EMERGING STRATEGIES FOR REHABILITATION OF CARPAL INSTABILITY

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Goal of Therapy:
A stable, symptom free wrist capable of withstanding the forces involved in the activities that the individual needs to perform for work, leisure and other ADLs

When the unstable wrist lacks full ROM
- Goals for ROM dictated by
  - Patient’s functional requirements
  - Limits of the condition and/or procedure

- **NOT**
  - Arbitrary ROM goals which approach what is considered “normal”
Functional motion

- Wrist ROM adequate for function
  - Palmer et al: 5° flex. & 30° ext.; 10° rad & 15° uln
  - Dart Thrower’s motion used to perform many of the tasks studied
  - Ryu et al: 40° flex. & 40° ext.; 10° rad & 30° uln
  - Brumfield et al: 10° flex & 35° ext

Foundation for Rehabilitation

- Thorough assessment
- Definitive diagnosis

* Ligament injury or instability can progress over time if undiagnosed or improperly treated

FOCUS OF THERAPY

- Provide support with specialized orthoses
- Develop wrist stability
  - Strengthen the stabilizing musculature
- Manage symptoms
- Return to function
  - Modify work, ADL and leisure
GENERAL CONSIDERATIONS

- Nature of the development of the problem
  - Traumatic tear or rupture of ligaments
  - Gradual onset of symptoms in a lax, hyper-mobile wrist
  - Degenerative process with gradual onset

GENERAL CONSIDERATIONS

- Stage of the wrist condition
- Stage of Healing
- Symptom Response – *an indicator of the capacity of the wrist to handle load*
  - At rest
  - With activity
  - With load

GENERAL CONSIDERATIONS

- Functional requirements and habits
  - Role in the onset of the problem
  - How impacted by the condition
- Previous treatment and efficacy
  - Exercise
  - Splints/supports
  - Physical agents
PRECAUTIONS

- Beware of undiagnosed wrist pathology
  - “wrist sprain”
  - “wrist pain”
- Perform clinical wrist exam
  - Localize pathology
  - Facilitate referral to Hand Surgeon for definitive diagnosis

PRECAUTIONS

- Remember: the provocative wrist maneuvers used to detect carpal instabilities are performed with motion combined with load
  - Avoid:
    - Repetitive wrist ROM
    - Aggressive wrist stretching
    - Generic wrist strengthening, e.g., wrist curls

GUIDELINES

- In the absence of best practice guidelines:
  - Observe established timetables for tissue healing in decision-making regarding
    - Duration of immobilization
    - Introduction of protected motion
    - Application of gentle loading
    - Return to function
General Goals of Rehabilitation

- Control of edema and pain
- Maintain ROM of uninvolved joints
- Achievement of functional ROM when healing permits based on patient need
- Preserve wrist stability
- Avoid activities and exercises that adversely load the wrist and undermine healing
- Return to prior level of functioning when healing permits if possible and not injurious to the health of the wrist

Current Practice in the diagnosis and treatment of carpal instability

Prosser, Herbert, LaStayo - J Hand Therapy 2007

Most used treatments
- Patient education
- Custom and pre-fabricated orthoses
- Isometric wrist exercises

Most commonly used tests
- Scaphoid shift
- L-T ballottement
- TFCC and MC stress tests
EMERGING STRATEGIES

- Dart Throwers Motion
- Wrist ligament mechanoreceptors and ligamento-muscular reflexes
- Proprioception re-education
- Muscle loading and carpal alignment
- Graded motor imagery

Dart-thrower motion (DTM)

- First described by Palmer et al 1985 as oblique wrist motion as that which occurs when throwing a dart.
- A plane in which wrist functional oblique motion occurs, specifically from radial extension to ulnar flexion

Dart-thrower motion

DTM is a common path of motion in many occupational, recreational and household activities.

Performance and accuracy of many tasks is linked to DTM.

