals	EDC (Sagittal Bands)
PIP	FDS, FDP	EDC (Central Slip), Lumbricals (Lateral Bands)
DIP	FDP	EDC (Terminal Tendon), ORL (Landsmeer's Lig)

### INNERVATION

*Lumbrical*: radial 2 lumbricals innervated by median n proper. Ulnar 2 lumbricals innervated by ulnar nerve

*FDP*: radial 2 innervated by AIN. Ulnar 2 innervated by ulnar nerve

*AIN*: innervates FPL, Pronator Quadratus, FDP to IF/LF

### NERVES

Palmar cutaneous branch of the median nerve lies between the PL + FCR at the wrist

Proper digital nerves are **volar** to the proper digital arteries in the DIGITS and **dorsal** to the common digital arteries in the palm

### VASCULATURE

Superficial Arch is distal; ulnar artery is the dominant supply

Deep Arch is proximal; deep branch of the radial artery is the dominant supply

Intrinsic vasculature to the nerves is in the endoneurial plane, which allows for transpositions of nerves without devascularization

### INTRINSIC MINUS HAND (CLAW HAND)

Ulnar/Median nerve palsy or Volkmann's ischemic contracture

MCP hyperextension and IP joint flexion

### INTRINSIC PLUS HAND (INTRINSIC TIGHT/BUNNELL POSITIVE)

*Intrinsic spasticity or tightness*

Results from trauma, distal joint malalignment, **RA** (Radial portion of sagittal band ruptures c extensor tendons subluxating to ulnar side)

*Bunnell Test* differentiates intrinsic from extrinsic tightness: **positive test result for intrinsic tightness is demonstrated when there is less PIP flexion with MCPJ hyperextended**

Most pts c RA will have intrinsic tightness, where the MP joints are flexed and PIP jts hyperextended; this will lead to a swan neck deformity

Rupture or attenuation of the terminal tendon on the DIP will also cause PIP jt hyperextension and ultimately a swan neck deformity (for example, chronic mallet finger)

### ULNAR WRIST IMPINGEMENT/ABUTMENT

Whenever you diagnose ulnar wrist impingement, assess **DRUJ**

### Operative Treatment

Ulnar shortening is treatment of choice when there is no associated DRUJ arthrosis

Darrach or Suave Kapandji is treatment when there is associated DRUJ arthrosis

### DeQUERVAIN'S DISEASE

*Operative risk:* superficial radial nerve (neuroma)

Most radial tendon in first compartment: "A" comes before "E"

Extensor pollicis brevis muscle belly is distal: used to confirm the correct tendon between EPB and AbPL for adequate release

- **EPB is commonly in a separate SUBcompartment that MUST be released for good results**
- **Common cause of RECURRENCE is not dividing the septum to EPB compartment**
- **AbPL has MULTIPLE SLIPS**
- *NB: AbPL, EIP, EDQ ALL have multiple slips*

*Complication*

Recurrence from not releasing EPB

### GANGLION

*Volar Wrist Ganglion*

Perform Allen test preoperatively, b/c of associated risk in damaging the radial artery c treatment

Volar ganglion is a relative contraindication to perform an aspiration of the cyst. The reason is that the radial artery often surrounds the volar ganglion and you risk damaging the hands blood supply

### GLOMUS

Exquisitely sensitive/tender in the cold weather

Diagnose with MRI

Xray may demonstrate small lucent lesion in 20 – 60% of patients

### Treatment

Excision

### **EPIDERMAL INCLUSION CYST**

Very common

History of trauma – usually a vignette involving a seamstress c penetrating injury

Painless, slow-growing mass in finger from the keratinizing epithelium

Lytic lesion in the distal phalanx with sclerotic border

#### **Treatment**

Excision

### **ENCHONDROMA**

COMMON HAND TUMOR

Age 10-60

Benign cartilage tumor

Plain imaging study: lytic lesion commonly seen in the metacarpal, proximal and middle phalanges

**Rare in the distal phalanx; when you see a destructive lytic lesion of the distal phalanx must consider squamous cell carcinoma**

Often, incidental finding associated with hand trauma or pathologic fracture

#### **Treatment**

1. Pathologic fx treated like other metacarpal or phalangeal fxs
2. Curettage and bone graft if fx heals and hand symptomatic or associated with multiple pathologic fxs

### **MUCOUS CYST**

Associated with osteoarthritis and the DIP joint

#### **Treatment**

Surgical resection of the capsule and the osteophytes

Do NOT aspirate because of INCREASED RISK OF INFECTION

### **BRACHIAL PLEXUS**

“Real Trojans Drink Cold Beer” (Roots Trunks Divisions Cords Branches)

C5 – T1 (C5, 6, 7, 8, T1)

*Root Injury*

- **Ventral Rami**
- Dorsal scapular nerve (C5) innervating rhomboids
- Long thoracic nerve (C5-C7) innervating serratus anterior muscle

*Trunk Injury*

- **Upper, Middle, Lower Trunks**
- Suprascapular nerve (Upper trunk) innervating supraspinatus/infraspinatus

*Divisions*

- **Anterior and Posterior Divisions**
- No exiting nerves

*Cord Injury*

- **Lateral, Posterior, Medial Cords**
- Lateral: Lateral pectoral nerve
- Posterior: Upper subscapular n., Thoracodorsal n., Lower subscapular (in order)
- Medial: Medial pectoral n., Medial brachial cutaneous n., Medial antebrachial cutaneous n. (in order)

*Branch Injury*

- Musculocutaneous n. (C5-C7): lateral cord
- Radial n. (C5-T1 ): posterior cord
- Axillary n. ( ): posterior cord
- Median n (C5-T1): lateral and medial cord
- Ulnar n (C8-T1): medial cord

