Objectives

- Wrist Biomechanics
- Essential anatomy of the wrist
- Carpal Kinematics
- Force Transmission
- Instabilities
  - CID (carpal instability dissociative)
  - CIND (carpal instability non-dissociative)
  - CIC (carpal instability complex)
- Wrist Rehabilitation

Wrist Anatomy

- Contributors to a functional stable wrist...
  - Bones (8 carpals of varied shape, radius, ulna, metacarpals that articulate with DCR)
  - Ligamentous structures (intrinsic and extrinsic)
  - Proprioception
  - Muscle Contraction for stabilization

Bones of the Wrist

- Complex shapes
- Intricate articulations with each other
- Radius to carpus
- Carpal bones with one another
- Grossly wrist motion is combination of motion at:
  - Radiocarpal Joint
  - Midcarpal Joint

Bone Anatomy

- Radiocarpal Joint
  - Ulnocarpal
- Midcarpal Joint
- Radial articulations
  - STT
  - SC
- Central articulations
  - LC
- Ulnar articulations
  - TqH

Extrinsic Carpal Ligaments

- Dorsal
- Palmar
Intrinsic Carpal Ligaments

Mechanoreceptor- Dense Carpal Ligaments

Carpal Kinematic Theory

Column theory first by Navarro (1919) and modified by Taleisnik (1976) - central column connected to DCR through capitate and paired w/ lunate

Lichtman’s Oval ring concept: triquetrum, lunate, scaphoid, DCR

Wrist Flexion/Extension

• Center of motion lies within the head of the capitate
• Wrist extension occurs more at radiocarpal joint
• Wrist flexion occurs more at mid carpal joint

Wrist Radial Deviation

• With Radial Deviation (RD)
  • PCR flexes
  • PCR glides dorsally
  • PRC translates ulnarily
  • Lunate pronates
  • Triquetrum rides proximally & dorsally on the hamate

Proximal row has more mobility between the individual carpal bones compared to the distal carpal row

Cardinal vs. Functional axis of motion of the wrist - F/E and RD/UD compared to Dart Throwing Motion (wrist extension/RD into wrist flexion/UD)

DCR secured firmly to hand unit (MC and Phalanges) by articular interlocking and strong ligaments. PCR are not as secured due to mid carpal joint

The scaphoid is strategically positioned to add stability to a naturally unstable mid carpal joint line

Wrist Flexion/Extension

• Center of motion lies within the head of the capitate
• Wrist extension occurs more at radiocarpal joint
• Wrist flexion occurs more at mid carpal joint

Wrist Radial Deviation

• With Radial Deviation (RD)
  • PCR flexes
  • PCR glides dorsally
  • PRC translates ulnarily
  • Lunate pronates
  • Triquetrum rides proximally & dorsally on the hamate

Wrist Flexion/Extension

• Center of motion lies within the head of the capitate
• Wrist extension occurs more at radiocarpal joint
• Wrist flexion occurs more at mid carpal joint

Wrist Radial Deviation

• With Radial Deviation (RD)
  • PCR flexes
  • PCR glides dorsally
  • PRC translates ulnarily
  • Lunate pronates
  • Triquetrum rides proximally & dorsally on the hamate
Wrist Ulnar Deviation

- With Ulnar Deviation (UD)
- PCR extends
- PCR glides volarly
- PCR translates radially
- Lunate supinates
- Triquetrum distally rides distally & volarly on hamate

Force Transmission

- Force travels through a neutral positioned wrist from
  - 3rd MC
  - To Capitate/Scaphoid/Lunate joint at Mid-carpal joint (~50%)
  - To Radio-carpal joint ~80% (RS 46% + RL 32%)
  - and Ulnocarpal joint ~20% (14% UL + 8% UT)
- With axial compressive loading (gripping), PCR tends to rotate into flexion and pronation that is checked by mid carpal ligaments

CARPAL INSTABILITIES

• CID = Carpal Instability Dissociative
  - Instability between carpal bones in same row
  - Static dissociation or gap between carpals due to ligament insufficiency (S-L and L-T tears)
• CIND = Carpal Instability Non-Dissociative
  - Instability of proximal row between either radio-carpal or mid-carpal joint w/o instability between the individual carpal bones in the proximal row
  - Seen w/ loading in patients with ligamentous laxity, or history of trauma
  - Example: Mid carpal instabilities (palmer > dorsal)

Carpal Instabilities

- CIC= Carpal Instability Complex
  - Combination of CID and CIND
  - Example: peri-lunate dislocations
- CIA= Carpal Instability Adaptive
  - Secondary instability due to malunion or bony deformity
  - Example: dorsally malunited distal radial fracture that makes the PCR conform to the abnormal radial tilt

Proximal Carpal Row

- Scaphoid wants to move into flexion
- Triquetrum wants to move into extension
- Scaphoid and triquetrum maintain balance through the SL and LT ligament
- The result in normal circumstances is a balanced lunate in the PCR.
- With wrist in neutral, scapho-lunate angle averages 45-47%

(LOOSEY) LUNATE (CID)

- Lunate goes with carpal bone to which it is still connected
- Flexes if connected to scaphoid (intact S-L)
- Extends if connected to triquetrum (intact L-T)
- If the lunate flexes, because the L-T is deficit, then lunate faces volarly = VISI. S-L angle < 30 deg
- If the lunate extends because the S-L is deficit, the lunate faces dorsally = DISI. S-L angle > 70 deg
Scapho-Lunate Dissociation

Most Common Carpal Instability

History of FOOSH-wrist E & UD

Presents w/ wrist weakness and pain with loading

End result of long standing SL rupture is SLAC (Scapho-Lunate Advanced Collapse)

http://www.rcsed.ac.uk/fellows/lvanrensburg/classification/hand/scapholunate_diss.htm

More About S-L Dissociation

• Timing is crucial...
  • < 3 weeks, healing potential is good
  • >6 weeks (chronic), can it be reduced? arthritis?