Injury and surgery to the wrist alters normal kinematic coupling (DTM) and performance of functional tasks.
Dart throwers motion

What’s known
- Scaphoid and lunate motion significantly less than with any other plane of wrist motion
- SLIL elongation is minimal

Werner FW et al. JHS 29A, 3, 2004

Dart throwers motion

- Werner et al studied 9 variations of DTM to determine the specific DT plane of motion that minimized scaphoid and lunate motion
- Far less scaphoid and lunate motion in intermediate motions
  - 15° extension, 15° radial deviation, 15° flexion, 15° ulnar deviation
  - DTM is a safe and protected range of motion for postoperative radio-carpal surgeries

Dart Throewers Motion

What’s not known
- When to introduce DTM after injury or surgery
- How to constrain the wrist along the DTM path
- Specific DTM pattern for specific injuries & procedures
- Outcomes
DTM orthoses

- Modification of the Scaphoid Mobilization splint (*Flexible wrist splint)
- Flexible rods oriented to allow a DT pattern of motion (Lynn Miles modification)

*Bora W, Skirven TM et al. JHS 1989

DTM splint design

Hamish Anderson, OTR - Australia

DTM splint design

Lynne Feehan
Wrist ligament mechanoreceptors and ligamento-muscular reflexes

(Hagert, Garcia-Elias)

- Examined differences in structural composition and presence of mechanoreceptors and nerve structures among wrist ligaments
- Found variations in composition and innervation of the ligaments studied
- Concluded that ligaments serve differential functions based on their composition

Wrist ligament mechanoreceptors and ligamento-muscular reflexes

(Hagert, Garcia-Elias)

- Wrist ligaments serve 2 functions
  - Mechanical function – to constrain and maintain carpal relationships
  - Sensory function - to convey afferent information believed to play a role in dynamic stabilization of the wrist
    - Sensory or proprioceptive function served by mechanoreceptors which are specialized neural end organs that convey physical stimuli to the CNS

Wrist ligament mechanoreceptors and ligamento-muscular reflexes

(Hagert, Garcia-Elias)

- Wrist ligamento-muscular reflex
  - Stimulation of the SLIL ligament with EMG monitoring in the FCU, FCR, ECRB and ECRL
    - Wrist extension produced a response in the FCR and FCU and then the ECRB and ECRL
    - Wrist flexion produced a response in the ECRB then reciprocal activation of the FCR and FCU
Wrist ligament mechanoreceptors and ligamento-muscular reflexes (Hagert, Garcia-Elias)

- Wrist ligamento-muscular reflex
  - A protective response of the antagonist muscle in response to impending injury and possibly damaging wrist positions
  - Followed by subsequent co-contraction of the agonist and antagonist to provide dynamic stabilization of the wrist

- The basis for wrist proprioception and neuro-muscular control
- Implication for rehabilitation
  - Specific muscles may be targeted in the rehabilitation of specific ligament injuries
  - Proprioception re-education may play an important role in the development of dynamic stability of the wrist

Proprioception Rehabilitation (Hagert, JTHH, 2010)

- Retraining of proprioception to improve dynamic stability of a joint
  - Dynamic stability refers to the role of proprioception in regulating joint function
  - Ligament injury or insufficiency may distort proprioception and adversely impact dynamic joint stability
Proprioception Rehabilitation

Hagert, JHTH, 2010

- Stages
  - Basic Rehabilitation
  - Proprioception awareness
  - Joint position sense
  - Kinesthesia
  - Conscious neuromuscular rehabilitation
  - Unconscious neuromuscular rehabilitation

Proprioception re-education (Hagert)

- Basic Rehabilitation
  - Initial rest and protection following injury
  - Controlled motion exercises
  - Pain & edema management

Proprioception Awareness

- Promote conscious joint control
Joint Position Sense

Kinesthesia (TTDPM)

- Perception of joint motion

Conscious neuro-muscular rehab

- Therapeutic exercises
- Isometric
- Isokinetic
- Co-activation
Conscious Neuro-muscular Rehab

- Isotonic exercise
- Eccentric
- Concentric

Unconscious neuro-muscular re-education

- To develop the unconscious activation of muscles to restore joint stability and balance
  - Reactive muscle activation
  - Perturbation training
  - Sensorimotor activation

REACTIVE MUSCLE ACTIVATION

- Acceleration of the gyroscope by means of wrist rotation
  - Random multidirectional forces
  - Requires unconscious activation of wrist muscles to react unpredictably to maintain gyroscope rotation
  - Stimulates proprioception

Utility of the Powerball in the regeneration of the musculature of the forearm
SA Balan, M Garcia-Elias, J Hand Surg 2008
Reactive muscle activation

- Requires unconscious activation of wrist muscles to maintain rotation or oscillation of the device
- Stimulates proprioception