*Preclavicular nerves*

Dorsal scapular, Long thoracic, Suprascapular nerve

**BRACHIAL PLEXUS INJURY – RECONSTRUCTION PRIORITIES**

1. Elbow flexion
2. Shoulder abduction
3. Hand sensibility
4. WE, FF
5. WF, FE
6. Intrinsic function

*Nerve Transfers for Upper Trunk lesions*

Ulnar nerve motor fascicles transferred to biceps to reconstitute elbow flexion

Pectoralis major motor transfer to Musculocutaneous nerve

*Obstetrical Palsy*

No function p 3 months is indication for operative management

Upper Trunk lesions are usually extraforaminal injuries and can be resected and grafted (good prognosis = Erbs palsy)

Lower Trunk lesion are usually avulsions requiring nerve transfers (poor prognosis = Klumpkes)

**PIN ORDER OF MUSCLE INNERVATION**

1. Supinator
2. EDC(4)
3. EDQ(5)
4. ECU(6)
5. APL(1)/EPB(1)
6. EPL(3)
7. EIP(4)

NB: - Compartment 2 (ECRL, ECRB) is innervated by radial nerve proper  
- PIN order of innervation starts and ends with 4<sup>th</sup> compartment except supinator

**GAMEKEEPER'S THUMB**

**Nonoperative Treatment**

First MCP joint stressed in flexion to assess UCL proper; Accessory UCL stressed in MCP extension  
Patients c less than 30 degrees of laxity of the UCL, less than 15 degree differential in laxity compared with the contralateral side, and discrete end point to joint opening are assumed to have incomplete tears

Immobilization of MP joint for 4 weeks in neutral varus/valgus alignment and slight flexion  
IP joint is left free to encourage ROM to avoid adherence of the extensor tendon to the healing capsule

**STENER LESION** (*Adductor aponeurosis interposed between torn UCL ends*)

*Operative Treatment*

Test proper UCL rupture c MPJ flexed

Stress that causes > 30 degrees radial/valgus laxity, or > 15 degrees compared to contralateral side

Requires primary surgical repair

**BIOMECHANICS OF THE WRIST JOINT**

*Load Borne by Radius and Ulna with TFCC Intact*

Neutral Ulna: 80% radius + 20% ulna

Ulna positive 2.5 mm: 60% radius + 40% ulna

Ulna negative 2.5 mm: 95% radius + 5% ulna

*Load Borne by Radius and Ulna with TFCC Disrupted*

Neutral Ulna: 94% radius + 6% ulna  
Ulna positive 2.5 mm: 78% radius + 22% ulna  
Ulna negative 2.5 mm: 97% radius + 3% ulna

Disruption of the TFCC will increase load on the radius

- *Intuitive:* radial head excision for fx leads to proximal radial shaft migration if interosseous membrane is disrupted

*Wrist Kinematics in DRFx*

**Radial shortening** causes the greatest disruption in the kinematics of the DRUJ in association with DRFx  
Dorsal tilt > **30 degrees** is associated with advanced radiocarpal DJD in DRFx

NB: If pt presents with wrist pain after DRFx treated nonoperatively must assess for these complications

### **LUNOTRIQUETRAL INSTABILITY**

*Pathoanatomy*

Injury to the lunotriquetral ligament is not enough to produce instability

Additional injured ligament is the **DORSAL RADIOTRIQUETRAL LIGAMENT** is required

### **NERVE FIBER FAILURE**

*Cause:* anesthesia, trauma (neuropraxia, axonotmesis, neurotmesis) + compression

*Nerve Loss in Descending Order (OITE Test)*

- Motor
- Proprioception
- Touch
- Temperature
- Pain

*NB: Pain is the last sense to be lost and first to return*

*NB: Concerning nerve compression injuries, the sensory nerves are effected before the motor nerves because of the anatomy of the nerves*

*Sensory Loss/Recovery (Miller Review)*

- **Threshold tests (Semmes-Weinstein monofilament (5.07 / 10 g) = slow adapting fibers, vibration = quick adapting fibers) = FIRST sensation to be lost and LAST to return after nerve injury**
- Static 2PD (slow adapting Merkel fibers) = density
- Moving 2PD (fast adapting Meisner fibers) = density
- Moving touch
- Pain
- Proprioception = Loss of Great toe joint position sense on exam indicates ALL sensation lost

*OITE Question:* After a primary nerve repair what sensation will recover after moving 2PD test? Answr: static 2PD test, then Semmes-Weinstein monofilament or vibratory test

*OITE Question:* What sensory test is the first to indicate sensory loss? Answr: Semmes-Weinstein monofilament test or vibratory test (Threshold Tests)

### **COMPRESSIVE NEUROPATHY**

*Double Crush Phenomen*

Compression proximally will decrease the threshold for compression distally

**Most common:** C6 radiculopathy c coexistent Carpal tunnel syndrome

Also common: C7 radiculopathy c coexistent Cubital tunnel syndrome

### **Treatment**

*Mild compressive neuropathy*

Symptoms, no neuro exam findings, no positive NC studies

Nonoperative with splints and injections

*Moderate CN*

Positive symptoms, positive neuro findings and NCS

Operative management = DECOMPRESSION +/- neurolysis

*Severe CN*

Positive symptoms, positive neuro findings and NCS

Poor surgical results b/c of endoneurial fibrosis

**EPS (NCV/EMG)**

**NCV**

Normal = 40 – 70 m/sec persists distal to the lesion for several days

Size of action potential proportional to the number of axons

*Latency*

Increased latency associated with demyelination

**EMG**

Normal pattern remains for up to 3 weeks after nerve injury

*Sharp Waves (always pathologic)*

Earliest EMG sign of denervation are sharp waves (5 – 14 days post injury)

