Hand Therapy Management of Wrist Instability

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Development of Rehabilitation Approach

Impairment → Mechanism → Design Testing → Functional Improvement

How can an understanding of wrist motion lead to better treatment and rehab?

Why is it important to understand carpal motion?
- Understand effect of injury on motion

Surgical planning
- Surgical approach selected based on motion

Early rehab
- Minimize motion at repaired/injured structures

Late rehab
- Maximize path of motion

First, Know and Understand the SCIENCE
Instability Patterns

**Scapho-Lunate**

**Mid-carpal**

**DRUJ**

### Proximal Row = “intercalated segment”

Motion is dependent on mechanical signals from ligaments

### Scapho-lunate intersosseous ligament (SLIL):

Primary stabilizer

- ACL of carpus

**ANATOMY**

1. Motion occurs primarily at RC and MC joints
2. Ligaments are important primary stabilizers

**Courtesy of Primal Pictures**

**Proximal row, palmar view**

**R wrist, palmar view**

**Distal row**

**Proximal row**

**RC Joint**

**MC Joint**

**Scapho-lunate interosseous ligament (SLIL):**

Primary stabilizer

- ACL of carpus

**Courtesy of Scott Wolfe, MD**

**Scapho-lunate interosseous ligament (SLIL):**

Primary stabilizer

- ACL of carpus
Know thy S-L Ligament

Resected

Photo courtesy of Eugene Ek, MD

Dissociation

Repair

Photo courtesy of Eugene Ek, MD

Photos courtesy of Eugene Ek, MD

Know and understand the anatomy

Scapho-lunate interosseous ligament (SLIL): Primary stabilizer

• ACL of carpus
Scapho-lunate Ligament

Take home points:
Scapho-lunate Interosseous Ligament (SLIL):

- SLIL is a primary wrist stabilizer - mechanics
- SLIL is richly innervated
- Traumatic partial SLIL tears result in impaired proprioception
  - Protective reflex function causing diminished dynamic stability
- Traumatic complete disruption leads to SL dissociation

Instability Patterns

- Scapho-lunate
- Mid-carpal
- DRUJ

Carpal Motion

- Distal carpal motion follows fingers
- Scaphoid follows distal motion
- Lunate follows passively (SLIL)

Biomechanics

Anatomy Biomechanics Kinematic Studies (DTM)
Proprioception Dynamic Carpal Stability

Courtesy of Eugene Ek, MD and Christopher Dy, MD

Courtesy of Scott Wolfe, MD
KINEMATICS:
“The promiscuous lunate” Ken Flowers

KINEMATICS: SL Dissociation

KINEMATICS: LT Dissociation

KINEMATICS: LT Dissociation

Spectrum of disability
Take Away Points

For pain relief and further degeneration
- No good options

Salvage procedures limit motion
- Proximal row carpectomy
- Range of intercarpal fusions
- 4 corner fusion/midcarpal arthrodesis
- STT fusion

Better strategy = prevention, early diagnosis
Early repair of SL ligament prevents further degeneration

Midcarpal Instability

- Involves both MC and RC joints
- Entire row is mal-aligned
- Involves multiple ligaments

Midcarpal Instability: Types

CIND-VISI
CINC-DISI
CIND-Combined
CIND-Adaptive

Midcarpal Instability: Variants

CIND VISI
- Most common
- No specific injury
- “snapping” wrist
- “catch-up Clunk”
- Midcarpal shift test
- 70% ligament laxity
- Non-operative treatment
**Kinematics Studies: HSS, Brown University**

- **Micro Kinematics - Brown**
  - Study of individual carpal motion
    - Micro Kinematics
  - Cadaveric studies (Crisco and Wolfe)
  - In Vivo – CT – Markerless bone registration (Crisco and Wolfe)

- **Macro Kinematics - HSS**
  - Development of biomechanical and kinematic model and solution to measure wrist motion
  - Study of functional wrist motion – motion lab

**Kinematics Studies: Take Away**

- **Coupled Wrist Motion**
  - Dart-thrower’s motion (DTM)
  - Minimal scaphoid and lunate motion during DTM plane
  - Early DTM safe in **protected range**
  - DTM impact on functional activities
  - Circumduction Envelope – task specific quadrants of motion

- **Surgical reconstruction of SLAC**
  - Alters kinematics and functional task performance
  - Findings from PRC and 4 CF patients

**Identification of task specific quadrants of motion**

- Singh, JHS, 2014
- Wolff, JHT, 2014
Seminal work in identifying innervation patterns in the wrist ligaments

- Used advanced staining techniques and immunohistochemical markers to identify presence of mechanoreceptors in each of the 15 wrist ligaments
- US and fine wire electrode to stimulate ligaments in healthy volunteers

Ligamento-muscular reflexes

Sensorimotor control of the wrist

Innervation Distribution in the Wrist

**Intrinsic ligaments**
- Radial
- Triquetal, dorsal
- Dorsal SLIL (Mataliotakis, JHS, 2009)
- Important sensory

**Extrinsic ligaments**
- Radio-ulnar
- Collagene, dense
- Poorly innervated
- Mechanically important

**Dynamic Carpal Stability**

**Proprioceptive Pathways**

**Immediate Pathway**
- Spinal level
- Stimulation of mechanoreceptors in intra-articular ligaments
- Activates control of muscles around the joint

**Secondary Pathway**
- Supraspinal
- Cerebellar
- Unconscious integration of somatosensation and proprioception
- Cortical conscious
Can the proximal row be dynamically stabilized?