Perturbation Training

- Expose the joint to carefully controlled forces that destabilize enough to elicit an appropriate response without putting the joint at risk for further injury

Perturbation Training

- Rocker board
- Beach ball
Plyometrics

Muscle loading and carpal alignment

(Garcia-Elias; Hagert)

- The contraction of specific muscles has an effect on carpal bone alignment
- This effect can be made use of in the rehabilitation for specific wrist ligament deficiencies

Isometric ulnar deviation
Muscle loading and carpal alignment

- **FCU contraction** – exerts an intrinsic pisiform boost which helps to achieve a more neutral carpal alignment and to reduce the clunk of MCI
- **ECU contraction** results in pulling or tightening of the SLIL.
  - Implication: avoid emphasis on ECU with SL injuries
- **FCR contraction** – helpful with partial SLD
- **FCU, APL, & ECRL** – DTM muscles serving a joint protective function; emphasize with S-L injuries

Muscle loading and carpal alignment

- **Unanswered questions…**
  - What difference does the position of the forearm have on the specific muscle loading effects?
  - How does the degree of ligament injury change the effect of specific muscle loading on carpal alignment?
  - What about the combined loading of agonist and antagonist on carpal alignment?
  - How to specifically apply this information in a rehabilitation program?

Graded motor imagery

- A technique to positively influence cortical areas which are involved in neuro-muscular control
  - Laterality training
  - Mental imagery
  - Mirror therapy
Graded motor imagery

Mirror therapy

- Reflected motion of the uninvolved wrist creates an illusion of motion of the involved wrist
- Visual input of the observed movement is intended to positively influence cortical areas involved in the sensorimotor control of the involved wrist to improve motor performance

Clinical evidence?

- Limited or lacking
- Practical advice:
  - Follow established guidelines for tissue healing in treatment planning
  - Duration of immobilization
  - Introduction of motion
  - Application of gentle loading
  - Return to activity

CLINICAL EVIDENCE?

- Emerging strategies
  - Intuitive and careful application
  - Critical evaluation
  - Continuous monitoring of symptom response
  - Case reports
CLINICAL EVIDENCE?

- “The first step in the development of adequate neuromuscular rehabilitation programs for the enhancement of proprioception after wrist injury are case reports”

  E. Hagert, J Hand Ther 2010

Midcarpal Instability

- Classification (Lichtman)
  - Palmar midcarpal instability
  - Dorsal midcarpal instability
  - Extrinsic midcarpal instability

CLASSIFICATION

  Dobyns, Linscheid, Wright

- CIND - instability of the PCR as a whole
  - Radiocarpal CIND
  - Midcarpal CIND
  - Combined RC and MC CIND
PALMAR MIDCARPAL INSTABILITY

Clinical Characteristics

- Volar sag on the ulnar side of the wrist
- Clunk with ulnar deviation in pronation

PALMAR MIDCARPAL INSTABILITY

Pathoanatomy

- Ligament laxity or disruption may result in
  - palmar translation of distal carpal row
  - volar flexed orientation of the proximal carpal row in neutral deviation

PALMAR MIDCARPAL INSTABILITY

Radiographic Evaluation

- Usually shows
  - volar flexion of the proximal carpal row
  - palmar translation of the distal carpal row
PALMAR MIDCARPAL INSTABILITY
Pathomechanics
- Loss of intimate midcarpal joint contact
  - Loss of the smooth transition of the PCR from a flexed to extended position as the wrist moves from radial to ulnar deviation

PALMAR MIDCARPAL INSTABILITY
Pathomechanics
- When moving from radial to ulnar deviation:
  - PCR stays in a flexed position
  - DCR stays palmarly subluxed
  - until the end range of ulnar deviation

PALMAR MIDCARPAL INSTABILITY
Pathomechanics
- A painful clunk occurs at the end range of ulnar deviation
  - PCR snaps into extension
  - DCR reduces from its palmarly subluxed position
Midcarpal Clunk

Clinical evaluation
- Tenderness with palpation
- Triquetral-hamate interval
- Capito-lunate interval

PALMAR MIDCARPAL INSTABILITY

Midcarpal shift test
- Pronation, neutral wrist deviation
- Palmar pressure over the capitate
- Ulnarly deviate the wrist with simultaneous axial load
**Midcarpal Shift Test**

![Image of a hand with fingers being manipulated]