*Fibrillations (always pathologic)*

At 15 – 30 days, sharp waves give rise to random sporadic firing of individual muscle fibers = *fibrillations*

Single muscle fiber activity

Fibrillations c large amplitude is c/w early injury

Fibrillations c small amplitude infers chronic injury

**Decreased amplitude is indicative of axonal loss and is an indication for surgery**

**Axonal loss is associated with EMG**

*Polyphasics*

**INDICATES REINNERVATION**

Axons reach muscle and polyphasics occur on EMG

KEY EMG finding 6 wks to 3 months that demonstrate reinnervation obviating surgery

**CASE:** Patient with brachial plexopathy 3 months out has polyphasics on EMG does not need exploration and may be observed

*Fasciculations*

**Indicative of a CNS/Neuromuscular disorder**

**MEDIAN NERVE COMPRESSION**

Forearm weakness secondary to pain is classic presentation

Numbness, paresthesias in median nerve distribution

*Sites of Compression*

Struthers ligament

Bicipital aponeurosis (Lacertus fibrosis): tested with resisted pronation with elbow FLEXED

Interval between pronator teres heads: tested with resisted pronation with elbow EXTENDED

Fascia of FDS

Gantzer's muscle (accessory of FPL)

**Carpal tunnel (MOST COMMON site of median nerve compression)**

**CARPAL TUNNEL SYNDROME**

*Pathology*

Not inflammatory

Edema and fibrosis of the tenosynovium

*Nonoperative Management*

Splints c wrist at **neutral** to prevent increased pressure in the CT

Injections provide 20% relief at 12 months

*Operative Management*

Failed nonoperative management

AbPB atrophy or sensory loss (prime thumb opposition therefore very important)

Decreased amplitude on EMG, indicating loss of axons

*Outcome*

Pinch will improve at 6 weeks

Grip will improve at 3 months

**CUBITAL TUNNEL SYNDROME**

*Symptoms*

Numbness in RF + SF

Clumsy + weak hand

*Signs*

Tinnel sign

Elbow flexion test (similar to Phalen test for CTS)

Positive compression test at cubital tunnel reproducing symptoms

**Decreased dorsal ulnar hand sensation (key differentiation from Guyon canal syndrome)**

*DDX*

TOS

Apical lung tumor (Pancoast tumor)

C7 pathology

Snapping Ticeps

**Treatment**

*Nonoperative*

Splints 45 degrees elbow flexion or more extended

Ergonomics

NSAIDs

50% get better with nonoperative management

*Surgical Management*

Mild = any procedure

Moderate/Severe = submuscular transposition

**Intrinsic atrophy may slightly improve but does not completely return**

Is not a CI to surgery but does portend poor outcome

*Complication*

Neuroma of medial antebrachial cutaneous nerve

**ULNAR TUNNEL SYNDROME (GUYON'S CANAL)**

*Etiology*

Number one cause: ganglion

Must r/o ulnar artery thrombosis, and hamate fracture

*Sign*

Normal dorsoulnar hand sensation

### *Diagnositic Studies*

MRI when suspect ganglion  
Allens test when supect thrombosis  
CT scan or carpal tunnel view xray for hamate fx

### *Site of Compression*

Proximal to hamate = mixed motor and sensory deficits (zone I)  
At hamate = motor only deficits (zone II)  
Distal to hamate = sensory only deficit (zone III)

## **RADIAL NERVE COMPRESSION**

### ***RADIAL TUNNEL SYNDROME***

Vague FOREARM PAIN  
NO PIN dysfunction  
EPS (NCV/EMG) are always **NORMAL**

### *Etiology*

Arcade of Frohse  
Fibrous bands  
Recurrent leash of Henry  
Distal Supinator

### **Treatment**

Nonoperative for 6 to 12 months  
Poor results with operative management (50 – 80% improvement)

### ***PIN SYNDROME***

Motor to PIN muscles affected  
SRN intact  
NCV/EMG are diagnostic (*Unlike Radial tunnel syndrome where EPS studies are negative*)

### **Treatment**

Operative management if no improvement by 3 months (*no fasciculations on EPS*)

### *Surgical Approaches*

Brachioradialis splitting approach = most direct approach to arcade of Frohse  
Posterior (Thompson) approach = interval is ECRB/EDC, best view of entire Supinator

## **AIN SYNDROME**

Rule out Parsonage Tuner syndrome (brachial neuritis), which presents like AIN syndrome  
Anomalous muscle of FPL (Gantzer's Muscle), can be a site of compression

### **Treatment**

Nonoperative management for 3 – 6 months  
Operative management c decompression

## **NERVE CONDUITS**

### *Limitation*

3 cm or less is limit for use (approximately 1 inch)  
Results equal to nerve grafting

## **NERVE LACERATION**

Most important factor in peripheral nerve repair outcome is patient AGE  
Not timing or technique

### *Epineural Repair*



Up to **3 weeks** p injury yields good results

Epineural repair = to fascicular repair in outcome studies EXCEPT for the Median and Ulnar nerves at the wrist where fascicles are easily appreciated and repaired

Orientation of the nerve in epineural repair is critical

*Suture:* 10-0 for digital nn; 8-0 or 9-0 for FA/Arm nn

**Number one factor affecting outcome is AGE OF PATIENT (<40 yrs better)**

Nerve tension is a major factor affecting outcome

- when in doubt = graft
- 8% elongation of nerve leads to approx 50% decrease of nerve perfusion (Stevonovich goes crazy EIGHTs when we do not graft gaps greater than 8%)