Role of Muscles in Carpal Stability

- **SL INJURY**  
  - Flexion and Pronation of Scaphoid
- Scapholunate “friendly” structures = **SUPINATE**  
  - FCU, FCR, APB, ECRL FCR
- Scapholunate “unfriendly” structures = **PRONATE**  
  - ECU

Garcia-Elias et al.

Indications/Contraindications

- **Indication**  
  - Predynamic/Partial SL Injury  
    - Secondary ligaments intact – dorsal  
    - Post-Surgical repair
- **Contra-Indication**  
  - Complete SL tears  
  - Dorsal translation of scaphoid

Then, apply that knowledge to your TREATMENT

Cautionary Tale

Anatomy  | Biomechanics  | Kinematic Studies (DTM)
---|---|---
Proprioception  | Dynamic Carpal Stability

Garcia Elias et al 2014
Cautionary Tale

Limit motion at S-L joint (biomechanics)

- Splints that limit motion to DT plane
- ONLY radial extension to neutral in SL acute injury and early post-repair

Limit activities to DT plane

Limit to radial extension to neutral in early phase

Rigid tape for pre-dynamic S-L instability

Proprioception

Begin proprioceptive training for injured ligaments

Goal: Increase/develop proprioceptive awareness and joint position sense

Hagert, JHT 2010
Case Example 1
- 56 y/o, female
- 10 months radial wrist pain
- Full ROM

Her midcarpal joint is only minimally maligned.

Case Example 2
- 60 y/o, male, Orthopedic Surgeon
- 6 month old injury to non-dominant right wrist, hit backhand shot, felt sharp pain
- Pain with resistive activities, able to work with moderate ache, and able play golf.
- Worried about progression and potential inability to play sports during retirement

Isometric stabilization exercises in PRONATION:
- ECRB
- APL
- FCU

Left and right wrist neutral lateral views show no dorsal subluxation of capitate, intact scapho-lunate ligament.
Right injured wrist PA

Right injured ulnar dev PA

Right injured grip

Template vSLIL intact but stretched
dSLIL intact but stretched

RSC and LRL intact and robust

Consecutive cuts of radioscaphoid fossa showing no dorsal translation

Cartilage-sensitive sequencing showing no cartilage loss
Later phase (stable joint and healed ligaments)

**Biomechanics**
- Full extension
- Circumduction envelope
- Begin strengthening in DT plane

**Proprioception**
- Isookinetic – BTE CPMs
- Isometric exercises

**Neuromuscular Rehab**
- Reactive muscle activation (RMA)
- Perturbation exercises (plyometrics)
- Oscillatory devices (body blade, weighted pipe, power ball) (Balan et al 2008)

Maximizing Circumduction Envelope
Strengthening in DT plane

Proprioception

Kinesthetic awareness
Smallest change in joint angle needed to elicit a conscious awareness of joint motion

BTE PRIMUS – CPM
Passive mode
Isokinetic mode
- Performed at constant angular speed

Neuromuscular
Purpose
Regain smooth motion after trauma or surgery
Use dynamic muscular compression
Promote motion in muscles that are joint protective while avoiding activation of muscles that are joint damaging
Oscillatory devices
Power Ball (Balan et al 2008)
Body Blade
Weighted pipe

Perturbation exercises
Plyometrics

Reactive muscle activation (RMA)

Holmes et al 2016

Holmes et al 2016

Karagiannopolous, JHT, 2016
Closed Chain

Sports Specific

- Multplanar movements
- Position specific maneuvers: shooting guard, power forward, center position etc.
- Flexible protective wrist support

Summary

- Great progress in understanding link between kinematics and carpal function
- Great progress in understanding role of muscles in dynamic carpal stability
- Great progress in understanding role of proprioception and neuromuscular joint control
- Many unanswered questions
- Need clinical studies in large cohorts to compare these treatments to previous standards of care

Challenge

- Small case reports n=1 studies
  - Hincapie, JHT 2016
  - Anderson, JHT 2016
  - Holmes, Hand Therapy 2016 (n=7)
- Let’s begin to report our outcomes
- Or we will never know….

Treatment recommendations

For Mid-Carpal Instability

- Stabilization Splint
- Direct dorsal force on pisiform and triquetrum
- Depress ulnar head

Mid-Carpal Instability
Splinting for midcarpal instability (CIND – VISI)

Why this works?
- Proximal row is in VISI
- Splint directs dorsal force on pisiform/triquetrum and depress ulnar head
- Shift row into dorsal alignment

Courtesy of Emily Altman, CHT, DPT

Challenges
- Difficult to fabricate
- Hard to control VISI with static splint
- Skin cannot tolerate the pressure required to push these bones into proper alignment
Selected References


Thank you

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