**MIDCARPAL SHIFT TEST**

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<th>CLUNK</th>
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<td>V</td>
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**PALMAR MIDCARPAL INSTABILITY**

*Conservative Management*

- Splinting
- Activity modification
- Symptom relieving measures/modalities
- Careful exercise
PALMAR MIDCARPAL INSTABILITY

Midcarpal Stabilization Splint

- Dorsally directed pressure on the pisiform (pisiform boost)
- Reduces the ulnar volar sag of the wrist
- Corrects the volar flexed position of the PCR

Midcarpal Stabilization Splint

Splint Pattern

Midcarpal Stabilization Splint

Splint Fabrication
Midcarpal Stabilization Splint

Splint Fabrication

- Attachment points over the pisiform and head of the ulna

PALMAR MIDCARPAL INSTABILITY

Midcarpal Stabilization Splint

- Splint allows nearly full wrist extension, ulnar and radial deviation
- Wrist clunk is eliminated

Wrist clunk is eliminated
MIDCARPAL SPLINT

- No splint
- With Splint

MIDCARPAL STABILIZATION SPLINT

*Observations*

- *Grade I-IV*: experienced pain relief and could wean from splint
- *Grade V*: require the splint to maintain pain relief and prevent wrist clunking

PALMAR MIDCARPAL INSTABILITY

CONSERVATIVE THERAPY

- Strengthen the stabilizing musculature of the ulnar wrist
  - ECU, FCU
- Modify work, ADL and leisure
- Manage symptoms
**Conservative management:**

*What not to do*

- The pathomechanics of palmar midcarpal instability are reproduced with wrist motion under load.
- Standard exercises that involve motion under load, e.g., wrist curls with weights, may reproduce the pathomechanics of the wrist and can exacerbate symptoms.

**Palmar Midcarpal Instability**

**Conservative Therapy**

*What not to do*

- Avoid aggressive wrist mobilization
- Avoid wrist curls or isotonic wrist strengthening
- Avoid repetitive putty squeezing especially in pronation

**Midcarpal Instability:**

*Conservative management*

- Exercise strategies
  - Stable wrist position: supination
  - Focus on the ECU and FCU, which together stabilize the ulnar wrist
  - Isometric versus isotonic
  - Use symptom response as a guide to the progression of activities and exercises
MIDCARPAL INSTABILITY: Conservative management

- Isometric ulnar deviation
  - Combined activity of the ECU and FCU
  - Together stabilize the ulnar carpus

Isometric ulnar deviation

MIDCARPAL INSTABILITY: Dynamic Muscle stabilization

- Activation of Hypothenars and ECU reproduces the normal joint contact forces in the absence of adequate ligament support
- Training may help to stabilize the wrist through dynamic muscle support
**MIDCARPAL INSTABILITY:**
**Dynamic Muscle stabilization**
*(Lichtman)*

**MIDCARPAL INSTABILITY:**
Case study

- 16 year old female violinist with lax wrists

**MIDCARPAL INSTABILITY:**
**Conservative management**

- Case study
  - Onset of pain associated with violin play
  - Progressed with symptoms during other activities
- DX: Midcarpal instability/laxity
  - + midcarpal shift test
  - VISI on xray
MIDCARPAL INSTABILITY: 
*Case Study*

- Radiographic findings: VISI deformity

MIDCARPAL INSTABILITY: 
*Case Study*

- Measures
  - DASH
  - Patient rated wrist evaluation (PRWE)
  - Canadian Occupational Performance measure (COPM)

MIDCARPAL INSTABILITY: 
*Case Study*

- Intervention
  - Midcarpal stabilization splint
  - Isometric ECU & FCU exercise in supination
  - Muscle stabilization exercise
Midcarpal stabilization splint

- Wearing schedule
  - During play
  - When painful
- Goal of splint
  - Reduce pain especially during violin play
  - Allow improved function

MIDCARPAL INSTABILITY:
Case Study Results

- PRWE: Reduction of pain by half with splint use
- COPM: Significant improvement in performance of activities and satisfaction with splint use
- DASH: Decrease in DASH score reflects less impairment with splint use

MIDCARPAL INSTABILITY:
Case Study Results

- Carpal alignment improved with splint
Effect of splint on ROM

- 5° less wrist extension and radial/ulnar deviation
- 20° less wrist flexion

Stabilizing effect of splint

- Reduces the volar sag of the wrist
- Grip strength increased by 5-10 pounds with splint
- Reduced pain, improved performance