*Nerve Conduits*

**Results just as good as grafts for gaps up to 3 cm**

### **EXTENSOR TENDON INJURY**

*Zones of Injury*

Odds at joints (I,III,V,VII)

Evens at shafts (II,IV,VII,VIII)

*Juncturae Tendinium*

Juncture tendon from EDC(IF) to EDC(MF) which may hide laceration to extensor tendon to MF. Patient must demonstrate full extension of MF with palm on table to determine if complete laceration present

#### **Treatment**

< 50% tendon laceration treated c early ROM (no repair indicated)

### **MALLET FINGER**

Pathology always at DIP (terminal tendon disruption)

#### **Treatment**

*Acute* = < 4 weeks

1. Treat with extension splinting for 6 weeks, leaving the PIP joint free
2. **Subluxation** or  $\geq 50\%$  joint involvement requires CRPP

*Chronic* =  $\geq 4$  weeks

1. Treat with debridement DIP and imbrication, tendon reconstruction
2. DIP fusion is other option

*Complication*

May lead to SWAN NECK DEFORMITY secondary to overpull of central slip

**Treatment:** SORL reconstruction or Fowler central slip tenotomy

### **BOUTONNIERE DEFORMITY**

Pathology always at the PIP (CENTRAL TENDON SLIP DISRUPTION)

Extension of DIP, flexion of PIP

3 STAGES:

- central slip disruption (essential lesion)
- triangular ligament attenuation
- volar subluxation of lateral bands (lumbricals)

**Elson Test** (*best test/most sensitive test*)

- Patient unable to actively extend PIP against resistance with MP flexed
- *NB: Bunnel Test is for intrinsic plus hand*

**Boutonniere deformity of thumb is most common THUMB deformity in RA**

- **Due to MPJ synovitis and rupture (pathology at MPJt unlike Bout in 2 – 5 at PIPJt)**
- *NB:* digits 2 – 5 in RA usually get swan neck deformities; RA also assoc with intrinsic plus hand

## **Treatment**

*Acute* = < 4 weeks

Static PIP splint for 6 weeks

MP, DIP ROM exercises

*Chronic* = > 4 weeks

**First objective is supple joint via splinting or surgical release**

- *NB*: Stiff joints require ROM before tendon work is performed

Second stage is Fowler Tenotomy or Matev reconstruction

## **SWAN NECK DEFORMITY**

*Multiple Etiology*

- Chronic mallet finger (leads to overpull of central slip)
- **RA**: PIP joint volar plate laxity, MP subluxation, synovitis
- CP: intrinsic spasticity

Pathology can be at the DIP, PIP, MCP joint

Flexion of DIP, extension of PIP

## **Treatment**

*Identify cause*

*Chronic Mallet* = SORL procedure

*PIP joint issue* = FDS tenodesis

*Rehabilitation*: early ROM with Short Arc Motion "SAM"

*Complication*

Most common complication is FLEXION lag

Extrinsic tightness: loss of flexion at the PIP secondary to fibrous adhesion to bone; **Treatment**: tenolysis

## **EXTENSOR TENDON LACERATIONS/REPAIR**

*Complications*

Number ONE complication is FLEXOR lag, not extensor lag

Associated fractures negatively affect the prognosis

## **SAGGITAL BAND RUPTURE**

Mechanical symptoms at the MP joint

Digit deformation with ULNAR deviation:

- Ruptured sagittal band is always on the RADIAL side
- Therefore the intact tendon subluxes ulnarly

## **Treatment**

*Acute* (< 4 weeks): Extension splint 4 – 6 weeks

*Chronic* (> 4 weeks): Repair or Reconstruct

## **INTRINSIC TIGHTNESS**

Commonly caused by *crush injury*

**Finocchio or Bunnel Test** positive: Decreased PIP jt flexion with hyperextension of MP Jt

## **Treatment**

*Nonoperative* with intrinsic stretching

*Operative*: Intrinsic release or tenolysis if nonoperative management fails

## **LUMBRICAL PLUS FINGER**

Traumatic laceration of FDP tendon distal to lumbrical insertion or amputation at the DIP

Paradoxical PIP extension with attempt at making a fist by FDP pulling through the Lumbrical

## **Treatment**

Lumbrical tenotomy

## **FLEXOR TENDON INJURY**

### *Tendon Healing*

0 – 5 days: Inflammatory phase

5 – 28 days: Fibroblastic phase; rupture phase because of disorganized collagen (**2 WEEKS is weakest point to tensile strength; 2 weeks to TWEAK the tendon**)

> 28 days: Remodeling phase; organized collagen

### **Treatment**

0 – 25% laceration = trim to prevent triggering

25 – 50% laceration = epitenon suture

> 50% laceration = core/epitenon suture (epitenon adds 20% strength to the repair)

### *Repair*

Best if done < 10 days: Gelberman

Good results up to 3 weeks

*Epitenon suture* (6-0 nylon) adds 20% strength to repair

*Core suture*: **linear increase in strength with number of core sutures**; must have at least 4 strand for early AROM

For tendon grafting of late injuries, **MUST** have full PROM before surgery, no excessive scar, intact nerves

### **Thumb (FPL)**

Avoid repair in zone III (under thenar muscle); reconstruct c graft

### *Complication*

High rupture rate (15 – 20%) is well-known complication b/c FPL muscle belly is large

### *Rehabilitation*

Dorsal splint with wrist flexion to 30 degrees and MP flexion to 70 degrees for 6 weeks with early passive flexion and controlled active digit extension