  Pre-dynamic: presents with dorsal wrist pain, (+) Watson’s, unremarkable x-rays, most commonly diagnosed through arthroscopic

• Dynamic
  • Isolated complete or partial SL tear
  • Can be seen radiographically with stress views
  • Clenched fist view

• Static
  • Ruptured SL and palmar ligaments
  • (+) Terry Thomas sign

still more...

Dynamic
  Isolated complete or partial SL tear
  Can be seen radiographically with stress views
  Clenched fist view

Static
  Ruptured SL and palmar ligaments
  (+) Terry Thomas sign

Various Interventions for SL Deficit Wrist

• Depends on stage of SL deficit:
  • Immobilization
  • Percutaneous pinning
  • Soft tissue reconstruction of the dorsal SL ligament
  • Bone-ligament-bone grafts
  • Capsulodesis (Blatt)
  • RASL (reduction association of SL joint)
  • Partial fusion (i.e. STT, 4 bone fusion)
  • PRC- Proximal Row Carpectomy (capitate sits in lunate facet on radius)

L-T Dissociation

• Can be confused w/ other ulnar sided wrist problems

• MOI: backward FOOSH w/ arm ER'd, forearm supinated, wrist E & RD

• May be combined w/ TFCC tear & avulsion UC ligament

More about L-T Dissociation

• (+) palmar sagging of the ulnar column

• (+) Ballottment test

• Painful crepitus w/ UD

• (+) giving away sensation w/ supination/UD/E
Surgical Interventions for Carpal Instability

- Various interventions depend on stage of LT deficit
  - Percutaneous pinning of LT joint
  - Immobilization paired w/ therapy program for proprioception re-training of FCU and hypothenar muscles
  - Reconstruction of L-T ligament using ECU (Shin)
  - Partial arthrodesis w/ partial resection of ulna if patient is ulnar (+)
  - Partial fusion (i.e. STT, 4 bone fusion)
  - PRC- Proximal Row Carpectomy (capitate sits in lunate facet on radius)

**Normal S-L angle**
47 deg

**VISI S-L angle**
<30 deg

**DISI S-L angle**
>70 deg

Mid Carpal Instability (CIND)

- Most common form of mid carpal instability is palmar
- Results: wrist unable to bear axial loads w/o collapsing into VISI position
- Results: clunking of wrist w/ UD
- (+) palmar sag, (+) MC shift test

Intervention for Palmar MC Instability

- Immobilization paired w/ therapy program similar to LT instability
- Improve joint stability w/ training of FCU and hypothenar muscles
- Palmar capsular shrinkage (helpful in the hyperlax)
- Tendon reconstruction
- MC fusion
- Radio-lunate fusion

Perilunate Dislocation (CIC)

- Often caused by acute hyperextension w/ UD and intercapal supination (fall onto thenar eminence)
- SL, CL, LT joints are disrupted torn and lunate can rotate into carpal tunnel
- May be associated w/ fractures of carpals, radial and ulnar styloids

Intervention for Perilunate Dislocation

Carpals reduced and fixed w/ K- wire and pins
The dorsal part of SL is repaired

http://rawwwdiographics.rsnra.info/content/28/6/1771.full

http://www.wikem.org/wiki/Perilunate_and_Lunate_Dislocations
General Rehab Guidelines

- Period of immobilization
- Intermittent immobilization
- Introduction of strengthening
- Return to PLOF

Immobilization

- Depends on type of intervention and quality of healing
- can be from 3-12 weeks
- should address edema
- should address joint motions not involved in immobilization

Introduction of Motion

- Removable orthosis worn between exercise bouts
- Address desensitization and scar management
- Exercise bouts starting w/ DTM and progressing to standard AROM
- Gradual resumption of ADLs while addressing proprioception deficits
- Begins between 3-12 weeks depending on intervention

Dart Throwing Motion

- Most functional tasks are performed in this plane of motion.
- Less stress placed on radio-carpal joints with this motion
- Less motion of the scaphoid and lunate
- May have future implications for early motion protocols for fractures, S-L injuries, and ligament repairs

Dart Throwing Motion

Radial E
40 deg E, 20 deg RD

Ulnar F
0 deg F, 20 deg UD

Proprioception Re-Training

- Discussed findings of innervation patterns in ligaments of wrist
- Proposed how these findings can translate to therapeutic intervention in wrist injuries.
- "The field of wrist proprioception and rehabilitation is vast, and we need a collective contribution and collaboration between surgeons and therapists to further our knowledge in this realm."
Muscles as Stabilizers

- Strengthening begins at ~12 weeks
- Start w/ isometrics progress to co-contraction, isotonic exercises. Focus strengthening to specific muscles supporting ligament stability.

  - Hagert & Garcia-Elias found FCU, APL, ECRL as dynamic stabilizers of SL. FCR, FCU, APL reduce stress @ SL
  - Garcia-Elias found FCU, hypothenar stabilizes LT and MCI. Litchman added ECU to stabilize MCI

- Avoid repeated power gripping, repetitive ROM, wrist curls

QUESTIONS

REFERENCES


