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

- 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

- 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

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

- 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
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

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

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 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 Throwers 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 splint design

Hamish Anderson, OTR - Australia

DTM orthoses

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

*Boza W, Skirven TM et al. JHS 1989

DTM splint design

Lynne Feehan
<table>
<thead>
<tr>
<th>Wrist ligament mechanoreceptors and ligamento-muscular reflexes</th>
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<tbody>
<tr>
<td>Examined differences in structural composition and presence of mechanoreceptors and nerve structures among wrist ligaments</td>
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<tr>
<td>Found variations in composition and innervation of the ligaments studied</td>
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<tr>
<td>Concluded that ligaments serve differential functions based on their composition</td>
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<tr>
<td>Wrist ligamentos serve 2 functions</td>
</tr>
<tr>
<td>Mechanical function – to constrain and maintain carpal relationships</td>
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<tr>
<td>Sensory function - to convey afferent information believed to play a role in dynamic stabilization of the wrist</td>
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<tr>
<td>Sensory or proprioceptive function served by mechanoreceptors which are specialized neural end organs that convey physical stimuli to the CNS</td>
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<tr>
<td>Stimulation of the SLIL ligament with EMG monitoring in the FCU, FCR, ECRB and ECRL</td>
</tr>
<tr>
<td>Wrist extension produced a response in the FCR and FCU and then the ECRB and ECRL</td>
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<td>Wrist flexion produced a response in the ECRB then reciprocal activation of the FCR and FCU</td>
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<tr>
<td>A protective response of the antagonist muscle in response to impending injury and possibly damaging wrist positions</td>
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<tr>
<td>Followed by subsequent co-contraction of the agonist and antagonist to provide dynamic stabilization of the wrist</td>
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<th>Wrist ligament mechanoreceptors and ligamento-muscular reflexes</th>
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<tr>
<td>The basis for wrist proprioception and neuro-muscular control</td>
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<tr>
<td>Implication for rehabilitation</td>
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<tr>
<td>Specific muscles may be targeted in the rehabilitation of specific ligament injuries</td>
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<td>Proprioception re-education may play an important role in the development of dynamic stability of the wrist</td>
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<th>Proprioception Rehabilitation</th>
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<tr>
<td>Retraining of proprioception to improve dynamic stability of a joint</td>
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<tr>
<td>Dynamic stability refers to the role of proprioception in regulating joint function</td>
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<tr>
<td>Ligament injury or insufficiency may distort proprioception and adversely impact dynamic joint stability</td>
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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
  - Requires unconscious activation of wrist muscles to react unpredictably to maintain gyroscope rotation
  - Stimulates proprioception

Utility of the Powerball in the invigoration of the musculature of the forearm

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

- 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

#### 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

#### Radiographic Evaluation
- Usually shows:
  - Volar flexion of the proximal carpal row
  - Palmar translation of the distal carpal row

#### 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

#### 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

PALMAR MIDCARPAL INSTABILITY
Clinical evaluation
- Tenderness with palpation
- Triquetral-hamate interval
- Capito-lunate interval

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

MIDCARPAL SHIFT TEST
GRADE  PALMAR TRANSLATION  CLUNK

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

- Attachment points over the pisiform and head of the ulna

PALMAR MIDCARPAL INSTABILITY

Midcarpal Stabilization Splint

Splint Fabrication

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

Midcarpal Stabilization Splint

Splint Fabrication
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

Dynamic Muscle stabilization

(Lichtman)

MIDCARPAL INSTABILITY: 
Case study

- 16 year old female violinist with lax wrists

Case study

MIDCARPAL INSTABILITY: 
Conservative management

- Onset of pain associated with violin play
- Progressed with symptoms during other activities
- DX: Midcarpal instability/laxity
  - + midcarpal shift test
  - VISI on x-ray
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

- 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

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

- 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

Hyper-mobility Syndrome

- 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

Hyper-mobility Syndrome  
**Case Report**

- 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

Hyper-mobility Syndrome  
**Case Report**

- 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 work day 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
- Arm 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.