Stress (motion) at the repair site increases the amount collagen deposited and aids in the organization of the collagen deposited, resulting in stronger repair

Early range of motion after tendon repair encourages a stronger repair

**Most important** advantage of early ROM following FT repair is increased excursion (decreased adhesion)

## **FLEXOR ZONE III LACERATIONS**

### *Complications*

High association of nerve and vascular injury

## **FLEXOR POLLICIS LONGUS**

Different can of worms b/c it has a large muscle belly and tendon leading to 15 – 20% rupture rate

- Consequently, no early AROM; perform Duran
- Also perform at least 4 or 6 strand repair

### Preserve the OBLIQUE LIGAMENT

Avoid zone III (under thenar muscle) primary repairs, treat with tendon grafting

## **JERSEY FINGER**

Commonly injured in football/rugby players

*Type I*: recedes in palm

*Type II*: recedes to proximal phalanx

*Type III*: recedes to A4 pulley

### **Treatment**

#### *Type I Injuries*

May attempt primary repair if performed < 2 weeks

Greater than 2 weeks = Excision of profundus stump with DIP fusion

## TENDON TRANSFERS

### *Principles*

Lose ONE unit of power with tendon transfers

### Synergistic Transfers

- Wrist Flexors make excellent Digit Extenders
- Wrist Extensors make excellent Digit Flexors

## FLEXOR PULLEY SYSTEM

*Cruciate pulleys:* 3

*Annular pulleys:* 5 (**A2 + A4 are critical to preserve to prevent bowstringing**)

**Clinical bowstring digit indicates rupture of A2, 3, 4 pulleys**

## TRIGGER FINGER

### *Thumb*

ALWAYS perform open b/c of risk of neurologic injury (RDN)

Complication of percutaneous release is damage to the radial digital nerve

## FINGER TIP LACERATIONS

### *Transverse Amputation/Laceration*

- No bone exposed; **Treatment:** granulation
- Bone exposed; **Treatment:** V-Y advancement

### *Dorsal Oblique Amputation/Laceration (Dorsoproximal to Volardistal)*

- V-Y advancement
- Shorten bone and close (ie. fish-mouth type closure)

### *Volar Oblique Amputation/Laceration (Dorsodistal to Volarproximal)*

- Cross finger flap
- Thenar flap (young patient; IF or LF)

### *Thumb Distal Amputation/Laceration*

- **Moberg**
  - o gives you sensation
  - o *complication:* flexion contracture at the IP joint

### *Principle Concepts*

Children < 2 c tip injuries remodel well with dressing changes

V-Y advancement flaps are good for dorsal and distal transverse wounds

Cross finger flap indicated for small volar digit wounds c tendon exposed

Axial flap flaps can be performed dorsal and volar wounds in proximal digits; cover tendons

Thenar flap is suitable for tip injuries to IF, MF; 10 – 14 days; risk stiffness

Moberg flap is limited to distal injuries to the thumb; good sensation; risk IP stiffness

STSG contract, have poor cosmesis, and no sensation; poor durability; dorsum hand

FTSG volar hand; tendon coverage; sensation

## SCAPHOID PATHOLOGY

Signet ring is seen on most all PA views. When the distance from the signet ring to the proximal pole of the scaphoid is less than 7 mm this indicates scaphoid pathology

When trauma patient presents with radial styloid fracture, you must inspect the scapholunate joint for widening and other perilunate findings because of the association of radial styloid fractures and carpal injuries

SL joint widening > **3mm** (Terry Thomas Sign) indicates open reconstruction percutaneous pinning

*Scaphoid Fx Instability:* displacement > **1 mm**, angulation > 45 degrees, SL angle > 60 degrees,

capitolunate angle > 15 degrees

Scaphoid instability indicates ORIF because nonoperative management is associated with nonunion, arthrosis, and carpal collapse

Disruption of SL ligament or unstable scaphoid fracture may result in a *DISI* carpal instability pattern

DISI carpal instability can then progress to SLAC or SNAC wrist

Associated pathology with DISI is *Kienbock's disease* (osteonecrosis of lunate)

#### **Treatment of DISI**

1. Repair of SL ligament (soft tissue repair) if deformity is correctible (supple) and pinning
2. Fusion procedure if deformity is not correctible (supple): STT fusion (scaphotrapezialtrapezoidal) or SLC fusion (scapholunocapitate)

#### **ISOLATED UNSTABLE SCAPHOID FRACTURE**

##### **Treatment**

Isolated unstable scaphoid fx can be treated with ORIF

Scaphoid waist fx approach from volar wrist between FCR and the radial artery

Screw placement **CENTRAL** one-third of proximal pole, shown to be stiffest/best position

#### **SCAPHOID NONUNION**

##### **Treatment**

Vascularized bone graft utilizing the *1,2 intercompartmental supraretinacular artery* (branch of the radial artery) as the pedicle

Interl fixation

#### **DARRACH EXCISIONAL ARTHROPLASTY**

For ulnar impingement syndrome + DRUJ arthrosis (*NB: Ulnar impingement without associated DRUJ pathology is treated with ulnar shortening*)

Ulnar head is excised, with ulnar styloid remaining intact

Factors influencing results

- Amount of bone resected, the less the better
- Good to excellent results occurred when the procedure was modified to involve minimal bone resection associated with soft-tissue reconstruction

*Complication*

**Proximal ulnar shaft instability is common complication**

#### **WRIST + HAND IMAGING**

The way to differentiate a PA versus AP radiograph is by the location of the ulnar styloid

- If the styloid is lateral to the ulna than the image is a PA view
- If the ulnar styloid is more posterior than lateral than the image is an AP view

Clenched fist view in ulnar and radial deviation should be in AP view for determining scaphoid pathology