Hypermobility Syndrome
Case Report

- 41 year old RD biostatistician with hypermobility syndrome and bilateral wrist pain and laxity
- Gradual onset, no precipitating incident, right wrist involved first and one year later the left
Hypermobility Syndrome

Case Report

- Symptoms - cracking and grinding at first progressing to pain with almost all activities
- Gave up tennis, piano, gardening and cooking
- Maintained employment which involved almost constant keyboard use

Hypermobility Syndrome

Case Report

- Previous Treatment
  - Non-steroidal anti-inflammatory medications; chiropractic treatments; wrist splinting and general therapy – all with limited to no benefit
- Evaluation
  - ROM – WNL both upper extremities with extreme hypermobility

Hypermobility Syndrome

Case Report

- Wrists – generalized multi-directional hypermobility
  - voluntarily dislocates the DRUJs and radio-carpal joints
  - midcarpal clunk with testing
  - ulnar sag both wrists
Hyper-mobility Syndrome

Case Report

- Unstable, subluxed DRUJ and wrist with hand resting lightly on a table surface
- Wrist and DRUJ stabilized on table surface

Grip testing
- Right – 90 lbs.
- Left – 80 lbs.

Pinch strength
- Right lateral pinch – 12 lbs.
- Left lateral pinch – 15 lbs.
- Right tip pinch – 10 lbs.
- Left tip pinch – 5 lbs

Motor function & Sensibility
- WNL

Diagnostic imaging
- Radiographs – 2 screws in shaft of well healed 5th metacarpal fracture; no other abnormalities noted;
- MRI – small TFCC abnormality left wrist

Genetics consultation
- Diagnosis – Familial joint instability (an inherited, ill defined condition with no specific genetic testing available and no known cause)
Hyper-mobility Syndrome

Case Report

- Initial focus on the left wrist
- Midcarpal stabilization splint to address ulnar volar sag
- For use during the day particularly during keyboard activity

Hyper-mobility Syndrome

Case Report

- Response to splint
  - Used the left midcarpal splint for keyboard and driving and was able to get much further into the workday without feeling pain
  - Trial of soft splints

Hyper-mobility Syndrome

Case Report

- Right wrist
  - Symptomatic over the S-L and L-T interval with significant laxity; ulnar volar sag apparent
  - Dart throwers motion splint (H. Anderson; Lyn Miles)
Hyper-mobility Syndrome

Case Report

- Exercise
  - Provided isometric wrist exercise in all planes to develop global wrist stability
  - Performed in neutral rotation to reduce gravity effects

Isometric ulnar deviation with forearm neutral pictured.

Isometric wrist flexion with forearm neutral
Isometric wrist extension with forearm neutral

Hyper-mobility Syndrome

Case Report

- Grip exercise with partial fist and wrist down by the side to enhance neutral wrist posture
- Arms down by the side reported by patient to be a symptom relieving posture for his left wrist (perhaps because this is a gravity neutral position)

- Grip exercise to result in light isometric wrist strengthening
- Incomplete fist is intentional to limit compressive carpal load (in contrast to a clenched fist which may result in greater carpal loading and may provoke the carpal bone shifting and symptoms that he describes)
- Grip force intentionally limited to prevent provocation of symptoms
- Weight bearing exercise with neutral forearm rotation and near neutral wrist position to stimulate joint proprioception without wrist/DRUJ subluxation.

- Exercise upgraded with slight variation of wrist position from neutral.

Position sense exercise – patient matches left wrist position to right with vision occluded.
Hyper-mobility Syndrome

Case Report

- Job modification
  - Ergonomic keyboard to position carpus and DRUJ in gravity neutral position during keyboarding

Dart Throwers Splint

Hyper-mobility Syndrome

Case Report - observations

- Careful and neutral positioning of the wrist and forearm while performing the exercises is critical
- Regular review of the patient’s manner of performing the exercise is essential
- Bilaterality of instability requires adaptation of exercise methods
Hyper-mobility Syndrome

Case Report - observations

- Minimal resistance and avoiding wrist loading with motion prevents shifting of carpal bones in this case which is characterized by general instability.
- The process takes a long time and requires consistency on the part of the patient.