#### *Metacarpal Fractures*

4/5<sup>th</sup> MC injuries best seen on oblique view – 30 degrees pronated from the lateral

2/3<sup>rd</sup> MC injuries best seen on oblique view – 30 degrees supinated from the lateral

#### **CLENCHED HAND CONTRACTURES**

##### **Treatment**

FDS to FDP proximal transfer to allow longer resting tendon length, finger extension and hygiene

#### **HAND INFECTIONS**

*Mycobacteria Marinum*

Patient work/play in water environment “water wound”

Direct penetration

**Diagnosis on special culture: Lownstein-Jensen culture 30 degree Celsius (all mycobacterium are diagnosed using this special culture – common question)**

**Treatment:**

- I+D

- Multi-agent antimycobacterial meds for 4 – 6 months
- *NB: MOST mycobacterial hand infections are treated with this regimen*

*Eikenella Corrodens*

**Treatment**

High dose PCN

*Vibrio Vulnificus*

**Associated with brackish water and shellfish**

Has devastating consequences c severe invasive infections

- **Mortality rate up to 50% with Vibrio septicemia**

**Treatment**

Local I + D

Third generation cephalosporin: Ceftazadime

**GENERAL HAND PATHOLOGY**

Hand patient who does not respond to antibiotics, consider TB, fungus, epithelioid sarcoma

**XRAY FINDINGS CHARACTERISTIC FOR PATHOLOGY**

*CPPD*

Calcification in the TFCC is pathognomonic for pseudogout

*Chondrocalcinosis*

Calcifications on the FCU

**ARTHRITIDES**

*Pseudogout (CPPD)*

Swollen wrist

Calcification of TFCC

Arthrocentesis

Do not be fooled into thinking it is a septic arthritis of the wrist

**REPLANTATION**

*Indications*

**Child:** Any part

**Adult:** Thumb; wrist and proximal; multiple digits; single digit distal to FDS

*Time*

**Distal to Carpus:** <12 hours warm ischemia, <24 hours cold ischemia

**Proximal to Carpus:** <6 hours warm ischemia, <12 hours cold ischemia

*Prognosis*

**The MOST predictive factor of replant survival is MECHANISM OF INJURY**

*Replant Monitoring*

**Signs of failure:** Drop in 2 degrees Celsius, < 30 degrees Celsius, O<sub>2</sub> sat < 94%

**Most common causes of failure:**

#1: Arterial thrombosis

#2: Venous congestion (blue with good refill)

- treat with leeches that excrete HIRUDIN (anticoagulant)

**THUMB RECONSTRUCTION**

*Operative Management Directed by Level of Injury*

**IP joint and distal:** Primary closure; Local flap; Toe to thumb (wrap around)

**Proximal phalanx:** Toe to thumb; Web deepening; Metacarpal lengthening

**MCP joint:** Toe to thumb

No CMC: Pollicization (IF to Thumb Transfer)

*Occupation/Activity Level also Directs Management*

**Manual Laborers:** NO pollicization b/c laborers need as many digits as possible

**Athlete:** NO toe to thumb transfer

### **BENNET FRACTURE**

MC IA Base

Abductor Pollicis Longus is deforming force

**Treatment:** CRPP; ORIF if cannot CR

1 mm displacement = arthritis

### **CMC DISLOCATIONS**

Inherently unstable

**Treatment**

Acute = CRPP

Chronic = ORPP

### **METACARPAL FRACTURES**

*Shortening*

**Up to 4 mm acceptable**

Complication > 4 mm shortening = **extensor lag**

Every 2 mm shortening leads to 7 degrees extension lag

### **GAMEKEEPERS THUMB**

Thumb MP Joint UCL injury

Must examine with MP joint in FLEXION

*Stener Lesion*

Adductor tendon interposed in UCL

*First Proper UCL Tested in Flexion*

- Greater than 15 degrees compared to well hand
- Greater than 30 degrees absolute

**Treatment:** open repair

### **TFCC INJURY**

Traumatic v Degenerative

End stage leads to ulnocarpal impingement

**Treatment**

*Mild/Central Tears*

- Debride TFCC
- Blood supply to the TFCC is peripheral

*Moderate/Ulnar Avulsion/No Trampoline Effect on Arthroscopy*

- Repair TFCC

*Severe/Ulnar Impingement*

- Repair + Ulnar wafer resection if less than or equal to **2 mm** shortening
- Repair + Ulna shaft shortening if **> 2 mm** shortening

### **DISTAL RADIUS FRACTURES**

**Treatment**

ORIF = Ex-Fix

Can accept up to 20 degrees dorsal tilt for good functional outcome

*Unacceptable Criteria*

- Greater than 2mm step off (leads to radiocarpal arthrosis)
- Greater than 5mm radial shortening (leads to DRUJ arthrosis)
- IA gapping

### *Complications*

**#1 complication is SOFT TISSUE injury = median neuropathy from CTS**

**#2 malunion/arthritis**

### **CPPD (PSEUDOGOUT)**

Metabolic disorder

Wrist pain

Limited ROM

*Plain imaging study:* CALCIFICATION OF TFCC (just like meniscus) + FCU

*Aspirator:* positive birefringent crystals on polarized light microscopy (rhomboid shape)

### **Treatment**

*Acute:* Colchicine or Indocin; +/- steroid injection

### **CONGENITAL HAND**

Hand forms for 5 – 8 weeks gestation (coincident with heart development)

Preaxial = Radial side (NB: Preaxial on foot is Great toe side)

### *Lack of Thumb Opposition*

Opponensplasty utilizing Abductor Digiti Minimi to PP of Thumb

### *Syndactaly*

Most common congenital disorder of hand

Most common involved digits MF to RF

Simple or Complex (Bone Fused); Incomplete or Complete

Perform operation from 18 months to 5 years for complete differentiation

Poland Syndrome: syndactaly, short digits, no sternocostal head of pectoralis major

### *Hypoplastic Thumb*

When considering management of thumb aplasia or hypoplasia, need to assess stability of CMC joint

Thumb absence or deficiency is part of longitudinal radial deficiency

Associated with VATERL syndrome (Vertebra, Anal deficiency, Trach-Esoph, Renal, Lung), and Radial club hand

### **Treatment**

1. Reconstruction

2. If CMC is destroyed/unstable then perform thumb ablation and index finger pollicization

### **FLAPS**

#### *Trauma*

Lowest infection rates and flap necrosis if free tissue transfers performed < 72 hours (3 days) after injury

#### *Groin Flap*

Blood supply: Superficial Circumflex Iliac Artery

#### *Lateral Arm Fasciocutaneous Flap*

Blood supply: Posterior branch off the deep brachial artery

### **POLANDS SYNDROME**

#### *4 Characteristic Features*

1. Absence sternocostal head of the Pectoralis Major muscle
2. Short digits secondary to absent or short middle phalanges
3. Syndactaly of the small finger
4. Hypoplasia of the hand and forearm

### **PARONYCHIA**



*Chronic*

**Treatment**

Marsupialization

**PERILUNATE DISLOCATION**

*Chronic*

**Treatment**

Proximal row carpectomy from a volar and dorsal approach

- volar approach to decompress the median nerve and excise Lunate
- dorsal approach to excise the scaphoid and triquetrum

**BASILAR THUMB ARTHRITIS**

Arthritis at the first CMC joint

Positive grind test

**Treatment**

*Stage I:* Opponens splinting (thumb abduction), rest, NSAID

*Stage II (mild-mod subluxation: radial/dorsal), III, IV:*

1. Ligament reconstruction
2. Dorsal metacarpal osteotomy to unload area of arthritis
3. Suspension arthroplasty: Partial or complete trapezium resection/FCR interposition

Fusion: young male laborers, or gross instability > 20 degrees MCP extension

**CREST SYNDROME**

Chondrocalcinosis

- Calcifications of the muscle on plain imaging studies

Raynauds Phenomenon

- Cold/numbness in digits
- Angiography demonstrates diminished flow to digits
- May result in autoamputation of the digits
- **Treatment:**
  - o Avoid environment/stress that causes flare
  - o Medications: calcium channel blockers, vasodilator cream
  - o Injections: sympathetic blocks
  - o Surgery: sympathectomy, amputations

Esophageal dysmotility

Sclerodactyly

Telangiectasia

**TUFT FRACTURE**

Blunt trauma, often associated with NAIL BED lacerations, subungual hematoma

**Treatment**

Tuft fracture with > 50% subungual hematoma requires:

- nail plate removal
- nail bed repair
- oral antibiotics
- splint

*Complications*

Repair the nail bed to prevent future nail plate deformity

**CALCIFIC TENDONITIS IN THE HAND AND WRIST**

**Most commonly occurs in the insertion of the FCU into the pisiform**

**Treatment**

NSAIDs and immobilization  
Occasionally, corticosteroid injection is necessary

### **CAT BITE INFECTION**

Pasturella Multicida

#### **Treatment**

Augmentin or Penicillin

### **SPOROTHRIX SCHENKII**

Fungal infection

**Gardening: soil, rose thorn pathology**

Violaceous cutaneous lesion

#### **Treatment**

Itraconazole over 3 – 6 months

### **SCAPHOLUNATE LIGAMENT TEAR (DISI)**

Wrist pain

Scapholunate ligament injury is most common ligament injury in the wrist

*Watson Test*

Radial deviation of the wrist applying dorsal pressure of the scaphoid

A positive test is when there is a clunk c radial deviation of the wrist

The clunk is the proximal pole of the scaphoid subluxating over the lip of the radius

The SL ligament normally stabilizes the scaphoid with radial deviation of the wrist

While radially deviating the wrist you can push the scaphoid up over the lip of the radius

*Plain Imaging*

Obtain clinched fist view

Widening S-L interval = 3 mm or greater

Scapholunate angle greater than 60 degrees (DISI Deformity)

#### **Treatment**

*Acute*

OPEN REPAIR and pinning (not CRPP)

*Chronic*

Open repair versus ligament reconstruction and pinning

Most are treated with bone fusions:

- STT fusion
- versus SLC fusion

### **LUNOTRIQUETRAL LIGAMENT TEAR (VISI)**

Wrist pain

*Pathoanatomy*

**NOT just a tear of the LT ligament but also the dorsal radiolunotriquetral ligament**

**LT ligament alone does not cause a VISI deformity**

*Plain Imaging*

Scapholunate angle is **30 degrees** or less

#### **Treatment**

*Acute*

OPEN REPAIR of ligament and pinning

*Chronic*

LT fusion

## **SLAC WRIST (SCAPHOLUNATE ADVANCED COLLAPSE)**

Number one cause of radiocarpal arthritis

Due to chronic SL rupture and develop arthritis

LUNATE FOSSA IS ALWAYS SPARED

Starts at the scaphoid fossa

*Stages*

I – Scaphoid tip/styloid

II – Scaphoid fossa

III – Capitate arthritis

IV – Wrist arthritis

### **Treatment**

*Stage II*

Proximal row carpectomy

Four corner fusion c scaphoidectomy

Essentially both have equivalent outcomes

- PRC favors motion (not statistically significant)
- Four corner fusion favors power (not statistically significant)

*Stage III*

Four corner fusion

Wrist fusion

*NB: when **capitate has arthritis** you have to perform a fusion*

*If you performed a PRC with capitate arthritis, pain would occur between radius and capitate*

*Stage IV*

Wrist fusion

## **SNAC WRIST (SCAPHOID NONUNION ADVANCED COLLAPSE)**

Differences from SLAC wrist:

- SNAC is due to a scaphoid fx nonunion with advanced collapse
- Proximal pole of scaphoid and corresponding fossa **not** involved in SNAC wrist

*Stages*

I – Distal pole of scaphoid fracture arthritis

II – Capitate arthritis

III – Wrist arthritis

### **Treatment**

Same as SLAC wrist

## **KEINBOCKS DISEASE**

AVN of the lunate

Associated with ulnar MINUS wrist and heavy labor

Early diagnosis by MRI and bone scan

*Lichtman Staging*

I – xray normal

II – Lunate sclerosis

IIIa – Lunate fragmentation

-

IIIb – Lunate fragmentation and collapse: scaphoid is collapsed in flexion

IV – wrist arthritis

### **Treatment**

*Stages I – IIIa*

**Joint leveling procedure: #1 procedure used is radial shortening**

STT fusion or SLC fusion

*Stage IIIb*  
STT or SC fusion  
*Stage IV*  
Wrist arthrodesis

### **DISTAL RADIUS FRACTURE**

*Complications*

**#1 problem are associated median nerve problems (SOFT TISSUES) / Stiffness**

Soft tissue problems like stiffness (50%)

Malunion or arthritis (38%)

### **FIRST CMC ARTHRITIS / BASILAR ARTHRITIS**

Positive grind test

Palmar beak ligament is most important for stability

Deformity is dorsoradial

### **Treatment**

*Stage I*

1. Palmar beak ligament reconstruction

2. Extension osteotomy (30 degree): shifts load to dorsal joint; less popular but effective in 80 – 90% of pts

*Advanced Stages*

Arthroplasty: suspension c FCR interposition; G/E results in 90%

Arthrodesis: 20 degrees extension, 45 degrees abduction, 15 degrees IP flexion and pronation; good for laborers and power, young pts; disadvantages: cannot get flat hand, STT arthritis; Nonunion 14%

### **RA TENDON RUPTURES**

*Principle: Address Wrist Deformity Before Correcting Distal Hand Disorders*

*Vaugh-Jackson Lesion*

Extensor tendon rupture to RF and SF

Associated with DRUJ instability

### **Treatment**

Darrach (DRUJ arthrosis) and Extensor tendon transfers

*FPL Rupture*

Associated with a Mannerfelt lesion, osteophyte on the volar scaphoid

### **Treatment**

CTR

Excise osteophyte

Bridge graft FPL or perform thumb IP fusion

If treatment not instituted early, could lead to other tendon ruptures

### **AUTOSOMAL DOMINANT CONGENITAL HAND DISORDERS**

Ulnar (Postaxial) Polydactyly

Camptodactyly

Brachydactyly

Cleft hand

### **PRINCIPLES IN MANAGEMENT OF CONGENITAL DISORDERS**

*Reconstructive Deformities*

Example: Pollicization

Perform 18 months to age 3 because developmental patterns mature

*Tendon Transfers*

Perform after age 4 b/c they require cooperation for rehabilitation

## **POLLICIZATION**

Index finger to thumb transfer

Commonly performed for either trauma to thumb where CMC is affected or congenital disorders like radial club hand

<u>Index Finger</u>	becomes	<u>Thumb</u>
DIP		IP
PIP		MP Jt
MPJt		CMC Jt
EIP		EPL
EDC		AbPL
1 <sup>st</sup> Volar Interosseous		AddPL
1 <sup>st</sup> Dorsal Interosseous		AbdPB

## **ULNAR IMPACTION SYNDROME**

Ulnar sided wrist pain

*Etiology*

Developmental

Acquired: DRFx, Essex-lopresti, Physeal injury

### **Treatment**

Assess DRUJ

*No DRUJ arthritis:* Ulnar diaphyseal shortening, Wafer resection (< 2mm ulnar positive), Arthroscopic debridement if ulna neutral

*DRUJ arthritis present:* Suave-Kapandji, Darrach, Hemiresection

## **DUPUYTREN'S DISEASE**

Myofibroblasts are cell responsible for the pathophysiology

*Risk Factors*

Northern Europeans

Rare before age 40

M > F

HIV

Associated with alcoholism, diabetes, chronic pulmonary disease

*Pathoanatomy*

Advanced stage of disease has excessive amount of Type III collagen (scar collagen); normally type I collagen is present in the palm

Cleland's ligament is preserved in Dupuytren's disease

The only part of the web coalescence not involved in the spiral cord is the natatory ligament

The spiral cord puts the neurovascular bundle at risk

### **Treatment**

*Operative Indications*

MCP flexion contracture > 30 degrees

PIP flexion contracture > 30 degrees

*Technique*

Regional palmar fasciotomy

Open palm technique is operation of choice in older pts who are at risk for stiffness

Leaving wounds open reduces edema, hematoma, and pain and allows early ROM

Open palm technique associated with lowest rate of complications

*Complications*

**Hematoma is MOST COMMON complication: meticulous hemostasis is critical**

Neurovascular injury: the best predictor of central neurovascular bundle displacement is the presence of a PIP joint flexion contracture (77% PPV)

Stiffness: AROM is started at day 5 – 7 postoperatively, Night splint in extension is worn for 6 months

Recurrence: 50% long-term recurrence rate